Anticipating Uncertainty: Straddles Around Earnings Announcements

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Abstract

On average, straddles on individual stocks earn significantly negative returns: daily holding period return is -0.19% and weekly holding period return is -2.09%. In sharp contrast, straddle returns are significantly positive around earnings announcements: average at-the-money straddle returns from one day before earnings announcement to the earnings announcement date yields a highly significant 2.3% return. The positive straddle returns around earnings announcements are robust to different stock and option characteristics. This finding suggests that investors underestimate the magnitude of uncertainty during the earnings announcement period, consistent with the cognitive bias "conservatism." Furthermore, we find the underestimation of uncertainty is more pronounced for smaller firms, firms with less analyst coverage, higher past jump frequency, higher kurtosis and more volatile past earnings surprises. This supports the notion that when there is more noise in the data, it is more likely for investors to display "conservatism."

JEL classification: G02, G11, G13.

Keywords: option returns, straddle, earnings announcement, transaction costs.

1. **Introduction**

Company earnings announcements are one of the most important corporate events. A typical public firm makes an announcement each quarter, and the date of future earnings announcement is made public ex ante.[1] During this event, firm management reveals fundamental information about the firm, and investors respond actively to the information by comparing the announced fundamentals to their ex ante expectations. Earnings announcement periods are information intensive periods, and stock trading volume can increase by as much as 50%. This is also a period of high returns. According to earnings premium literature,[2] 60% of a typical stock return can be achieved if investors trade only on each quarterly earnings announcement. A well-known fact for earnings announcements is that, whether the earnings announcement brings good news or bad news, uncertainty builds up before the news and plummets afterwards. Given the sharp changes in uncertainty around earnings announcements, we consider earnings announcements to be a particularly interesting venue to study how investors form their expectations of firm's fundamental uncertainty.

The main question we address in this paper is the following: can investors by and large correctly forecast the magnitude of the sharp increase in uncertainty during earnings announcement? To focus directly on uncertainty rather than the direction of the news, we choose to adopt one particular option trading strategy, the straddle. Straddles consist of a pair of call option and put option with matching strikes and times-to-maturity and can be structured to be delta-neutral, which allows one to trade on underlying uncertainty without any directional exposure to the underlying security.

Expected returns on straddles typically include a volatility risk premium and a jump risk premium. Absent of such premia, Coval and Shumway (2001) show that under mild assumptions, the expected return on delta-neutral straddles should equal to the risk-free rate. Coval and Shumway (2001) further document that delta-neutral straddles on the S&P 500 index approximately earn a negative three percent return per week and interpret this as consistent with market volatility carrying a negative risk premium. We confirm Coval and Shumway's (2001)

[1] For instance, Wall Street Journal keeps an earnings calendar for public firms, indicating on which day the earnings will be announced. Moreover, according to Bagnoli et al (2001), the managers usually follow previous year's announcement date, and they are reluctant to change the date, because that would be bad signal to the general public.
[2] For instance, Frazzini and Lamont (2006).

finding on straddle returns at the individual stock level. In particular, volume-weighted delta-neutral at-the-money individual stock straddles have an average return of -2.08% per week with a t-statistic of -42.35. At daily and monthly frequencies, the delta-neutral straddle earns -0.14% and -16.21% on average, respectively. The negative straddle return is robust to volume weighting, open interest weighting and equal weighting.

Following the same reasoning, if the options market correctly forecasts the magnitude of the sharp increase in uncertainty associated with earnings announcements, then straddle holders should earn similarly negative average returns around earnings announcements. In striking contrast, delta-neutral at-the-money straddles earn significantly positive returns during earnings announcement periods. To be more specific, we construct at-the-money short-term straddles on individual stocks[3] prior to the earnings announcement. Earnings announcement dates are scheduled ex ante and are public information appearing on almost all major financial websites from The Wall Street Journal to Yahoo! Finance. Nevertheless, there is a possibility that information gets incorporated into option prices slowly as investors start to realize the imminence of the upcoming earnings announcement events. Therefore, we consider multiple holding periods around earnings announcements. We construct straddles five, three, and one trading days before the scheduled earnings announcement date, and hold the straddle until the earnings announcement date or one day after the earnings announcement date. The daily straddle returns around earnings announcements are all significantly positive across all holding periods, ranging from 0.31% to 2.30%. Meanwhile, in anticipation of increased information flow into the market and increased uncertainty, market makers naturally increase transaction costs to protect themselves from informed traders. Even in the existence of higher transaction costs, straddles around earnings announcements still deliver positive and significant returns when we focus on short-term options with more liquidity.

The combination of significantly positive straddle returns around earnings announcements and significantly negative straddle returns over the whole sample suggests that options market investors consistently under-react to the rise in uncertainty regarding firm fundamentals prior to earnings announcements. In this paper, we work with raw returns of straddles without any risk adjustment. One could argue that the positive straddle returns around

[3] Our paper focuses on delta-neutral straddle returns as in Coval and Shumway (2001), rather than delta-neutral, vega neutral and gamma neutral straddles as in Cremers et al (2012), due to data limitation at individual stock level.

earnings announcements represent compensation for risks. Nevertheless, numerous studies have shown that the volatility risk premium and the jump risk premium, when significant, carry a negative sign. For instance, a recent paper by Cremers, Halling and Weinbaum (2012) show that both market volatility risk and market jump risk carry significant and negative risk premia. So it is less likely that the positive straddle returns around earning announcement represent compensation for risks.[4]

An alternative explanation for this underestimation is a behavioral bias among investors, namely conservatism, as discussed in Barberis, Shleifer and Vishny (1998). Conservatism means that investors are too slow to draw inferences from data, which leads to investors' under-reaction to information in the data. Barberis et al (1998) use conservatism to explain momentum anomaly and post-earnings announcement drift as investor conservatism results in under-reaction towards information in stock prices and earnings announcements. A recent study by Hilbert (2012) models eight well-documented decision-making biases, including conservatism, in a noisy information processing framework. In the Hilbert (2012) model, noise in the retrieval of information from memory is the underlying mechanism for conservatism, where he defines noise as a mixing of evidence. A direct implication from his model is that, for a process with more noise in its signal (and thus also more noise in the memory retrieval process), the conservatism bias should be more severe. Consistent with the noisy-information-processing driven "conservatism" model in Hilbert (2012), we find supporting evidence that positive straddle returns are more pronounced for firms with more noisy signals in the price and earnings processes. Firms with smaller size, less analyst coverage, higher historical volatilities, higher historical jump frequencies, larger historical jump sizes, larger historical earnings surprises and more volatile past earnings surprises all experience stronger underestimation of uncertainty and higher straddle returns around earnings announcements. This clearly suggests that investors tend to underestimate uncertainties more when there is more noise.

[4] Other than market level aggregate jump premium, we also examine how firm specific jumps are related to straddle returns. Earlier research has shown that earnings announcement date is quite often associated with price jumps. For instance, Lee and Mykland (2008) find that at index level, jumps are associated with general market news announcement whereas at stock level, jumps are associated with prescheduled earnings announcement. Both Lee and Mykland (2008) and Lee (2012) provide evidence that earnings announcement date is an important source of stock level jumps. Our own calculation shows that the probability of a jump is 13% around earnings announcement date, which is 10 times larger than otherwise. The earnings announcement period is clearly an excellent window to examine jump dynamics, yet this does not address the question that why the mis-estimation is consistently underestimation.

Our study is closely related to the over-reaction and under-reaction literature in the options market. Stein (1989) finds there is over-reaction in the long-term implied volatility on S&P 100 index as they move by same amount as in the short-term implied volatility. Poteshman (2001) examines the same issue using S&P 500 index options and find evidence for both long-term over-reaction and short-term under-reaction. The rationales for financial market over-reaction and under-reaction are mostly based on behavioral explanations. As mentioned earlier, Barberis et al (1998) reconcile these two effects by using two well-established cognitive biases: conservatism and the representativeness heuristic. When one investor is subject to conservatism, she clings to prior beliefs and updates slowly to arrival of new information, which leads to under-reaction in the short-term. Ni and Lemmon (2010) show that there is a significant difference in clienteles in the index options and the stock options markets. Compared to index options trading, which is largely dominated by institutions, the stock options market is mainly driven by individual investors. Individual options traders are more likely to exhibit the cognitive biases described in Barberis et al (1998) than institutional traders, which is consistent with our empirical results. A recent paper by Goyal and Saretto (2009) examines cross-sectional differences in straddle returns, and finds that straddles on stocks with larger differences between historical realized volatility and implied volatility tend to have higher returns. Goyal and Saretto (2009) interpret their results to be consistent with the Barberis and Huang (2001) hypothesis that people display both loss aversion and mental accounting. Our paper is also related to the vast literature on the earnings premium and post earnings announcement drift, discussed in Bernard and Thomas (1989). Our finding of underestimated uncertainty around earnings announcements provides an additional perspective on how information in earnings surprises becomes incorporated in security prices.

Our paper is the first in the literature to document a puzzling empirical phenomenon: positive and significant straddle returns around earnings announcements in sharp contrast to significantly negative straddle returns on stocks. Our finding is a challenge for current options pricing models, which, in general, do not generate such implications. We conjecture that this under-reaction to uncertainty in earnings announcement periods is due to investors' conservatism, but it is also possible that other mechanisms not examined in this paper could drive our results.

