Inconsistent Signals, Earnings Announcements and Market Uncertainty*

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Abstract

We test the proposition in Johnstone (2015a) that new information may lead to higher, rather than lower, uncertainty about firms' future payoffs. Based on the Bayesian rule, we hypothesize earnings news that is inconsistent with investors' prior belief will lead to higher market uncertainty. Using earnings surprises in the past few quarters to proxy for investors' prior belief, we find supporting evidence that inconsistent signals increase market uncertainty measured by implied volatility. Inconsistent earnings news has a larger effect on market uncertainty when prior beliefs are stronger, when the news is negative, when firms have a better information environment, and when investor sentiment is low. Overall, our evidence shows that new information does not necessarily reduce market uncertainty.

Key words: Earnings news; market uncertainty; information; implied volatility; accounting disclosure

JEL Classification: G13, G14, M41

1. Introduction

A commonly held belief in accounting research is that new information leads to the resolution of uncertainty and therefore more and better financial disclosure will reduce market uncertainty about future cash flows and may decrease the cost of capital.[1] The underlying intuition is that a piece of new information is equivalent to a draw of a coloured ball from an urn and more draws of balls help to better understand the distribution of the coloured balls in the urn. In other words, assuming the distribution of future payoffs is held constant, accounting disclosure with precision higher than zero should help investors learn more about the underlying distribution and thus reduce the uncertainty of future payoffs. This belief is supported by the empirical evidence that stock return volatility generally declines after earnings announcements, suggesting earnings announcements in general reduce uncertainty (Patell and Wolfson, 1979, 1981).

In a recent study, Johnstone (2015a) points out that while it is true that new information *on average* reduces uncertainty, it can often increase uncertainty for a Bayesian investor. According to the Bayesian rule, when investors update their beliefs with new information, their posterior beliefs depend on both their prior beliefs and the sign of the information. When the information contradicts investors' prior beliefs, posterior beliefs can become more uncertain. Johnstone (2015a) formalizes this idea in a mean-variance capital asset pricing model (CAPM) where the probability distribution of variance is unknown *ex ante*.[2] Johnstone's Proposition 2 (2015a, 5) posits that the posterior variance of future payoff conditional on a signal can be higher

[1] See Johnstone (2013) for a critical review of recent studies that rely on the belief that better disclosure reduces uncertainty and cost of capital.

[2] Johnstone (2015a, 2015b) further proposes that information, particular bad news, can increase the cost of equity capital. This proposition is supported by empirical evidence in Biddle, Ma and Wu (2012) that cost of capital is positively related to the degree of conditional conservatism that requires firms to disclose bad news in a more timely manner. However, Li (2015) finds firms domiciled in countries with more conservative financial reporting have lower cost of equity and debt capital.

than the prior variance. More specifically, signals that shift the probability distribution of future payoffs towards states where the variance of payoffs is larger must commonly increase the posterior variance of the payoffs.

To understand the proposition, consider an example where a Bayesian investor updates his belief about whether a firm is a 'good' or 'bad' type after observing an earnings signal. The uncertainty in this example is captured by the probability that the firm is a 'good' one, with 100% or 0% probability indicating total certainty and 50% probability indicating total uncertainty. Suppose the investor knows that there is a 70% chance of a 'good' firm issuing a positive signal and a 30% chance of the firm issuing a negative signal, while for a 'bad' firm, the chance of issuing a positive signal is 30% and the chance of issuing a negative signal is 70%. The investor starts with a prior belief that the firm is 70% likely to be a 'good' firm so that the firm is more likely to be a 'good' one than a 'bad' one. Now suppose the earnings signal is positive, consistent with the prior belief. Bayesian rule suggests that posterior belief will increase to 84.5% and the investor will become more certain that the firm is a 'good' one.[3] In contrast, if the signal is negative, which is inconsistent with prior belief, the posterior belief will decrease from 70% to 50%. Thus the inconsistent signal increases uncertainty and causes the investor to be more uncertain about the type of the firm.

Using a large sample of quarterly earnings announcements, this study empirically tests Johnstone's (2015a) proposition and the intuition in the above example by examining the impact of earnings news on changes in market uncertainty. Following Rogers, Skinner and Van Buskirk (2009), we use the implied volatility embedded in stock options to measure market uncertainty. Based on psychological findings that people tend to extrapolate past events to form expectations, we use the

[3] Details of this example, including the calculation of posterior beliefs, are provided in Section 2.

string of earnings surprises of same signs in the past few quarters to proxy for investors’ prior beliefs. Therefore, a string of positive earnings surprises in the past quarters implies that investors are likely to expect positive earnings news in the current quarter as well. Johnstone’s (2015a) proposition predicts if the current quarter’s earnings surprise is positive, market uncertainty will be reduced because the earnings news is consistent with investors’ prior belief. However, if the current quarter’s earnings surprise is negative, the news is inconsistent with investors’ prior beliefs and will increase market uncertainty.

Our empirical evidence supports the predictions. We find that earnings surprises inconsistent with the string of past earnings surprises significantly increase implied volatility embedded in 30-day, 60-day and 91-day stock options. The effect of inconsistent signals on implied volatility becomes weaker when the option horizon is longer, suggesting that quarterly earnings announcements have a larger effect on short-horizon market uncertainty. When we differentiate the sign of inconsistent earnings news, we find that negative earnings news following a string of positive earnings surprises causes much larger increases in market uncertainty than positive news following a string of negative earnings surprises.

The Bayesian rule also predicts that the effect of inconsistent signals on market uncertainty will be larger when prior belief is stronger. In our setting, we expect that investors’ prior beliefs will be stronger if the string of earnings surprises is longer because a larger number of consistent signals strengthen investors’ belief that the firm is of a particular type. Consistent with this prediction, we find that the impact of inconsistent signals on implied volatilities increases with the number of past quarters in the string of earnings surprises with the same sign.

We also examine whether the impact of inconsistent earnings news on market uncertainty varies with firm characteristics. We find that the impact is larger for larger firms, firms with more analysts following, and firms with lower stock return volatility in non-announcement periods. The result suggests that inconsistent earnings news increases uncertainty more in firms with better information environments that allow investors to be more confident in their prior beliefs. For these firms, inconsistent earnings news could present more of a surprise to investors.

Finally, we investigate whether market sentiment affects the impact of inconsistent signals on market uncertainty. Prior studies document that investors pay more attention to financial markets during low sentiment periods and that high investor attention can result in higher return volatility (Lustig and Verdelhan, 2012; Vlastakis and Markellos, 2012; Andrei and Hasler, 2015). Consistent with these studies, we find that inconsistent earnings news increases market uncertainty more in low sentiment periods than in high sentiment periods.

Our study contributes to the literature by providing empirical support to Johnstone's (2015a) model that rectifies a long-held misbelief in accounting literature. As Johnstone points out, the belief that new information reduces uncertainty is almost a law among many accounting researchers, and the belief underlies numerous studies on accounting disclosure. Although on average and in the long run, more information does resolve market uncertainty, Johnstone notes that the Bayesian rule indicates new information does not necessarily lead to lower uncertainty and in many cases new information can increase uncertainty. Based on the Bayesian rule, we use archival data to show earnings news that is inconsistent with investors' prior beliefs leads to higher market uncertainty, which supports Proposition 2 in Johnstone (2015a). By considering both the nature of earnings news and investors' prior beliefs, our results extend early evidence in Patell and Wolfson (1979, 1981) who show an average decline in uncertainty following earnings announcements. Together with Johnstone (2015a), our study cautions accounting researchers not to over-focus on the average effect while overlooking basic decision making processes such as the Bayesian rule.

Our study is not the first to examine how inconsistent signals affect market reactions to the signals. Barth, Elliott and Finn (1999) and DeAngelo, DeAngelo and Skinner (1996) show that earnings decreases after a string of earnings increases cause significant price decline. Our results suggest that the earnings decreases following a string of earnings increases are likely to be an inconsistent signal and cause higher market uncertainty that may lead to a higher discount rate and a larger price drop.[4] Conrad, Cornell and Landsman (2002) show that market reactions to negative earnings surprises are stronger when the market is in a relatively good state. Choi (2014) also documents that the market responds to bad earnings news more negatively during economy expansions with high market-wide uncertainty. Both studies rely on the analytic work of Veronesi (1999) to argue that bad news in good times is likely to cause larger price declines because of two compounding effects: lower future cash flows (numerator effect) due to the earnings decreases and higher discount rates (denominator effect) due to the higher uncertainty resulting from earnings news inconsistent with the prevailing market state. However, both studies focus on price reactions, and neither disentangle these two effects and examine the market uncertainty. To the best of our knowledge, our study is the first to directly investigate how inconsistent earnings signals affect market uncertainty.

