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Does analyst forecast dispersion represent investors' perceived uncertainty toward earnings?

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Abstract

Purpose – This paper aims to investigate the association between analyst forecast dispersion and investors' perceived uncertainty toward earnings.

Design/methodology/approach – A new measure for investors' expectations of earnings announcement uncertainty is constructed, using changes in implied volatility of option contracts prior to earnings announcements. Unlike other proxies of uncertainty, this measure isolates the incremental uncertainty regarding the upcoming earnings announcement and is a forward-looking measure.

Findings – Using this new proxy, this paper finds a significant negative correlation between analyst forecast dispersion and investors' uncertainty regarding the upcoming earnings announcements. Further tests show that this negative correlation is driven by analysts' private information acquisition rather than analysts; uncertainty toward upcoming earnings announcements. Additional cross-sectional tests show that this negative relationship is more pronounced in the subsample with lower earnings quality.

Social implications – This paper helps to further the understanding of the information content of analyst forecast dispersion, particularly the ways in which they gather and produce private information and their incentives for so doing.

Originality/value – This paper introduces a new market-based and forward-looking proxy of earnings announcement uncertainty that should be useful in future research. This paper also provides original empirical evidence that analysts gather and produce an additional private information to the market when facing noisy signals and that their information reduces investors' uncertainty toward upcoming earnings announcements.

Keywords Earnings announcement, Analyst forecast dispersion, Options implied volatility

Paper type Research paper

1. Introduction

The information content of analyst forecast dispersion[1] has long been a topic of interest in the accounting and finance literature. Givoly and Lakonishok (1984) were the first to argue that the level of analyst forecast dispersion reflects the level of uncertainty regarding firms' future performance. The literature that followed has used analyst forecast dispersion as a proxy of either uncertainty or information asymmetry among analysts (i.e. a lack of consensus). Nevertheless, Barron *et al.* (1998) suggest that analyst forecast dispersion is likely to be a proxy for *both* uncertainty and information asymmetry among analysts. Using an analytical model, Barron *et al.* (1998) decompose analyst forecast dispersion into uncertainty (common forecast error) and information asymmetry (idiosyncratic forecast error or analysts' individual private information acquisition) components. This decomposition process has been widely used in recent research (Barron *et al.*, 2002, 2009; Botosan *et al.*, 2004; Byard *et al.*, 2011). Despite the theoretical appeal of Barron *et al.*'s (1998) model, many papers do not use this decomposition process; instead, they continue to use total analyst forecast dispersion as a proxy for the uncertainty of future earnings. For

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example, Zhang (2006) uses analyst forecast dispersion directly, without decomposition, to measure the uncertainty of future earnings, as do Diether *et al.* (2002) and Johnson (2004).

Without knowing the extent to which total analyst forecast dispersion captures uncertainty or information asymmetry among analysts, it is difficult to interpret results with mixed implication from the prior literature. For example, the negative correlation that these researchers find between analyst forecast dispersion and future abnormal return can be driven by either the uncertainty component of analyst forecast dispersion or the information asymmetry in the analyst's component (i.e. the analyst's individual private information acquisition). In this study, I first construct a refined measure of investors' perceived uncertainty toward an upcoming earnings announcement using the option contract's implied volatility. The study then considers how analyst forecast dispersion is associated with the uncertainty that investors perceive in upcoming earnings announcements. Finally, the study examines how the two components of analyst forecast dispersion based on Barron *et al.*'s (1998) decomposition process are associated with investors' perceived uncertainty toward upcoming earnings.

The study develops a measure that uses the *change* in the implied volatility of exchange-traded option contracts prior to a scheduled earnings announcement to evaluate investors' expected uncertainty related to the upcoming earnings announcement. The level of option contracts' implied volatility measures the average expected total price volatility between the measurement date and the expiration date of the option contract. This total uncertainty measure is affected heavily by firm characteristics, such as size, financial risk (e.g. leverage) and operating risk. By taking the first difference of the implied volatility of exchange-traded option contracts one day prior to the earnings announcement and 30 days prior to the earnings announcement, this measure isolates the incremental uncertainty toward the upcoming earnings announcement and controls for firms' normal level of uncertainty. This measure provides an estimation of the uncertainty that closely matches the timing and forecast horizon of the uncertainty embedded in analyst forecast dispersion regarding the upcoming earnings announcement.

Following the intuition modeled by Kim and Verrecchia (1991), who show analytically that as the diversity of opinion among information processors (analysts) increases, the stock price becomes more informative (less uncertain) at the time of an earnings announcement, the study hypothesizes that analyst forecast dispersion is negatively correlated with the investors' expected uncertainty toward upcoming earnings announcements. Using both univariate correlation and multivariate regression analyses that control for macroeconomic and firm-specific variables, the study finds that total analyst forecast dispersion is significantly negatively correlated with investors' expected uncertainty toward upcoming earnings announcements. Following Barron *et al.* (1998), additional tests reveal that this negative correlation is driven by the information asymmetry component of the analyst forecast dispersion rather than the uncertainty component, which is consistent with the theoretical development in Kim and Verrecchia (1991).

To further understand the relationship between analyst forecast dispersion and market uncertainty, the study hypothesizes that this negative relationship should be moderated by the quality of a firm's earnings if this negative association is driven by the information asymmetry among analysts. Theoretical research by Kim and Verrecchia (1991) shows that as the quality of previously received information signals decreases (low earnings quality), investors have stronger incentives to acquire private information. Based on their prediction of this complementary relationship between the quality of public information and the acquisition of private information by analysts, private information (as proxied by information asymmetry among analysts) plays a more important role in terms of forming earnings expectations and reducing market uncertainty when the quality of public information is low. The study predicts that the negative correlation between analyst forecast dispersion and investors' perceived uncertainty is more intensified when the earnings quality is low. In an empirical test, this study finds that, for the subsample with firms of lower earnings quality (as proxied by various earnings quality measures, including the performance-matched modified Jones model measure and the earnings smoothness measure), analyst forecast dispersion has a stronger negative correlation with investors' perceived market uncertainty toward earnings announcements.

An additional robustness test, using inter-temporal data, shows that the moderating effect of earnings quality discussed above also appears in the context of an accounting restatement. In this test, the study uses a firm's accounting restatement as a proxy for a sudden decrease in perceived earnings quality. Based on a similar argument, the study predicts that the negative correlation between analyst forecast dispersion and investors' expected uncertainty toward earnings is more pronounced in the post-restatement period, due to increased private information acquisition, than in the pre-restatement period. The empirical tests support the hypothesis and find that the negative association between analyst forecast dispersion and investor-perceived uncertainty toward earnings announcements becomes more pronounced for the same firm after the restatement than before the restatement.

In summary, this study investigates the informational content of analyst forecast dispersion and its association with investors' perceived uncertainty toward earnings announcements. It contributes to the accounting and finance literature in two different ways. First, the study provides evidence that analyst forecast dispersion is negatively associated with investors' perceived uncertainty toward upcoming earnings announcements and that this association is driven by the information asymmetry component of analysts' forecast dispersion. The findings further validate the mechanism behind this association by demonstrating that this negative association is more pronounced when a firm faces lower earnings quality. Second, the study proposes and validates an *ex ante* and market-based uncertainty measure that isolates the market expected uncertainty toward earnings announcements only. This measure is readily available and does not require a long-time series of data to estimate. Additional tests show that this measure is significantly correlated with future idiosyncratic risk and future investor opinion divergence variables. The measure is not correlated with either the current quarter's idiosyncratic risk or the current quarter's other investor opinion divergence variables. For these reasons, it is an ideal candidate to serve as a proxy for forward-looking uncertainty around a future earnings announcement.

