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Market uncertainty and trading volume around earnings announcements

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ABSTRACT

This study examines the changes in trading volume around quarterly earnings announcements in regard to market uncertainty. When market conditions are volatile, investors face difficulty in predicting future cash flows and their beliefs are more dispersed. Under this larger dispersion in prior beliefs, investors learn more from earnings news, but they are also likely to differ in their interpretations. This leads to increased trading volume around earnings announcements under high market uncertainty. I find that abnormal trading volume around the 2-day announcement window increase with market return volatility and the *VIX* index. The increase in trading volume is more pronounced for firms with more market-wide information and larger firms, which tend to have larger market earnings components.

1. Introduction

This paper examines the changes in trading volume around earnings announcements in regard to market conditions. Firms' earnings contain not only a firm-specific component, but also a market-wide component because firm performance is not independent of the economy in which firms operate (Ball et al., 2009; Patton and Verardo, 2012; Savor and Wilson, 2016; Bonsall et al., 2013).[1] Therefore, investors can learn about both the market and firm components of cash flows from earnings announcements (Patton and Verardo, 2012; Savor and Wilson, 2016). When market conditions are volatile, the possible cash flow outcomes increase because volatility in the market-wide component of the firm's earnings increases. For example, Bloom (2009) shows that firm and industry earnings as well as GDP, become more volatile when *VIX*, a proxy for market uncertainty, is high. As a result, investors tend to have more dispersed prior beliefs about market cash flows. This study examines how the differences in investors' beliefs about the *market* affect the *firm*'s trading volume around earnings announcements.

To the best of my knowledge, this study is the first to examine the effect of market uncertainty on trading volume around earnings announcements. It differs from past studies that focus on how the firm's information uncertainty is associated with trading volume (Bamber, 1987; Bamber et al., 1997, 1999; Brockman and Chung 2000).[2] Recent studies focus on differentiating the two earnings components: the market and firm-specific components, and examine the different effects of the two components on firms' stock returns (Savor and Wilson, 2016; Choi, 2018). These studies examine the risk premium or the stock price reaction to earnings

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[1] For example, Patton and Verardo (2012) finds an increase in firm's beta during the earnings announcement period, and Savor and Wilson (2016) finds an increase in the earnings announcement return (premium) due to investor learning about the economy as well as other firms from earnings news.

[2] Also see Pevzer et al. (2015) for international evidence on how trust affects investors' learning from earnings announcements.

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announcements (i.e. earnings response coefficients). The stock price reaction captures the average investors' updating of beliefs, while trading volume measures investors' divergence of opinions (e.g., Bamber, 1986; Karpoff, 1986, among others).[3] There is little empirical evidence on how the divergence in investors' beliefs about market conditions affects the divergence of investors' beliefs about the firm.[4]

I use a simple Bayesian updating framework to build the necessary predictions regarding market uncertainty and trading volume. In the model, earnings news contains two information signals: one about the market and one about the firm (Barron et al., 1998; Savor and Wilson, 2016). Investors infer about market and firm cash flows from earnings news, although they fully learn about the market cash flow after all firms have announced their earnings during the quarter. When the market prior to earnings announcements is volatile, there is more dispersion in investors' prior beliefs about market cash flows. According to Bayes' rule, there is more updating of investors' assessments of future cash flows, when prior market uncertainty is high. More information flow from earnings announcements leads to larger trading volume (Kim and Verrechia, 1991)). Investors' posterior beliefs have greater dispersion when their priors are dispersed, which may also lead to increased trading volume (Kim and Verrechia, 1991; Karpoff, 1986). Accordingly, the main prediction is that abnormal trading volume around firms' earnings announcements increases when prior market uncertainty is high.

This study examines the changes in firm-level abnormal trading volume around the 2-day earnings announcement window, across different levels of market uncertainty (i.e., high versus low). I use two complementary measures of market uncertainty. One is market return volatility, which is the standard deviation of daily market returns of the prior month of the scheduled earnings announcement. The 30-day ex-post market return volatility measure captures investors' realized prior uncertainty directly related to the stock market (Amiram et al., 2017). The other measure is the *VIX* index, which is the expected market volatility in the future (30 days) (Loh and Stulz, 2018).

First, I show that there is greater dispersion in investors' beliefs when markets are volatile. Using analyst forecast dispersion as a proxy for investor beliefs (Ziebart, 1990; Richardson et al., 2010), I find that aggregate forecast dispersion increases with the level of prior market uncertainty. Next, I show that abnormal trading volume around earnings announcements significantly increase during periods of high market uncertainty. The effect of market uncertainty is robust to controlling for market liquidity, firm-level analyst forecast dispersion, firm size, market-to-book ratio, and firm and quarter fixed effects. In the cross-section, I find that firms with more market-wide information and large firms are more likely to experience an increase in abnormal trading volume under high market uncertainty. The findings suggest that investors learn more about market conditions from earnings announced by firms that are considered to be future market indicators (i.e., bellwether firms), since these types of firms tend to have more weight in calculating market cash flows.