[4] Skinner and Sloan (2002) find that high growth firms experience larger price declines when they report negative earnings news. If investors expect high growth firms to continue to deliver higher earnings, then negative earnings news is also a signal inconsistent with investors' prior belief and will cause higher uncertainty in the market and a higher discount rate.

Our study also adds to recent studies on the effect of new information on market uncertainty measured by implied volatility in stock options. Rogers, Skinner and Van Buskirk (2009) find management forecasts unbundled from earnings announcements increase short-term market uncertainty. Billings, Jennings and Lev (2015) find that market uncertainty generally increases before, and then declines after, management forecasts bundled with earnings announcements, a pattern similar to that documented by Patell and Wolfson (1979) for earnings announcements. Iselin and Van Buskirk (2015) document a stronger price reaction to earnings announcements that have larger increases in uncertainty before the announcements. Also using option data, Barth and So (2014) find that at quarterly earnings announcements volatility risk premiums embedded in stock options increase with announcing firms' exposure to non-diversifiable volatility risk. Evidence from Barth and So (2014) suggests that earnings announcements can increase volatility risk that leaves investors more uncertain about the distribution of stock returns.[5]

The remainder of the paper proceeds as follows. Section 2 develops our hypotheses and Section 3 describes our research design. We report the empirical results in Section 4 and conclude in Section 5.

2. Hypothesis Development

2.1 Inconsistent earnings news and uncertainty

A dominant view in accounting literature is that new information leads to lower uncertainty and potentially cost of capital. For example, Christensen, de la Rosa and Feltham (2010, 817) state that "releasing more information and, in particular, more public information through financial reports and other public disclosures by

[5] Some studies argue and find that earnings announcements may increase stocks' systematic risk measured by market beta (Ball and Kothari, 1991; Hsieh, Jerris and Kross, 1999; Patton and Verardo, 2012).

firms reduces the uncertainty about the size and the timing of future cash flows and, therefore, also the risk premium". In an asset pricing model, Lambert, Leuz and Verrecchia (2007) assume that firms' future payoffs follow normal or joint normal distributions with a constant variance that investors need to estimate. Under this assumption, Lambert et al. (2007) show that any new information with a precision higher than zero will lead to a lower estimated variance of future payoffs, suggesting new information will always reduce investors' uncertainty about the distribution of future payoffs. Lambert et al. (2007) proceed to show that new information will also lead to a lower covariance between the firm's future payoffs and aggregate market payoffs, or a lower beta, which in turn leads to a lower cost of capital. A number of studies cite Lambert et al. (2007) to support the argument that more accounting disclosure can reduce firms' cost of capital (see Johnstone, 2013, 2015a for a critical review of related studies).

Johnstone (2015a, 2015b) points out that the results in Lambert et al. (2007) hinge on the assumption of normal distributions with a constant variance. Relaxing this assumption and using a more general Bayesian rule, Johnstone (2015a) observes that investors' posterior estimation of the variance does not necessarily decrease after receiving a signal about future payoffs. Johnstone (2015a, 5) states in Proposition 2: "the variance of payoff V_j conditional on signal S, var ($V_j|S$), can be higher than the unconditional or prior variance, var(V_j)". More specifically, he posits that any signal S that shifts the probability distribution of V_j towards states under which V_j has a high variance, must commonly add to the variance of V_j. Therefore, information does not always lead to certainty; it can often leave a Bayesian user more uncertain.

To understand Johnstone's proposition, let us consider a simple example where a Bayesian investor updates his belief about a firm after observing an earnings signal. In this example, the investor is uncertain whether the firm is a ‘good’ or ‘bad’ type, and his uncertainty is captured by the probability that the firm is a ‘good’ type. Probability of 100% or 0% indicates complete certainty and that the investor is sure of the company’s type. Suppose the investor also knows that a ‘good’ firm has a 70% chance of issuing a positive earnings signal and a 30% chance of issuing a negative signal, while for a ‘bad’ firm, the chance of issuing a positive signal is 30% and the chance of issuing a negative signal is 70%. After observing an earnings signal, the investor will update his belief following Bayesian theorem:[6]

$$P(Good|S) = \frac{P(S|Good) \times P(Good)}{P(S|Good) \times P(Good) + P(S|Bad) \times P(Bad)}$$

where *P(Good|S)* is the posterior estimate of the probability that the firm is a ‘good’ type after observing a signal *S*. *P(S|Good)* is the probability that a ‘good’ type firm issues *S*, and *P(S|Bad)* is the probability that a ‘bad’ type firm issues *S*. *P(Good)* is the prior belief that the firm is a ‘good’ type, and *P(Bad)* is the prior belief that the firm is a ‘bad’ type.

Suppose that the investor starts with a prior belief that the firm is 70% likely to be a ‘good’ firm so that the investor expects that the firm is more likely to be a ‘good’ type. In this case, prior uncertainty is *P(Good)* = 0.7. Now suppose the earnings signal is positive, consistent with the investor’s prior belief. Bayesian theorem suggests that posterior belief, *P(Good|S),* will increase to 84.5% and the investor will become more certain that the firm is a ‘good’ type.[7] In contrast, if the signal is negative, which is inconsistent with the investor’s prior belief, the posterior

[6] See Winkler (2003) for more exposition and examples of Bayesian theorem.
[7] Since the earnings signal is positive, *P(S|Good)*=0.7, *P(S|Bad)*=0.3, *P(Good)*=0.7, and *P(Bad)*=0.3. *P(Good|S)* = (0.7×0.7)/(0.7×0.7 + 0.3×0.3) = 0.845.

belief will decrease from 70% to 50%.[8] Thus the earnings signal increases uncertainty and causes the investor to be more uncertain about the type of the firm.

This simple example illustrates the key message of Proposition 2 in Johnstone (2015a) that information can increase uncertainty. Bayesian theorem suggests that the posterior belief depends on both the prior belief (*P(Good)*) and the sign of the signal (positive or negative). When the sign of the signal is inconsistent with the prior belief, the signal will increase posterior uncertainty. In our example, an inconsistent signal essentially shifts the posterior probability towards 50% (the maximum uncertainty) while consistent signals move the posterior probability towards either 0% or 100%.

Following this discussion, we expect to find that earnings news that is inconsistent with investors' beliefs will be likely to increase market uncertainty. We state our first hypothesis as follows:

> **H1:** Market uncertainty increases after firms report earnings surprises that are inconsistent with investors' prior beliefs.

It is also worth emphasizing that the *average* posterior estimated variance of future payoffs after observing many signals is lower than the prior variance. In other words, in the long run, more information does reduce uncertainty. This can be seen from the law of conditional variance, $\text{var}(V_j) = \text{E}[\text{var}(V_j|S)] + \text{var}(\text{E}[V_j|S])$. The posterior uncertainty, captured by $\text{var}(\text{E}[V_j|S])$, should be smaller than prior uncertainty $\text{var}(V_j)$. This is consistent with Bayesian statistics that sufficient data about an unknown variable will in the long run make the variable certain although any signal data observation does not necessarily increase certainty.

2.2 Bad news versus good news

[8] Since the earnings signal is negative, $P(S|Good)$=0.3, $P(S|Bad)$=0.7, $P(Good)$=0.7, and $P(Bad)$=0.3. $P(Good|S)$ = (0.3×0.7)/(0.3×0.7 + 0.7×0.3) = 0.5.

Rogers, Skinner and Van Buskirk (2009) document that short-term implied option volatility increases more following bad earnings forecasts than following good earnings forecasts. There are several explanations for the results that bad news increases volatility more than good news. The leverage effect proposes that bad news causes stock prices to decline and leverage ratios in market value terms (e.g., debt divided by market value of equity) to increase, making the stock riskier and increasing equity volatility. Volatility feedback posits that earnings news increases volatility and thus the discount rates, which in turn will exacerbate price declines following bad news and mitigate price increases following good news.

From a psychological point of view, bad news is more likely to be a shock to individuals and grab investors' attention. People are particularly averse to losses (Kahneman and Tversky, 1979), so they pay more attention to bad news to avoid losses associated with the bad news. In the evolutionary process humans learn to be more alert to bad news or signals which are more life threatening (Shoemaker, 1996; Soroka 2014). It is also argued that humans tend to be mildly optimistic, so negative news is more likely to be viewed as a surprise and to attract attention (Fiske, 1980; Skowronski and Carlston, 1989).

