Information Processing in the Option Market around Earnings and Macroeconomic Announcements*

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Abstract

We empirically analyze attention allocation of informed option traders around firm-specific and economy-wide news announcements. Using high-frequency trade data to measure informed trading, we find that when earnings announcements coincide with macro releases, sophisticated option investors process private information more effectively compared to earnings-announcement days without macro releases. This enhances the predictive power of option trading on underlying stock returns. The impact of macro releases on the predictive power of option trading is especially pronounced if the option market effective bid-ask spread is low or absolute earnings surprise is high. This indicates that informed traders prefer liquid option markets and valuable information to benefit from their private information.

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1 Introduction

Investors who have access to private information and believe that a firm's stock price does not reflect their full information set yet clearly have an incentive to trade on their information. Sophisticated investors will also decide on their preferred trading venue. Most likely, they will choose the market that benefits them the most from the public revelation of that information, say a leveraged and low-cost market. According to Black (1975) and many subsequent studies[1] option markets are an ideal trading venue for informed investors due to their embedded leverage, their built-in downside protection, and their lower margin requirements. Yet, we know little about how the interplay between different news events affects informed option traders' strategies.

In this paper, we make a first attempt to analyze how the arrival of economy-wide (macro) news affects the information processing of firm-specific (micro) news by informed option investors. We focus on equity option markets for single stocks. To benefit from private information, investors face the decision on how to allocate their attention, i.e., decisions on what information to collect and to trade on. We concentrate on scheduled earnings announcements and analyze whether the behavior of informed option traders is affected by macro news. We do so by examining the effect that the arrival of news about the aggregate economy has on the predictive power of signed option volume on the stock price adjustment to earnings news. Thus, we provide new evidence on how informed equity option investors attention distribution differs when different news types are released on the same day.

We start our analysis by showing that prior to earnings news announcements, option trading volume increases and the direction of option trading on the day prior to earnings announcements relates to the information content of firm-specific news, while the stock volume responds to earnings news mainly after announcements. This points to option markets as preferred trading venue for informed investors and option traders superior forecasting ability,

[1] E.g. John, Koticha, and Narayanan (2003), Chakravarty, Gulen, and Mayhew (2004), Boyer and Vorkink (2014), Ge, Lin, and Pearson (2016), and Chordia, Lin, and Xiang (2020).

consistent with previous literature on informed option trading.

We next look at earnings-announcement days with macro releases. Our study confirms the result of Hirshleifer and Sheng (2019) of enhanced attention of investors in stock markets as response to macro releases for option market investors. We find increased attention in option markets around macro releases. In detail, our results suggest that around earnings announcements with interacting macro news, option and stock trading volumes are up to 10.15 percentage points higher than around earnings news days without macro news.

Most interestingly, we find that macro releases on earnings announcement days increase the predictive power of directional option trading on stock returns. This macro-effect is economically significant. Specifically, the coefficient is 3.6 times as high as for earnings news releases without macro news. In fact, the predictive power of option order imbalance on earnings news days without important macro-economic news announcements disappears, once we include the macro news indicator into our regression model. This result indicates that option traders process firm-specific private information more effectively before earnings days with macro news than before earnings days without macro news. This increase in predictability by macro news can be rationalized by a higher uncertainty about a stock's future price movement. As information choice models predict, information has most value on the least certain outcomes (Kacperczyk, Van Nieuwerburgh, and Veldkamp (2016)). Around earnings announcements with interacting macro news, higher uncertainty seems very plausible, since the cash flow uncertainty is in many cases compounded by uncertainty about the discount factor. Our findings thus fit well with Andrei, Friedman, and Ozel (2020)'s theoretical model of optimal attention allocation predicting that an increase in economic uncertainty rises investors' attention towards firm-specific news.

Furthermore, we want to gain more insight on trading preferences of informed investors. We do so by dividing our sample into groups based on average effective option bid-ask spreads and absolute earnings surprise (we provide single and double sort evidence). We expect the predictive power of option order imbalance on stock returns to increase with

profitability. Thus, we expect predictability to increase with lower effective bid-ask spreads and with higher absolute earnings surprises. We repeat our main predictive regression for the highest and lowest effective-spread and earnings surprise groups. The results confirm our expectation that private information will only enter the option market if it is profitable. The macro news effect can only be found for high earnings surprise and low cost groups.

Our results are robust to a variety of different order imbalance measures. We find triggered attention by macroeconomic releases also for volume-weighted, out-of-the money, delta-weighted, and buyer-initiated order imbalance. Consistent with Hu (2014), we find that out-of-the money options do not have higher predictive power compared to order imbalance of the whole universe of options. The delta-weighted option order imbalance inspired by Hu (2014) also confirms our results. Finally, we construct buyer-initiated option order imbalance of calls for news with a positive earnings surprise and of puts for news with negative earnings surprise. We find highly significant predictability patterns. This measure does not distinguish between volatility trading and informed trading. Therefore, besides confirming our initial results, our analysis also gives hints of new evidence of enhanced volatility hedging on days with macroeconomic news announcements.[2]

In summary, this paper shows how the attention of sophisticated investors is affected by different types of news and how attention allocation affects the interaction between individual equity options and underlying stock markets. Finally, our results give insights on the trading behavior of informed option market investors.