The rest of the paper is organized as follows: section two develops the main hypotheses. Section three lays out the research design and describes the sample data and variables. Section four details the empirical results, including the univariate tests and the multivariate tests, and the cross-sectional analyses. Section five discusses alternative explanations and section six concludes.

2. Hypotheses development

This study compares trading volume around earnings announcements across different market uncertainty levels. How investors interpret and trade on earnings news depends on the level of their prior uncertainty, which may change with aggregate market conditions. In this section, I develop the main hypothesis regarding the effect of market uncertainty on trading volume around earnings announcements, based on the Bayesian learning models by Pastor and Veronesi (2009) and Savor and Wilson (2016). No formal model will be presented, although I will use simple equations to facilitate the exposition.

The value of a firm's stock is the present value of current and expected future cash flows, discounted by constant rates. As in Savor and Wilson (2016), each firm's cash flow is the sum of the common market component and its own firm-specific component: $\theta_i = \theta_c + \theta_{fi}$, where the common market cash flow component θ_c (of which the market condition is an important factor) follows a normal distribution with prior mean $\theta_{c,0}$ and variance $\sigma^2_{c,0}$. The firm-specific cash flow component θ_{fi} also follows a normal distribution with prior mean $\theta_{fi,0}$ and variance $\sigma^2_{fi,0}$. The common market component and firm-specific cash flow component are uncorrelated, by construction.[5] When markets are volatile, investors' prior beliefs about the market component are dispersed (i.e., $\sigma^2_{c,0}$ is high). For example, Bloom (2009) provides evidence that cash flows at firm, industry, and market levels become more dispersed when market uncertainty (*VIX*) is high.

Investors cannot directly observe firms' fundamental cash flows, but they learn over time about θ_i from firms' signals (i.e., earnings announcements), $s_i = \theta_i + \varepsilon_i$, where ε_i follows a normal distribution with zero mean and known variance δ_i^2. Patton and Verardo (2012) and Savor and Wilson (2016) show that investors learn about both the market- and firm-specific component of cash

[3] See Bamber et al. (2011) for a review of this literature.

[4] I do not distinguish between trading activity arising from differential private information and differential interpretation of information as in McNichols and Trueman (1994). Investors are less likely to obtain private information about the market compared to firm-specific information. Therefore, this study focuses on the dispersion of investors' beliefs about the market.

[5] We can relax this assumption and allow investor uncertainty about the firm-specific cash flow component to increase with market volatility. In this case, we have a simple one parameter model (θ_i), instead of a two parameter model (θ_c, θ_{fi}).

flows from earnings announcements. After observing the earnings announcement of firm i in quarter T, investors update their beliefs about cash flows θ_i, θ_c and θ_{fi} according to Bayes' rule.[6] The quarterly updating of investors' beliefs on a firm's cash flows can be expressed recursively as:

$$\Delta\tilde{\theta}_{i,t} = \tilde{\theta}_{i,t} - \tilde{\theta}_{i,t-1} = m_{i,t}(s_{i,t} - \tilde{\theta}_{i,t-1}), \text{ with } m_{i,t} = \frac{\tilde{\sigma}^2_{c,t-1} + \sigma^2_{fi,t-1}}{\delta_i^2} \tag{1}$$

Conditional on the earnings surprise $(s_{i,t} - \tilde{\theta}_{i,t-1})$, the magnitude of investors' revisions depends on the multiplier $m_{i,t}$. Eq. (1) suggests that investors' updating of beliefs $m_{i,t}$ increases proportionately with the variance of the common cash flow component of the prior quarter $\tilde{\sigma}^2_{c,t-1}$, while holding other factors constant. Investors' updated beliefs are incorporated into the changes in stock prices at earnings announcements. Firm i's unexpected announcement return in response to earnings news can be expressed in terms of $\tilde{\sigma}^2_{c,t-1}$ as follows:

$$\tilde{R}_{i,t} - \tilde{R}_{m,t} \propto m_{i,t}(s_{i,t} - \tilde{\theta}_{i,t-1}) = \frac{\tilde{\sigma}^2_{c,t-1} + \sigma^2_{fi,t-1}}{\delta_i^2}(s_{i,t} - \tilde{\theta}_{i,t-1}) \tag{2}$$

Kim and Verrecchia (1991) show that trade volume around earnings announcements is proportional to the absolute price change at the time of the announcement. Accordingly, trade volume can be expressed as a function of Eq. (2), where *Vol* indicates trade volume.