Our paper is organized as follows. Section 2 introduces the data. Section 3 presents the main findings of positive straddle returns around earnings announcement periods. In section 4, we examine straddle returns in the cross-section. In Section 5, we discuss the effect of transaction costs. Section 6 concludes.

2. **Data**

Our sample period is January 1996 to December 2010. We obtain information about the underlying stocks, such as stock returns and characteristics, accounting data, and earnings announcement data from CRSP, COMPUSTAT, and IBES, respectively. Our option data is from Option Metrics, which provides end-of-day bid and ask quotes, open interests, volumes, implied volatilities and option Greeks for all listed options. We only include options with 10 to 60 days to maturity on common stocks with prices of at least $5. We take the mid-quote value as a fair reflection of the option price and require it to be at least $0.125. To filter out erroneous observations, we require bid and ask price to satisfy basic arbitrage bounds.[5] At the time of the straddle formation, we include only options with an absolute delta between 0.375 and 0.625 (as in Bollen and Whaley (2004)), and with positive open interest. Moneyness of the option, "money," is computed as stock price over strike price. If it is close to 1, then it is at-the-money. We require options to have moneyness between 0.95 and 1.05 to be at-the-money.

In Table 1, we present summary statistics for the stocks and options included in our sample. Panel A reports firm-level characteristics: market capitalization, book-to-market ratio computed as the ratio of book value of equity over market value of equity, past 12-month stock return, past 3-month daily stock return volatility, skewness and kurtosis. These firm characteristics are observed at the end of December, March, June and October and are merged with options returns on earnings announcement events in the four quarters of each year.

We provide the number of observations, mean, median and standard deviation for each of the firm characteristic variables. The summary statistics are computed by pooling over all firms and all dates. In total, our sample includes more than 30,000 firm-quarter observations. For each quarter, the number of sample firms ranges between 200 and 1100. Our sample covers a good size of the cross-section of stocks. The median market cap in our sample is about $2.0 billion. Over the same time period, the median market cap for NYSE firms is $ 1.3 billion. So our

[5] Arbitrary boundaries include: bid>0, bid<offer; for put options we require strike >= bid and offer >= max(0, strike price-stock price); for call option we require stock price >=bid and offer >= max(0, stock price-strike price).

sample firms are slightly larger than a typical NYSE firms. For book-to-market ratios, the median of our sample is 0.343. During the same period, the median book-to-market ration for NYSE firms is 0.576. This indicates our sample include more value firms than growth firms when compared to the NYSE firms. The mean stock return over the past 12 months is 10.2%, similar to the US stock market risk premium. The mean stock return volatility is 46.2%, which is lower than an average NYSE firm's volatility of about 55%. Means of skewness and kurtosis are 0.056 and 5.434, respectively. Overall, our sample firms are larger-than-average firms with lower-than-average book-to-market ratios. This is consistent with our knowledge that option listing is more prevalent for larger firms.

Panel B reports summary statistics for individual options. The mean and median of moneyness is 1.014 and 1.010, respectively, indicating that most of the sample options are fairly close to at-the-money. Days to maturity is on average about 38 days, so our sample options are short-term options. In terms of liquidity, open interest is on average 2,318, and daily volume is 386. Implied volatility is on average 50.7%, which is higher than past realized volatility of 46.2%. The fact that implied volatility is higher than historical volatility is expected, because implied volatility contains a component of the volatility risk premium. Overall, we are confident that our sample includes only close to maturity, at-the-money options with reasonable trading activities.

3. **Straddle Returns**

We consider two ways to construct straddles: the simple straddle and the delta-neutral straddle. For the simple straddle, the investor purchases a pair of call and put options with matching strike prices and maturity dates. The idea of delta-neutral straddle is discussed in Coval and Shumway (2001). Option delta measures the option price's sensitivity to the underlying price movements. When we pair the puts and calls, the weights are adjusted to make the straddle delta to be zero. By doing so, the straddle becomes delta-neutral, and theoretically has no exposure to price changes in the underlying. Whenever there is more than one pair of delta-neutral straddles on the same stock on the same day, we either equal weight or volume weight individual straddles.[6] Results obtained using simple straddles and delta-neutral straddles are quantitatively very similar, and we choose to report only delta-neutral straddle results.

The expected returns on a straddle depend on its exposure to market return, volatility risk and jump risk. Since delta-neutral straddles have zero exposure to the underlying asset, they presumably have little to no exposure to the market return.[7] To control for exposure to market volatility risk and market jump risk, Cremers et al (2012) construct delta-neutral, vega-neutral and gamma-neutral index straddles by using index options with different maturity dates. However, since individual stock options tend to be much less actively traded than index options (especially for longer maturities), it is difficult to construct reasonably liquid straddles that are simultaneously vega-, gamma-, and delta-neutral. Therefore, we choose to focus on delta-neutral straddles, rather than vega- or gamma-neutral. Meanwhile, both volatility premium and jump premium are found to be negative in the literature, and straddles in general have positive exposures to both volatility risk and jump risk. Following this reasoning, not adjusting for any volatility risk premium or jump risk premium would understate the returns on straddles, which biases against our findings of positive straddle returns.

In section 3.1, we examine straddles formed over all days and use them as benchmark. Then we focus on straddles formed around earnings announcement days in section 3.2.

3.1 Straddle Returns at Stock Level

We examine daily, weekly and monthly straddle returns over all trading days from 1996 to 2010. For daily straddle returns, we construct the straddle based on the midpoint of previous day closing ask and bid prices to identify the at-the-money options, and compute the straddle return over the next day using the midpoints. The holding period of the at-the-money daily straddle is only one day. For weekly straddle returns, we hold the straddle for five business days from Tuesday to the next Tuesday. We construct monthly straddles from month end to the next month end. The average straddle returns are reported in Panel A of Table 2. To compute the

[6] From results not shown, we also compute open-interest weighted returns, and results are very similar.
[7] From results not reported, we also construct beta-neutral straddles to have zero exposure to market risk, and the results are quite similar to delta-neutral straddles.

average returns, we average straddle returns over time and stocks. To be comparable across different holding windows, we report the holding period returns as well as daily returns.

We start with the equal-weighted straddle returns on the left. For a one-day holding period, the average straddle return is -0.19% (-47.50% if annualized), with a highly significant t-statistic of -24.29. For weekly holding period, the average equal weighted straddle return is -2.09% (-108.68% if annualized), with a t-statistic of -53.49. If we extend the holding period to a month, the holding period return becomes -17.10% (-205.20% if annualized), with a t-statistic of -96.03. For the volume-weighted returns on the right, the magnitude and significance are quite similar to the equally weighted results.

The strong negative returns associated with straddles are not surprising given the findings in Coval and Shumway (2001). We know that volatility carries a negative risk premium, and straddle returns on stock indices usually are significantly negative. Straddles on individual stocks might also have a positive loading on market volatility, and thus they on average deliver strongly negative returns. For instance, Bollen and Whaley (2006) show that straddles on average lose money, about 3% per week, which is comparable with our finding.

3.2 Straddle Returns Around Earnings Announcements

In this section, we focus on straddle returns around earnings announcements. We start by examining the dynamics of uncertainty around earnings announcements, measured by implied volatilities. We average implied volatilities of firm level at-the-money calls and puts for each trading day from 20 days before earnings announcement to 20 days after the earnings announcement. We obtain the earnings announcement dates from IBES. We define day 0 as the event day, during which earnings is announced. The trading day before announcement is day -1, and the trading day after announcement is day 1. One complication in the real world is that some announcements are made before trading hours while others are after trading hours. Previous studies show that data on exact announcement hours can be imprecise; therefore we choose to only make use of announcement date and do not adjust for announcement hours.

Figure 1 plots mean implied volatility over the horizon [-20, 20], i.e., from 20 days before announcements until 20 days after. Starting from day -20, the mean implied volatility is 0.493, and it gradually increases to 0.520 on day -4. Between day -4 and day -1, the slope for implied volatility becomes steeper and the implied volatility increases to 0.532 on day -1, which is the highest point in the graph. On day 0, the average stays around 0.524, which is still relatively high. On day 1, the implied volatility crashes down to 0.491. This pattern suggests that the uncertainty regarding the news released in earnings announcements is generally resolved around day 0. Over the next 20 days, the implied volatility remains mostly flat. For day 20, the implied volatility becomes 0.482, which is slightly lower than implied volatility on day -20. The implied volatility generally stays low until the next earnings announcement, unless some other important events happen unexpectedly. The dynamics of implied volatility around earnings announcements clearly shows that implied volatility gradually runs up before earnings announcements, stays at the peak for one day, then drops to normal level.

In Panel B of Table 2, we report average short-term at-the-money delta-neutral straddle returns. We construct straddles over different windows around earnings announcements. For instance, for the strategy over [-5, 0], we buy the straddle on day -5, and sell the straddle on earnings announcement day, and the holding period for this straddle is 5 days. We vary the starting date among -5, -3 and -1, and the ending date among between 0 and 1. As a result, the longest holding period is 6 trading days for strategy [-5, 1], and the shortest holding period is 1 trading day for strategy [-1, 0]. To be comparable across different holding windows, we report the holding period returns as well as daily returns. For each strategy, we pool across all stocks over all quarters to compute the mean and the t-statistics.