Accounting studies propose that managers have incentives to withhold bad news until a threshold and then release the accumulated bad news all together at mandatory earnings announcements (Kothari, Shu and Wysocki, 2009; Roychowdhury and Sletten, 2012). Bad earnings news therefore contains more information and has a greater impact on stock prices.

Following these studies, we expect to find that, among earnings news that is inconsistent with investors' prior beliefs, negative news results in larger uncertainty than positive news. Our second hypothesis is thus stated as:

H2: Market uncertainty increases more following negative inconsistent earnings news than positive inconsistent earnings news.

2.3 Strength of prior belief

It is likely that the strength of investors' prior beliefs can have an effect on how investors update their belief after observing inconsistent earnings news. However, there are two offsetting effects. On one hand, confirmation bias suggests that investors with a strong prior belief may choose to discount signals inconsistent with their prior belief. This behavior appears consistent with belief updating under Bayesian theorem. To see this, consider our example above where an investor has a prior belief that the firm has a 70% chance of being a 'good' type. Recall that the investor updates this belief to 84.5% after positive (consistent) earnings news and to 50% after negative (inconsistent) earnings news. Suppose the investor's prior belief is stronger at 80%. According to Bayesian theorem, the posterior belief will increase to 90.3% after a positive (consistent) signal and decrease to 63.2% after a negative (inconsistent) signal. In this example, the inconsistent signal decreases certainty from 80% to 63.5% (a change of 16.5%) under a stronger prior belief of 80%. When the investor has a prior belief of 70%, the decrease in certainty is 20% (= 70% - 50%). Therefore, stronger prior belief may reduce the effect of inconsistent signals on investors' uncertainty.[9]

On the other hand, a stronger prior belief indicates that an inconsistent signal is more of a surprise to investors. For example, after observing a stream of positive earnings news, investors may strongly believe the firm is a 'good' type and thus expect the firm to continue to release good news. Another piece of good news will be consistent with investors' expectations and thus present no surprise; but a piece of bad

[9] Note that in this example, the certainty (uncertainty) is bounded. So the marginal changes become smaller when the prior belief is closer to the boundaries.

news will contradict investors' expectations and present a large surprise that is more likely to cause investors to revise their prior beliefs. Therefore, when investors have a stronger prior belief inconsistent signals will be more surprising and cause larger uncertainty.

These two conflicting effects imply that it is unclear ex ante which effect will dominate, and it leaves the net effect an empirical question.[10] We therefore state our third hypothesis in null form as follows:

> **H3:** The strength of investors' prior beliefs does not affect the changes in market uncertainty resulting from inconsistent earnings news.

3. Research Design

3.1 Measure of market uncertainty

Following Roger, Skinner and Van Buskirk (2009), we use implied volatility derived from stock option prices to measure investors' uncertainty about firms' future returns. Relative to realized stock return volatility that has been used in early studies such as Beaver (1968), implied volatility has two key advantages. First, implied volatility captures investors' uncertainty about future returns, rather than historical returns. Second, it is available on a daily basis as long as daily option prices are available. The daily availability of implied volatility allows us to examine how market uncertainty changes in response to the earnings news in a short window.

We obtain data on implied volatility from the *OptionMetrics* Standardized Options dataset. Based on exchange-traded stock options, *OptionMetrics* constructs

[10] Using analyst forecast dispersion as a measure of uncertainty, prior studies find that stock price volatility increases more at earnings announcements when analyst forecast dispersion is wider (Abarbanell, Lanen and Verrecchia, 1995; Lobo and Tung, 2000). However, these studies do not differentiate whether the earnings news is consistent or inconsistent with prior beliefs. Furthermore, Imhoff and Lobo (1992) argue that analyst forecast dispersion is more likely to proxy for noisy earnings than for investors' uncertainty.

standardized options with constant maturity and at-the-money, in order to reduce measurement error resulting from using options with different duration and different degree of in-the-money (Dumas, Fleming and Whaley, 1998; Hentschel, 2003). *OptionMetrics* then calculates implied volatility for these standardized options with horizons ranging from 30 to 730 days. Since our earnings news is released at quarterly earnings announcements, we choose three horizons within a quarter: 30-day, 60-day and 91-day.

Following Rogers, Skinner and Van Buskirk (2009), we examine the changes in implied volatility around earnings news releases. We define changes in implied volatility ΔIV = $\log(IV_{\_post}) - \log(IV_{\_pre})$. $IV_{\_post}$ and $IV_{\_pre}$ are the implied volatility measured 3 days before and 3 days after quarterly announcements, respectively. ΔIV captures the changes in investors' uncertainty in response to quarterly earnings announcements. *ΔIV30d*, *ΔIV60d* and *ΔIV91d* are calculated using standardized options with 30-day, 60-day and 91-day durations, respectively.

3.2 Regression models

To examine the effect of inconsistent earnings signals on market uncertainty, we estimate the following cross-sectional regressions for a pooled sample of firm-quarter observations:

$$\Delta IV_{i,t} = \beta_0 + \beta_1 Inconsistent_{i,t} + \text{controls} + \varepsilon_{i,t}$$

where $\Delta IV_{i,t}$ is the change in natural logarithm of implied volatility around the earnings announcements of firm *i* in quarter *t*.

The variable of interest is an indicator variable, *Inconsistent*, which equals 1 for earnings news that is inconsistent with investors' prior belief. Following prior studies, we use earnings surprises to capture earnings news, and define positive earnings surprises (actual earnings per share larger than consensus analyst forecasts) as positive earnings news. To capture investors' prior belief, we start with considering an earnings announcement as a draw of a ball from an urn that contains many balls with different colors. Each draw provides a piece of new information about the balls in the urn, and consecutive draws of balls of the same color will likely generate a particular belief about the color distribution of the balls in the urn. In our example of investors learning about the type of a firm from earnings news, if the investor starts with a prior belief of 70%, Bayesian theorem suggests that the investor's belief will increase to 92.7% after observing two consecutive pieces of good earnings news. So we expect that after a string of positive (or negative) earnings news, investors have a predictable belief about the type of the firm and the sign of the next earnings news. Specifically, a string of positive (negative) earnings surprises suggests that investors expect another positive (negative) earnings surprise. Therefore, a negative earnings surprise following a string of positive earnings surprises represents a signal that is inconsistent with investors' prior belief. Similarly, a positive earnings surprise after a string of negative surprises is also an inconsistent signal.

Since it is unclear how long the string should be, we use the number of quarters ranging from 1 to 8 and define eight dummy variables for *Inconsistent*. *Inconsistent1* indicates that the current quarter's earnings news has a different sign from the last quarter's news. *Inconsistent2* indicates that the firm has the same earnings surprises in the past two quarters (e.g., both are positive) but the current quarter's earnings surprise has a different sign (i.e., negative). Similarly, *Inconsistent3* to *Inconsistent8* compare the current quarter's earnings news with the sign of the string of earnings news in the past 3 to 8 quarters. Moving from *Inconsistent1* to *Inconsistent8*, the string of earnings news with the same sign is longer and investors' prior belief is stronger. To see this, recall our example above where an investor starts with a prior belief of 70%. One positive earnings signal increases the investor's belief to 84.5% and two consecutive positive signals increase his belief to 90.3%.

Our H1 predicts $\beta_1 > 0$, suggesting inconsistent earnings news increases market uncertainty, compared with consistent signals. As we discuss above, the longer the string of earnings surprises with the same sign, the stronger the investors' belief before current earnings announcements. If stronger prior beliefs make an inconsistent signal more surprising to investors, we expect β_1 to increase when we move from *Inconsistent1* to *Inconsistent8*. Alternatively, β_1 could decrease from *Inconsistent1* to *Inconsistent8* if stronger prior beliefs reduce the impact of inconsistent signals on market uncertainty.

To test our H2, we differentiate the sign of the current quarter's earnings news and replace *Inconsistent* with two new indicator variables. *Inconsistent_Good* equals 1 if the earnings surprise is positive in the current quarter but negative in the past quarters. *Inconsistent_Bad* takes a value of 1 if the earnings surprise is negative in the current quarter but positive in the past quarters. H2 predicts that the coefficient of *Inconsistent_Bad* will be larger than the coefficient of *Inconsistent_Good*, suggesting inconsistent and bad news causes larger market uncertainty than inconsistent and good news.