The rest of the paper is organized as follows: Section 2 provides the related literature. Section 3 presents the hypothesis development and research design. Section 4 contains descriptive statistics of the sample and the statistical properties of market uncertainty derived from implied volatility. Section 5 presents the main test results for the hypotheses proposed earlier and Section 6 provides additional robustness test results. Section 7 concludes the paper.

2. Literature review

2.1 Analyst forecast dispersion

The literature in accounting and finance interprets analyst forecast dispersion in different ways. Most of the literature uses analyst forecast dispersion as a proxy for uncertainty related to firms' price-relevant fundamentals. Accounting and finance research has investigated the information content of analyst forecast dispersion, but existing empirical results are inconclusive. As noted, Givoly and Lakonishok (1984) are the first to argue that analyst forecast dispersion is related to a firm's future level of uncertainty. Daley *et al.* (1988) test Givoly and Lakonishok's theoretical prediction and find that forecast dispersion is, in fact, positively correlated with forecast error and a firm's implied volatility level; however, their results are inconsistent with those of Imhoff and Lobo (1992), who locate a negative correlation between dispersion and the future earnings response coefficient (ERC). Abarbanell *et al.* (1995) explain Imhoff and Lobo's results by arguing that uncertainty after an earnings announcement may trigger investors to acquire more private information, which, in turn, leads to a higher level of analyst forecast dispersion. This increased information asymmetry among analysts could lead to a negative correlation between analyst forecast dispersion and the market's future response to earnings.

Barron *et al.* (1998) first combine these two streams of research on analyst forecast dispersion and model analyst forecast dispersion as representing both uncertainty and information asymmetry among analysts (due to analysts' individual private information acquisition). The intuition behind their model is that the correlation between individual analyst forecast errors measures analysts' use of public information, whereas the variation around the mean forecast reflects analysts' use of private information. Barron *et al.* (1998) calculate the mean squared error of each individual analyst's forecast to measure average uncertainty toward earnings numbers and divide total dispersion by the mean squared error to measure information asymmetry among analysts. The subsequent accounting research that tests the validity of Barron *et al.*'s (1998) measure shows that the theoretical decomposition process is consistent with empirical evidence (Barron *et al.*, 2002, 2009).

Despite the appeal of Barron *et al.*'s (1998) model, a large body of research does not use this decomposition process and simply assumes that total analyst forecast dispersion is a proxy of uncertainty toward earnings numbers. One example is the research on the equity market consequence of analyst forecast dispersion that finds a significantly negative correlation between total analyst forecast dispersion and future abnormal returns. Zhang (2006) uses analyst forecast dispersion directly as a proxy for uncertainty of future earnings. Additionally, both Diether *et al.* (2002) and Johnson (2004) use analyst forecast dispersion as a proxy of firm-level uncertainty toward future performance without decomposition. Prior studies rarely decompose analyst forecast dispersion into uncertainty and information asymmetry among analysts and tend to use total dispersion as a proxy of uncertainty only. Without knowing exactly the extent to which total dispersion proxies for uncertainty or information asymmetry among analysts, it is difficult to interpret the literature's results on the consequences of analyst forecast dispersion, as the cross-sectional difference of analyst forecast dispersion could be driven by either uncertainty or information asymmetry among analysts due to individual analysts' private information acquisition. A more recent study by Keshk and Wang (2018) uses the decomposition of analyst forecast in the context of investigating analysts' private information production when investor sentiment changes. This paper also follows their methodology and decomposes analyst forecast dispersion directly into two components in the main analysis.

In summary, it is evident from the literature on the information content of analyst forecast dispersion that analyst forecast dispersion is likely a proxy of both uncertainty and information asymmetry among analysts. The current literature, however, is ambiguous regarding which one of the two components is the main driver of the association between analyst forecast dispersion and other constructs.

2.2 Motivation for a market-based uncertainty measure

Prior academic research on analyst forecast dispersion typically uses the abnormal returns surrounding earnings announcement, the cost of capital or ERC as dependent variable to examine the information content of analyst forecast dispersion. Because analyst forecast dispersion measures analysts' *ex ante* uncertainty or disagreement toward upcoming earnings numbers, to investigate the exact information content of analyst forecast dispersion, an exogenous means to either directly measure *ex ante* uncertainty toward earnings or measures the level of analysts' disagreement is needed. Because it is difficult to gauge analysts' individual private information, as each individual analyst has a different incentive, utility function and access to information, a natural alternative to consider is the market expected uncertainty toward earnings announcements. The exchange-traded option contract provides a fruitful venue to extract such *ex ante* information of uncertainty toward earnings.

Implied volatility[2] is the value of the volatility that, when plugged into an option pricing model (e.g. Black–Scholes Merton model, binomial model), exactly returns the current market price of the option contract (Mayhew, 1995). The implied volatility or implied standard deviation (ISD), provides a comparable measure of the value of an option contract across different strike prices, expiration dates and put/call contracts. Theoretically, it is an *ex ante* measure of the average expected total risk of the underlying equity stock that extends over the life of the option (Ross, 1978). More recent literature shows that implied volatility is, indeed, a forward-looking measure of uncertainty and is superior to historical volatility (Canina and Figlewski, 1993; Christensen and Prabhala, 1998). Implied volatility also captures the expected volatility induced by a scheduled news release, such as an upcoming earnings announcement. Ederington and Lee's (1996) model shows that implied volatility impounds the anticipated impact that important news will have on price volatility for a scheduled announcement.

Other empirical studies (Isakov and Perignon, 2001; Patell and Wolfson, 1979, 1981) document that implied standard deviation increases before scheduled news announcements (e.g. earnings announcements) and declines thereafter. As a qualification, however, the extent of this decline depends on the information that the earnings announcement contains (i.e. good news or bad news). Specifically, Isakov and Perignon (2001) document that a negative shock (bad news) during earnings announcement has a greater impact on volatility than does a positive shock, and it takes longer for implied volatility to return to normal after a negative shock. They also document that implied volatility on average reaches a local maximum one day before the scheduled earnings announcement and gradually decreases until it reaches its long-term norm.

In summary, these studies demonstrate that implied volatility is an *ex ante* measure that captures the uncertainty in the market around earnings announcements. The options market provides a potentially useful venue to extract market expected uncertainty toward earnings announcements.

2.3 Investors' uncertainty toward earnings announcements

This study proposes three reasons for using implied volatility from exchange-traded option contracts to derive a measure of market uncertainty instead of relying on traditional uncertainty measures such as idiosyncratic risk, total risk or other investor opinion divergence measures. First, implied volatility is a market-based measure. Measures derived from an actively traded market have an innate advantage over others because they are less distorted by incentives. Second, implied volatility is a forward-looking measure; thus, it matches the *ex ante* property of analyst forecasted earnings. Third, and perhaps most important, the estimation process is simple and does not involve a long-time series of data, reducing the probability of measurement errors.