$$Vol = f(|\tilde{R}_{i,t} - \tilde{R}_{m,t}|) \propto m_{i,t}(|s_{i,t} - \tilde{\theta}_{i,t-1}|) = \frac{\tilde{\sigma}^2_{c,t-1} + \sigma^2_{fi,t-1}}{\delta_i^2}(|s_{i,t} - \tilde{\theta}_{i,t-1}|) \tag{3}$$

From Eq. (3), trading volume around earnings announcements increase with the dispersion of prior beliefs about the market cash flow ($\tilde{\sigma}^2_{c,t-1}$). This intuition is similar to the theoretical prediction of Kim and Verrecchia (1994) that show trading volume at earnings announcements increase with the divergence of opinions about firm-specific cash flows. This leads to the following testable hypothesis:

Main Hypothesis. Trading volume around earnings announcements increases with the level of prior market uncertainty.

3. Data and research design

Analysts' earnings forecasts, actual earnings and earnings announcement dates come from the Institutional Brokers Estimate System (I/B/E/S) annual update U.S. Detail History datasets. The I/B/E/S dataset contains statistics on individual analyst's forecasts, including the mean, median, and standard deviation of the forecasts and number of revisions, as well as the number of analysts making forecasts. The sample period of 1980 to 2015 yields 177,595 quarterly earnings announcements on U.S firms listed on the NYSE, NASDAQ, and AMEX. The earnings data are subsequently matched with returns data from the Center for Research in Security Prices (CRSP). Data on stock returns, trading volume, and return volatility are from the daily and monthly stock files of the Center for Research in Security Prices (CRSP). The accounting data are from the merged CRSP/Compustat database, through the fiscal year 2015. I calculate the market value of equity using the Compustat annual data. I use all available firms included in the I/B/E/S, Compustat and CRSP datasets. For each firm-quarter, I use only the last forecast-observation before the actual earnings announcement. To minimize the effect of market frictions (Ball et al., 1995), I delete observations with a prior fiscal quarter ending price of less than $5.00. Following prior research that shows that the information content is close to zero for firms with negative earnings (Hayn, 1995; Lipe et al., 1998), I delete observations with negative actual earnings.[7]

I estimate abnormal trading volume around the earnings announcement date using the following definitions used in previous studies (Beaver, 1968; Landsman and Maydew, 2002; Truong, 2012).

Abnormal trading volume is defined as:

$$AVOL_{i,q} = \ln\left[\sum_{t=0}^{t=1} \frac{VOL_{i,q,t} - MVOL_{i,q}}{\sigma(VOL)_{i,q}}\right] \tag{4}$$

where $VOL_{i,q,\,t}$ is the trading volume turnover, which is the number of traded shares divided by the total number of shares outstanding of firm i on day t around the earnings announcement event window ([0,1] days) for the earnings announcement made in quarter q .

[6] While investors cannot directly observe θ_c and θ_{fi}, they infer the market component θ_c at the end of each quarter, when all firms have announced their earnings. Investors' posterior belief about θ_c is normally distributed with mean $\tilde{\theta}_{c,T}$ and variance $\tilde{\sigma}^2_{c,T}$, and investors' posterior belief about θ_{fi} is normally distributed with mean $\tilde{\theta}_{fi,T}$ and variance $\tilde{\sigma}^2_{fi,T}$. Accordingly, investors' posterior belief about θ_i is normally distributed with mean $\tilde{\theta}_{iT}$ and variance $\tilde{\sigma}^2_{i,T}$, where $\tilde{\theta}_{i,T} = \theta_{i,0}\frac{\frac{1}{\sigma^2_{i,0}}}{\frac{1}{\sigma^2_{i,0}} + \frac{T}{\delta_i^2}} + \bar{s}\frac{\frac{T}{\delta_i^2}}{\frac{1}{\sigma^2_{i,0}} + \frac{T}{\delta_i^2}}$, $\tilde{\sigma}^2_{i,T} = \frac{1}{\frac{1}{\sigma^2_{i,0}} + \frac{T}{\delta_i^2}} = \frac{1}{\frac{1}{\sigma^2_{c,0} + \sigma^2_{fi,0}} + \frac{T}{\delta_i^2}}$, with $\theta_{i,0} = \theta_{c,0} + \theta_{fi,0}$ and $\sigma^2_{i,0} = \sigma^2_{c,0} + \sigma^2_{fi,0}$, and $\bar{s} = (1/T)\sum_{t=1}^{T} s_t$. Eq. (1) is derived in continuous time. The discrete time equation is materially similar (see, Pastor and Veronesi (2009)).

[7] The restricted sample is motivated by prior research that shows that the information content is close to zero for firms with negative earnings (Hayn, 1995; Lipe et al., 1998). The sample size decreases by approximately 12% when I exclude announcements with negative earnings. I repeat the analysis on a sample of all earnings announcements, including negative actual earnings, and find materially similar results (untabulated).