Based on prior research, we include a number of control variables that may affect market uncertainty at earnings announcements. We control for the magnitude of the earnings news, captured by the absolute value of earnings surprises deflated by share price at the beginning of the quarter (*AFE*). Following Rogers et al. (2009), we control for firm size (*Log(MktCap)*, the natural logarithm of market capitalization), firm leverage (*Leverage*, debt divided by total assets), market-to-book ratio (*MTB*, market value of equity divided by book value of equity), accounting losses (*Loss*, an indicator variable equal to 1 if actual earnings per share is negative) and market volatility measured by the Chicago Board Options Exchange Volatility Index (*Log(ΔVIX)*) over the same period as we measure the change in firm level market uncertainty. Additionally, we also control for the information environment by including the number of analysts following the firm (*Log(Analyst)*) and analyst forecast dispersion measured by the standard deviation of their earnings forecasts (*Dispersion*). Finally we control for firm risk with beta from the market model (*Beta*) and for non-announcement period stock return volatility (*Volatility*) with the standard deviation of daily stock returns in the period starting from 4 days after the last quarter's earnings announcement to 10 days before the current quarter's earnings announcement.

To mitigate the effect of extreme values, we winsorize all the continuous variables at the top and bottom 1% of their distribution. Since we use pooled firm-quarter observations in the multivariate regressions, we adjust standard errors for two-way clustering effects at both firm and quarter levels.

3.3 Sample selection and data description

Our sample selection starts with firms with consensus analyst forecasts or quarterly earnings available in the summary file of International Brokers Estimate System (I/B/E/S). We obtain the last median forecast before the current quarter's earnings announcement date, the number of analysts and forecast dispersion from I/B/E/S. We collect accounting data from Compustat North America and stock return data from CRSP. From *OptionMetrics*, we obtain data on implied volatility for the period from 1996 to 2010. After requiring firms to have non-missing data for all the variables in the multivariate regressions, we have 88,020 firm-quarter observations with 30-day option implied volatility data in the final sample. Requiring firms to have 60-day or 91-day options slightly reduces sample size.

Table 1 reports the descriptive statistics for all the variables in the final sample. First, we notice that the mean and median of *ΔIV* have negative signs, consistent with the results in Patell and Wolfson (1979, 1981) that market uncertainty decreases *on average* following earnings announcements. However, there is significant variation in *ΔIV*, and the third quartile of *ΔIV* is positive. Untabulated statistics show that 33.8% of *ΔIV30d* are positive, 38.0% of *ΔIV60* are positive, and 40.9% *ΔIV91d* are positive. This evidence suggests that a substantial number of firms experience an increase in the implied volatility immediately after earnings announcements.

[Insert Table 1 about here]

Second, the mean of *Inconsistent1* is 38.3%, suggesting that 61.7% of quarterly earnings surprises have the same sign as the previous quarter. *Inconsistent2* has a mean of 33.2%, suggesting that conditional on having positive (negative) earnings surprises in the past two quarters, 66.8% of firms continue to report a positive (negative) earnings surprise in the current quarter. Moving from *Inconsistent1* to *Inconsistent8*, the mean decreases with the number of past quarters in which earnings surprises have the same sign. This evidence suggests that the longer the string of quarters with consistent earnings surprises, the more likely that the next quarter's earnings surprises will have the same sign as past quarters, or the more likely the string will be extended rather than broken. This evidence provides some support to the rationality of investor expectations under Bayesian theorem that, in the ball and urn example, consecutive draws of red balls increase investors' expectation that the next draw will also be a red ball.[11]

Third, the descriptive statistics of control variables are comparable to those reported in previous studies. Notably, relative to an average firm in the U.S. stock market, our sample firms on average are larger, have more analysts following, and are less likely to report negative earnings per share. These characteristics result from our sample selection that requires firms to have options traded in the market and options are typically available for firms with a large size and active trading. These characteristics also indicate that our sample may not be representative of the population of U.S. firms and caution is needed in generalizing our results to other firms.

4. Empirical Results

4.1 Univariate test

Table 2 reports the result from a univariate test. We partition the sample based on *Inconsistent1* and compare the changes in implied volatility around the earnings announcements for firms reporting earnings surprises that are consistent and inconsistent with last quarter's earnings surprises. For 30-day options, the mean (median) decrease in implied volatility is about 6.2% (5.5%) following consistent earnings news, compared with a 5.3% (4.9%) decrease following inconsistent earnings news. The difference in both the mean and the median is statistically significant at 1%. The same result is observed using 60-day and 91-day options. This result suggests that, while implied volatility on average decreases immediately after quarterly earnings announcements, the decrease is significantly smaller for

[11] In the long run, more information will reveal the true type of the firm, assuming the type is constant. A longer string of positive (negative) earnings surprises may reveal the firm is a 'good' ('bad') type so that the firm will continue to issue positive (negative) earnings surprises.

inconsistent earnings news than consistent earnings news. Since firm characteristics and other factors also impact the changes in implied volatility, we proceed to multivariate analysis to control for these factors.

[Insert Table 2 about here]

4.2 Effect of inconsistent signals on market uncertainty

Table 3 reports the results from our baseline regressions to test H1 using *Inconsistent1* as the variable of interest. The dependent variables are changes in implied volatility (ΔIV) around earnings announcements. The coefficients on *Inconsistent1* are all positive and statistically significant in all three models, suggesting that relative to consistent earnings signals, inconsistent earnings surprises increase (or decrease to a less extent) implied volatilities in the market. This evidence is supportive of H1 that inconsistent earnings news can increase market uncertainty. In terms of economic significance, the coefficient of *Inconsistent1* is 0.007 in Model 1, suggesting that an inconsistent earnings surprise can increase implied volatility by 0.7 percentage points, or 12.7% of the median change in implied volatility following a consistent earnings surprise. Comparing the coefficients across three models, we find that the effect of inconsistent signals on market uncertainty decreases with option durations. This is consistent with findings in Rogers, Skinner and Van Buskirk (2009) that earnings news has a larger impact on shorter horizon implied volatility.

Turning to control variables, we find results very similar to those reported in Rogers, Skinner and Van Buskirk (2009). Specifically, implied volatility increases more after earnings announcements from firms with accounting losses, high leverage, and in time periods with a large increase in market volatility. High levels of analysts following and larger analyst forecast dispersion are associated with smaller increases in implied volatility. Collectively, the independent variables explain around 6.9% to

7.5% of the variations in changes in implied volatility, which is comparable to that reported by Rogers, Skinner and Van Buskirk (2009).

[Insert Table 3 about here]

In Table 4, we test H3 by examining the effect of the strength of prior belief captured by the length of the string of consistent signals, or the number of previous quarters in which earnings surprises have the same sign. Note that the variable of interest, *InconsistentN*, requires firms to have positive (or negative) earnings surprises in the past N consecutive quarters. For purposes of brevity, we report the results based on 30-day options.[12] We note that moving from *Inconsistent1* to *Inconsistent8*, the coefficient of *Inconsistent* gradually increases, and the increase is almost monotonic. For example, the coefficient of *Inconsistent8* is 0.028 (t-statistic = 5.18), about 4 times larger than the coefficient of *Inconsistent1*. The evidence suggests that when investors' prior belief is getting stronger following a longer string of consistent earnings surprises, an inconsistent earnings surprise causes a larger increase in market uncertainty. This evidence is consistent with the argument that inconsistent signals are more likely to be surprising when prior beliefs are stronger.

[Insert Table 4 about here]

Focusing on *Inconsistent1*, Table 5 provides initial evidence on H2 that bad news inconsistent signals increase uncertainty more than good news inconsistent signals. We find that the coefficients of *Inconsistent1_GoodNews* are negative in the three models, while the coefficients of *Inconsistent1_BadNews* are positive and statistically significant. Besides having opposite signs, the coefficients of *Inconsistent1_BadNews* also have much larger magnitude than those of

[12] Full results are available from the authors upon request.

Inconsistent1_GoodNews. The evidence suggests that bad news inconsistent earnings surprises are more likely to increase market uncertainty.

[Insert Table 5 about here]

In Table 6, we focus on implied volatilities from 30-day options and examine the effect of good news and bad news inconsistent signals with varying degree of prior beliefs. First, we notice that *Inconsistent_BadNews* has a positive and statistically significant coefficient in all models, corroborating the results in Table 4. Second, the negative coefficient of *Inconsistent_GoodNews* is only observed in Model 1, and in all other models *Inconsistent_GoodNews* has a positive coefficient. The evidence suggests that when investors' prior beliefs are sufficiently strong, inconsistent signals, regardless of their nature (e.g., both good news and bad news), result in an increase in market uncertainty. Lastly, the magnitude of the coefficients is much larger for *Inconsistent_BadNews*. For example, *Inconsistent4_BadNews* has a coefficient of 0.025 (t-statistic = 8.80), while *Inconsistent4_GoodNews* has a coefficient of 0.010 (t-statistic = 3.19). Overall, the results in Table 4 and Table 5 support our H2 that among inconsistent earnings news, bad news increases market uncertainty more than good news.