When investigating how option prices reflect the risks embedded in earnings, it is important to understand the evolution of implied volatility around earnings announcements. Periodic prescheduled earnings announcements contain critical information regarding the level and volatility of a firm's equity price. The original Black–Scholes model is a static model, whereby the underlying volatility of a stock is assumed to remain constant, and its creators use implied volatility to represent the average instantaneous volatility over the remaining life of the option. Thus, implied volatility here is a forward-looking measure of expected future uncertainty over the life of the option. Implied volatility should account for any expected volatility shock from scheduled news announcements over the remaining life of the option contract. If a stock return's volatility on the day of an earnings announcement is higher than on days without an announcement, the implied volatility of the option contract will increase as the earnings announcement approaches. Implied volatility increases as the earnings announcement time approaches because the market puts a higher weight of time (lower discount rate) on the expected high volatility after earnings announcements (Patell and Wolfson, 1979).

Given the above theoretical reasoning, the implied volatility of a firm's option contract should gradually increase prior to the earnings announcement. It will reach its peak immediately before the earnings announcement date. After this announcement, the implied volatility should decrease to its long-term level if no other information disclosures have been scheduled immediately thereafter. Patell and Wolfson (1979, 1981) empirically confirm this theory of the evolution of implied volatility around the earnings announcement.

Donders and Vorst (1996) summarize the results of Patell and Wolfson (1981) with a simple model that represents the evolution of implied volatility around earnings announcements:

$$ISD_{0,\tau} = \sqrt{\frac{\tau - 1}{\tau}\sigma^2_{normal} + \frac{1}{\tau}\sigma^2_{high}}$$

where *ISD* refers to the implied standard deviation and τ represents the number of days until the option contract expires. Normal volatility is the volatility of a stock price without a scheduled earnings announcement and high volatility is the volatility on the day of the earnings announcement.

Recent empirical results suggest that the change in implied volatility around an earnings announcement also reflects an options market's expectation of upcoming earnings news and contains significant amount of forward looking information. Isakov and Perignon (2001) find that earnings announcement with bad news leads to greater implied volatility after the earnings announcement. In addition, it takes longer for implied volatility to recede to its normal level than it does after a positive earnings announcement. Furthermore, both Skinner (1990) and Ho (1993) provide evidence that an option listing improves the information environment of individual firms such that firms with option listings are associated with lower abnormal return volatility surrounding earnings announcements and the post-earnings announcement price drift. Amin and Lee (1997) show that option traders engage in directional trading as they anticipate the dissemination of earnings news. In fact, Chakravarty *et al.* (2004) show that the options market contributes to a hefty 17 per cent of price discovery, on average, and Ni *et al.* (2008) confirm that traders exchange information about volatility around earnings announcements.

More recently, Billings and Jennings (2011) propose a new measure, which is calculated as the price of the soon-to-expire option contract deflated by analyst forecast dispersion. They show that this measure is correlated with future ERC. Additional studies also have shown strong evidence that option trading activities contain information regarding an equity's future returns. For example, Roll *et al.* (2009) show that the options' trading volume contains forward-looking information regarding a company's future value. To sum up, these studies suggest that at least part of the increase in implied volatility prior to an earnings announcement is the market's expectation of the increased volatility induced by the upcoming earnings announcement.

3. Hypothesis development and research design

3.1 Hypothesis development

To investigate the information content of analyst forecast dispersion, the study tests empirically the relationship between analyst forecast dispersion and the study's constructed measure of investors' uncertainty toward earnings announcements and hypothesizes that analyst forecast dispersion is negatively associated with investors' perceived uncertainty regarding an upcoming earnings announcement. The intuition of this negative correlation is modeled by Kim and Verrecchia (1994), who show analytically that as the diversity of opinions among information processors (analysts) increases, the stock price becomes more informative and less uncertain at the time of an earnings announcement. As analysts produce more private information regarding the upcoming earnings news, the market aggregates these pieces of information into price, and the expected price uncertainty during the earnings announcement (the dependent variable) is reduced. *Ex ante*, however, this negative correlation is not mechanical, as it is also possible that the underlying driver of analyst forecast dispersion is not analysts' private information acquisition but, rather, the general uncertainty toward future earnings announcements based on Barron *et al.*'s (1998) decomposition of analyst forecast dispersion. Thus, whether this association is negative remains an empirical question. Considering the mixed evidence from prior literature regarding the correlation between analyst forecast dispersion and investors' uncertainty toward earnings, the study develops the following hypothesis:

> *H1a*. Ceteris paribus, analyst forecast dispersion is negatively correlated with investors' perceived uncertainty regarding an upcoming earnings announcement.

To confirm that this negative correlation is driven by analysts' private information production rather than uncertainty toward upcoming earnings announcements, the study further tests whether the negative correlation is driven by the information asymmetry component of analyst forecast dispersion or the uncertainty component of the analyst forecast dispersion, using Barron *et al.*'s (1998) decomposition methodology:

> *H1b*. Ceteris paribus, the negative correlation between analyst forecast dispersion and investors' perceived uncertainty regarding an upcoming earnings announcement is driven by the private information production by the analysts.

To enhance the validity of this prediction, the study further hypothesizes that such a negative association should be moderated through firms' earnings quality if it is, indeed, driven by analysts' private information production. Kim and Verrecchia (1991) show that as the noise of prior information signals increases (earnings quality decreases), investors have stronger incentives to acquire more private information. This prediction implies that the acquisition and production of private information by analysts play a more important role in terms of forming earnings expectations and reducing market uncertainty when the quality of public information is low.

Lang and Lundholm (1996) are the first to examine the effect that the quality of financial reporting has on analyst forecast dispersion. They show that firms with better policies for information disclosure enjoy a lower level of analyst forecast dispersion. Healy *et al.* (1999) and Byard and Shaw (2003) use Association for Investment Management and Research (AIMR) scores to confirm this relationship; yet, their results do not help to distinguish whether analyst forecast dispersion represents uncertainty or information asymmetry among analysts. There are two reasons for this lingering doubt. First, the acquisition of private information is endogenous to earnings quality. As the quality of prior information (disclosure quality) decreases, investors (analysts) tend to acquire more private information (Kim and Verrecchia, 1991). Recent empirical evidence provided by Lobo *et al.* (2012) confirms this theoretical prediction and provides corroborating evidence that analysts generate more private information in response to lower earnings quality.

The next hypothesis concerns the association between analyst forecast dispersion and the market-based uncertainty measure in subsamples with different levels of earnings quality to provide a stronger test of the mechanism behind the negative association between analyst forecast dispersion and investors expected uncertainty toward upcoming earnings announcement:

H2. Ceteris paribus, the negative association between analyst forecast dispersion and investors' perceived uncertainty toward an earnings announcement is more pronounced when earnings quality is low.

Aside from the cross-sectional relationship presented above, how the intertemporal change in earnings quality affects the association between analyst forecast dispersion and investors' uncertainty toward earnings provides an alternative robustness test. Because it is difficult to estimate the intertemporal change of earnings quality by using traditional earnings quality measures, which generally require a long-time series of data to estimate, the study uses restatement announcements as a proxy for a sudden decrease in perceived earnings quality. Kravet and Shevlin (2010) document that firms that have recently experienced accounting restatements have higher information risk and thus lower perceived earnings quality. Kim and Zhang (2013) show that restating firms' stock faces a higher risk of crashing. Additionally, both Wilson (2006) and Chen *et al.* (2013) illustrate that restating firms have a lower ERC after restatement announcements. Hribar and Jenkins (2004) show a higher cost of equity after restatement announcements. Based on these prior studies, this study uses accounting restatements as a proxy for a sudden decrease in perceived earnings quality and develop the following hypothesis:

H3. Ceteris paribus, the negative association between analyst forecast dispersion and investors' perceived uncertainty toward an upcoming earnings announcement is more pronounced after accounting restatements.