Related literature The scope of literature addressing informed trading in option markets has increased profoundly since the 1980s. Several studies provide evidence of sophisticated, privately informed investors in the option market that create predictability of future stock returns by various option market measures. In detail, a broad part of the existing literature measures informed trading with option pricing measures, see Cremers and Weinbaum (2010), Muravyev, Pearson, and Broussard (2013), and Jones (2018), among others. They

[2]To the best of our knowledge, enhanced hedging in single stock option markets on macroeconomic news announcement days is not yet documented in the literature.

interpret implied volatility spreads, i.e. the difference in implied volatilities of call and put options, as a proxy for price pressure in the option market that arises from informed trading. Du, Fung, and Loveland (2018) and Chordia, Lin, and Xiang (2020) additionally analyze the informativeness of implied volatility skewness. Roll, Schwartz, and Subrahmanyam (2010) and Johnson and So (2012) use option to stock volume to study the informational content in option markets.

Our study adds to the scarce empirical literature that analyzes the information content of *option order imbalance* around news announcements, which includes Cao, Chen, and Griffin (2005), Pan and Poteshman (2006), Hu (2014), and Weinbaum, Fodor, Muravyev, and Cremers (2020). Cao, Chen, and Griffin (2005) find that call option trading before extreme news events, i.e. takeover announcements, can predict stock returns, while during normal times option volume is not informative. Pan and Poteshman (2006) analyze the informational role of buyer-initiated put/call ratios and find that the source of this predictability is nonpublic information possessed by option traders. Moreover, Pan and Poteshman (2006) suggest that out-of-the-money options exhibit high predictive power due to their high leverage. Hu (2014) analyzes imbalances in stock transactions that stem from option market makers hedging away underlying stock exposures. He shows that option-induced stock imbalance predicts future stock returns. Hu (2014) also investigates delta-weighted option order imbalance in more detail and finds that at-the-money and in-the-money option contracts contain future stock price information, whereas out-of-the-money options do not. According to his results, informed trading is more prevalent for e.g. firms with low institutional ownership and low analyst converge.

Weinbaum, Fodor, Muravyev, and Cremers (2020) analyze informed trading during scheduled and unscheduled news events. Their news data comes from Thomson Reuters News Analytics and contains all news announcements that are released on the Reuters data feed. Among the studies on option markets leading stock markets, Weinbaum, Fodor, Muravyev, and Cremers (2020) is one of the few studies that analyze the behavior of informed op-

tion market investors. Their main finding is that informed traders use short (long) option positions before scheduled (unscheduled) news announcements.

Our paper contributes to this literature by providing new evidence on the prevalence, the origin, and the observed investment behavior of informed traders in the option market.

The other strand of literature to which our paper contributes, is the literature analyzing attention allocation of investors. Attention is a scarce cognitive resource and investors need to allocate their limited attention between different types of information (Kahneman, 1973). Thus, theory suggests that due to limited capacity, investors need to choose which information to process into the market. Israeli, Kasznik, and Sridharan (2020) show that unexpected distractions only alter retail investors' attention allocation while institutional investors are unaffected. Peng and Xiong (2006) provide theoretical evidence that investors tend to focus their attention more on market and sector-wide information than firm-specific information. Hirshleifer and Sheng (2019), however, find opposing empirical evidence. The publication of economy-wide (macro) news increases stock market investors' attention and firm-specific (micro) news is processed more efficiently into the market. They call it the "attention trigger effect". Andrei, Friedman, and Ozel (2020) propose a rational explanation for the finding of Hirshleifer and Sheng (2019) with a model for optimal attention allocation. They show that higher macro uncertainty yields to an increase in investor attention because the incentive to gather firm-specific information rises. We are not aware of any existing studies evaluating how major macro releases affect informed single stock option investors' trading behavior and option market predictive power on future stock returns.[3] Our study contributes to this literature by providing evidence that the option market trading leads stock market returns on days where earnings announcements and macroeconomic releases coincide.

[3]There has been a considerable interest in the impact of macroeconomic announcements on index option markets. E.g. using intraday data and order imbalances of E-mini Standard & Poor's (S&P) 500 futures calculated for each minute, Bernile, Hu, and Tang (2016) argue that in the 30 minutes prior to a Federal Open Market Committee (FOMC) announcement, most order imbalances are in the direction of this upcoming macroeconomic news surprise and can predict the market reaction to FOMC news. Chordia, Kurov, Muravyev, and Subrahmanyam (2018) analyze the index option market and its predictability on index returns on a weekly basis. They provide evidence that net buying pressure in S&P 500 index put options positively predicts underlying movements.

2 Data and Variable Construction

We base our empirical analysis on four data sources: LiveVol, OptionMetrics, I/B/E/S, and Bloomberg. We merge OptionMetrics, LiveVol, and I/B/E/S to combine individual equity and option information. Therefore, in order to be included in our analysis, a single stock is required to have data available in all three databases. The information on the timing of macroeconomic news is collected from Bloomberg.