The first three strategies are [-5,0], [-3,0] and [-1,0], all of which involve selling at the end of the earnings announcement day. Panel B of Table 2 includes results for both equal weighting and volume weighting. We first look at the equal weighting results. Straddle holding period returns over [-5, 0], [-3, 0] and [-1, 0] are 2.22%, 3.00% and 2.30%, which is equivalent to daily return of 0.44%, 1.00% and 2.30%. All returns have t-statistics higher than 15. It is interesting that the daily returns on straddles become higher as the holding period gets shorter. Next, we consider three strategies where straddles are held until day 1, and they are [-5,1], [-3,1] and [-1,1]. Berkman and Truong (2008) have found that more than 30% of firms announce their earnings after the market close during the period from 1995 to 1999. Thus, holding the straddles until one day after the earnings announcement dates guarantees that all the uncertainties associated with the earnings release are resolved. From the dynamics of implied volatility in

Figure 1, we know that implied volatility decreases to pre-announcement level on day 1. The average holding straddle returns for [-5,1], [-3,1] and [-1,1] are 2.68%, 1.25% and 3.09%, respectively, and they remain highly significant.

When we switch to the volume-weighted returns in the right half of the panel, all straddle returns are still positive and significant with similar magnitudes. To ensure that the positive straddle returns are not driven by how we construct straddles, we conduct additional robustness checks on simple straddle returns. From results not reported, with different combinations of holding periods and weighting schemes, the simple straddle returns are between 0.80% and 2.25%, and they all have t-statistics above 6.0.

Are the average positive returns on straddles driven by a special time period or outliers in the data? To answer this question, Figure 2 plots the time-series of returns for both delta-neutral straddles and simple straddles using the [-3,0] window over the past 15 years. It is evident from the plot that most of the time, the delta-neutral straddle returns are close to 1% per day, except for 7 out of 60 quarters. The pattern for simple straddle returns is quite similar, which implies that the significant positive returns are not driven by any particular period. Meanwhile, we notice interesting time variation patterns in the straddle returns. For instance, straddle returns are relatively lower around 2001 and 2008, which coincides with market downturns.

We further explore this relation between straddle returns and market downturns by relating straddle returns with the VIX, the implied volatility index on the S&P 500 options. VIX contains two types of information: the level of uncertainty and premium people are paying for uncertainty. During a time of high uncertainty, it is possible that investors would like to buy straddles to protect against high uncertainty. If most investors hedge using straddles, the price of straddles might be pushed too high, and straddles would deliver low returns. If that is the case, straddle returns would be lower after VIX is high. In Panel C of Table 2, in a pooled regression, we regress straddle returns on lagged VIX from the end of the previous quarter. Consistent with our expectation, the loadings on past VIX are always negative and mostly significant. This suggests that the magnitude of the positive straddle returns around earnings announcements are related to the level of VIX in the past.

To summarize the empirical findings in this section, we document significantly positive straddle returns around earnings announcements, and this finding is robust over time and using different ways of constructing straddle returns. This finding is in sharp contrast with the negative average straddle returns computed over all trading days, which we use as a benchmark. The average negative straddle returns in Panel A is well expected, given that straddles have positive exposure to volatility risk and jump risk, which are both negatively priced. The positive straddle returns in Panel B is puzzling, which are at odds with negatively priced volatility risk and jump risk. One potential explanation is that options market investors on average underestimate the magnitude of uncertainty around earnings announcements, which leads to positive returns on straddles.

The investors' underestimation of uncertainty is consistent with a behavioral bias, "conservatism," meaning that investors are too slow to draw inferences from data and that leads to investors' under-reaction towards information in the data. Barberis, Shleifer and Vishny (1998) use conservatism to explain the momentum and post-earnings announcement drift anomalies, in the sense that investor conservatism results in their under-reaction to information contained in stock prices and earnings surprises. In our setting, even though it is well-known that stock price uncertainty peaks around earnings announcements, investors still fail to fully anticipate the magnitude of the uncertainty. Thus, the underestimation of uncertainty generates positive returns on straddles around earnings announcements.

Recently, Hilbert (2012) outlines a consistent mechanism that could lead to eight well-documented decision-making biases, including conservatism, in a noisy information-processing framework. In his model, the process of information retrieval from memory is contaminated with noise. Low frequency events are retrieved with higher-than-objective frequency and high frequency events are retrieved with lower-than-objective frequency, leading to a lower-than-objective volatility estimate. Whenever the underlying process contains more noise, the process of memory-retrieval also becomes noisier, and this will result in a more severe conservatism bias. In the next section, we first examine the robustness of our findings of positive straddle returns around earnings announcements, and then we explore whether the underestimation of uncertainty during earnings announcement is related to measures of how noisy a firm's stock price process is.

4. **Straddle Returns in the Cross-section**

We examine the cross-sectional patterns of straddle returns in this section, which serves two purposes. First, it allows us to examine whether the positive straddle returns documented in the previous section are robust across different firm and option characteristics. Second, we investigate whether measures of stock price noisiness help to predict patterns in straddle returns around earnings announcements, in order to shed more light on how our findings are related to the conservatism bias.

In the previous section, we construct straddles over various windows around earnings announcements, and the results are qualitatively similar. For brevity, in this section we focus on delta-neutral straddles over the window of [-3,0], meaning we long straddles 3 days before the earning announcement and sell them at the close on earnings announcement days, which results in a 3-day holding period.[8]

4.1 Straddle Returns across Option Characteristics

The most important features for options are whether it is a call or a put, its moneyness, its time to maturity and its implied volatility. Since we only consider at-the-money straddles in this paper, we leave out moneyness and focus on the three other features. In the interest of predicting straddle returns, all features should be available to investors when constructing straddles. For options, both maturity and whether the option is a call or put are public information. The implied volatility can also be computed when constructing straddles. To compute straddle returns along different option characteristics, we first group options each quarter by days to maturity, historical implied volatilities, and by whether they are puts or calls. Next, we compute the cross-sectional average straddle returns for each option characteristic category for each quarter. The final means and t-statistics are computed over the 60 quarters of option returns over different option characteristics.

The results are presented in Table 3. For mean straddle returns, we report the 3-day holding return and the t-statistics. We omit the daily returns, because all returns in this table are over 3 days and thus are readily comparable. In Panel A, we compare returns on calls with returns on puts. If we use equal weighting, the average 3-day holding return for call is 8.18%,

[8] Our results are quantitatively similar using alternative windows and they are available upon request.

and for put, it is -1.88%. The difference between call return and put return becomes 10.06%. All three numbers are statistically significant, especially for the call returns and the difference between the call and put returns. The magnitudes of returns are quantitatively similar when we use volume weighting. Previous literature on the earnings premium documents that the average stock return over earnings announcements is positive, meaning that the stock prices, on average, would increase over the earnings announcement period[9]. Given it is more likely to observe positive earnings shocks than negative earnings shocks, it is not surprising to observe calls making positive returns and puts making negative returns over earnings announcement periods.

The next option characteristic we examine is time to maturity. For options with shorter time to maturity, the sensitivity to volatility changes (measured by vega) is higher. All else equal, underestimation of uncertainty would presumably impact shorter-term straddles harder, which indicates that shorter-term straddles might have higher returns. Meanwhile, Stein (1989) finds there is over-reaction in the long-term implied volatility on S&P 100 index as it moves by same amount as the short-term implied volatility. In Panel B, we separate firm level straddle returns into four groups based on days to maturity. For the low group, the average number for days to maturity is 24 days, while the average number of days to maturity for the high group is 53 days. For equal weighting, straddles with the shortest and longest time to maturity have average holding period returns of 3.51% and 3.01%, respectively. The difference between the longest and shortest time to maturity straddles is not significant.

One might suspect that the level of implied volatility at the time of straddle construction could be indicative of underestimation of uncertainty during the earnings announcement. Next, we sort all straddles into four groups based on implied volatilities computed as an average of implied volatility from call and put in Panel C. Using equal weighting, the average straddle returns for firms with the lowest implied volatilities is 3.65%, while average straddle returns for firms with the highest implied volatilities is 1.90%. The difference between the two is 1.75%, and is significant with a t-statistic of 4.52. Volume weighting delivers very similar results. The results show that a low level of implied volatility is associated with more severe underestimation of uncertainties, which leads to more positive straddle returns during earnings announcement periods.

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[9] One possible reason, supported by evidence in Burgstahler and Dichev (1997), is that managers manage reported earnings to avoid earnings decreases and losses.

To summarize, we find large positive returns on call options and negative returns on put options around earnings announcements. For straddles with different time to maturity and historical implied volatility, straddles with shorter horizon and lower implied volatility tend to have higher returns. Overall, average straddle returns stay significantly positive across all option characteristics, confirming the robustness of our finding in previous section[10].

4.2 Straddle Returns across Different Stock Characteristics

In this section, we investigate whether straddle returns around earnings announcements follow any patterns across observable stock-level characteristics. If the positive straddle returns around earnings announcements are driven by conservatism-led underestimation of the uncertainty, then this effect might be stronger among firms with more noise in their observable data. In other words, our conjecture is that in the cross-section of stocks, if the price signals from the firms are more difficult for investors to understand or make inferences, then those firms would be subject to stronger "conservatism" bias, which possibly leads to higher positive straddle returns around earnings announcements.