3.2 Research design

The study uses the following empirical model to test *H1a*:

$$DIV = \alpha + \beta_1 * DISP + \beta_2 * Macro\ Economic\ Control + \beta_3 * Firm - specific\ Control + Fixed\ Effects + \varepsilon \quad (1)$$

The dependent variable, DIV, is the 30-day change in implied volatility prior to an earnings announcement. Specifically, following Donders and Vorst (1996), the study decomposes implied volatility into two components, namely, normal implied volatility and high implied volatility induced by the scheduled earnings announcement. The decomposition can be estimated quarterly by using option contracts of similar terms (call options, same dates to expiration and both at the money), measured at different points in time. The estimation method is structured around the timeline of an earnings announcement. As illustrated in Figure 1, the day of an earnings announcement is denoted as "current earnings announcement day."

The study focuses on the implied volatility of option contracts with the shortest time to expiration. These option contracts have the highest delta (option price's sensitivity to stock price change) and Vega (option price's sensitivity to stock volatility change) and are most sensitive to changes in the firm's risk and stock price. The study obtains implied volatility of standardized option contracts with a hypothesized 30 days to expiration, available from the option-metrics database. Standardized options[3] are calculated as at-the-money contracts with constant time to maturity. In total, 31 days before an earnings announcement, the implied volatility contains only the average volatility expected over the next 30 days; thus, it does not contain information on the volatility on the day of an earnings announcement. This implied volatility σ T-31 is used as benchmark volatility, as it contains only the normal level of uncertainty (σ normal) in the Donders and Vorst (1996) model. The σ T-1 is the implied volatility one day prior to an earnings announcement; thus, it gives the heaviest weight on the incremental volatility (σ high) in the Donders and Vorst model regarding earnings announcement uncertainty.

By reversing the Donders and Vorst (1996) model and control for non-linear relationship between standard deviations, $\sqrt{(\sigma_{t-1})^2 - (\sigma_{t-31})^2}$ yields an *ex ante* measure of the incremental uncertainty (σ high) from an upcoming earnings announcement, as it is expected by option traders. This measure isolates investors' uncertainty toward the upcoming earnings announcement and controls for the firm's normal volatility.

On the right-hand side of equation (1), the variable of interest *DISP* is the standard deviation of the most updated individual analyst forecast, deflated by the prior quarter's end

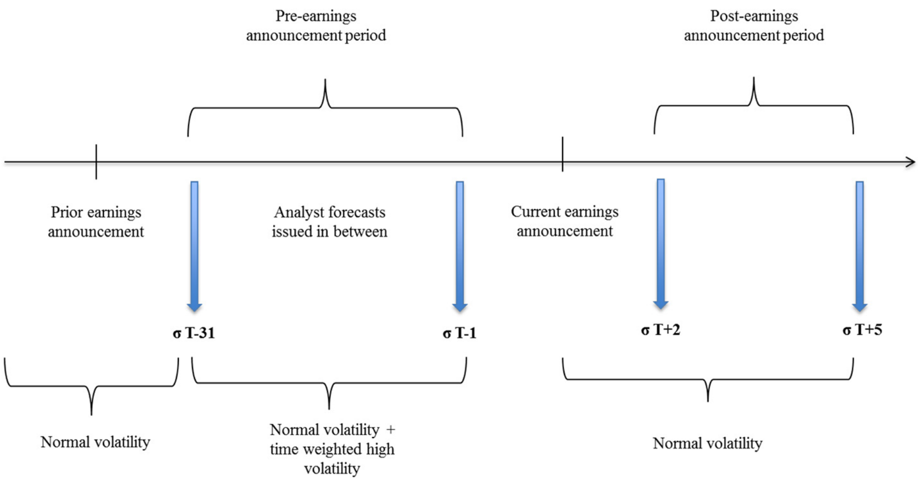

Figure 1.
Timeline of change in volatility between earnings announcements

price. *DISP* includes only the most updated quarterly earnings forecast issued between T-31 and T-1 to match the estimation period of *DIV*. The macroeconomic control variable is the change in the VIX index over the same period covered by *DIV*. *VIX* index is a real-time market index created by the Chicago Board Options Exchange (*CBOE*) that represents the market's expectation of 30-day forward-looking volatility derived from the price inputs of the S&P 500 index options. The firm-specific control variables include a set of firm characteristic variables related to the firm's risk profile, such as leverage (*Leverage*), return on assets (*ROA*), size as measured by the log market value of equity (*LMV*) and book-to-market ratio (*BTM*).

To provide further empirical evidence on the fundamental driver of the association between analyst forecast dispersion and the change of implied volatility prior to earnings announcement, I test *H1b* using equations (2) and (3). These two equations replace *DISP* in equation (1) with the two components of DISP following Barron *et al.* (1998): the information asymmetry among analysts (InfoAsym) and the uncertainty toward upcoming earnings announcement (Uncertainty) in the empirical model similar to equation (1).

$$DIV = \alpha + \beta_1 * InfoAsym + \beta_2 * Macro\,Economic\,Control + \beta_3 * Firm - specific\,Control + Fixed\,Effects + \varepsilon \tag{2}$$

$$DIV = \alpha + \beta_1 * Ucertainty + \beta_2 * Macro\,Economic\,Control + \beta_3 * Firm - specific\,Control + Fixed\,Effects + \varepsilon \tag{3}$$

To test *H2*, subsamples are created by using earnings-quality measures as partition variables and testing whether the coefficient on DISP differs between subsamples using equation (1). Following Francis *et al.* (2004), the study investigates the cross-sectional relationship using a group of earnings quality measures to enhance the validity of the results. Specifically, the study uses two earnings-quality measures[4] to test the hypotheses:

(1) The performance-matched modified Jones model accrual (MJonesPM) (Kothari *et al.*, 2005).

(2) Earnings smoothness, defined as the ratio of earnings volatility over the operating cash flow volatility of the past five fiscal years (Smooth) (Leuz *et al.*, 2003).

To test *H3*, a dummy interaction variable, RES, which is set to 1 to represent observations after restatement and set to 0 to represent observations prior to restatement, is added. The empirical models used to test *H2* and *H3* are structurally similar to the model used to test *H1a*.

4. Sample selection and descriptive statistics

4.1 Sample selection

Information about implied volatility is obtained from the OptionMetrics database's standardized options data set. Implied volatility is standardized in this database so that it represents as-if at-the-money option's implied volatility with a standardized expiration date. Because the study focuses on short-term change in implied volatility before an earnings announcement, the standard option contract with the shortest days to expiration, which is 30 days (see footnote 3 for the detailed standardization process), is chosen. The standardized option database provides comparable implied volatility across different firms, as each represents at-the-money option's implied volatility with same days to expiration at the date of observation.

To obtain analyst earnings forecast information, the study collects analyst forecast information from the Institutional Brokers' Estimate System (IBES) detailed database for fiscal years 1996-2011. The sample starts in 1996 because that is when the OptionMetrics database began to its coverage. The financial information for companies is collected from the Compustat database. The primary sample contains 29,248 firm-year observations with non-missing control variables.