$MVOL_{i,q}$ and $\sigma(VOL)_{i,q}$ are the mean and standard deviation of the daily trading volume during the estimation period of [–240, –5] days relative to the earnings announcement made in quarter q (Truong, 2012). Abnormal trading volume is the sum of the ratio of the excess trading volume during the 2-day earnings announcement period, scaled by the standard deviation of daily volume for firm i (in natural logarithm).

The main market uncertainty proxy, market return volatility, is the standard deviation of value-weighted daily market returns of each month. The alternative proxy, the *VIX* index, is the implied volatility of stock options. I compute the average monthly *VIX* from the daily *VIX* data available from the Chicago Board of Exchange website. The findings are similar across the two market uncertainty proxies.

The main hypothesis predicts that abnormal trading volume increases with investors' divergence of prior opinions about the market. Accordingly, I compare abnormal trading volume between high and low market uncertainty periods. I sort the monthly market return volatility and the *VIX* index into quintiles. A dummy variable for high market uncertainty, $High_m$, is set equal to one if the earnings announcement is made during the highest market uncertainty quintile prior month, and zero otherwise. The main findings are materially similar when examining contemporaneous market uncertainty months or continuous market uncertainty levels.

$Surp_{iq}$ is the earnings surprise, defined as the absolute value of (actual earnings per share minus median forecast earnings), normalized by the price at the prior fiscal quarter ending date (Conrad et al., 2002).[8] Analyst forecast dispersion has been used to proxy for opinion divergence at the firm-level (Diether et al., 2002). Analyst forecast dispersion ($Dispersion_{iq}$) is defined as the standard deviation of analysts' earnings forecasts, divided by prior fiscal quarter ending price. I include analyst forecast dispersion of the prior month in the regressions to control for divergence in prior beliefs at the firm-level.[9] I also include the variables $Size_{iq}$ and $Market/Book_{iq}$ (market-to-book ratio) of the prior quarter to control for risk differences not already reflected in the excess return (Fama and French, 1992, 1993).[10] Pastor and Stambaugh (2003) market liquidity factor ($PSLiquidity_{iq}$) is included to control for market-wide liquidity levels that may affect the level of trading activity.

These variables appear in the following equation, which I use to compare the level of trading volume around earnings announcements between high and low market uncertainty periods.

$$\begin{aligned} Vol_{i,q} = b_0 \; + \; & b_1 High_{m-1} + b_2 Surp_{i,q} + b_3 Size_{i,q-1} + b_4 Market/Book_{i,q-1} \\ + \; & b_5 Dispersion_{i,m-1} + b_6 PSLiquidity_{i,q-1} + \varepsilon_{i,q} \end{aligned} \tag{5}$$

The subscript i represents firm i, q represents the fiscal quarter, and m represents the prior month whose earnings are announced. The dependent variable, $VOL_{i,q}$, is the abnormal trading volume around the 2-day earnings announcement period. In some specifications, I include firm and (fiscal) quarter fixed effects to control for firm and time characteristics that may be correlated with market uncertainty and trading volume. Standard errors are clustered by firm and quarter. The coefficient $b_1$estimates the differences in trading activity during high market uncertainty periods, compared to that during other periods. The main prediction is that the coefficient of *High* is positive. In other words, I predict that $b_1 > 0$ in Eq. (5).

4. Empirical results and analysis

4.1. Descriptive statistics

Table 1 shows the descriptive statistics for the main variables: abnormal trade volume, earnings surprises, market uncertainty, liquidity, and firm characteristics variables. The mean earnings surprise is 0.005, and the mean abnormal trading volume (in logs) is around 0.591. Market return is shown to be volatile, as suggested by a mean market return volatility of 0.043 per month.

Table 2 presents tests for the differences of the main variables and uncertainty proxies between high and low market uncertainty periods. The *t*-test results confirm that there is a significant difference in the level of trading volume and earnings surprises between periods of high and low market uncertainty. The average values of abnormal trading volume and earnings surprises are both larger during high market uncertainty times than low market uncertainty times. The t-statistics of the differences are highly significant at the 1% level. Overall, the results in Table 2 show that there is a significant difference in the level of trading volume around earnings announcements made between high and low market uncertainty periods.

4.2. Multivariate results

4.2.1. Forecast dispersion and market uncertainty

I first examine whether investors' prior beliefs are more dispersed when market uncertainty is high. I use the aggregate analyst forecast dispersion to proxy for the differences in investors' beliefs. In Table 3, I examine the association between the aggregate forecast dispersion and market volatility of the prior month. Analyst forecast dispersion is the standard deviation of analysts' earnings

[8] I winsorize the earnings surprise variable at 1% to reduce the impact of extreme outlier values.