[Insert Table 6 about here]

4.3 Effect of firm characteristics

After documenting that inconsistent earnings news increases market uncertainty, we examine whether the effect of inconsistent earnings news varies with firms' information environment. This examination is motivated by prior research suggesting that a better and more transparent information environment allows investors to have more accurate forecasts of earnings. For example, among many others, Lang and Lundholm (1996) show that firms with larger size and better financial disclosure have more accurate analyst forecasts. If investors learn from the past that their earnings forecasts are more accurate for these firms, we argue that better information environment is likely to cause investors to be more confident in their forecasts and thus to have a stronger belief. Following our results in Table 4, this argument predicts that inconsistent earnings news will be more surprising and have a larger impact on market uncertainty for firms with a better information environment. To test this prediction, we capture a firm's information environment with multiple proxies including firm size, the number of analysts following, and stock return volatility in non-announcing periods. Firms with a larger size, more analysts following and smaller return volatility are expected to have a better information environment. We divide the full sample into two-equal sized subsamples based on the median of these proxies and re-estimate our baseline model separately for each subsample. For the sake of brevity, we report in Table 7 the results from regressions using changes in implied volatilities of 30-day options as dependent variables and *Inconsistent1* as the variable of interest.[13]

[Insert Table 7 about here]

The results in Table 7 generally show that *Inconsistent1* has a larger coefficient for firms with a better information environment. For example, compare large and small firms. The coefficient of *Inconsistent1* is 0.04 (t-statistic = 1.79) for small firms and 0.10 (t-statistic = 5.78) for large firms. The difference in the coefficients is statistically significant. Similarly, the coefficient of *Inconsistent1* is larger for firms with more analysts following and low return volatility (both coefficients = 0.008) than for firms with less analysts following and high volatility (both coefficients = 0.006). This result generally supports the prediction that

[13] Given the earlier results that the reaction to inconsistent news is stronger the longer the string of consecutively positive or negative results, we use *Inconsistent1* as a baseline.

inconsistent signals increase market uncertainty more among firms with a better information environment and stronger investor prior beliefs.

4.4 Effect of market sentiment

A number of studies show that investor sentiment could have a significant impact on stock prices and investor reaction to earnings news. For example, Baker and Wurgler (2006) show that stock returns exhibit predictable patterns following waves of investor sentiment. Conrad, Cornell and Landsman (2002) document that the market reacts more negatively to bad earnings news in good times when corporate earnings have a higher valuation. Mian and Sankaraguruswamy (2012) find that stock price reactions to earnings news vary with investor sentiment, with high valuations given to positive earnings surprises in high sentiment periods. Hribar and McInnis (2012) and Walther and Willis (2013) provide evidence that financial analysts tend to have more optimistic earnings forecasts in high sentiment periods. Therefore, we investigate how investor sentiment affects the impact of inconsistent signals on market uncertainty.

The first test we conduct is to use market-wide investor sentiment as a proxy for investors' prior beliefs. The evidence in Hribar and McInnis (2012) and Walther and Willis (2013) suggests that, to the extent that analyst forecasts capture investor expectations, investors would expect higher earnings in high sentiment periods than in low sentiment periods. Therefore, we redefine *Inconsistent* by comparing earnings news with prevailing investor sentiment. Following prior studies, we use the monthly Consumer Sentiment Index developed by University of Michigan to measure investor sentiment, and divide the sample period (1996 to 2010) into two equal-sized high and low sentiment sub-periods based on the median sentiment index. We then define *Inconsistent* equal to 1 for positive earnings surprises in low sentiment periods and for negative earnings surprises in high sentiment periods. The main regressions are re-estimated with this new definition of *Inconsistent*. Unreported results show that *Inconsistent* defined in this way does not have statistically significant coefficients. The results imply that market-wider investor sentiment may not capture firm-specific investor prior beliefs.

It is also possible that market sentiment may affect our results through investor attention. Andrei and Hasler (2015) argue and find that stock return volatility is positively related to investor attention because it is necessary for investors to pay attention to new information before the information is incorporated into stock prices. Some studies also find evidence that investors pay more attention to the financial market in recessions when investor sentiment is low (Lustig and Verdelhan, 2012; Vlastakis and Markellos, 2012). Therefore, we investigate whether the effect of inconsistent earnings signals on market uncertainty is stronger during periods of high investor sentiment. To do so, we estimate the main regression separately using firm-quarter observations in high and low sentiment periods, and then compare the coefficients between the sub-periods.

Table 8 reports the results from regressions of implied volatility based on 30-day options. Panel A examines low sentiment periods and Panel B focuses on high sentiment periods. The results show that *Inconsistent* has positive and statistically significant coefficients in all models, and the coefficients increase with the number of past quarters in which earnings surprises have the same sign. Comparing the coefficients between the two Panels, we find the coefficient in low sentiment periods is significantly larger than the corresponding coefficient in high sentiment periods. For example, the coefficient of *Inconsistent1* is 0.010 (t-statistic = 4.14) in low sentiment periods and 0.005 (t-statistic = 2.23) in high sentiment periods.

In further tests, we also differentiate between good news and bad news among inconsistent earnings news. Unreported results show that the results in Table 8 are driven by inconsistent bad news earnings surprises. Inconsistent good news does not have any significant effect on market uncertainty in both high and low sentiment periods. In contrast, inconsistent bad news increases implied volatilities in both periods, and particularly in low sentiment periods. These results in general support the view that inconsistent earnings news has a larger impact on market uncertainty during periods of low investor sentiment.

5. Conclusion

Accounting researchers generally believe that new information resolves uncertainty and thus better financial disclosure can help reduce investor uncertainty and firms' cost of capital. Johnstone (2015a) points out that, while it is true that information *on average* reduces market uncertainty, new information can often leave a Bayesian investor more uncertain about a firm's future payoffs. In this study, we provide empirical evidence to support Johnstone's (2015a) propositions. Based on Bayesian theorem, we hypothesize that earnings news that is inconsistent with investors' prior beliefs is likely to increase market uncertainty. Using implied volatilities embedded in stock options to measure market uncertainty, we find evidence consistent with our hypotheses. Specifically, we find implied volatilities increase after inconsistent earnings news, particularly if the inconsistent earnings news is bad news. We also find the effect of inconsistent signals is larger when investors' prior beliefs are stronger, when firms have a better information environment, and when investor sentiment is low.

Our study contributes to the literature by providing important empirical evidence to support Johnstone (2015a) who cautions accounting researchers that information does not necessarily lead to lower uncertainty. It reminds researchers of the basic Bayesian theorem that the effect of information on market uncertainty depends on both the nature of the information and investors' prior beliefs, and new information can often increase market uncertainty if the information contradicts investors' prior beliefs. Therefore, researchers need to be cautious when relying on the assumption that information always leads to certainty to develop hypotheses or to make policy recommendations.

For future research, we think it is worthwhile to empirically revisit the research question about the effect of information on the cost of capital. Johnstone (2015a, 2015b) points out that information does not necessarily lead to a lower cost of capital. In many cases, information can increase the cost of capital. Given the mixed evidence documented in the literature, researchers need to draw insights from Johnstone (2015a, 2015b) to carefully consider research designs and consider specific situations in which information may increase or decrease the cost of capital. Evidence from such finer tests in future research will help us better understand the effect of information on market uncertainty and the cost of capital.

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Appendix A
Definitions of Variables