4.2 Descriptive statistics

The analysis starts with firms that have enough information to calculate *DIV* (change of implied volatility of 30-day standardized call option contracts) from the OptionMetrics database. Figure 2 presents the time series evolution of the implied standard deviation around earnings announcement. Figure 2 Panel A shows the average percentage change in implied volatility for 20 days surrounding an earnings announcement during the fourth quarter.

Day 0 is set as the day of the earnings announcement, and the implied volatility of Day 0 is used as the benchmark to calculate implied volatility change. Consistent with Ederington and Lee (1996), the change in implied volatility shows a distinctive pattern: it reaches a local maximum one trading day prior to the earnings announcement and decreases sharply after the announcement to revert to normal volatility. Figure 2 Panel A also indicates that, on average, implied volatility decreases to a level lower than it was immediately before the earnings announcement. Figure 2 Panel B shows the daily change in implied volatility for an extended period (from 40 days prior to the earnings announcement to 10 days post-earnings announcement). These figures present a clear pattern: implied volatility begins to increase 30 days before the announcement. This is consistent with Donders and Vorst's (1996) model of implied volatility during event days (earnings announcement) and non-event days. As the announcement date approaches, the high volatility receives a heavier weight in the time-weighted model.

Table I shows the sample distribution across years (Panel A) and the descriptive statistics of regression variables (Panel B). The change in implied volatility (*DIV*) variable has a mean value of 6.9 per cent. This number indicates that the implied volatility increases by as much as 6.9 per cent during the last trading days prior to the earnings announcement, as compared to the implied volatility present on a normal day, i.e. without an upcoming earnings announcement.

5. Empirical results

5.1 DIV and analyst forecast dispersion around the earnings announcement (H1a and H1b)

The results of the empirical test for *H1a* and *H1b* are summarized in Table II. Column 1 of Table II show that the coefficient on dispersion (*DISP*) is significantly negative, the coefficient on DISP is −0.905, with a *t*-statistic of −2.85. These results provide strong support for *H1a*. To further interpret the results and reconcile the findings with prior literature, the study decomposes analyst forecast dispersion, according to Barron *et al.* (1998), into information asymmetry (InfoAsym) among analysts and uncertainty components (Uncertainty). The results are presented in Columns 2 and 3 of Table II. Column 2 shows that the InfoAsym portion is significantly negatively correlated with DIV (the coefficient = −0.140, $p < 0.001$), while the uncertainty portion (Uncertainty) in Column 3 is not significantly correlated with DIV. These results are consistent with *H1b* that the negative correlation is driven by the information asymmetry among

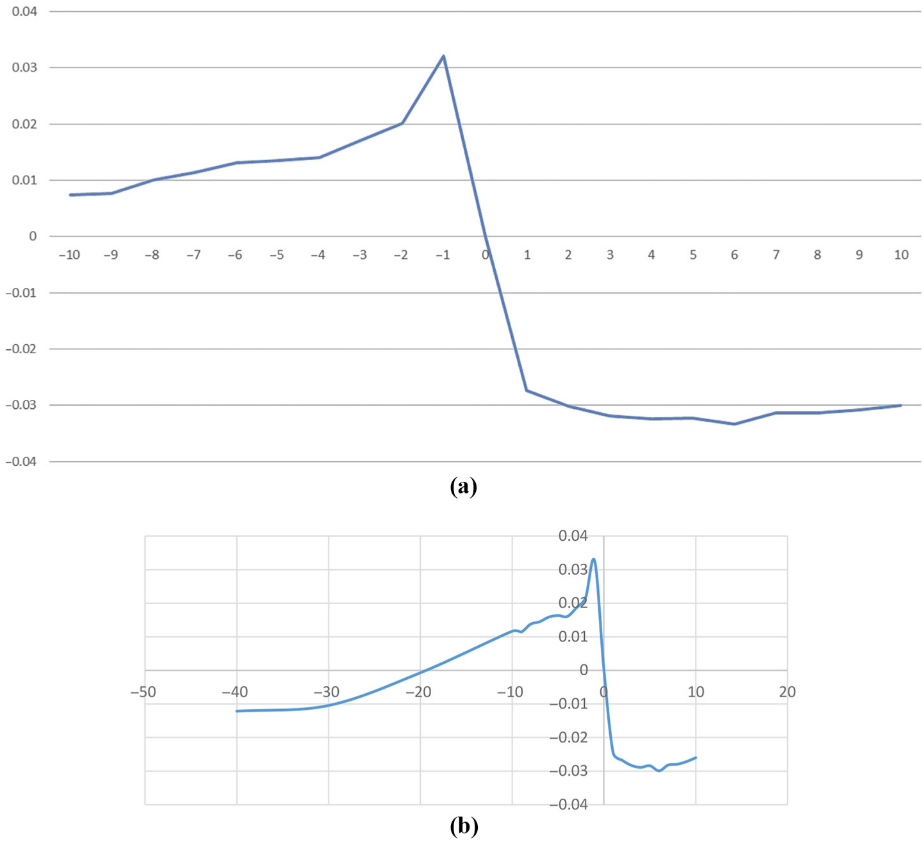

Figure 2.
Panel a: Daily change in implied volatility around earnings announcements, Panel b: Daily change in implied volatility around earnings announcements over an extended period prior to the earnings announcement

Notes: Panel A shows the percentage change of implied volatility 10 trading days before and after an earnings announcement. The sample includes 29,248 firm year (fourth quarter) observations from 1996 to 2011. Earnings announcement day implied volatility is used as the benchmark implied volatility and is set to 0. If the earnings announcement day is not a trading day, the next trading day is used as Day 0. Panel B shows the percentage change of implied volatility around an earnings announcement for an extended period. Earnings announcement day implied volatility is used as the benchmark implied volatility and is set to 0. If the earnings announcement day is not a trading day, the next trading day is used as Day 0

analysts rather than by the uncertainty. The VIFs in the regression models are tested, and the highest VIF observed is 2.3; thus, it appears that multicollinearity does not pose an issue in the regression models. Additionally, in untabulated univariate tests, both the Pearson and Spearman correlation coefficients between analyst forecast dispersion and the change in implied volatility are significantly negative.

Table I. Sample distribution and descriptive statistics of the annual sample

Calendar year	No. of firm-years	(%)
Panel A: Annual sample size by calendar year		
1996	1,470	5.03
1997	1,801	6.16
1998	1,950	6.67
1999	1,882	6.43
2000	1,656	5.66
2001	1,650	5.64
2002	1,650	5.64
2003	1,634	5.59
2004	1,820	6.22
2005	1,956	6.69
2006	2,135	7.30
2007	2,182	7.46
2008	2,120	7.25
2009	2,194	7.50
2010	2,245	7.68
2011	903	3.09
Total	29,248	100.00

Variable	Mean	SD	25%	Median	75%	*N*
Panel B: Descriptive statistics						
DIV	0.069	0.320	−0.150	0.116	0.262	29.248
VIX	0.002	0.049	−0.019	0.000	0.023	29.248
LMV	7.430	1.522	6.320	7.220	8.333	29.248
BTM	0.484	0.383	0.238	0.405	0.634	29.248
Leverage	0.223	0.205	0.032	0.192	0.346	29.248
ROA	0.003	0.048	0.000	0.010	0.024	29.248
DISP	0.003	0.010	0.000	0.001	0.002	29.248
MJonesPM	0.103	0.111	0.028	0.066	0.135	26,224
Smooth	1.300	1.445	0.522	0.888	1.424	25,894

Notes: Panel A presents the annual sample size distribution by fiscal years; Panel B presents the descriptive statistics of the variables used in the regression analysis. The sample contains firm-years from 1996 to 2011. All variables are defined in the Appendix. All variables are winsorized at the top and bottom 1%

5.2 Impact of earnings quality on the association between option volatility and analyst forecast dispersion (H2)

Table III shows the main effect of earnings quality on investors' perceived uncertainty toward earnings announcements. The table illustrates that the inclusion of the main effect of earnings quality proxy in the multi-variable regression does not affect the sign and significance of other variables of interest. Column 1 of Table IV presents the augmented regression results using performance matched discretionary accrual (MJonesPM) and Column 2 presents the results by adding earnings smoothness (Smooth).