We group "relevant" stock-level information into four different groups: the first group is industries; the second group includes the standard firm characteristics that have been shown to be related to equity returns such as size, book-to-market ratio, past stock returns and difference between implied volatility and historical volatility; the third group includes higher moments and jumps in the historical return process, and the last group includes historical earnings surprises. To examine patterns in the cross-section, we follow a similar portfolio sorting procedure as in section 4.1. For every quarter, we sort all firms into 4 groups, based on stock characteristics observed at the end of the previous quarter, and we average firm level straddle returns for each of the four groups. The means and t-statistics for each group are computed over 60 quarters for each of the four groups. We focus on the window of [-3,0], and we present 3-day holding period

[10] From results not reported, we also investigate sorting based on put-call volume ratio, as in Pan and Poteshman (2006), and implied volatility difference between call and put options, as in Xing, Zhang and Zhao (2010). The average straddle returns are significantly positive across straddles with different put-call ratios and different volatility skew measures. Meanwhile, there is no uniform pattern across different put-call ratio/volatility skew groups.

returns and t-statistics on delta-neutral straddles. To be conservative, we use volume weighting at firm level whenever there are more than one at-the-money straddles[11]. Table 4 reports the results.

We start the discussion with analysis of straddle returns on firms from different industries in Panel A of Table 4. The 12-industry classification scheme is obtained from Ken French's website. In general, people are more familiar with well-established industries and can more precisely predict future performances in those industries. In contrast, people are less familiar with new industries, and thus have more difficulty with processing information about them and might exhibit more behavioral biases towards those firms' future performances. Among the 12 industries, the highest straddle return is achieved at 4.74% for "business equipment" industry, and the lowest straddle return is -0.71% for the "utilities" industry. Out of 12 industries, except for the "utilities" and "energy" industries, 10 industries obtain significant and positive straddle returns around earnings announcement periods. Both the "utilities" and "energy" industries in the U.S. have historically been highly regulated, and they slowly underwent deregulation process during our sample period. Maybe it is no surprise that earnings announcements have minimal impact on their stock prices and option prices, given that there usually were not big earnings surprises for the above two industries. Similarly, it might not be a surprise to see high straddle returns on "business equipment" and "telecom" industry, given the nature of high uncertainty on their cash flows. For the high straddle returns on "durables" industry, one possible reason is that investors underestimate the size of uncertainty, given their relatively low historical uncertainty.

Panel B reports results based on sorts on four firm characteristics that have been shown in previous literature to be significantly related to stock returns (or option returns). The first three are the most well-known firm level characteristics: size, book-to-market ratio and past 3-month return. Ex ante, one might expect that it is harder to estimate uncertainty associated with earning for small firms and growth firms (firms with low book-to-market ratio). The reason is the following: for smaller firms, there is less analyst coverage and more information asymmetry, and thus it might be more difficult to correctly forecast the changes in uncertainty surrounding earnings announcements. For growth firms, they have more growth options and less assets-in-place than value firms, and more volatile earnings in general, it might be more difficult to estimate uncertainty for growth firms than for value firms. For size groups, the average straddle

[11] We conduct many robustness checks using different windows and different weighting schemes. The results are qualitatively similar and are available on request.

return is 4.10% and 1.71% for firms in the smallest and the largest size quartile, respectively, and the difference is significant with a t-statistics of 3.74. This finding supports the notion that investors tend to underestimate uncertainty more for smaller firms rather than for bigger firms. For value effect, the average straddle return is 3.17% and 3.11% for firms in the lowest and the highest book-to-market ratio quartile, respectively. But the difference is insignificant. For momentum effect, the average straddle return is 3.16% and 3.47% for firms in the lowest and the highest past return quartile, respectively. The difference in straddle returns between the loser and winner portfolios is not statistically significant.

The last variable is the difference between historical volatility and implied volatility, which is introduced in Goyal and Saretto (2009). The main idea is that investors tend to be slow to adjust their expectations towards implied volatility in general, and the difference between historical volatility and implied volatility can affect straddle returns on average. They find that the larger the difference between historical volatility and implied volatility, the higher the straddle returns. From our results, the average straddle returns around earnings announcements for the highest and the lowest difference between historical volatility and implied volatility are 3.87% and 1.80%, respectively. The difference between the two is 2.07% with a significant t-statistic of 4.18. This finding strongly supports the argument in Goyal and Saretto (2009), and also indicates that the under-reaction to volatility is also relevant for earnings announcement period.

The results in Panel B clearly show the positive straddle returns around earnings announcement are robust across all characteristic groups in consideration. And it seems that only size and the difference between historical volatility and implied volatility make a difference for cross-sectional straddle returns around earnings announcements.

Next, we turn our focus to variables that are more directly related to measures of noise in the stock return process and earnings process. As Hilbert (2012) suggested, noise is an important mechanism that can lead to decision making biases such as conservatism. We construct measures of noise for both the stock return process and earnings process and examine if they are related to the magnitude of underestimation. For the stock return process, we compute historical higher moments: variance, skewness and kurtosis using past three months daily return data. We also compute historical jump frequency and historical jump size. We follow the Lee and Mykland

(2008) procedure and use one year of daily returns data to extract the jump process for each firm in our sample.[12] Presumably, it is more difficult for investors to make precise estimates of uncertainty around earnings announcements for firms with larger higher moments, more frequent jumps, or larger jumps. Therefore, we expect that firms with larger high moments and larger jumps to have higher positive straddle returns around earnings announcements.

The results are presented in Panel C of Table 4. For firms with the lowest and highest historical volatility, the straddle returns are 2.70% and 3.66%, respectively. For firms with the lowest and highest historical skewness, the straddle returns are 2.40% and 2.69%, respectively. For firms with the lowest and highest historical kurtosis, the straddle returns are 2.36% and 4.17%, respectively. Evidently, larger historical moments do increase the difficulty of correctly estimating uncertainty around earnings announcements. Out of the three moments, the difference between the high and low is significant for both volatility and kurtosis. For the jump frequency measure, firms with the lowest and highest jump frequency have average straddle returns of 2.21% and 4.43%, respectively. The difference is 2.12%, with a t-statistic of 4.46. For the jump size measure, firms with the smallest and largest jump size have average straddle returns of 3.09% and 3.77%, respectively. However, the difference is smaller than in the case of jump frequency, and it is not statistically significant. The conclusion from using jump measures is similar to that of historical higher moments: higher jump frequency and larger jump size increase the difficulty of correctly estimating uncertainty around earnings announcements.[13]

Since our straddles are constructed during earnings announcement periods, an interesting question is whether investors learn from past earnings surprises about the size of uncertainty and make correct inferences afterwards. Obviously, this depends on the precision of the signal received from previous earnings announcements. If the information from previous earnings announcements contains more noise than signal, then it would be more difficult to form correct estimation on the magnitude of uncertainty. In other words, the question we examine in Panel D is whether "conservatism" is more pronounced for firms with bigger and noisier earnings in the past.

[12] Our results remains the same when we use past 2-year daily return data to compute jump frequency and jump size.

[13] For results not reported, we separate jumps into positive jumps and negative jumps. Both positive jump frequency and negative jump frequency affect straddles returns in similar ways as the jump frequency overall. For positive jump size and negative jump sizes, we find more significance for negative jumps sizes.

We start by considering the number of analysts as a proxy for the overall quality of the information environment. Firms with more analysts following tend to have more transparent information environments, and this would possibly lead to less behavioral biases from options investors. We obtain the number of analysts following each firm from IBES. The average straddle returns for firms with the lowest and highest number of analysts are 4.23% and 2.44%, respectively. The difference between the two groups is 1.78% with a significant t-statistic of -3.25. This supports the notion that the better information environment, the less options investors underestimate uncertainty around earnings announcements.[14]

There are many ways to measure earnings surprises. One conventional measure is the difference between the announced earnings and the analyst forecast consensus, which is our main "EA surprise" measure.[15] A more direct surprise measure for investors is the cumulative return over the earnings announcement period, because the return only responds to "true surprises." Therefore, we compute cumulated abnormal return, CAR, over [-1,1] after adjusting for market return over the same period. For historical uncertainty in earnings surprises, we compute the variance of "EA surprise" and "CAR", using the previous 8 quarters.

For firms with the lowest and highest EA surprise, the average straddle returns are 3.41% and 3.60%, respectively. The difference is positive but not significant. For firms with the lowest and highest CAR over earnings announcements, the average straddle returns are 2.75% and 4.42%, respectively. The difference is 1.68% with a significant t-statistic of 3.86. The above patterns support the hypothesis that bigger historical surprises mean more under-adjustments to uncertainty. Next we turn to the variance measure of earnings surprises. For firms with the lowest and highest variance of EA surprises, the average straddle returns are 2.39% and 3.55%, respectively. The difference is 1.15% with a marginally significant t-statistic of 1.94. For firms with the lowest and highest variance of CAR, the average straddle returns are 1.83% and 4.93%, respectively. The difference is 3.10% with a marginally significant t-statistic of 6.10. Those findings are consistent with the explanation that if there are more fluctuations in the past earnings surprises, the investors have more susceptibility towards "conservatism."

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[14] From unreported results, we also examine how institutional ownership affects straddle returns. We find straddle returns across different levels of institutional ownership are always positive and significant. But there doesn't exist a clear cross-sectional pattern.

[15] From results not reported, we also compute earnings surprises using random walk model and seasonality model. The results are quite similar to those using consensus forecast.

In a nutshell, this section presents strong evidence that short-term at-the-money straddles have positive and significant results across firms with many different characteristics. In particular, we find firms with less transparent information environments and with more noise in the past returns and earnings processes are more subject to the conservatism bias.