Variable Name	Definition
ΔIV30d	The difference between natural log of post-announcement implied volatility (3 days following earnings announcement date) and natural log of pre-announcement implied volatility (3 days before the announcement date) using 30-day standardized options.
ΔIV60d	The difference between natural log of post-announcement implied volatility (3 days following earnings announcement date) and natural log of pre-announcement implied volatility (3 days before the announcement date) using 60-day standardized options.
ΔIV91d	The difference between natural log of post-announcement implied volatility (3 days following earnings announcement date) and natural log of pre-announcement implied volatility (3 days before the announcement date) using 91-day standardized options.
ConsistentN	An indicator variable taking value 1 if current quarter earnings surprise has the same sign as the earnings surprise in the past consecutive N quarter in which earnings surprises have the same sign. For example, if earnings surprises are all positive in past four quarters and current quarter also has positive earnings surprise, then *Consistent4* = 1. N ranges from 1 to 8.
InconsistentN	An indicator variable taking value 1 if current quarter earnings surprise has a different sign from the earnings surprise in the past consecutive N quarter in which earnings surprises have the same sign. For example, if earnings surprises are all positive in past four quarters but current quarter has negative earnings surprise, then *Inconsistent4* = 1. N ranges from 1 to 8.
InconsistentN_Goodnews	An indicator variable taking value 1 if current quarter earnings surprise is positive and the earnings surprises in the past consecutive N quarters are all negative. N ranges from 1 to 8.
InconsistentN_Badnews	An indicator variable taking value 1 if current quarter earnings surprise is negative and the earnings surprises in the past consecutive N quarters are all positive. N ranges from 1 to 8.
AFE	Absolute value of the difference between actual earnings and the median analyst forecast, deflated by share price at the beginning of the quarter.
Loss	A dummy variable equal to 1 for firms reporting negative earnings per share as reported in I/B/E/S.
Log (ΔVIX)	The natural logarithm of the ratio of the level of the Chicago Board Options Exchange Volatility Index on the 3 days after earnings announcement to the 3 days before the announcement.
MktCap ($b)	Market value of equity (in billions).
Size	The natural logarithm of market value of equity (in millions).
Analysts	The number of analysts issuing earnings forecasts.
Dispersion	The standard deviation of analyst earnings forecasts, deflated by share price at the beginning of the quarter.
BM	Book value of equity divided by market value of equity.
Leverage	The ratio of long-term debt to total assets.
Beta	Market beta, estimated from the market model using daily stock returns in the past fiscal year.
Volatility	Standard deviation of daily stock returns in the period from 5 days after the previous announcement date to 10 days before the current earnings announcement.

Table 1
Descriptive statistics

This table reports the descriptive statistics for the variables. The sample spans from 1996 to 2010. The definitions of all variables are given in Appendix A.

Variable	N	Mean	Std	P1	Q1	Median	Q3	P99
ΔIV30d	88,020	-0.058	0.160	-0.514	-0.153	-0.053	0.032	0.416
ΔIV60d	87,631	-0.029	0.123	-0.390	-0.099	-0.029	0.036	0.356
ΔIV91d	87,197	-0.016	0.102	-0.323	-0.072	-0.017	0.035	0.320
Inconsistent1	88,020	0.383	0.486	0.000	0.000	0.000	1.000	1.000
Inconsistent2	53,999	0.332	0.471	0.000	0.000	0.000	1.000	1.000
Inconsistent3	35,816	0.301	0.459	0.000	0.000	0.000	1.000	1.000
Inconsistent4	24,896	0.273	0.445	0.000	0.000	0.000	1.000	1.000
Inconsistent5	17,991	0.257	0.437	0.000	0.000	0.000	1.000	1.000
Inconsistent6	13,163	0.244	0.430	0.000	0.000	0.000	0.000	1.000
Inconsistent7	9,703	0.235	0.424	0.000	0.000	0.000	0.000	1.000
Inconsistent8	7,206	0.221	0.415	0.000	0.000	0.000	0.000	1.000
AFE	88,020	0.004	0.009	0.000	0.000	0.001	0.003	0.069
Loss	88,020	0.151	0.358	0.000	0.000	0.000	0.000	1.000
Log (ΔVIX)	88,020	0.009	0.127	-0.282	-0.074	-0.004	0.080	0.394
MktCap	88,020	6.156	15.321	0.078	0.554	1.449	4.291	110.028
Size	88,020	7.417	1.525	4.355	6.316	7.279	8.364	11.608
Analysts	88,020	9.385	5.979	2.000	5.000	8.000	13.000	28.000
Dispersion	88,020	0.032	0.045	0.000	0.010	0.020	0.040	0.290
BM	88,020	0.486	0.362	-0.172	0.244	0.410	0.637	1.992
Leverage	88,020	0.188	0.189	0.000	0.011	0.146	0.298	0.837
Beta	88,020	1.147	0.697	-0.463	0.684	1.077	1.532	3.375
Volatility	88,020	0.028	0.016	0.008	0.017	0.024	0.035	0.090

Table 2
Univariate tests

This table reports the univariate test on changes in implied volatility surrounding quarterly earnings announcements using 30, 60, and 91 day standardized options. Firm-quarter observations are divided into two groups based on *Inconsistent1*, or whether the current quarter earnings surprise has the same sign as last quarter's earnings surprise. *** indicates that the difference is statistically different from 0 at the 1% level.

	Inconsistent1= 1			*Consistent1=1*			Difference in	
	N	Mean	Median	N	Mean	Median	Mean	Median
ΔIV30d	33,668	-0.053	-0.049	54,352	-0.062	-0.055	0.008***	0.006***
ΔIV60d	33,526	-0.027	-0.026	54,105	-0.031	-0.03	0.004***	0.004***
ΔIV91d	33,362	-0.014	-0.015	53,835	-0.018	-0.018	0.003***	0.003***

Table 3
Baseline regression

This table reports the results from regression of changes in implied volatility around quarterly earnings announcements. Dependent variables are *ΔIV30d*, *ΔIV60d* and *ΔIV91d* estimated using standardized options with 30-day, 60-day and 91-day durations, respectively. All the variables are defined in Appendix A. ***, ** and * indicate the coefficients are statistically significant at 1%, 5% and 10% level, respectively. Standard errors are adjusted for clustering effect at both firm and quarter level.

Independent Variable	Option Duration		
	30 days	60 days	91 days
Intercept	-0.013	-0.005	0.001
	(-1.05)	(-0.59)	(0.18)
Inconsistent1	0.007***	0.004***	0.003***
	(5.18)	(3.91)	(3.95)
AFE	-0.109	-0.072	-0.028
	(-1.07)	(-0.92)	(-0.44)
Loss	0.023***	0.015***	0.012***
	(9.42)	(9.50)	(10.21)
Log (ΔVIX)	0.280***	0.246***	0.207***
	(10.88)	(10.68)	(10.05)
Size	-0.002	-0.001	0.000
	(-1.44)	(-0.62)	(-0.46)
Log (Analysts)	-0.023***	-0.013***	-0.008***
	(-12.18)	(-10.06)	(-9.38)
Dispersion	-0.092***	-0.051***	-0.019
	(-4.00)	(-3.19)	(-1.55)
BM	0.005	0.002	-0.001
	(1.33)	(0.75)	(-0.31)
Leverage	0.041***	0.024***	0.015***
	(8.87)	(7.32)	(5.87)
Beta	-0.003	-0.002*	-0.001
	(-1.60)	(-1.64)	(-0.83)
Volatility	0.123	-0.050	-0.142*
	(0.82)	(-0.50)	(-1.94)
Adj. R^2	0.069	0.075	0.075
N	88,020	87,631	87,197

Table 4

The effect of the strength of investors' prior beliefs

This table reports the results from regression of changes in implied volatility around quarterly earnings announcements. Dependent variables are *ΔIV30d* estimated using standardized options with 30-day duration. All the variables are defined in Appendix A. ***, ** and * indicate the coefficients are statistically significant at 1%, 5% and 10% level, respectively. Standard errors are adjusted for clustering effect at both firm and quarter level.

	InconsistentN							
Independent Variable	1	2	3	4	5	6	7	8
Intercept	-0.013	-0.014	-0.019	-0.022	-0.015	-0.031	-0.034	-0.064**
	(-1.05)	(-1.05)	(-1.36)	(-1.41)	(-0.85)	(-1.58)	(-1.54)	(-2.39)
Inconsistent	0.007***	0.012***	0.016***	0.020***	0.024***	0.027***	0.026***	0.028***
	(5.18)	(7.73)	(7.75)	(8.83)	(8.55)	(8.41)	(6.62)	(5.87)
AFE	-0.109	-0.147	-0.220*	-0.228	-0.326*	-0.386**	-0.609**	-0.591*
	(-1.07)	(-1.37)	(-1.73)	(-1.49)	(-1.81)	(-1.96)	(-2.46)	(-1.95)
Loss	0.023***	0.022***	0.022***	0.022***	0.023***	0.032***	0.038***	0.043***
	(9.42)	(7.88)	(6.82)	(5.32)	(4.50)	(5.38)	(4.63)	(4.48)
Log (ΔVIX)	0.280***	0.281***	0.282***	0.283***	0.285***	0.282***	0.298***	0.307***
	(10.88)	(11.03)	(10.72)	(10.93)	(11.60)	(10.82)	(10.80)	(10.97)
Size	-0.002	-0.002	-0.002	-0.001	-0.002	0.000	0.000	0.002
	(-1.44)	(-1.56)	(-1.17)	(-0.85)	(-0.84)	(-0.02)	(0.12)	(0.77)
Log (Analysts)	-0.023***	-0.024***	-0.026***	-0.027***	-0.031***	-0.031***	-0.032***	-0.030***
	(-12.18)	(-11.67)	(-10.42)	(-9.25)	(-8.98)	(-7.74)	(-6.63)	(-5.56)
Dispersion	-0.092***	-0.092***	-0.085***	-0.080**	-0.071*	-0.077*	-0.101*	-0.137**
	(-4.00)	(-3.76)	(-2.88)	(-2.39)	(-1.81)	(-1.82)	(-1.92)	(-1.99)
BM	0.005	0.006	0.010**	0.014***	0.015**	0.021***	0.027***	0.041***
	(1.33)	(1.32)	(2.16)	(2.74)	(2.31)	(2.80)	(3.19)	(4.11)
Leverage	0.041***	0.042***	0.041***	0.044***	0.046***	0.047***	0.049***	0.065***
	(8.87)	(7.82)	(6.32)	(6.09)	(5.05)	(4.65)	(4.12)	(4.83)
Beta	-0.003	-0.002	-0.001	-0.001	-0.001	-0.001	-0.002	-0.004
	(-1.60)	(-0.93)	(-0.55)	(-0.25)	(-0.44)	(-0.45)	(-0.38)	(-0.82)
Volatility	0.123	0.140	0.168	0.132	0.100	0.120	0.045	0.149
	(0.82)	(0.92)	(1.02)	(0.75)	(0.52)	(0.57)	(0.21)	(0.60)
Adj. R^2	0.069	0.073	0.076	0.079	0.085	0.086	0.093	0.102
N	88,020	53,999	35,816	24,896	17,991	13,163	9,703	7,206