To test *H2*, the study partitions the sample into tercile based subsamples using proxies of earnings qualities. Table IV shows the regression results, using two different measures of earnings quality. The results show that the significant correlation between *DISP* and *DIV* is concentrated in subsamples with low earnings quality using either performance matched modified Jones model discretionary accrual or earnings smoothness as a proxy of earnings quality[5], supporting *H2*. Based on these results, analyst forecast dispersion's negative correlation with market uncertainty is more pronounced when earnings quality is low,

Table II. Regression results for the relationship between analyst forecast dispersion and market uncertainty

Dependent variable: DIV Variable	Column 1 Coefficient (*t*-statistic)	Column 2 Coefficient (*t*-statistic)	Column 3 Coefficient (*t*-statistic)
DISP	−0.905*** (−2.85)		
InfoAsym		−0.140*** (−4.22)	
Uncertainty			−0.002 (−0.52)
VIX	1.821*** (41.47)	2.101*** (29.65)	2.104*** (29.67)
LMV	0.003** (2.35)	−0.002 (−1.03)	0.001 (0.26)
BTM	−0.026*** (−3.29)	−0.039*** (−5.39)	−0.038*** (−5.22)
Leverage	−0.034*** (−2.88)	−0.029** (−2.34)	−0.032*** (−2.48)
ROA	0.230*** (3.61)	0.316*** (6.05)	0.231*** (3.12)
Intercept	0.057** (2.10)	0.160*** (4.64)	0.131*** (3.87)
Industry fixed effect	Included	Included	Included
Year fixed effect	Included	Included	Included
Adjusted R^2	0.114	0.118	0.112
Observations (*n*)	29,248	29,248	29,248

Notes: Table II presents the multivariate regression analyses for the impact of analyst forecast dispersion on market uncertainty change. The sample consists of firm-year observations from 1996 to 2011. All variables are defined in Appendix. All variables are winsorized at the top and bottom 1%. When estimating the coefficients' standard errors, we use a clustering procedure that accounts for serial dependence across years of a given firm; $^*p < 0.10$; $^{**}p < 0.05$; and $^{***}p < 0.01$, based on two-tailed *t*-tests

Table III. Regression results for the effect of earnings quality on market uncertainty

Dependent variable: DIV Variable	Column 1 Coefficient (*t*-statistic)	Column 2 Coefficient (*t*-statistic)
DISP	−1.019*** (−4.88)	−0.855*** (−4.22)
VIX	1.881*** (46.52)	1.844*** (47.42)
LMV	0.002 (1.24)	0.002 (1.12)
BTM	−0.029*** (−5.12)	−0.028*** (−5.00)
Leverage	−0.031*** (−2.98)	−0.037*** (−3.64)
ROA	0.263*** (6.00)	0.189*** (4.21)
MJonesPM	0.003*** (2.83)	
Smooth		−0.002 (−1.13)
Intercept	0.078*** (2.52)	0.080** (2.68)
Industry fixed effect	Included	Included
Year fixed effect	Included	Included
Adjusted R^2	0.117	0.122
Observations (*n*)	26,224	25,894

Notes: This table presents the multivariate regression analyses for the impact of analyst forecast dispersion and earnings quality on market uncertainty change. The sample contains firm-years from 1996 to 2011. All variables are defined in Appendix. All variables are winsorized at the top and bottom 1%. When estimating the coefficients' standard errors, a clustering procedure that accounts for serial dependence across years of a given firm is used; $^*p < 0.10$;$^{**}p < 0.05$; and$^{***}p < 0.01$, based on two-tailed *t*-tests

whereby analysts have a much stronger incentive to acquire private information to compensate for the low-quality public information. This result provides further evidence that the negative correlation between analyst forecast dispersion and investors' perceived uncertainty is driven by the information asymmetry among analysts rather than by uncertainty toward earnings. In unablated results, this effect is concentrated in the

Table IV. Regression results for the moderating effect of earnings quality

Dependent variable: DIV	MJonesPM		Smooth	
Variable	Low earnings quality Coefficient (*t*-statistic)	High earnings quality Coefficient (*t*-statistic)	Low earnings quality Coefficient (*t*-statistic)	High earnings quality Coefficient (*t*-statistic)
DISP	−1.381*** (−4.53)	−0.421 (−1.45)	−0.874*** (−4.89)	−0.462 (−1.07)
VIX	1.996*** (28.16)	1.822*** (38.79)	2.044*** (29.68)	1.765*** (35.83)
LMV	0.004 (1.47)	0.002 (1.18)	0.005 (1.03)	0.000 (0.07)
BTM	−0.033*** (−3.35)	−0.019** (−2.79)	−0.041*** (−4.16)	−0.019*** (−2.78)
Leverage	−0.031* (−1.77)	−0.027** (−2.14)	−0.045** (−2.60)	−0.022** (−1.69)
ROA	0.191*** (3.22)	0.431*** (6.05)	0.234*** (3.90)	0.279*** (4.02)
Intercept	0.045 (0.64)	0.073** (2.18)	0.085 (1.12)	0.080** (2.39)
Industry fixed effect	Included	Included	Included	Included
Year fixed effect	Included	Included	Included	Included
Adjusted R^2	0.111	0.132	0.123	0.120
Observations (*n*)	10,603	10,103	10,449	10,775
F-test	$p < 0.001$		$p < 0.001$	

Notes: This table presents the multivariate regression analyses for the impact of analyst forecast dispersion and earnings quality on market uncertainty change. The sample contains firm-years from 1996 to 2011. All variables are defined in Appendix. All variables are winsorized at the top and bottom 1%. When estimating the coefficients' standard errors, a clustering procedure that accounts for serial dependence across years of a given firm is used; $^{*}p < 0.10$; $^{**}p < 0.05$; and $^{***}p < 0.01$, based on two-tailed *t*-tests information asymmetry component of the analyst forecast dispersion when the regression is run using InfoAsym instead of DISP, consistent with findings in support of *H1b*.

5.3 Impact of accounting restatements on the association between option volatility and analyst forecast dispersion (H3)

In addition to the cross-sectional analysis in testing *H2*, the study also tests the impact of restatement on the relationship between analyst forecast dispersion and investors' perceived uncertainty toward an earnings announcement. To visualize the impact of restatement on the change in implied volatility, I plot the change of implied volatility for the fourth quarter earnings announcement before the restatement announcement year, the fourth quarter during the restatement announcement year, and the fourth quarter after the restatement announcement in Figure 3.