2.1 Stock and option data

Our main data source is LiveVol, which covers real-time transaction-level data on the entire universe of U.S. listed individual equity options. Our sample period is restricted to the availability of LiveVol and begins in January 2004 and ends in October 2017. We retain options whose underlying asset is a common stock and exercise style is American. Daily information on options' delta and underlying assets such as stock prices, trading volumes, and shares outstanding is collected from the OptionMetrics Ivy database. Observations with stock prices under one dollar are excluded to avoid data errors. The trade data from LiveVol does not flag the direction of the transaction, but it contains matched quote prices. We apply a modified Lee-Ready algorithm to classify buyer-initiated put and call option trades. According to the quote rule, a trade is buyer-initiated if it occurs above the midpoint of the best bid-ask spread. Trades that occur exactly at the midpoint of the national best bid and best ask cannot be classified in this first step. We make use of the detailed exchange information provided by LiveVol to classify those trades by comparing the trade price to the bid and ask price of the exchange the trade was executed, respectively. In case trades still cannot be classified they are excluded from the sample. Savickas and Wilson (2003) show that 88.65% of equity option trades can be correctly classified by the quote rule.

We use similar filters as in previous studies, like Goyal and Saretto (2009) and Cao and Han (2013), to reduce the impact of recording errors. We eliminate option observations that

violate obvious no arbitrage conditions. We exclude all observations where the option bid price is zero and the bid-ask spread is smaller than the minimum tick size ($0.05 for options trading below $3 and $0.1 for all other options). Finally, we drop options with missing implied volatility or delta.

2.2 Earnings news of companies

Firm specific data on actual earnings and estimates of earnings forecasts are provided by I/B/E/S. The data contain timestamps of the announcements. We include forecasts about the forthcoming quarterly earnings release of the last 30 calendar days. In case more than one earnings forecast in the last 30 calendar days is available for the same stock in the same quarter, we keep the most recent forecast. Earnings news where actual or estimated earnings per share are higher than the stock price are excluded to avoid data errors. For merging actual earnings news announcements that are published out of trading hours with stock and option data, we use the NYSE (New York Stock Exchange) closing time 4 p.m. Eastern as a cutoff, as suggested by Weinbaum, Fodor, Muravyev, and Cremers (2020). Earnings news that are released after 4 p.m. are assigned to the following trading day. In our sample, 47.4% of earnings news is released after stock and option trading hours, 43.2% before trading hours. Only 9.2% of the announcements occur during trading hours, while 0.2% of the news is announced on non-trading days.[4]

2.3 Macroeconomic news announcements

We focus our analysis on important macroeconomic news announcements. Savor and Wilson (2013) suggest that important macroeconomic events can be identified by analyzing their statistical and economical impacts on the market excess return. Following this method, Hirshleifer and Sheng (2019) find that announcements on FOMC (Federal Open Market Com-

[4]The earnings data are merged with OptionMetrics stock data by the historical CUSIP (Committee on Uniform Securities Identification Procedures) number and the forecast period end date.

mittee) decisions, Nonfarm Payroll employment, ISM PMI (Institute of Supply Management, Purchasing Managers' Index), and Personal Consumption Expenditure have significant impact on the market excess return. Therefore, we obtain release dates of these four scheduled announcements from Bloomberg Econoday and define a dummy variable for macro news days (MD). $MD = 1$ if at least one of these four announcements is released on this day, otherwise $MD = 0$.[5] In total, 15.8% of trading days in our sample period are macro news days. Out of all earnings announcement days, 16.2% of earnings news is released on a macro news day.

2.4 Informed trading in the option market

The idea that sophisticated and informed traders are prevalent in option markets because options offer high leverage, while simultaneously limiting the downside risk of an option investment is well documented by academics, see, for instance, Black (1975) and Back (1993). Still, measuring the magnitude of informed trading in the option market is challenging because the timing of informed trades and the identity of investors is unobservable.

We want to overcome this challenge by, firstly, studying time periods where information is often asymmetric and informed trading is likely, namely, before corporate and macroeconomic news announcements, and, secondly, using option order imbalance to proxy informed trading.

Our decision to use option order imbalance to forecast future stock returns is based on the theoretical findings of Easley, O'Hara, and Srinivas (1998). Informed investors that are buying a call (put) or selling a put (call) before an information event profit from stock price growth (decline). Easley, O'Hara, and Srinivas (1998) consequently argue that option trades and thus option order imbalance rather than option prices first carries information about future underlying stock prices.

Existing literature that uses option transaction data to measure informed trading is rare. Hu (2014) is one of the few studies that measure informed trading directly with (delta-

[5]In our sample, eight days with one of the four macroeconomic announcements are non-trading days of stocks and options. In this case, we set the following trading day as a macro news day ($MD = 1$).

weighted) option order imbalance. Pan and Poteshman (2006) base their analysis also on high-frequency trading data to analyze buyer-initiated option volume and find predictable patterns for stock returns. We also have the advantage to be equipped with high-frequency option trading data. Thus, our main measure of informed trading is option order imbalance, which is the difference between buy and sell trading volumes divided by the total volume of option trades. We additionally test our main hypotheses with different specifications of order imbalance, among these, the one proposed by Hu (2014) (see Chapter 4).