4.3 Fama-MacBeth Regression

In previous sections, we compute average straddle returns at the portfolio level. We find all average straddle returns are positive and significant, and firm characteristics on higher moments, jump processes and historical earnings shocks are related to the magnitude of underestimation in the cross-section. In this section, we use the Fama-MacBeth regression approach to directly examine whether individual straddle returns can be predicted by past information and to determine which of the past information has the strongest predictive power. The Fama-MacBeth regressions also help us to understand what type of firm-level information induces more investor conservatism. To be more specific, for each quarter, we estimate a cross-sectional regression for individual straddle returns. Then, we average all quarterly coefficients over 60 quarters to obtain the mean coefficient estimates and conduct inferences.

We estimate four FM regressions. In the first regression, we include the following stock-level characteristics: size, book-to-market ratio, past returns and the difference between historical volatility and implied volatility. In the second regression, we only include historical higher moments and historical jump frequency and jump size. In the third regression, we only include measures related to earnings: number of analysts covering each firm, past earnings surprises, and the variance of past earnings surprises. The above three regressions help to understand whether each category of information is relevant for the straddle returns. In the last regression, we include all information used in the previous three regressions in order to find out which variables have the strongest predictive power.

As in previous sections, we only report results for delta-neutral straddles, holding over [-3,0]. Results on different windows are both qualitatively and quantitatively similar and are available upon request. To normalize the variables, we take logs of size, book-to-market ratio, historical volatility and kurtosis. There are 14 variables in total, and multi-collinearity becomes a natural concern. Before we estimate the regressions, we compute correlation coefficients to filter out high-correlation pairs. There are two correlations higher than 60%, and those are between historical volatility and historical skewness, and between EA surprise and variance of EA surprises. We choose to keep skewness and variance of EA surprises, and discard volatility and EA surprise. In all regressions, we control for option-level information, such as time to maturity and moneyness.

Regression results are reported in Table 5. In the first regression, coefficients on size and book-to-market ratio are both negative and significant, while past 3-month return is positive and significant. These results confirm previous findings that it is more difficult to estimate the proper magnitude of uncertainty for smaller firms and growth firms. The positive significance on the past returns might result from the under-reaction to winners' positive returns. The under-reaction bias as in Goyal and Saretto (2009) is significantly positive, which indicates the "conservatism" carries over from the overall difference between historical volatility and implied volatility, and when the difference between the two is greater, the underestimation of uncertainty during earnings announcement periods increases, leading to higher straddle returns. The adjusted R2 for the first regression is 1.97%.

Next we examine historical higher moments and historical jump statistics. As expected, higher historical moments and higher jump statistics all carry positive signs, indicating that the underestimation of uncertainty is larger for firms with more noise in their returns. The only significant coefficient in this regression is jump frequency, which dominates all other higher moments and jump size. The adjusted R2 is 0.89%, substantially lower than the first regression.

The third regression only includes information on earnings. The coefficient on the number of analysts is significantly negative, which suggests that when there are fewer analysts following the firm, there seems to be more underestimation of the uncertainty around earnings announcements. We find both CAR and variance of CAR carry positive and significant coefficients, indicating that investors tend to underestimate uncertainty more for firms with bigger and more fluctuations in their past earnings announcements. In the presence of CAR and variance of CAR, the variance of earnings surprise, measured as difference between announced earnings and forecast consensus, becomes insignificant. The adjusted R2 now is 1.14%, slightly higher than the second regression.

The last regression combines all variables. Firm size, book-to-market ratio, the under-reaction proxy from Goyal and Saretto (2009), number of analysts, CAR and variance of CAR are all significant with expected signs, while most of the historical jump frequency becomes insignificant. Now the adjusted R2 becomes 3.61%, indicating the characteristics in the first regression contributing the most to the predictive regression.

To summarize the findings in this section: we confirm that the positive straddle returns around earnings announcements are a robust phenomenon across different option characteristics and firm characteristics. Furthermore, there is strong evidence that the noisier the stock returns process and the earnings process are, the more severe is the underestimation of uncertainty during earnings announcement periods.

5. **Straddle Returns in the Existence of Transaction Cost**

In this section, we examine straddle returns around earnings announcements in the presence of transaction costs. We believe this question is particularly interesting for the following two reasons. First, options market makers are important participants in the market, and they help to set the option prices. Historically, transaction costs in individual stock options market is notoriously high, partially to compensate the options market makers for providing liquidity. Now in anticipation of rising uncertainty around earnings announcement and in anticipation of possibly more informed trading around this period, should liquidity providers such as options market makers be compensated more? Second, if liquidity providers are compensated more, meaning higher transaction costs for investing in straddles, would that eliminate the average positive returns on straddles? Our main focus of this paper is to document investors' anticipation of rising uncertainty around earnings announcements rather than to search for a profitable trading strategy. Whether the positive straddle returns around earnings announcements can survive the high transaction costs provides an additional robustness check on the severity of the conservatism bias.

In previous sections, our results are based on returns computed using the mid-point prices of bids and offers as a reference. If the mid-points fairly reflect market perception of real prices, then the findings of underestimation of uncertainty in previous section are not systematically biased. However, if we are concerned that trade might not be executed at mid-quote prices, then we need real transactions prices, which are unfortunately not available in our dataset. In this section, we still use quoted prices as proxies for trading prices, and we are aware of the following caveats. First, the quotes at end of the day could be stale and might not reflect real trading prices during the day. Second, a substantial amount of trades happen within quotes, meaning that using quoted prices might over-estimate the real transaction costs. According to De Fontnouvelle et al (2003) and Mayhew (2002), effective spreads for equity options are large in absolute terms but small relative to the quoted spreads. Typically, the ratio of effective to quoted spread is less than 0.5. On the other hand, Battalio et al (2004) study a period around the year 2000, and find that for a small sample of large stocks, the ratio of effective spread to quoted spread can be between 0.8 and 1. To cope with the within quotes problem, we focus on two cases by assuming the realized spread is either 50% or 100% of the quoted spread[16]. Our assumption for transaction costs is very conservative, given that transaction costs for options over recent years can be as low as 1-2 cents.

We start our investigation of transaction costs by plotting the average closing bid-ask spread around earnings announcements in Figure 3. We first compute the option level relative bid-ask spread as the difference between the closing bid and ask prices, and then we divide it by the average of the closing bid and ask. Next we average the relative spreads across all short-term at-the-money options around earnings announcement. In Figure 3, the average relative bid-ask spread starts at around 14% at 20 days before the announcement, and it stays stable until day -2. On day -1, the relative bid-ask spread jumps up to 15%, and it rises to above 16% on day 0. The relative bid-ask spread stays at 16% until day 1, and decreases to 15% on day 2. After day 2, the bid-ask spread goes down to 14.5%, and stays there until day 20. The overall pattern clearly indicates that the relative bid-ask spread increases by 2% right before the earnings announcement, stays high for 2-3 days, and decreases afterwards[17]. The observed spike in bid-ask spreads around earnings announcements is well expected. One possible scenario is that investors' demand for options surpasses supply around earnings announcements, and options market

[16] For instance, if the best bid price is 3 and best ask price is 4, then with 50% of quoted spread, the effective purchasing price becomes 3.75, and the effective selling price becomes 3.25..

[17] Since the mean level can be affected by influential outliers, from unreported results, we also investigate median relative bid-ask spreads. The general pattern is very similar to the mean bid-ask spreads, but with lower magnitudes. Up until day -2, the median spread is around 10.5%. Between day -1 and day 1, the median spread increases to 12%. After day 2, the spread decreases to 11% and stay low afterwards.

makers charge more to cover their inventory costs. It is also possible that options market makers anticipate more informed trades around these information-intensive periods, and thus increase bid-ask spreads to protect themselves. In either case, increased quoted spreads around earnings announcements are expected for a well-functioning options market.

Increased bid-ask spread is costly for straddle investors. For an investor adopting the [-3,0] delta-neutral straddle strategy, she needs to buy the straddle on day -3, incurring transaction costs one way, and she needs to sell the straddle on day 0, incurring another one-way transaction cost. Even if we use 50% of the quoted spread as the realized spread, with average 3-day return of 3%, and around 11% relative spread for a round trip trade, this strategy would deliver a 3-day return of -8%. Combining this negative number with early dynamics of bid-ask spread around earnings announcements, we interpret the results as evidence that, to some extent, the options market efficiently adjusts to surprises around earnings announcements.

Given the high transaction cost, investors need to modify their strategy to survive these transaction costs. There are two approaches to reduce the transaction costs. First, for a [-3,0] strategy, the investor is supposed to first buy, and then sell, which doubles the cost of a buy and hold strategy. An investor can easily cut the trading costs in half by using a buy and hold to maturity strategy. Second, since bid-ask spread tend to be persistent at firm level, investors can possibly limit their investments to those with lower historical transaction costs.

Next we focus on a buy and hold strategy similar to Goyal and Saretto (2009). We buy the straddle 3 days before earnings announcement, and hold it until option's first maturity after earnings announcement rather than selling the straddle on earnings announcement day. To be more specific, we use the case where we assume realized spread is the same as the quoted spread as an example. That is, we buy both call and put options on day -3 at the closing ask price and hold the straddle until maturity. On maturity, the return on straddle is realized as follows: if the option is in the money, we use the in the money amount; if the option is out of the money, then the payoff is zero. Would this buy and hold strategy still catch the underestimation of uncertainty around earnings announcement? As long as the straddle is constructed before the earnings announcement, and it expires after the earnings announcement, the underestimation of uncertainty would increase returns on the straddle, because options are forward-looking until the maturity date. The only concern here is that when the maturity date goes further away from the earnings announcement day, the underestimation of uncertainty might be averaged over a longer horizon and becomes insignificant. Therefore, we expect the above buy and hold strategy to achieve the highest return for options with shorter times to maturity. Similarly, we expect the buy and hold strategy would deliver better returns for options with lower historical transaction costs.