[9] Findings are materially similar when I average monthly analyst forecast dispersion by each quarter.

[10] Firm size is the log of market value of equity, and the market-to-book ratio is the market value of the firm's equity at the end of the fiscal quarter plus the difference between the book value of the firm's assets and the book value of the firm's equity at the end of the quarter, divided by the book value of the firm's assets at the end of the quarter (Fich and Shivdasani (2006)).

Table 1
Descriptive Statistics. This table presents summary statistics for the key variables analyzed in the paper. The sample includes 177,595 quarterly earnings announcements from 1980–2015 for which we have analyst forecast and return data available. *Abnormal Volume* is the total abnormal trading volume during the earnings announcement period of [0, 1] days, scaled by the standard deviation of the trading volume during the pre-announcement period [−240, −5] days (in logs). *Surp* is the absolute value of the difference between actual earnings and the analyst median forecast, normalized by the prior fiscal quarter ending stock price. *Mktretvol* is the monthly standard deviation of the daily market return. *VIX* is the 30-day implied volatility of stock options and is averaged by month. *PS-Liquidity* is the monthly Pastor-Stambaugh market liquidity factor. Analyst forecast dispersion (*Dispersion*) is the standard deviation of analysts' earnings forecasts, divided by prior fiscal quarter ending price.

	N	Mean	Std Dev	Median	Min	10%	25%	75%	90%	Max
Earnings announcement variables										
Abnormal Trading Volume (logs)	177,595	0.591	1.368	0.775	−3.551	−1.176	−0.149	1.527	2.114	3.147
Surp	177,595	0.005	0.019	0.001	0.000	0.000	0.000	0.003	0.009	0.500
Market uncertainty variables										
Mktretvol	432	0.043	0.017	0.041	0.015	0.023	0.029	0.054	0.063	0.094
VIX	240	20.554	7.824	19.274	10.818	12.266	14.455	24.886	30.239	62.639
Control variables										
PS-Liquidity	177,595	0.011	0.04	0.009	−0.101	−0.038	−0.011	0.033	0.062	0.21
Dispersion	177,595	0.002	0.066	0.001	0.000	0.000	0.000	0.002	0.003	21.028

Table 2
Difference tests between high and low market uncertainty. This table compares the averages of the key variables between high and low market uncertainty periods. Market uncertainty is measured by the standard deviation of the daily market returns during the month. Monthly market uncertainty is sorted into quintiles. *High* is a dummy variable, which equals one if the month is within the highest quintile market uncertainty group and zero otherwise. *Low* is a dummy variable, which equals one if the month is within the lowest quintile market uncertainty group and zero otherwise. Other variables follow the definitions in the Appendix Table.

		HIGH (1)	*LOW* (2)	Test Statistic (1–2)	*P*-value (1–2)
Earnings announcement variables					
Abnormal trading volume (logs)	Mean	0.695	0.568	14.924	<0.0001
Surp	Mean	0.002	0.001	12.258	<0.0001
Market uncertainty variables					
Mktretvol	Mean	0.067	0.036	22.477	<0.0001
VIX	Mean	25.374	14.237	41	<0.0001

Table 3
Market uncertainty and differences in opinion. This table reports the relationship between market uncertainty and the differences in investors' opinions (measured by analyst forecast dispersion). The dependent variable is the aggregate analyst forecast dispersion, which is the sum of consensus forecast dispersion of each month. Consensus forecast dispersion is the monthly standard deviation of analysts' forecasts for firm *j* (scaled by 100). In column (1), market return volatility (*MKTRETVOL*) is used as a proxy for market uncertainty. In column (2), market uncertainty is estimated using the average monthly *VIX* index one month prior to the analyst forecast dispersion measurement date. Standard errors are clustered by year. ***, **, and * denote significance levels of 1%, 5%, and 10%, respectively.

Dependent variable	Aggregate dispersion	
	(1)	(2)
MKTRETVOL	13.578***	
	(1.464)	
VIX		1.461***
		(0.110)
Constant	17.719***	0.108
	(1.572)	(2.304)
N	3963	3816
R-sq	0.027	0.051

forecasts of firm *j* in month *m*, year *t*, scaled by fiscal year end price in year *t*−*1*. This is the firm-level consensus dispersion measure. I then sum the forecast dispersion of all firms for each month to get an aggregate dispersion measure. Market return volatility is used as a proxy for market uncertainty in column (1), and the *VIX* is used as the market uncertainty proxy in column (2). Findings in Table 3 show that an increase in market uncertainty of the prior month is positively associated with an increase in the aggregate forecast dispersion in the following month. The coefficients of *MKTRETVOL* and *VIX* are positive and highly significant in both columns. In