2.5 Variable construction

2.5.1 Option order imbalance

We use option transaction data and compute the total order imbalance (TOI) of options on stock k at day j as the difference between buy and sell trading volumes divided by the total volume of option trades at day j in the following way:

$$TOI_{k,j} = \frac{\sum_{i=1}^{n} sign_{k,j,i} \cdot size_{k,j,i}}{\sum_{i=1}^{n} size_{k,j,i}}, \tag{1}$$

where $sign_{k,j,i}$ represents the information signal of an option trade i. In the case of buyer-initiated (seller-initiated) call option trades $sign_{k,j,i} = 1$ ($sign_{k,j,i} = -1$) and if the trade is a buyer-initiated (seller-initiated) put option, then $sign_{k,j,i} = -1$ ($sign_{k,j,i} = 1$). $size_{k,j,i}$ corresponds to the trade size of trade i.

We only retain stocks with at least 10 call (put) option contracts per day and exclude options in the highest effective spread percentile to avoid biases by illiquid option trading.[6] Inspired by Bernile, Hu, and Tang (2016) our final measure of informed trading with respect to a specific announcement date (τ) is the difference in market activity at day j minus the

[6]We calculate effective spread percentiles on a weekly basis to control for time dependent differences in spreads as well as differences in spreads between macro and non-macro news days. As we show in a later analysis macro news affects the information processing in option markets of earnings news also on other days then the same day. Furthermore, a weekly basis to calculate percentiles makes sure that there are enough observations to be divided into 10 groups.

mean TOI of non-announcement days

$$OI_{k,j} = TOI_{k,j} - \overline{TOI}_{k,\tau-40\rightarrow\tau-10}, \tag{2}$$

where $\overline{TOI}_{k,\tau-40\rightarrow\tau-10}$ is the mean TOI of non-announcement days from 40 trading days to 10 trading days prior to the current earnings announcement.[7] If an informed option trader has positive private information on stock k, she will buy call options or sell put options. Keeping all else fixed, this will increase option order imbalance (OI_k). On the other side, negative information will lead the investor to buy put options or sell call options which will lower order imbalance.

When testing the hypothesis of whether informed trading is more prevalent on days where macroeconomic and earnings announcements coincide, it is of high importance to make sure our informed trading measure is not biased by hedging strategies. Hedging purposes that are formed independently of the event will be absorbed by subtracting order imbalance during normal times (40 to 10 trading days before the event). Earnings announcements increase stock price volatility and options are used for volatility hedging purposes in other options or the underlying stock. Forming straddles is a popular way for hedging volatility in the underlying stock. If the fraction of straddles increases, our measure remains constant. Thus, this strategy for volatility hedging should be no cause of concern and will not bias our results towards higher predictive power. The remaining fraction of options that are bought for hedging purposes will rather add noise to our informed trading measure and bias our results towards rejecting the null hypothesis that informed trading is prevalent in the option market.

[7] We choose a broader definition of the non-announcement period compared to Bernile, Hu, and Tang (2016), because we deal with single equity options that are less liquid compared to index options investigated by Bernile, Hu, and Tang (2016). In the rare case that another micro event occurs in this time period, we exclude the five days before and the five days after the event.

2.5.2 Earnings surprise of companies

Following Hirshleifer, Lim, and Teoh (2009) and Hirshleifer and Sheng (2019), we calculate earnings surprise (ES) as the difference between actual earnings ($actual$) of the quarter and the median estimate ($medest$) of the most recent forecasts normalized by the stock price at the end of the forecast quarter:

$$ES = \frac{actual - medest}{price}. \tag{3}$$

2.5.3 Stock return and volume reaction

Cumulative abnormal stock returns ($CAR[h, H]$) after the earnings announcement date τ of quarter t is the cumulative excess return of the stock over the period $[\tau + h, \tau + H]$ adjusted by the market model:[8]

$$\begin{aligned} CAR[h, H] =& [\prod_{j=\tau+h}^{\tau+H}(1 + R_{j,k}) - \prod_{j=\tau+h}^{\tau+H}(1 + r_j)] \\ & - \hat{\beta}_{t,k}[\prod_{j=\tau+h}^{\tau+H}(1 + R_{j,m}) - \prod_{j=\tau+h}^{\tau+H}(1 + r_j)], \end{aligned} \tag{4}$$

where $R_{j,k}$ is the return of stock k on date j, $R_{j,m}$ is the market return on date j, r_j is the risk-free rate on date j, and $\hat{\beta}$ is estimated from the market model $R_{j,k} - r_j = \alpha_{t,k} + \beta_{t,k}(R_{j,m} - r_j) + \varepsilon_{t,k}$ with j varying from $\tau - 300$ to $\tau - 46$ for each earnings announcement. We use $CAR[0, 1]$ to measure the immediate stock return reaction to unexpected earnings announcements.