The restatement fiscal year shows the highest benchmark level of implied volatility, which suggests that the restatement announcement provokes a higher level of uncertainty (0.488, on average). Although the post-restatement fiscal year has a lower benchmark level of uncertainty (0.475, on average), it contains the largest increase in market uncertainty prior to the earnings announcement. To formally test the impact of a restatement, the study creates a sample that contains only the firm year observations right after the restatement announcement year and firm year observations immediately prior the restatement announcement year. The latter serves as a self-control sample and contains 1,100 restatement announcements, with non-missing values for all regression variables. This produces a total sample size of 2,200. A dummy variable, RES, which is set to 1 for observations post restatement announcement, is created. Table V shows the regression results.

The main effect of dispersion is marginally positive but with a small coefficient, indicating low economic significance. The interaction of restatement and dispersion, however, is significantly negative with a much larger coefficient, which indicates that when earnings quality decreases after restatement, analyst forecast dispersion becomes

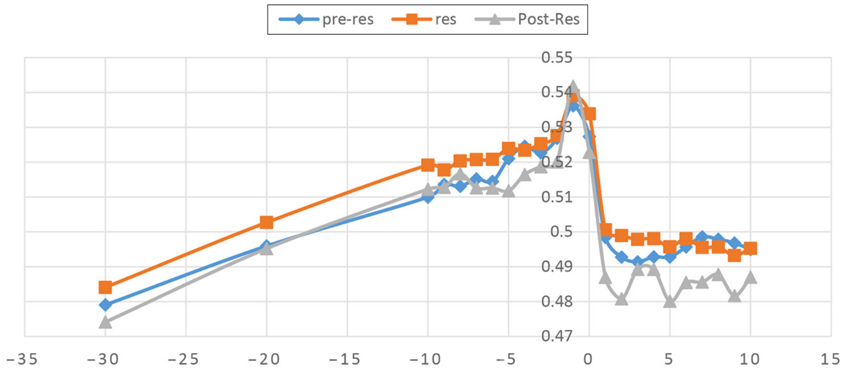

Figure 3.
Daily change of implied volatility around the fourth quarter earnings announcement prior to, during and after an accounting restatement

Notes: The percentage change of implied volatility around the earnings announcement is shown. The sample consists of 1,100 restatement announcements from 1996 to 2011. The change of implied volatility for the fourth quarter earnings announcement of the pre-restatement fiscal year, during the restatement fiscal year, and post the restatement fiscal year are plotted in this figure

Table V. Regression results for the effect of restatement

Variable	Dependent variable: *DIV* Coefficient (t-statistic)
DISP	0.158* (1.94)
*RES*DISP*	−2.539** (−2.11)
VIX	2.02*** (20.87)
LMV	−0.002 (−0.42)
BTM	−0.041*** (−2.81)
Leverage	−0.028 (−1.05)
ROA	0.323** (2.47)
RES	0.011 (0.87)
Intercept	0.130*** (3.85)
Industry fixed effect	Included
Year fixed effect	Included
Adjusted R^2	0.140
Observations (n)	2,200

Notes: This table presents the regression analysis for the impact of analyst forecast dispersion and accounting restatement on market uncertainty change. The sample period is from 1996 to 2011. All variables are defined in the Appendix. All continuous variables are winsorized at the top and bottom 1%. When estimating the coefficients' standard errors, we use a clustering procedure that accounts for serial dependence across years of a given firm; *$p < 0.10$; **$p < 0.05$; ***$p < 0.01$, based on two-tailed t-tests

significantly and negatively correlated with market uncertainty. This is consistent with the previous cross-sectional regression analysis.

In summary, the empirical support of *H2* and *H3* confirms that the negative relationship between analyst forecast dispersion and investors' perceived uncertainty is concentrated in subsamples with low earnings quality, whereby analysts have more incentives to acquire private information to compensate for low-quality public information.

6. Additional analysis and robustness checks

To reconcile the results with prior research, the study also tests the correlation between analyst forecast dispersion and the fourth quarter's idiosyncratic risk defined as the standard deviation of total daily returns. The findings (untabulated for brevity) show a significantly positive correlation (correlation coefficient = 0.24), and the decomposed information asymmetry portion also correlates positively with the concurrent fourth quarter idiosyncratic risk (correlation coefficient = 0.10). This finding is consistent with that of Abarbanell *et al.* (1995), who predict a positive correlation between analyst forecast dispersion and concurrent stock price volatility.

On the other hand, *DIV* is a forward-looking measure that focuses on the incremental price variance that an investor expects around an upcoming earnings announcement rather than concurrently with the issuance of analyst forecast dispersion. The negative correlation between analyst forecast dispersion and *DIV* is consistent with Kim and Verrecchia's (1994) prediction. In fact, in further empirical tests, *DIV* correlates significantly and positively with the next fiscal year's fourth quarter idiosyncratic risk (correlation coefficient = 0.18), and it does not correlate with the current fiscal year fourth quarter's idiosyncratic risk (correlation coefficient = 0.002 and not statistically significant). In summary, the negative correlation is attributable mainly to the use of a market-based, forward-looking measure of future uncertainty that captures different constructs from traditional uncertainty measures, such as the idiosyncratic risk.

Prior research also documents other variables that serve as proxies for "divergence of investors' opinion" (Garfinkel, 2009). More recent research also documents that the trading volume of equity stock around earnings announcement contains information regarding investors' perceived uncertainty toward earnings (Ahmed *et al.*, 2003; Bamber *et al.*, 2011). The correlation between DIV and proxies of divergence of investors' opinion in the concurrent and future fiscal year is tested, and the untabulated findings show that *DIV* is significantly correlated with proxies related to the divergence of investors' opinion regarding the upcoming fourth quarter earnings announcement (these measures include standardized unexplained volume, idiosyncratic volatility, bid-ask spread, and annual analyst forecast dispersion). Further, *DIV* is not correlated with the investors' opinion divergence variables regarding the past fiscal year's fourth quarter earnings announcement. This further validates *DIV* as a forward-looking proxy for investors' perceived uncertainty toward upcoming earnings announcements.

To mitigate the concern of endogeneity,[6] whereby analyst forecast dispersion and investors' uncertainty toward earnings are simultaneously driven by firm characteristics, the study decomposes analyst forecast dispersion based on dispersion affected by innate firm characteristics and the residual that is orthogonal to these characteristics. Table VI shows the two-stage regression results. Panel A shows the first-stage regression; the residual from the first-stage regression (*Residual*) is used as a proxy of analyst forecast dispersion orthogonal to firm characteristics. The results in Panel B illustrate the second-stage regression. Column 2 of Panel B shows that the residual from the first-stage regression is still significantly negatively correlated with *DIV*, indicating that the main results are not driven by the firm characteristics.

Regulation Fair Disclosure (REG FD) significantly limits analysts' ability to acquire private information directly from management teams. Because the sample span across the pre- and post-REG FD periods, the regression for the subsample is re-run before and after REG FD. The untabulated results indicate that the coefficient on analyst forecast dispersion is statistically more negative for the pre-REG FD period than the post-REG FD period, based on an F-test in untabulated results (F-value = 23.22, $p < 0.0001$). This is consistent with the main result that analyst forecast dispersion is likely to be a proxy of information asymmetry among analysts rather than uncertainty, as higher analyst forecast dispersion leads to an even lower uncertainty toward earnings in a pre-REG FD period, when analysts have more individual access to private information. Nevertheless, the change of analysts' incentive to acquire private information before and after REG FD is beyond the scope of this paper.