Table 4
Market uncertainty and abnormal trading volume. This table describes the relationship between market uncertainty and abnormal trading volume around earnings announcements. The dependent variable is the total abnormal trading volume (in logs) during the earnings announcement period. *Abnormal Trading Volume* is the total abnormal trading volume during the earnings announcement period of [0, 1] days, scaled by the standard deviation of the trading volume during the pre-announcement period [−240, −5] days (in logs). In columns (1)–(3), market return volatility is used as a proxy for market uncertainty, and columns (4)-(6), the *VIX* index is used. Monthly market uncertainty and the *VIX* index are sorted into quintiles. *High* is an indicator variable, which equals one if the month is within the highest quintile market uncertainty group and zero otherwise. *Dispersion* is orthogonal residual component from regressing the respective market uncertainty proxies on forecast dispersion. Other variables follow the definitions in the Appendix Table. Columns (3) and (6) report the findings excluding recessionary periods based on the NBER business cycle dates. Columns (2), (3), (5) and (6) include firm and quarter fixed effects. Standard errors are clustered by firm and quarter. *** denotes a significance level of 1%, ** 5%, and * 10%.

Market uncertainty	*Market return volatility*			*VIX*		
	(1)	(2)	(3)	(4)	(5)	(6)
High	0.132***	0.056***	0.039**	0.023***	0.038***	0.026**
	(0.011)	(0.014)	(0.016)	(0.009)	(0.011)	(0.013)
Surp	2.969***	6.140***	7.421***	3.269***	6.311***	7.466***
	(0.497)	(0.915)	(1.158)	(0.503)	(0.904)	(1.159)
Size	0.104***	0.263***	0.253***	0.096***	0.263***	0.253***
	(0.003)	(0.007)	(0.008)	(0.003)	(0.007)	(0.008)
Market/Book	0.042***	−0.002	−0.003	0.047***	−0.001	−0.002
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Dispersion	-0.089	−0.762	−1.201	−0.088	−0.614	−1.134
	(0.136)	(0.890)	(1.302)	(0.132)	(0.797)	(1.261)
PS-Liquidity	−0.400***	−0.512***	−0.340**	−0.446***	−0.527***	−0.373***
	(0.093)	(0.108)	(0.138)	(0.093)	(0.108)	(0.140)
Constant	−0.281***	−1.292***	−1.232***	−0.207***	−1.278***	−1.229***
	(0.021)	(0.049)	(0.055)	(0.020)	(0.049)	(0.055)
N	167,907	167,907	131,411	167,907	167,907	131,411
R-sq	0.123	0.297	0.319	0.122	0.297	0.319
Firm and quarter fixed effects	No	Yes	Yes	No	Yes	Yes
Recessionary periods	Include	Include	Exclude	Include	Include	Exclude

sum, the findings indicate that overall investors' beliefs become more dispersed when markets are volatile, which is consistent with the Bayesian learning framework.

4.2.2. Trading activity and market uncertainty

The main empirical analysis compares abnormal trading volume between high and low market uncertainty periods, using pooled OLS regressions. Table 4 reports the regression results using Eq. (5). The dependent variable is abnormal trading volume (in logs). In columns (1)–(3), market return volatility is used as a proxy for market uncertainty, and in columns (4)–(6), the *VIX* index is used. Columns (3) and (6) exclude recessionary periods, while all other columns include the entire sample period.[11] Columns (1) and (4) report the coefficient estimates without firm and (fiscal) quarter fixed effects, and all other columns include firm and quarter fixed effects. Firm fixed effects and analyst forecast dispersion control for prior dispersion in investors' beliefs at the firm-level.

The main coefficient of interest is the coefficient of *High*, which is positive and highly statistically significant in all columns. This indicates that abnormal trading volume increases when market uncertainty is high, which is consistent with the theoretical prediction that dispersed beliefs about market cash flows is associated with greater trading activity around earnings announcements. The findings are robust to the choice of market uncertainty proxy, since the *High* coefficient is significant in all columns.[12] This finding is consistent with prior studies that examine firm-level dispersion and trading volume. For example, Brockman and Chung (2000) find that the divergence of prior beliefs (of the firm) increases trading volume, in addition to liquidity trading.[13]

The positive association between market uncertainty and trading volume around earnings announcements remains similar when excluding recessionary periods (columns (3) and (6)). This is consistent with the paper's hypothesis, which does not condition on the state of the economy.[14] Firm characteristics, such as firm size, market-to-book ratio, and analyst forecast dispersion are included to control for firm characteristics that may affect investor learning from earnings news. The coefficient of the market-to-book ratio variable is significantly positive in columns (1) and (4), while it becomes negative and insignificant when including firm and quarter fixed effects in other columns. This indicates that the firms' market-to-book ratio is highly correlated with other unobservable firm

[11] Recessionary periods are identified based on the NBER business cycle dates.