We also investigate the stock dollar volume reaction to earnings news using the immediate

[8] We have similar results when using the Fama-French three-factor model. Results can be provided upon request.

abnormal trading volume ($AVOL$) measure of DellaVigna and Pollet (2009):

$$\begin{aligned} AVOL[j, j+1] &= \frac{AVOL[j] + AVOL[j+1]}{2}, \\ AVOL[j] &= \ln(V_{\tau+j} + 1) - \frac{1}{14} \sum_{k=\tau-20}^{\tau-6} \ln(V_k + 1), \end{aligned} \tag{5}$$

where $V_{\tau+j}$ is the dollar amount of the trading volume on the day $\tau + j$. Abnormal option dollar volume is calculated in the same way.

2.6 Summary statistics

Table 1 presents summary statistics of our sample. Panel A is based on the full sample of all earnings news days.[9] In total, we have 2,628 news days and 3,986 stocks in our sample. The median number of firms announcing earnings per earnings announcement day is about 12. Abnormal stock volume is on average 70.644% and abnormal option volume 117.574%. Events with positive earnings surprises are more prevalent than events with negative earnings surprises during our sample period (approximately 2.2 times), which also can be seen when looking at the slightly positive but close to zero median ES in Panel A. The negative ES-mean suggests that some unexpected negative events with a high surprise occurred during our sample period. Accordingly, average cumulative abnormal return (CAR) after the event is slightly negative.

Our main explanatory variable abnormal order imbalance has negative mean and median values on the day before earnings announcements. This indicates that before news events investors on average sell more calls than they buy and are more puts long than puts short.

The quoted bid-ask spread (QBA) and effective bid-ask spread (EBA) of put and call options are pretty high (compared to, e.g., stock market spreads). This result is well documented in the literature; see, for instance, Christoffersen, Goyenko, Jacobs, and Karoui

[9]Our daily stock data are collected from OptionMetrics so that all the stocks are underlying assets of equity options. As these stocks are on average bigger than the universe of all exchange traded stocks, market capitalization, share turnover and number of analysts are higher than those in Hirshleifer and Sheng (2019).

Table 1: Summary Statistics

This table reports summary statistics. SAVOL (OAVOL) is the abnormal stock (option) volume. ES is earnings surprise. #Analysts is the number of analysts per earnings announcement. Market cap is the market capitalization. Share turnover is the turnover of the company's shares. #Earnings news is the number of earnings announcements per day. CAR[h,H] is the cumulative excess return from the h-th to the H-th day after earnings announcements. Volatility[-21,0] is the historical stock return volatility. OI[-1] is the order imbalance of options before earnings news. QBA (EBA) is the quoted (effective) bid-ask spread of options. The sample period is from Jan. 2004 to Oct. 2017.

Panel A: Full sample

	N	Mean	SD	25%	50%	75%
SAVOL[0,1] %	122,574	70.644	63.993	29.540	66.493	107.768
OAVOL[-1,0] %	51,503	117.574	115.163	43.477	112.420	188.932
OI[-1] %	51,503	−2.82	42.87	−26.99	−2.92	20.50
CAR[0,1] %	51,503	−0.07	8.79	−4.21	−0.04	4.19
CAR[2,61] %	50,942	−0.34	18.63	−9.29	−0.65	7.60
Volatility[-21,0] %	51,503	2.41	1.75	1.37	1.99	2.89
QBA %	51,503	27.80	14.83	17.17	25.15	35.25
EBA %	51,503	17.02	11.71	9.28	13.90	21.28
Share Turnover %	51,503	4.00	5.02	1.40	2.55	4.72
ES	51,503	−0.03	3.67	−0.03	0.05	0.20
Market cap (mln)	51,503	11,463	30,959	1,039	2,867	9,140
#Analysts	51,503	12.29	7.33	7	11	17
#Earnings per news-day	2,628	42.73	65.43	5	12.5	45
# News-Days	2,628					
# Stocks	3,986					

Panel B: Macro news days vs. other days

	N		Mean		SD	
	no macro	with macro	no macro	with macro	no macro	with macro
SAVOL[0,1] %	99,421	22,928	70.309	71.523	63.945	63.935
OAVOL[-1,0] %	42,248	9,255	116.26	123.648	114.714	117.033
OI[-1] %	42,248	9,255	−2.83	−2.79	42.69	43.68
CAR[0,1] %	42,248	9,255	−0.09	0.04	8.64	9.41
CAR[2,61] %	41,791	9,151	−0.40	−0.03	18.17	20.60
Volatility[-21,0] %	42,248	9,255	2.39	2.51	1.73	1.83
QBA %	42,248	9,255	27.39	29.68	14.68	15.36
EBA %	42,248	9,255	16.82	17.92	11.66	11.92
Share Turnover %	42,248	9,255	3.98	4.11	4.94	5.35
ES	42,248	9,255	−0.04	−0.03	3.65	3.80
Market cap (mln)	42,248	9,255	11,881	9,553	31,202	29,750
#Analysts	42,248	9,255	12.44	11.59	7.39	6.98
#Earnings per news-day	2,211	417	41.21	50.76	64.68	68.82

(2017).

Panel B compares the mean values and standard deviations on macro news days to those on other days. On earnings days with macro releases, the abnormal stock volume ($SAVOL[0,1]$) and abnormal option volume ($OAVOL[-1,0]$) are higher for dates with macro releases. The same is the case for share turnover and option transaction costs. This is a first indication that the release of economy-wide news attracts investors' attention to the single stock and option market, which we will explore more formally in the next sections.