Table 5

The effect of good news versus bad news

This table reports the results from regression of changes in implied volatility around quarterly earnings announcements. Dependent variables are *ΔIV30d*, *ΔIV60d* and *ΔIV91d* estimated using standardized options with 30-day, 60-day and 91-day durations, respectively. All the variables are defined in Appendix A. ***, ** and * indicate the coefficients are statistically significant at 1%, 5% and 10% level, respectively. Standard errors are adjusted for clustering effect at both firm and quarter level.

	Option Duration		
Independent Variable	30 days	60 days	91 days
Intercept	-0.013	-0.005	0.001
	(-1.03)	(-0.55)	(0.24)
Inconsistent1_GoodNews	-0.006***	-0.008***	-0.008***
	(-3.69)	(-7.17)	(-9.31)
Inconsistent1_BadNews	0.019***	0.015***	0.013***
	(12.01)	(12.83)	(14.37)
AFE	-0.081	-0.044	-0.003
	(-0.80)	(-0.58)	(-0.05)
Loss	0.022***	0.014***	0.011***
	(9.15)	(9.15)	(9.77)
Log (ΔVIX)	0.280***	0.246***	0.207***
	(10.90)	(10.69)	(10.06)
Size	-0.002	-0.001	0.000
	(-1.53)	(-0.73)	(-0.60)
Log (Analysts)	-0.023***	-0.013***	-0.008***
	(-12.11)	(-9.99)	(-9.31)
Dispersion	-0.094***	-0.053***	-0.021*
	(-4.07)	(-3.32)	(-1.68)
BM	0.006	0.003	0.000
	(1.47)	(0.93)	(-0.11)
Leverage	0.041***	0.025***	0.015***
	(8.97)	(7.49)	(6.02)
Beta	-0.003	-0.002	-0.001
	(-1.60)	(-1.63)	(-0.82)
Volatility	0.120	-0.053	-0.144**
	(0.80)	(-0.53)	(-2.00)
Adj. R^2	0.072	0.078	0.079
N	88,020	87,631	87,197

Table 6

Robustness test: The effect of good news versus bad news

This table reports the results from regression of changes in implied volatility around quarterly earnings announcements. Dependent variables are *ΔIV30d* estimated using standardized options with 30-day duration. All the variables are defined in Appendix A. ***, ** and * indicate the coefficients are statistically significant at 1%, 5% and 10% level, respectively. Standard errors are adjusted for clustering effect at both firm and quarter level.

	InconsistentN							
Independent Variable	1	2	3	4	5	6	7	8
Intercept	-0.013	-0.013	-0.018	-0.021	-0.014	-0.030	-0.033	-0.062**
	(-1.03)	(-0.98)	(-1.29)	(-1.34)	(-0.81)	(-1.55)	(-1.50)	(-2.32)
Inconsistent_GoodNews	-0.006***	0.000	0.006**	0.010***	0.016***	0.018***	0.014*	0.012
	(-3.69)	(-0.18)	(2.28)	(3.19)	(3.95)	(3.00)	(1.86)	(1.30)
Inconsistent_BadNews	0.019***	0.021***	0.022***	0.025***	0.027***	0.030***	0.030***	0.033***
	(12.01)	(10.54)	(8.26)	(8.80)	(7.55)	(7.77)	(6.61)	(6.05)
AFE	-0.081	-0.117	-0.200	-0.207	-0.310*	-0.367*	-0.581**	-0.551*
	(-0.80)	(-1.10)	(-1.58)	(-1.35)	(-1.72)	(-1.89)	(-2.37)	(-1.84)
Loss	0.022***	0.022***	0.022***	0.022***	0.023***	0.033***	0.039***	0.044***
	(9.15)	(7.84)	(6.84)	(5.39)	(4.58)	(5.44)	(4.71)	(4.56)
Log (ΔVIX)	0.280***	0.282***	0.282***	0.283***	0.285***	0.282***	0.298***	0.307***
	(10.90)	(11.07)	(10.74)	(10.95)	(11.60)	(10.81)	(10.82)	(11.02)
Size	-0.002	-0.002*	-0.002	-0.002	-0.002	0.000	0.000	0.002
	(-1.53)	(-1.70)	(-1.28)	(-0.93)	(-0.88)	(-0.04)	(0.09)	(0.74)
Log(Analysts)	-0.023***	-0.024***	-0.026***	-0.028***	-0.031***	-0.031***	-0.032***	-0.031***
	(-12.11)	(-11.65)	(-10.41)	(-9.24)	(-8.97)	(-7.73)	(-6.68)	(-5.62)
Dispersion	-0.094***	-0.094***	-0.086***	-0.081**	-0.072*	-0.079*	-0.103**	-0.140**
	(-4.07)	(-3.81)	(-2.90)	(-2.44)	(-1.83)	(-1.86)	(-1.96)	(-2.05)
BM	0.006	0.006	0.011**	0.015***	0.015**	0.021***	0.028***	0.042***
	(1.47)	(1.49)	(2.31)	(2.86)	(2.38)	(2.87)	(3.27)	(4.18)
Leverage	0.041***	0.043***	0.042***	0.045***	0.047***	0.048***	0.050***	0.066***
	(8.97)	(7.99)	(6.44)	(6.19)	(5.15)	(4.74)	(4.22)	(4.92)
Beta	-0.003	-0.002	-0.001	-0.001	-0.001	-0.002	-0.002	-0.004
	(-1.60)	(-0.94)	(-0.57)	(-0.27)	(-0.46)	(-0.46)	(-0.41)	(-0.87)
Volatility	0.120	0.137	0.162	0.125	0.094	0.115	0.036	0.135

	(0.80)	(0.89)	(0.99)	(0.71)	(0.49)	(0.54)	(0.17)	(0.54)
Adj. R^2	0.072	0.075	0.077	0.080	0.085	0.087	0.093	0.103
N	88,020	53,999	35,816	24,896	17,991	13,163	9,703	7,206

Table 7

The effect of firm characteristics

This table reports the results from regression of changes in implied volatility around quarterly earnings announcements. Dependent variables are *ΔIV30d* estimated using standardized options with 30-day duration. Firm-quarter observations are divided into two groups based on the median firm size (small and large), number of analysts following (small and large) and return volatility (high and low). All the variables are defined in Appendix A. ***, ** and * indicate the coefficients are statistically significant at 1%, 5% and 10% level, respectively. Standard errors are adjusted for clustering effect at both firm and quarter level.