We present the results of holding straddles from day -3 to options' maturity in Table 6. In Panel A, we group straddles by days to maturity from day -3. About 18% of firms announce their earnings within 10 days of option expiration dates. Another 19% of firms announce earnings within 11 and 20 days of option expiration dates. The majority of firms announce earnings about 21 to 30 days before option expiration dates. The reason is simple: it usually takes about 4-5 weeks to get the financial reports ready after the fiscal quarter-end. If the fiscal quarter-end is the same as last day of a month, while the options expire on the third Saturday of each month, the majority of firms would announce their earnings about 20 days from the option expiration date. How firms choose their earnings announcement dates is beyond the scope of this paper. As mentioned in the introduction, firms tend to choose their earnings announcement date to be consistent with the previous year's announcement date, and it is public information long before the actual announcement. In terms of whether particular firms prefer or avoid option expiration dates, there is no perceivable pattern, so we assume the days between announcement date and option expiration date are exogenously determined.

In Panel A of Table 6, for our hypothetical case of the effective spread being 50% of the quoted spread, the first groups of straddles, with 4 to 10 days to expiration, have daily return of 1.64% with a t-statistic of 5.14. If the holding period is 4 days, the cumulative return becomes 7%. When the straddle forming dates are between 11 and 20 days away from expiration dates, the average daily straddle return reduces to 0.15% with a marginally significant t-statistic of 1.64. For the last two groups with longer time to maturity, average straddle returns turn to significantly negative numbers. For the hypothetical case of the effective spread being the same as the quoted spread, for the shortest time to maturity group, the average daily straddle return is 0.61% with a significant t-statistic of 2.08, while all other three groups have significantly negative straddle returns. This result confirms our prior that, to overcome transaction costs, one needs to focus on short-term straddles.

The last two lines separate all straddles based on historical bid-ask spread into “low” and “high” groups based on the median bid-ask spread. If the effective spread is only 50% of the quoted spread, both groups have positive and significant straddle returns. If effective spread is 100% of the quoted spread, only the straddles with lower-than-median transaction costs can deliver average positive returns. This result suggests that historical bid-ask spread can be used to help constructing profitable options trading strategies around earnings announcements.

In Panel B of Table 6, we further separate straddles based on days to maturity and historical bid-ask spread. Even in the case of the effective spread being the same as the quoted spread, average daily straddle returns can be 1.16%, if investors choose options with 4-10 days to maturity and lower than median bid-ask spreads. Clearly, shorter time to maturity and lower transaction costs are the keys for the straddle to deliver tradable positive returns.

In Panel C, we only include options with 4-10 days until maturity and examine whether stock level characteristics still help to predict straddle returns. The short answer is yes. Overall, straddles all deliver positive daily average returns over this short period, for both cases with effective spreads being 50% or 100% quoted spreads. Higher and more significant straddle returns are achieved by smaller firms, firms with higher historical volatility and skewness, more under-reaction bias as in Goyal and Saretto (2009), larger jump size, larger earnings surprises and more volatile CAR over earnings announcement periods. This is consistent with our finding in section 4.

The empirical evidence in this section shows that even though the transaction costs at stock option level is extremely high, a subset of straddles with short time to maturity can still deliver significant positive returns around earnings announcements when 50% or even 100% quoted spreads are considered as effective spreads. This suggests that the positive straddle returns around earnings announcements are not merely an artifact resulting from high bid-ask spread.

6. Conclusion

How investors form their expectations of uncertainty has been one of the central themes in academic research in the finance area. In this paper, we use firm earnings announcements as a special event to study investors' perceptions of firms' fundamental uncertainty. We construct delta-neutral straddles five days, three days and one day prior to scheduled earnings announcement dates and hold the straddles until the day of or one day after the earnings announcement dates. We find that the straddle returns around earnings announcements are significantly positive, suggesting that investors on average underestimate the uncertainty prior to the earnings announcement. This is in stark contrast with the straddle returns on individual stocks during normal periods. Consistent with Coval and Shumway (2001), we find straddle returns on stocks over our whole sample from 1996 to 2010 are significantly negative. Our conjecture is that investor conservatism is one of the possible reasons that investors in general underestimate the uncertainty during the earnings announcement period. Furthermore, we find that the underestimation of uncertainty prior to earnings announcements is particularly severe for smaller firms, firms with less analyst coverage, firms with higher past return volatilities, firms with higher past jump intensities, firms with higher past earnings surprises, and firms with larger variance in historical earnings surprises. This suggests that investors tend to underestimate more when it is more difficult to make correct inference about future uncertainties. The documented empirical phenomenon could also be consistent with a rational options pricing model void of any cognitive biases. The exploration of such a mechanism is beyond the scope of this paper and warrants future research.

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Table 1. Summary statistics on options and stocks

Our sample period is from January 1996 to December 2010. We obtain data from several data sources. Data on stock returns and firm characteristics, accounting data, and earnings announcement data are obtained from CRSP, COMPUSTAT, and IBES, respectively. Data on options are from Option Metrics. In both panels below, we report summary statistics on stock and option characteristics.

Panel A. Stock characteristics

	N	Mean	Std	Median
market cap ($ mil)	35673	9268	28003	1952
book to market ratio	35039	0.455	0.444	0.343
past 12 month return	35665	0.102	0.498	0.107
past 3 month daily return volatility	35673	0.462	0.243	0.407
past 3 month daily return skewness	35673	0.056	1.059	0.099
past 3 month daily return kurtosis	35673	5.434	4.878	3.850

Panel B. Option characteristics

	N	Mean	Std	Median
moneyness	58361	1.014	0.030	1.010
days to maturity	58361	38	13	37
open interest	58361	2318	7007	420
volume	58361	386	1838	23
implied volatility	58361	0.507	0.219	0.465

Table 2. Delta-neutral Straddle returns

Our sample is from January 1996 to December 2010. Data on options are from Option Metrics. Panel A reports daily, weekly and monthly returns on at the-money-delta-neutral straddles. Panel B reports returns on at-the-money delta-neutral straddles over different windows around earnings announcements, where day 0 is the earnings announcement day. In the case when one stock has more than one pair of at-the-money straddles, we either equal weight or volume weight straddles at stock level. Panel C reports parameter estimates when we regress delta-neutral straddle returns on previous quarter VIX.

Panel A. All delta-neutral straddles

	equally weighted			volume weighted		
holding period	holding ret	ret per day	tstat	holding ret	ret per day	tstat
Daily	-0.0019	-0.0019	-24.29	-0.0014	-0.0014	-14.39
Weekly	-0.0209	-0.0042	-53.49	-0.0208	-0.0042	-42.35
Monthly	-0.1710	-0.0086	-96.03	-0.1621	-0.0081	-72.18

Panel B. Delta-neutral straddles around earnings announcements

	equally weighted			volume weighted		
holding period	holding ret	daily ret	t-stat	holding ret	daily ret	t-stat
[-5,0]	0.0222	0.0044	17.29	0.0207	0.0041	13.07
[-3,0]	0.0300	0.0100	26.22	0.0282	0.0094	20.24
[-1,0]	0.0230	0.0230	26.18	0.0208	0.0208	19.31
[-5,1]	0.0268	0.0045	17.38	0.0179	0.0030	9.59
[-3,1]	0.0125	0.0031	7.59	0.0052	0.0013	2.54
[-1,1]	0.0309	0.0154	22.90	0.0220	0.0110	13.58

Panel C. Time-variation in delta-neutral straddle returns

	equally weighted				volume weighted			
holding period	intercept	t-stat	lag vix	t-stat	intercept	t-stat	lag vix	t-stat
[-5,0]	0.0465	3.67	-0.0885	-1.63	0.0506	3.66	-0.1047	-1.77
[-3,0]	0.0631	7.21	-0.1350	-3.61	0.0615	7.01	-0.1347	-3.59
[-1,0]	0.0374	6.82	-0.0500	-2.14	0.0371	6.21	-0.0539	-2.11
[-5,1]	0.0460	3.96	-0.0633	-1.28	0.0359	2.80	-0.0497	-0.91
[-3,1]	0.0248	1.67	-0.0231	-0.37	0.0214	1.33	-0.0289	-0.42
[-1,1]	0.0390	4.03	-0.0102	-0.24	0.0306	2.79	0.0004	0.01

Table 3. Delta-neutral Straddle over [-3,0] across different option characteristics

Our sample is from January 1996 to December 2010. Data on options are from Option Metrics. Delta-neutral straddles are constructed over [-3,0], relative to earnings announcement days, where day 0 is the earnings announcement day. In the case when one stock has more than one pair of short term at-the-money straddles, we adopt either equal weighting or volume weighting. To compute means and t-stats for straddle returns, each quarter, we first group options by whether they are puts or calls, days to maturity and implied volatilities. Next, we compute the cross-sectional average straddle returns for each option characteristic category for each quarter. The final means and t-statistics are computed over the time-series of option returns over different option characteristics.