We include the variables from the summary statistics as control variables into our prediction model to account for differences in characteristics on macro news and other days.

3 Empirical Analysis

First, we analyze whether attention in general is triggered by the announcement of macro news in option and stock markets, by exploring abnormal stock and option trading volumes. The second main question we wish to address is whether option trading contains informational content for future movements in underlying stock prices. In contrast to many other studies that analyze informed trading in the option market, we benefit from our option volume data based on high-frequency transactions that we have over 14 years. This long time-series enables us to analyze how efficient firm-specific information is processed into the equity option market. Finally, we analyze preferences of informed option investors and find that they prefer liquid option markets, events with high earnings surprises, and stocks with high market beta and high idiosyncratic volatility.

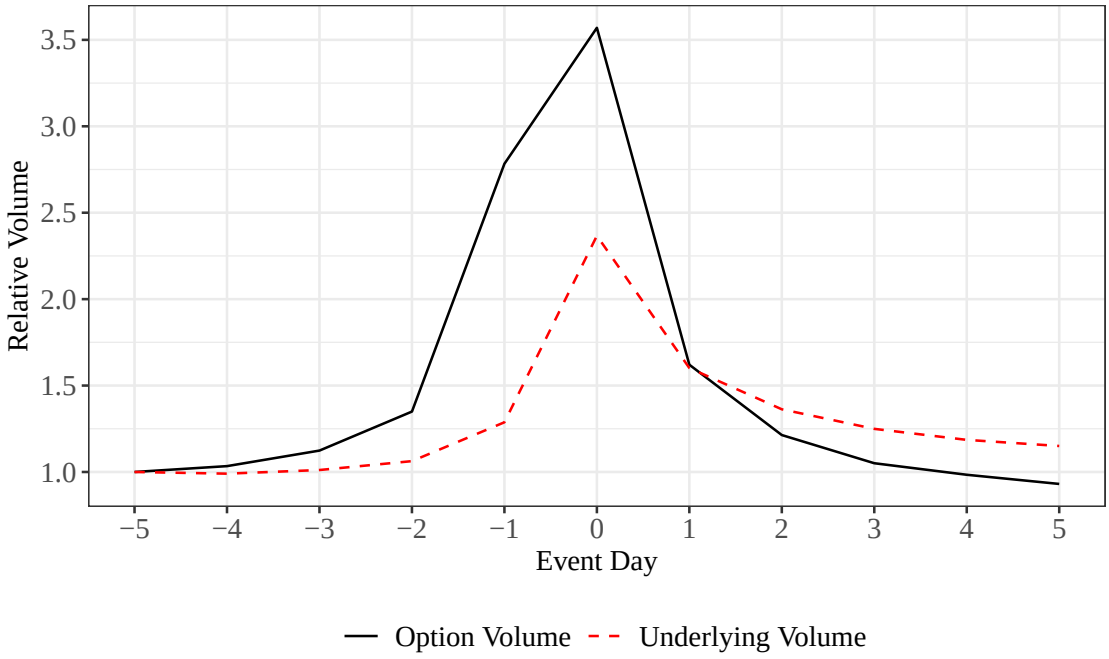
3.1 Macro news effect and trading behavior

3.1.1 Stock and option trading volume

Figure 1 shows that the option and stock volumes both increase around earnings announcement days. The day prior to the news announcements, the option volume rises by a factor

Figure 1: Stock and Option Trading Volume around Earnings Days

This figure shows the median daily trading volume of options (solid line) and stocks (dashed line) from 5 days before to 5 days after the earnings news day. The sample period is from January 2004 to October 2017.

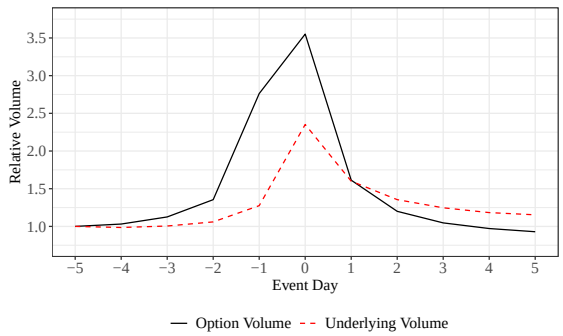


of more than two (2.18), whereas stock volume increases abruptly on the day of the news announcement. While these results are a first indication that some option market participants believe that they possess relevant (potentially private) information about the upcoming event, it is interesting to understand how the concurrent occurrence of macro news affects this pattern. Therefore, we compare the stock and option trading volume on news days with both micro and macro announcements to news days where only earnings are announced.