	Firm size		**No. of analysts**		**Return volatility**	
	Small	Large	Small	Large	High	Low
Intercept	0.020	0.003	-0.006	0.016	-0.006	-0.011
	(1.40)	(0.12)	(-0.45)	(0.86)	(-0.45)	(-0.62)
Inconsistent1	0.004*	0.010***	0.006***	0.008***	0.006***	0.008***
	(1.79)	(5.78)	(3.01)	(4.47)	(3.04)	(4.34)
AFE	-0.052	-0.730***	0.058	-0.367*	-0.109	-0.597**
	(-0.55)	(-2.98)	(0.58)	(-1.95)	(-1.21)	(-2.21)
Loss	0.022***	0.021***	0.021***	0.025***	0.025***	0.015***
	(9.44)	(4.85)	(8.02)	(6.58)	(10.85)	(3.07)
Log (ΔVIX)	0.223***	0.334***	0.241***	0.318***	0.274***	0.287***
	(9.15)	(11.35)	(9.13)	(12.11)	(11.67)	(10.25)
Size	-0.009***	-0.002	-0.003**	0.001	-0.007***	-0.001
	(-4.51)	(-1.13)	(-1.98)	(0.67)	(-5.03)	(-0.92)
Log(Analysts)	-0.019***	-0.027***	-0.020***	-0.046***	-0.018***	-0.026***
	(-7.96)	(-11.06)	(-6.92)	(-9.18)	(-8.28)	(-9.62)
Dispersion	-0.112***	-0.050	-0.116***	-0.070**	-0.067***	-0.089***
	(-4.29)	(-1.60)	(-4.96)	(-2.26)	(-3.03)	(-2.90)
BM	0.002	0.007	0.001	0.012**	-0.001	0.009
	(0.60)	(1.16)	(0.25)	(2.15)	(-0.38)	(1.44)
Leverage	0.041***	0.042***	0.029***	0.053***	0.032***	0.047***
	(7.83)	(5.47)	(5.83)	(7.63)	(6.12)	(6.49)
Beta	-0.003	-0.003	-0.002	-0.003	-0.003*	0.004
	(-1.50)	(-1.09)	(-1.39)	(-0.96)	(-1.64)	(1.35)
Volatility	0.250*	-0.105	0.072	0.194	0.520***	0.016
	(1.89)	(-0.48)	(0.52)	(1.02)	(3.78)	(0.04)
Adj. R^2	0.044	0.099	0.043	0.090	0.075	0.072
N	43,849	44,171	43,986	44,034	43,922	44,098

Table 8

The effect of investor sentiment

This table reports the results from regression of changes in implied volatility around quarterly earnings announcements. Dependent variables are *ΔIV30d* estimated using standardized options with 30-day duration. Sample period is divided into two sub periods based on the median investor sentiment. Panel A reports the results in low sentiment periods and Panel B reports the results in high sentiment periods. All the variables are defined in Appendix A. ***, ** and * indicate the coefficients are statistically significant at 1%, 5% and 10% level, respectively. Standard errors are adjusted for clustering effect at both firm and quarter level.

Panel A: Low Sentiment Periods

	InconsistentN							
Independent Variable	1	2	3	4	5	6	7	8
Intercept	-0.054***	-0.061***	-0.070***	-0.074***	-0.052**	-0.062**	-0.079**	-0.108***
	(-3.54)	(-3.23)	(-3.28)	(-2.87)	(-1.99)	(-2.25)	(-2.44)	(-2.60)
Inconsistent	0.010***	0.016***	0.020***	0.024***	0.024***	0.027***	0.028***	0.031***
	(4.14)	(5.95)	(5.96)	(6.72)	(8.72)	(7.03)	(4.90)	(3.93)
AFE	0.001	-0.061	-0.100	-0.022	-0.345*	-0.426**	-0.709**	-0.840***
	(0.00)	(-0.60)	(-0.93)	(-0.11)	(-1.79)	(-2.10)	(-2.22)	(-3.35)
Loss	0.030***	0.032***	0.031***	0.032***	0.040***	0.056***	0.067***	0.065***
	(7.78)	(6.95)	(6.20)	(4.73)	(5.69)	(5.66)	(5.12)	(3.67)
Log (ΔVIX)	0.435***	0.432***	0.445***	0.444***	0.428***	0.428***	0.460***	0.466***
	(9.61)	(9.64)	(10.78)	(11.53)	(13.04)	(10.82)	(14.19)	(12.57)
Size	-0.003	-0.002	-0.001	-0.001	-0.002	-0.001	0.002	0.004
	(-1.43)	(-0.99)	(-0.33)	(-0.16)	(-0.71)	(-0.29)	(0.45)	(0.89)
Log(Analysts)	-0.025***	-0.026***	-0.030***	-0.031***	-0.032***	-0.033***	-0.036***	-0.036***
	(-7.96)	(-7.06)	(-8.09)	(-6.88)	(-5.58)	(-4.10)	(-3.81)	(-3.11)
Dispersion	0.040*	0.051**	0.080***	0.066*	0.052	0.093*	-0.014	0.048
	(1.78)	(2.12)	(2.68)	(1.73)	(1.06)	(1.80)	(-0.20)	(0.51)
BM	0.005*	0.001	0.007**	0.013***	0.020**	0.024**	0.030**	0.036***
	(1.82)	(0.34)	(2.19)	(2.77)	(2.52)	(2.47)	(2.46)	(2.61)
Leverage	0.039***	0.041***	0.039***	0.043***	0.048**	0.046**	0.049**	0.066***
	(6.27)	(5.39)	(3.49)	(3.61)	(2.38)	(2.34)	(2.11)	(2.84)
Beta	-0.003	-0.003	-0.002	-0.001	-0.004	-0.006	-0.008	-0.010
	(-1.11)	(-0.77)	(-0.55)	(-0.22)	(-0.78)	(-1.11)	(-1.28)	(-1.23)
Volatility	0.575***	0.640***	0.599***	0.518***	0.334	0.196	0.268	0.269
	(3.76)	(4.58)	(4.21)	(2.79)	(1.58)	(0.86)	(1.05)	(0.95)
Adj. R^2	0.158	0.163	0.176	0.178	0.176	0.185	0.203	0.217
N	24,055	14,743	9,698	6,669	4,795	3,473	2,534	1,898

Panel B: High Sentiment Periods

Independent Variable	*InconsistentN* 1	2	3	4	5	6	7	8
Intercept	0.010	0.009	0.006	0.006	0.023	-0.008	-0.007	-0.008
	(0.72)	(0.62)	(0.29)	(0.31)	(1.06)	(-0.31)	(-0.21)	(-0.22)
Inconsistent	0.005**	0.011***	0.015***	0.013***	0.018***	0.018***	0.019**	0.018*
	(2.23)	(3.47)	(4.06)	(3.74)	(4.04)	(2.72)	(2.31)	(1.87)
AFE	0.462*	0.487*	0.184	0.104	0.072	0.345	0.139	0.450
	(1.68)	(1.67)	(0.44)	(0.19)	(0.11)	(0.54)	(0.21)	(0.63)
Loss	0.013***	0.015***	0.016***	0.020***	0.033***	0.034***	0.032**	0.018
	(3.52)	(3.49)	(2.88)	(3.03)	(3.47)	(3.74)	(2.03)	(1.06)
Log (ΔVIX)	0.115***	0.113***	0.116***	0.115***	0.114***	0.114***	0.111***	0.120**
	(5.00)	(4.28)	(4.00)	(3.57)	(3.30)	(3.17)	(2.85)	(2.53)
Size	-0.001	-0.002	-0.002	-0.002	-0.002	0.002	0.002	0.001
	(-0.79)	(-0.86)	(-0.76)	(-0.66)	(-0.66)	(0.59)	(0.39)	(0.19)
Log(Analysts)	-0.005**	-0.005	-0.007*	-0.008*	-0.015**	-0.017**	-0.018*	-0.014
	(-2.07)	(-1.37)	(-1.82)	(-1.86)	(-2.17)	(-2.01)	(-1.70)	(-1.29)
Dispersion	-0.009	-0.048	-0.041	-0.055	-0.006	-0.080	-0.043	-0.060
	(-0.29)	(-1.24)	(-0.80)	(-1.13)	(-0.09)	(-0.93)	(-0.78)	(-0.40)
BM	-0.001	0.001	0.004	0.007	-0.003	0.004	0.006	0.011
	(-0.23)	(0.22)	(0.60)	(0.99)	(-0.33)	(0.44)	(0.46)	(0.66)
Leverage	0.020***	0.027***	0.028***	0.027**	0.017	0.018	0.010	0.024
	(2.73)	(2.89)	(2.60)	(2.51)	(1.33)	(1.22)	(0.48)	(1.17)
Beta	0.003	0.003	0.004	0.007*	0.012***	0.013***	0.019***	0.013
	(1.17)	(1.16)	(1.14)	(1.94)	(2.67)	(2.63)	(2.74)	(1.54)
Volatility	-0.809***	-0.835***	-0.725***	-0.801***	-0.946***	-0.890***	-1.034***	-0.950***
	(-4.94)	(-4.97)	(-3.39)	(-3.88)	(-4.29)	(-4.25)	(-5.39)	(-3.86)
Adj. R^2	0.025	0.027	0.028	0.030	0.040	0.036	0.039	0.034
N	14,518	9,136	6,170	4,402	3,215	2,350	1,706	1,228