Panel A. Call vs. put

	equal weighted holding ret	t-stat	volume weighted holding ret	t-stat
call	0.0818	7.58	0.0812	7.71
put	-0.0188	-1.95	-0.0209	-2.19
call-put	0.1006	5.15	0.1021	5.34

Panel B. Time to maturity

	Days to T mean	equal weighted holding ret	t-stat	volume weighted holding ret	t-stat
low	24	0.0351	6.95	0.0346	6.68
2	33	0.0262	5.44	0.0242	5.04
3	42	0.0388	9.25	0.0351	7.98
high	53	0.0301	10.33	0.0290	9.05
high-low		-0.0050	-1.41	-0.0056	-1.31

Panel C. Implied volatility

	Implied vol mean	equal weighted holding ret	t	volume weighted holding ret	t
low	0.298	0.0365	8.33	0.0364	7.33
2	0.416	0.0425	10.17	0.0410	9.04
3	0.542	0.0319	8.30	0.0305	7.51
high	0.750	0.0190	5.63	0.0183	4.95
high-low		-0.0175	-4.52	-0.0182	-4.09

Table 4. Sorting straddles by underlying stock characteristics [-3,0]

Our sample is from January 1996 to December 2010. Data on options are from Option Metrics. Straddles are computed over [-3,0], relative to earnings announcement days, where day 0 is the earnings announcement day. In the case when one stock has more than one pair of short term at-the-money straddles, we adopt volume weighting. Each quarter, we sort all firms into 4 groups based on previous period stock characteristics, and we average firm-level straddle returns for each of the four groups. The means and t-statistics for each group are computed over 60 quarters for each of the four groups. In Panel C, historical moments are computed over past 3 months of daily returns, and historical jump statistics are computed over the past 12 months of daily returns. In Panel D, earnings surprises, “EA surprise,” are calculated as the difference between announced earnings and consensus forecast. The cumulative abnormal return, CAR, is computed over [-1,1] around earnings announcement and adjusted for market return. The variance of EA surprises and CAR are computed over the previous 8 quarters.

Panel A. Different industries

industry	holding return	t-stat	n
Non Durables	0.0320	3.70	28
Durables	0.0445	3.64	15
Manufacturer	0.0319	4.49	71
Energy	0.0119	1.44	32
Chemicals	0.0257	2.51	18
Business Equipment	0.0474	10.20	123
Telecom	0.0341	2.05	12
Utilities	0.0071	0.48	15
Shops	0.0369	7.10	74
Health Care	0.0213	4.16	62
Money	0.0205	2.64	62
Other	0.0264	5.71	82

Panel B. Commonly used characteristics

	size		BM		past return		hist. vol – implied vol	
	holding ret	t-stat	holding ret	t-stat	holding ret	t-stat	holding ret	t-stat
low	0.0410	8.19	0.0317	7.36	0.0316	7.48	0.0180	4.78
2	0.0439	8.80	0.0339	8.37	0.0308	5.96	0.0368	8.55
3	0.0344	7.89	0.0335	7.57	0.0336	7.36	0.0394	8.07
high	0.0171	4.19	0.0311	6.45	0.0347	8.77	0.0387	7.10
high - low	-0.0239	-3.74	-0.0006	-0.12	0.0031	0.63	-0.0207	-4.18

Panel C. Historical moments and jumps

	variance		skewness		kurtosis		jumpfreq		jumpsize	
	holding ret	t-stat	holding ret	t-stat	holding ret	t-stat	holding ret	t-stat	holding ret	t-stat
low	0.0270	5.73	0.0240	6.72	0.0236	6.23	0.0221	5.29	0.0309	7.08
2	0.0360	7.24	0.0201	5.79	0.0317	6.64	0.0270	5.65	0.0324	7.06
3	0.0305	7.57	0.0217	6.14	0.0340	7.50	0.0413	7.00	0.0349	6.76
high	0.0366	8.63	0.0269	6.71	0.0417	9.54	0.0433	10.80	0.0377	8.82
high - low	0.0096	1.90	0.0029	0.83	0.0182	4.23	0.0212	4.46	0.0067	1.55

Panel D. Historical earnings surprises

	n analyst		EA surprise		CAR		Variance(EA surprise)		Variance(CAR)	
	holding ret	t-stat	holding ret	t-stat	holding ret	t-stat	holding ret	t-stat	holding ret	t-stat
low	0.0423	8.13	0.0341	6.77	0.0275	6.19	0.0239	5.30	0.0183	3.48
2	0.0376	7.10	0.0257	6.01	0.0243	5.28	0.0332	6.72	0.0275	6.48
3	0.0311	7.16	0.0336	7.47	0.0314	6.18	0.0381	8.44	0.0324	7.89
high	0.0244	6.11	0.0360	8.40	0.0442	10.30	0.0355	7.60	0.0493	11.24
high - low	-0.0178	-3.25	0.0019	0.34	0.0168	3.86	0.0115	1.94	0.0310	6.10

Table 5. Predicting straddle returns [-3,0] with Fama-MacBeth regressions

Our sample is from January 1996 to December 2010. Data on options are from Option Metrics. Straddles are computed over [-3,0], relative to earnings announcement days, where day 0 is the earnings announcement day. In each quarter, we estimate a cross-sectional regression for straddle returns. Then, we average all quarterly coefficients over 60 quarters to conduct inferences. Historical moments are computed over past 3-month daily returns, and historical jump statistics are computed over past 12-month daily returns. Earnings surprises, "EA surprise," are calculated as the difference between announced earnings and consensus forecast. The cumulative abnormal return, CAR, is computed over [-1,1] around earnings announcement and adjusted for market return. The variance of EA surprises and CAR are computed over the previous 8 quarters.

Regression	I		II		III		IV	
	coef.	t-stat	coef.	t-stat	coef.	t-stat	coef.	t-stat
Intercept	-0.1564	-1.89	-0.2770	-3.56	-0.2581	-2.83	-0.1369	-1.59
Log size	-0.0139	-7.21					-0.0155	-6.80
Log book-to-market	-0.0054	-2.77					-0.0061	-2.11
Past return	0.0085	2.12					0.0075	1.12
Hist. vol – implied vol	0.1470	8.67					0.2103	9.89
Skewness			0.0027	0.74			0.0037	0.82
Log kurtosis			0.0034	0.58			0.0063	0.85
Jump freq			0.7888	2.90			0.3687	1.12
Jump size			0.0135	0.78			-0.0089	-0.45
N analyst					-0.0009	-3.38	0.0009	2.32
CAR					0.0723	1.20	0.1506	2.24
Variance (EA surprise)					-0.1109	-0.24	0.5750	0.94
Variance (CAR)					0.2408	6.62	0.4117	8.93
R2	2.93%		1.93%		2.32%		6.63%	
ADJ. R2	1.97%		0.89%		1.14%		3.61%	

Table 6. Holding the option from 3 days before EA to maturity

Our sample is from January 1996 to December 2010. Data on options are from Option Metrics. Straddles are constructed 3 days before earnings announcement, and then held until option expiration. In the case when one stock has more than one pair of short term at the money straddles, we adopt volume weighting. In Panel A, each quarter, we sort all straddles into 4 groups, based on days to maturity, or into 2 groups according to past bid-ask spread. Next, we average straddle returns for each of the groups. For panel B, we further separate straddles first based on days to maturity and then on past bid-ask spread each quarter. Panel C only includes options with maturities of between 4 and 10 days. We separate all straddles based on other relevant characteristics. In all panels, the means and t-statistics are computed across straddles in each group.

Panel A. Separate straddles by time to maturity and bid-ask spread

			50% quoted spread		100% quoted spread	
		n(obs)	daily ret	t-stat	daily ret	t-stat
days to T	[4,10]	8273	0.0164	5.14	0.0061	2.08
days to T	[11,20]	8592	0.0015	1.64	-0.0023	-2.72
days to T	[21,30]	19158	-0.0014	-4.47	-0.0029	-9.93
days to T	[31,50]	9034	-0.0019	-6.02	-0.0029	-9.45
quoted spread	low	22764	0.0027	2.80	0.0004	0.48
quoted spread	high	22293	0.0019	2.40	-0.0027	-3.92

Panel B. Interaction between time to maturity and bid-ask spread

			50% quoted spread		100% quoted spread	
days to T	quoted spread	n(obs)	daily ret	t-stat	n(obs)	daily ret
[4,10]	low	4858	0.0188	4.29	0.0116	2.85
[4,10]	high	3415	0.0130	2.85	-0.0018	-0.45
[11,20]	low	3624	-0.0023	-1.83	-0.0042	-3.47
[11,20]	high	4968	0.0043	3.41	-0.0008	-0.72
[21,30]	low	9343	-0.0013	-3.02	-0.0022	-5.18
[21,30]	high	9815	-0.0015	-3.29	-0.0037	-8.80
[31,50]	low	4939	-0.0017	-3.73	-0.0022	-5.13
[31,50]	high	4095	-0.0022	-4.92	-0.0036	-8.71

Panel C. Characteristics sort for days to maturity less than 10 days

sort variable	50% quoted spread				100% quoted spread			
	low		high		low		high	
	daily ret	t-stat	daily ret	t-stat	daily ret	t-stat	daily ret	t-stat
size	0.0300	3.87	0.0139	1.87	0.0163	2.36	0.0055	0.79
bm	0.0213	2.66	0.0216	2.52	0.0120	1.60	0.0090	1.17
past return	0.0252	2.84	0.0186	2.55	0.0130	1.63	0.0087	1.29
hist. vol	0.0187	1.69	0.0246	4.40	0.0067	0.66	0.0148	2.85
hist. skew	0.0209	2.03	0.0224	3.91	0.0097	1.03	0.0118	2.22
hist. kurt	0.0246	2.69	0.0189	3.10	0.0137	1.63	0.0080	1.43
hv - iv	0.0167	1.76	0.0252	3.79	0.0050	0.58	0.0150	2.46
jumpfreq	0.0218	2.38	0.0183	2.81	0.0113	1.32	0.0071	1.22
jumpsize	0.0179	1.79	0.0279	2.98	0.0066	0.74	0.0167	1.92
EA surprise	0.0148	1.57	0.0241	3.50	0.0040	0.46	0.0132	2.10
CAR	0.0112	1.78	0.0279	2.45	0.0008	0.14	0.0165	1.61
var(EA surprise)	0.0185	1.99	0.0210	3.04	0.0079	0.92	0.0098	1.58
var(CAR)	0.0153	1.58	0.0232	3.53	0.0039	0.43	0.0129	2.16

Figure 1. Implied volatility around earnings announcement

Data on option are from Option Metrics, over January 1996 to December 2010. The figure reports mean implied volatilities for short term at-the-money calls and puts around earnings announcements. Day 0 is the earnings announcement day.