[12] I find materially similar results when examining the changes in *VIX* levels instead of levels of *VIX*. The results are untabulated and are available upon request. I also find that trading volume increases under high market uncertainty, for both positive and negative earnings news (untabulated due to space constraints). The coefficient of analyst forecast dispersion is insignificant, which might be due to firm-level uncertainty proxies including both prior dispersion of investor beliefs and firm's information uncertainty (i.e., signal precision), Choi, 2018).

[13] See also Karpoff (1986), Harris and Raviv (1993), Kim and Verrechia (1994), Kandel and Pearson (1995), and Garfinkel and Sokobin (2006).

[14] The findings are also robust to excluding firms that exit the sample during the sample period from bankruptcy and mergers, etc.

Table 5
Market uncertainty and firm characteristics. This table describes the relationship between market uncertainty and abnormal trading volume across different firm characteristics. Firms are sorted into high (*Q5*) and low (*Q1*) quintile groups based on the level of market-wide information (columns (1) and (2)) and firm size (columns (3) and (4)). In all columns, the dependent variable is the total abnormal trading volume (in logs) during the earnings announcement period. Market uncertainty is measured by the standard deviation of the daily market returns during the month. Monthly market uncertainty is sorted into quintiles. *High* is an indicator variable, which equals one if the month is within the highest quintile market uncertainty group and zero otherwise. *Dispersion* is orthogonal residual component from regressing the respective market uncertainty proxies on forecast dispersion. Other variables follow the definitions in the Appendix Table. All columns include firm and quarter fixed effects. Standard errors are clustered by firm and quarter. *** denotes a significance level of 1%, ** 5%, and * 10%.

Sorted by	Market-wide information		Firm size	
Quintile group	*Q5*	*Q1*	*Q5*	*Q1*
	(1)	(2)	(3)	(4)
High	0.049***	0.037	0.070***	0.012
	(0.018)	(0.437)	(0.016)	(0.084)
Surp	7.596***	4.194**	7.555***	7.830*
	(1.473)	(1.855)	(2.272)	(4.349)
Size	0.211***	0.021	0.223***	0.115
	(0.012)	(0.390)	(0.015)	(0.088)
Market/Book	0.016***	0.111	0.010**	0.029
	(0.004)	(0.288)	(0.004)	(0.058)
Dispersion	−3.576	-4.278	−0.255	−4.043
	(2.908)	(4.192)	(0.404)	(7.678)
PS-Liquidity	−0.746***	1.996	−1.003***	−0.283
	(0.180)	(4.837)	(0.186)	(0.974)
Constant	−0.871***	−0.043	−1.181***	−0.149
	(0.090)	(1.952)	(0.131)	(0.403)
N	43,883	33,621	40,681	36,557
R-sq	0.337	0.692	0.242	0.568
Firm and quarter fixed effects	Yes	Yes	Yes	Yes

characteristics that firm fixed effects captures. Firm-level analyst forecast dispersion is orthogonal residual component from regressing market uncertainty on analyst forecast dispersion. This is to control for the collinearity between analyst forecast dispersion and market uncertainty.[15] Finally, market liquidity is also included to control for market conditions that may impact trading activity.

In sum, the empirical findings are consistent with the theoretical prediction based on Bayes' rule. The increase in abnormal trading activity indicates that earnings announcements have stronger impact on investors' beliefs and they are more likely to interpret earnings news differently, during high market uncertainty periods.

4.2.3. Cross-sectional firm characteristics and market uncertainty

In this section, I examine the association between market uncertainty and trading volume across different firm characteristics. I examine the level of market-wide information of the firm, and firm size that captures the degree of market cash flows in firms' earnings. Market-level information is measured by the R^2 from regressions of daily firm returns on the daily market returns in year $y-1$ (Frankel et al., 2006). The larger the correlation between a firm's return and the market, the larger the market component of the firm's return and the smaller the firm-specific component (Bhushan, 1989). Firm size is calculated as discussed in Section 3. For each year, I sort firms into quintile groups based on firm size and market-wide information. I then estimate the changes in the abnormal trading volume as in Eq. (5) for the highest and lowest firm quintile group subsamples.

In Table 5, firms are sorted each year by their level of market-wide information (columns (1) and (2)) and firm size (columns (3) and (4)). For example, column (1) reports regression results on firms with more market-wide information (*Q5*), and column (2) reports results on firms with less market-wide information (*Q1*). Firm characteristics and market liquidity variables are included in the analysis. All columns include firm and quarter fixed effects. The coefficient of *High* is positive and significant only for firms with more market-wide information (column (1)). The finding shows that the effect of market uncertainty is greater for firms with more market-wide information in their earnings. A similar pattern exists across firm size. I find that the effect of market uncertainty on abnormal trading volume is stronger for larger firms than for smaller firms (column (3)).