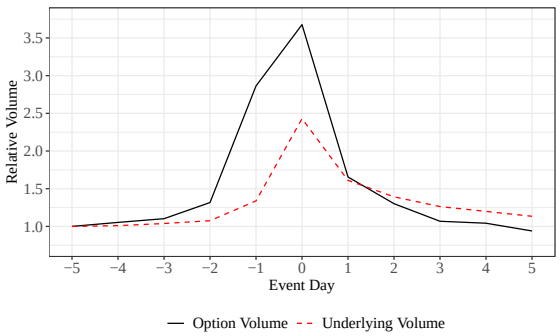
Figure 2 shows that stock and option trading volume around micro news days with macro releases, in Panel (b), is generally higher than trading volume around micro news days without macro releases in Panel (a). In detail, relative option volume increases significantly by 10.15 percentage points on the day prior to announcements ($t = -1$) before increasing further slightly on the event day ($t = 0$) when macro news and micro news coincides. This

Figure 2: Trading Volume around Earnings Days with or without Macro News

This figure shows the median daily trading volume of options (solid line) and stocks (dashed line) from 5 days before to 5 days after the earnings news day with (Panel (b)) and without (Panel (a)) macro news on the same day. The macro news day dummy is 1 if at least one of the four macroeconomic releases FOMC (Federal Open Market Committee) decision, Nonfarm Payroll, ISM PMI (Institute of Supply Management, Purchasing Managers' Index) or Personal Consumption is announced on a micro news day. The sample period is from January 2004 to October 2017.



(a) Earnings day without macro news



(b) Earnings day with macro news

macro-effect can also be found for stock volume, where on the proceeding day ($t = -1$) as well as on the announcement day ($t = 0$), stock volume is higher than on other days.

Our findings suggest that macro news enhance investors' attention and reaction to micro news. For stock traders, this effect is more prevalent on the day of the announcement than on days before or after the announcement, whereas for option traders this effect is higher on the days prior to earnings announcements.

In the following, we examine the hypothesis more formally that macro releases increase investors' attention, and thus, lead to increased trading volume. We test the abnormal stock (SAVOL) and option volume (OAVOL) reactions to micro and macro news with the following regressions:

$$\begin{aligned} SAVOL[0,1] &= \alpha + \beta_1 MD_\tau + \sum_{i=1}^{n} b_i X_i + \varepsilon, \\ OAVOL[-1,0] &= \alpha + \beta_1 MD_\tau + \sum_{i=1}^{n} b_i X_i + \varepsilon, \end{aligned} \tag{6}$$

Table 2: Stock and Option Volume Reaction to Micro and Macro News

This table reports the regression results from the abnormal dollar volume of stocks and options on the macro news day dummy. AVOL[i,j] is the average abnormal dollar volume on the date i and date j. $MD_{\tau+d}$ is the macro news day dummy variable and $d = -1, 0$. Control variables include absolute earnings surprise quantiles, market capitalization, share turnover, the number of analysts, the number of earnings announcements on the same day, lag return and return volatility of the last 21 trading days. The sample period is from January 2004 to October 2017. Standard errors are in brackets. ***, ** and * note statistical significance of coefficients at the 1%, 5% and 10% level, respectively.

	Stock AVOL[0,1]		Option AVOL[-1,0]	
	(1)	(2)	(3)	(4)
MD_τ	0.0112**	0.0148***	0.0294**	0.0349***
	(0.0048)	(0.0047)	(0.0127)	(0.0123)
Constant	0.7055***	0.7284***	1.0592***	1.3450***
	(0.0021)	(0.0063)	(0.0054)	(0.0171)
Controls	No	Yes	No	Yes
Observations	111,871	111,871	58,516	58,516
Adj. R^2	0.0004	0.0497	0.0001	0.0760

where our main explanatory variable MD is a dummy-variable equal to 1 if macro news (i.e., FOMC decision, Nonfarm Payroll, ISM PMI, or Personal Consumption) coincides with micro news. We make sure that our results are not driven by omitted variable bias by including existing factors that affect stock market reactions to earnings news as control variables. We follow Hirshleifer and Sheng (2019) and include absolute earnings surprise quantile[10], market capitalization, share turnover, the number of analysts, the number of earnings announcements on the same day, lag return and return volatility of the last 21 trading days as X_i into our model.[11]

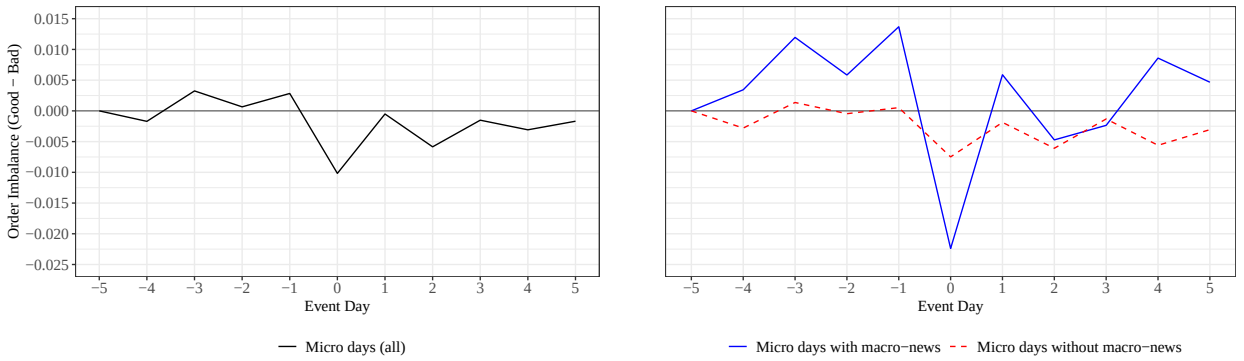
Table 2 presents the results of the regression in Equation (6). Among all the announcement days, the abnormal dollar volumes for stocks (SAVOL[0,1]) as well as options (OAVOL[-1,0]) are significantly higher on macro news days than on days without macro news. There-

[10]Following Hirshleifer and Sheng (2019) absolute earnings surprise quantile is a categorical variable that indicates the quantile of absolute earnings surprises with values from 1 to 11 to measure the magnitude of the difference between actual and expected earnings.