Finally, following Hennes *et al.* (2008), a sample that includes only incidents of restatements classified as irregularities is created to filter out unintentional error-induced restatements. The untabulated results are qualitatively similar to those of the full sample of restatement incidents.

7. Summary and conclusions

This study investigates the association between analyst forecast dispersion and investors' perceived uncertainty toward earnings announcements and shows a negative correlation between the two variables. Further tests following Barron *et al.*'s(2009) methodology show that this seemingly counterintuitive negative correlation is driven by the private information acquisition and information asymmetry among analysts, not by the uncertainty toward upcoming earnings announcement. This evidence is consistent with the theoretical development of Kim and Verrecchia (1991). Additional investigation shows that this relationship is concentrated in subsample firms with low earnings quality, whereby analysts have stronger incentives to acquire private information.

Variable		Coefficient (*t*-statistic)
Panel A: First-stage regression		
Dependent variable: DISP		
TA		−0.001*** (−18.06)
NA		0.000*** (6.72)
ROE		−0.040*** (−27.07)
Leverage		0.005*** (17.01)
SG		0.001* (1.88)
EVol		0.012*** (13.02)
Intercept		0.007*** (20.24)
Industry fixed effect		N/A
Year fixed effect		N/A
Adjusted R^2		0.120
Observations (n)		26,776
Variable	Coefficient (*t*-statistic)	Coefficient (*t*-statistic)
Panel B: Second-stage regression		
Dependent variable: DIV		
MJonesPM	0.062*** (3.00)	−0.016 (−0.79)
Residual		−0.597* (−1.71)
*MJonesPM***Residual*		−4.573*** (−3.00)
VIX	1.890*** (47.51)	1.976*** (44.75)
LMV	0.003** (2.34)	0.001 (0.57)
BTM	−0.028*** (−4.90)	−0.035*** (−5.26)
Leverage	−0.033** (−3.16)	−0.043*** (−3.52)
ROA	0.310*** (7.24)	0.258*** (5.00)
Intercept	0.063** (2.06)	0.073*** (2.10)
Industry fixed effect	Included	Included
Year fixed effect	Included	Included
Adjusted R^2	0.138	0.151
Observations (n)	17,824	17,824

Notes: This table presents the regression analysis for the impact of analyst forecast dispersion and earnings quality on market uncertainty change. The sample contains firm-years from 1996 to 2011. All variables are defined in Appendix. All continuous variables are winsorized at the top and bottom 1%. When estimating the coefficients' standard errors, a clustering procedure that accounts for serial dependence across years of a given firm is used; $^{*}p < 0.10$; $^{**}p < 0.05$; and $^{***}p < 0.01$, based on two-tailed *t*-tests

Table VI. Two stage regression analysis

This study contributes to the literature by furthering our understanding of the role that analysts play in the capital market, including the ways in which they gather and produce information and their incentives for so doing. The results indicate that analysts supply additional private information to the market when facing noisy signals and that their information reduces investors' uncertainty toward upcoming earnings announcements. The empirical results suggest that the decomposition of analyst forecast dispersion, constructed by Barron *et al.* (1998), provides a more precise interpretation of results related to analyst forecast dispersion. The study also proposes and validates a new dependent variable obtained directly from the options market that isolates the market expected uncertainty toward upcoming earnings announcements. One caveat of this result is that the inferences hinge on the assertion that option market accurately estimates the incremental uncertainty surrounding upcoming earnings announcements. Gao *et al.* (2018) find that the average 3-day return of at-the-money straddles prior to an earnings announcement is significantly positive indicating that option market, in general under-estimates the uncertainty around future earnings announcements. However, this paper investigates the cross-section of the change of option market's estimation of upcoming earnings uncertainty. As long as the options market is relatively more accurate in the cross-sectional differences in the level of incremental uncertainty across firms than the equity market, the inference in this paper is still statistically valid even though on average options market under-reacts to the information in the upcoming earnings announcement news.

Future research could further investigate the information content and market consequences of the cross-sectional difference in investors' uncertainty toward earnings announcements and further explore the cross-sectional factors that moderate the main effect discussed in this paper. For example, one potential area is to investigate how properties of analyst forecast dispersion, including information asymmetry and uncertainty changes over time, may have an impact on options' implied volatility prior to earnings announcements, as prior literature shows that, as a forecast horizon shortens, analyst forecast bias shortens (Ackert and Athanassakos, 1997).

Notes

1. Analyst forecast dispersion is defined in this paper as the standard deviation of individual analyst forecasts issued within 30 days of an earnings announcement and deflated by the prior fiscal quarter end stock price. There are, however, alternative measures of analyst forecast dispersion. For example, Sheng and Thevenot (2012) use a generalized autoregressive conditional heteroscedasticity (GARCH) model to create a new measure of uncertainty from individual analyst forecasts. Their GARCH model requires a long-time series of data to estimate; thus, it is not considered in this paper.
2. This paper uses implied volatility interchangeably with implied standard deviation (ISD), which is the square root of implied volatility.
3. The implied volatility for a standardized 30-day as-if at-the-money option is calculated as the weighted average of the implied volatility of the four traded options with strike prices i and j and days to maturity of m and *n*, such that the current stock price is right between i and j and time to maturity is across 30 days: $m < 30 < n$ (Rogers *et al.*, 2009).
4. For robustness check, this study also uses the modified Jones measure of accrual quality and the cash flow volatility over the past five fiscal years as a sensitivity test and the results are qualitatively similar.
5. In unablated results, using modified Jones model and cash flow volatility as proxies of earnings quality yield similar results.
6. There are also concerns about the endogeneity that arises from the self-selection issue related to option listing. Unlike a firm's decision to pursue an IPO, however, the decision to be listed on the option exchange is not voluntary. The options exchange makes such decisions based on market demand to trade a particular firm's option contracts (Mayhew and Mihov, 2004).

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Appendix : Variable definitions

DIV	The 30-day change of implied volatility of an option contract that expires 30 days prior to an earnings announcement, as defined in the Hypothesis Development section
VIX	The change of VIX index during the same period as the DIV
LMV	The log market value of equity
BTM	The quarterly book-to-market ratio measured as the book value of total equity divided by the market value of total equity
Leverage	The leverage ratio calculated as the total long-term and current liabilities deflated by the total assets
ROA	The return on asset defined as income before extraordinary items scaled by the average total assets
DISP	The analyst forecast dispersion deflated by the prior fiscal year-end price
InforAsym	The information asymmetry component of the analyst forecast dispersion
Uncertanty	The uncertainty component of the analyst forecast dispersion
MJonesPM	The performance matched modified Jones measure of discretionary accruals
Smooth	The ratio of earnings volatility over cash flow volatility estimated over the past 5 fiscal years
RES	An indicator variable that take the value 1 for observations in the post accounting restatement period
TA	The log-transformed total assets of the firm
NA	The log-transformed number of analysts following the firm
ROE	The return on equity calculated as the income before extraordinary items over total equity
SG	The sales growth measured as the percentage change of total sales
EVol	The earnings volatility estimated over the past 5 fiscal years
Residual	The residual value from the first stage regression model representing analyst forecast dispersion that cannot be explained by the firm characteristics

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