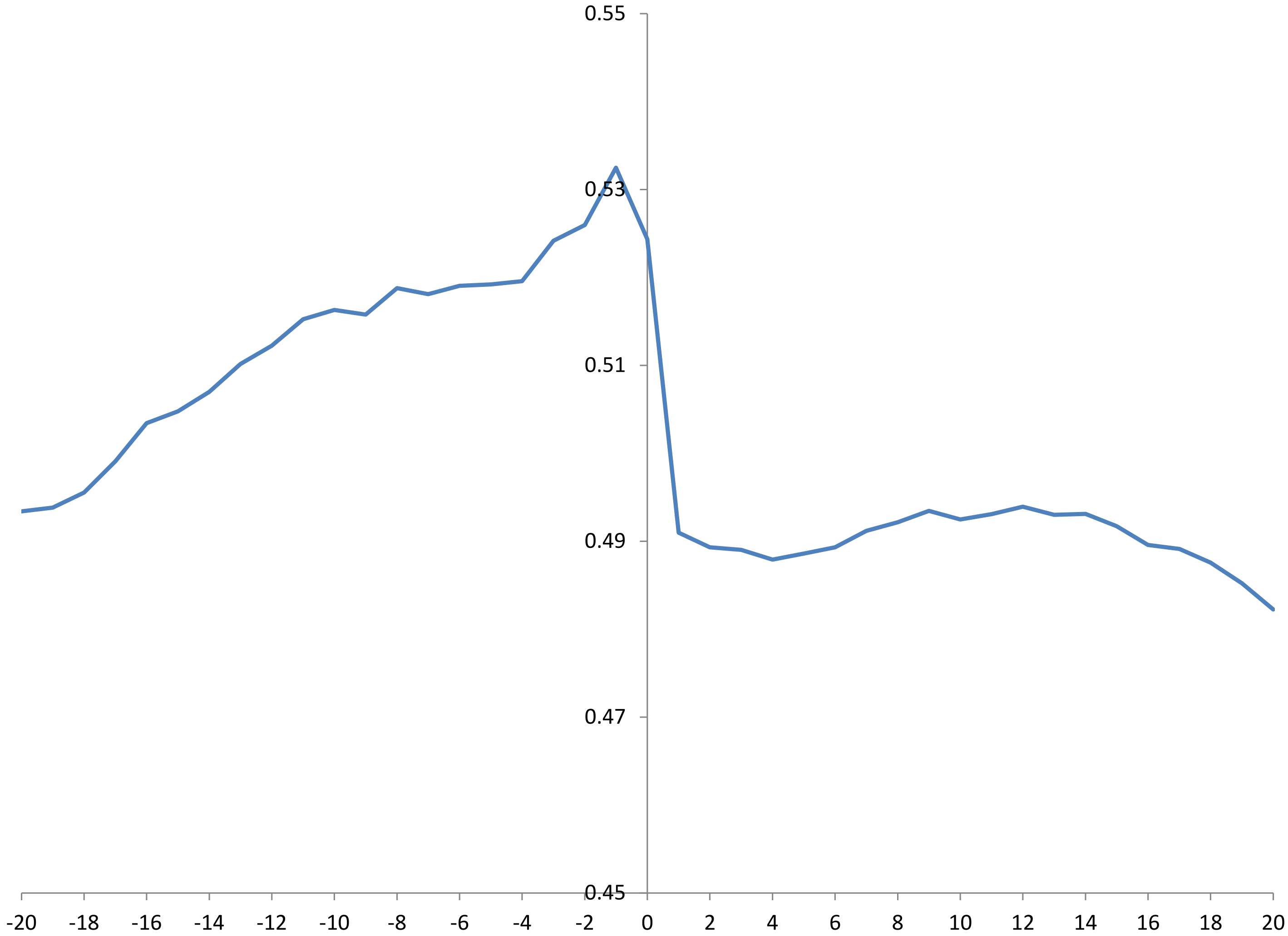

Figure 2. Delta-neutral straddle returns over time

Our sample is from January 1996 to December 2010. Data on options are from Option Metrics. The figure plots the time-series of both simple and delta-neutral straddle returns over different windows around earnings announcements, where day 0 is the earnings announcement day. In the case when one stock has more than one pair of at the money straddles, we equal weight straddles at stock level.

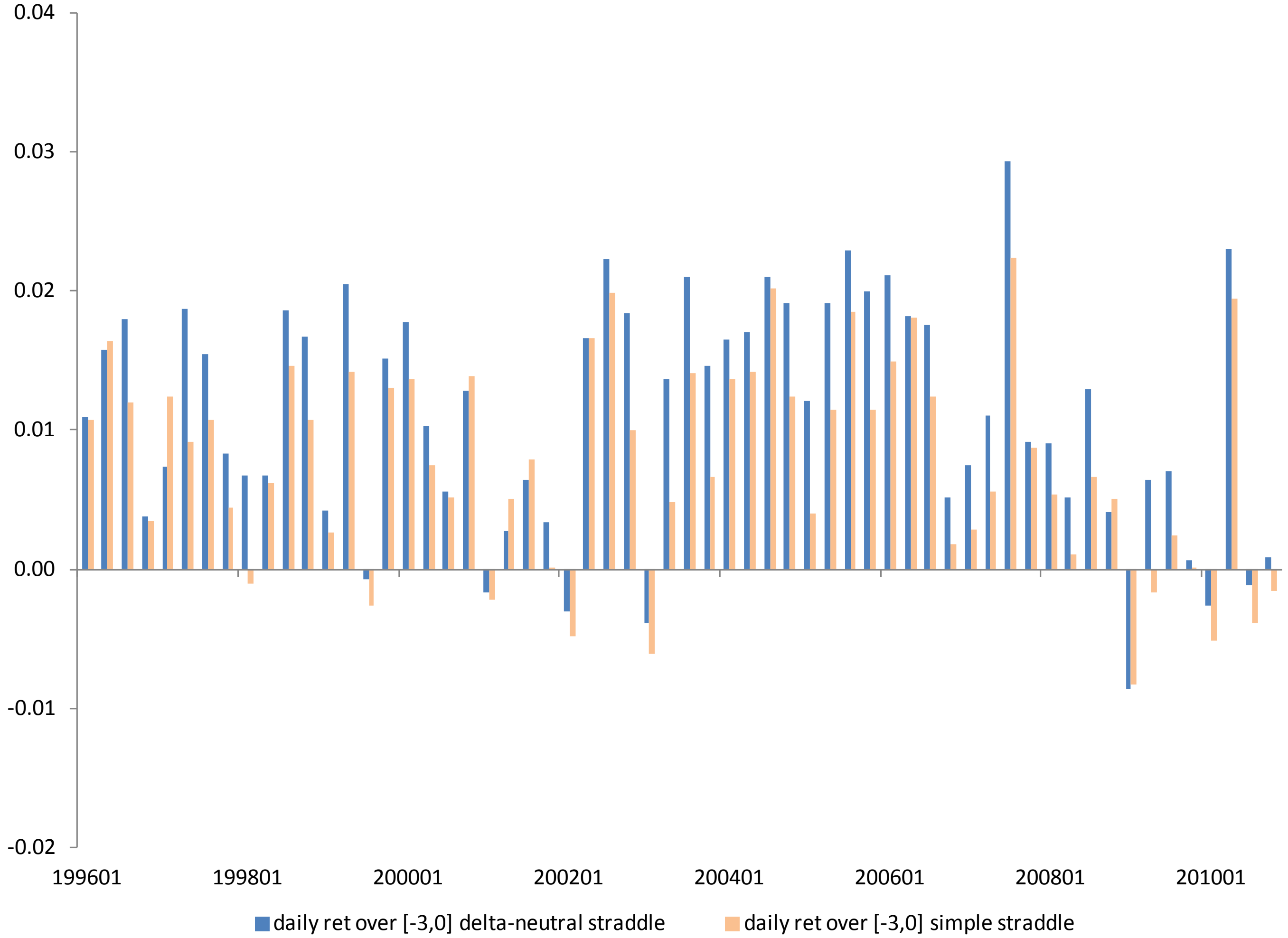

Figure 3. Bid ask spread around earnings announcement

Data on options are from Option Metrics, over January 1996 to December 2010. The figure reports mean relative bid-ask spread for short term at-the-money calls and puts around earnings announcements. Day 0 is the earnings announcement day.