In sum, I find that abnormal trading volume increases for larger firms and firms with more market-wide information, when market uncertainty is high. The results indicate that dispersed prior beliefs about market cash flows leads to more differences in opinions about the firms' earnings news, especially for firms with greater degree of market cash flows in their earnings. The findings are also consistent with view that investors learn about the market and the economy from firm earnings announcements, since these firms are typically considered as indicators for future market conditions (i.e., bellwether firms).

[15] The findings are materially similar when I include analyst forecast dispersion instead of the residual component. The results are also robust to excluding analyst forecast dispersion (untabulated). The results are similar across different dispersion measures, since the correlation between market uncertainty and firm-level forecast dispersion is quite low (0.003).

5. Robustness tests discussion

As robustness checks, I consider an alternative explanation regarding investor sentiment and an alternative uncertainty proxy.[16] One potential explanation is that market uncertainty can be highly correlated with investor sentiment indicators, which may affect the level of trading activity. Previous studies have found significant effects of investor sentiment on stock prices.[17] To address this possibility, I repeat the main analysis by including the University of Michigan Consumer Confidence Index and the Baker and Wurgler (2006) Sentiment Index as proxies for investor sentiment level (Bergman and Roychowdhury, 2008; Walther and Willis, 2013). I find that the effect of market uncertainty on trading volume remains robust to controlling for the level of investor sentiment.

I also repeat the main analysis on the effect of market uncertainty by using an alternative economic uncertainty proxy: the Economic Policy Uncertainty Index by Baker et al., 2016. This economic uncertainty index is measured using media reports, and therefore, the measure is exogenous of the stock market. This uncertainty measure complements the main market uncertainty measure, since market uncertainty might be correlated with the level of abnormal trading activity of the firm. I find that trading volume increases under economic uncertainty as well.

6. Conclusion

This study shows that market-level uncertainty affects the level of trading volume around earnings announcements. Earnings announcements contain both market-wide and firm-specific information that investors use to predict future cash flows. When market conditions are volatile, investors' beliefs about market cash flows are more dispersed. During high market uncertainty periods, earnings announcement provide valuable information to investors in forecasting future cash flows, but investors' interpretation of earnings news also differ. Taken together, high market uncertainty is associated with greater trading volume around earnings announcements. Consistent with this prediction, I find that abnormal trading volume around earnings announcements increase in the presence of high market uncertainty. The empirical finding is consistent with Bayes' rule that predicts greater divergence in posterior beliefs when priors are dispersed. The increase in trading volume under market uncertainty is greater for firms with more market-wide information and larger firms. These firms tend to be regarded as "bellwether" firms, and are often used as informative indicators about future market conditions.

The study sheds light on the informativeness of earnings announcements by examining the changes in trading volume around earnings announcement in regard to time-varying market conditions. I assume that firm management incentives (i.e., earnings management) are constant over time, since the focus of this study is on the effect of market uncertainty on earnings' informativeness. One extension of this study is to examine whether the accuracy of earnings announcements or management forecasts due to managerial incentives varies over different levels of market uncertainty, which is beyond the scope of the current research.

Appendix variable definitions

Variable	Definition
Abnormal volume (AVOL)	The total abnormal trading volume during the earnings announcement period of [0, 1] days, scaled by the standard deviation of the trading volume during the pre-announcement period [−240, −5] days (in logs).
Dispersion	Analyst forecast dispersion is the standard deviation of analysts' earnings forecasts, divided by prior fiscal quarter ending price. In the multivariate regressions, the orthogonalized residual from the regressing market uncertainty on dispersion is included.
High	An indicator variable, which equals one if the month is within the highest quintile market uncertainty group and zero otherwise.
Institutional holdings	The percentage of shares held by institutional investors.
Market/Book	The market value of the firm's equity at the end of the fiscal quarter plus the difference between the book value of the firm's assets and the book value of the firm's equity at the end of the quarter, divided by the book value of the firm's assets at the end of the quarter.
Mktretvol	The monthly standard deviation of the daily market return.
PS-Liquidity	The monthly Pastor-Stambaugh market liquidity factor.
Size	Firm size is the log of market value of equity.
Surp	The absolute value of the difference between actual earnings and the analyst median forecast, normalized by the prior fiscal quarter ending stock price.
VIX	The 30-day implied volatility of stock options and is averaged by month.

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[16] The robustness tests findings are untabulated due to space constraints, but are available upon request.

[17] See, for example, Bird and Yeung (2012), Mian and Sankaraguruswamy (2012), Statman et al. (2006), Griffin et al. (2007), Baker and Wurgler (2006), Bergman and Roychowdhury (2008), and Walther and Willis (2013). Statman et al. (2006) and Griffin, Nardari, and Stulz (2007) find that trading volume increases during high sentiment periods and decreases during low sentiment periods.

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