[11]We use the period from $\tau - 5$ to $\tau - 3$ ($\tau - 21$ to $\tau - 6$) as a benchmark for the abnormal option (stock) dollar volume. We have similar results when using the trading volume instead of the dollar volume for stocks and options.

Figure 3: Option Order Imbalance around Earnings Days

This figure shows abnormal option order imbalance from 5 days before to 5 days after earnings announcements with the value on day -5 set to zero. Earnings surprises (ES) in the 10th and 11th (1st and 2nd) quantiles are classified as good (bad) news. We combine good and bad ES days in the following way: $OI_j^{good-bad} = OI_j^{good} - OI_j^{bad}$, thus, independent of the type of news, positive $OI^{good-bad}$ points towards informed trading. The sample period is from January 2004 to October 2017.



(a) All event days

(b) Event day subsamples by macro news

fore, Table 2 reconfirms our previously discussed descriptive result more formally, namely that investor attention is enhanced when macro and micro news announcements coincide. This raises the question whether the observed enhanced option trading before news announcements is informative.

3.1.2 Option order imbalance

Our main predictive variable to approximate the informativeness of option market trades is option order imbalance. To get a first impression of the informativeness of OI on upcoming events, we use earnings surprise as a proxy for the information signal of the upcoming event. In Figure 3, we visualize option order imbalance combined for good and bad news in the following way:

$$OI_j^{good-bad} = OI_j^{good} - OI_j^{bad}, \tag{7}$$

where OI_j^{good} (OI_j^{bad}) is the option order imbalance of events in the 10th and 11th (1st and 2nd) earnings surprise quantile. This simply gives a measure that, independent of the news type (good or bad), should be positive before the event day if informed trading is prevalent. Figure 3 Panel (A) presents the mean daily $OI^{good-bad}$ from 5 days before to 5 days after earnings announcements.[12] On the days immediately before earnings news releases, option order imbalance is positive and slightly growing. This finding points towards the informativeness of options order flows about the upcoming earnings surprise. In other words, it seems that options traders execute orders in the right direction of the upcoming event. On the announcement day, option order imbalance is strongly negative, indicating that investors close their positions after earnings news is released. On the days after news announcements, OI reverts back towards zero but stays slightly negative. Combining the evidence from Figures 1 and 3, many option traders are aware of earnings announcements, but only a fraction of them can correctly predict whether actual earnings are higher or lower than the expectation.

After establishing a first empirical relationship between order imbalance and informed trading in general, we now turn to the more important question of whether macro releases influence the pattern of order imbalance around earnings announcements. Figure 3 (b) illustrates the option order imbalance around micro news *with macro releases* on the same day and option order imbalance around micro news *without macro releases* on the same day. The graph clearly shows that on earnings announcement days with macro news, the option order imbalance is much higher, which reflects more successful trading on information.

In the following chapter, we analyze the predictive power of option order imbalance. We aim to shed light on the macro news effect on informed trading in the option market.

[12] We winsorize the data on the 5% and 95% level. Calculating the median option order imbalance yields similar results.

3.2 Macro news effect and predictive power of options on stock returns

This section examines the predictive power of option order imbalance for subsequent stock returns both for earnings announcements on days with and without macro news. In particular, we are interested in whether the attention to earnings news of informed option traders is reinforced or distracted by macroeconomic news. We expect the predictive power of option trading on stock returns to rise (decrease) before macro news days, if option investors' attention to firm-specific news is enhanced (distracted) by macro news announcements.

We use option order imbalance on the day prior to earnings announcements to measure informed trading in the option market. First, we regress the immediate stock return response $CAR[0,1]$ on OI as a point of reference. In the next step, we regress $CAR[0,1]$ on OI, MD, and their product:

$$CAR[0,1] = \alpha + \beta_1 OI_{\tau-1} + \beta_2 MD_{\tau+d} + \beta_3 (OI_{\tau-1} \times MD_{\tau+d}) + \sum_{i=1}^{n} b_i X_i + \varepsilon_\tau, \tag{8}$$

where $OI_{\tau-1}$ is the option order imbalance on the day before the earnings announcement. All the other variables are the same as in Equation (6). The coefficient of most interest is β_3. It indicates how macro news arrival changes the predictive power of option market trading on stock returns.

We make sure that our forecasting results are not driven by higher standard deviation of stock returns on macro news days compared to earnings news days without macro news, and therefore, we standardize all variables separately for macro and non-macro news days prior to the predictive regression. Note that our results in general turn more significant if we do not standardize our variables in this way.

Columns (1) and (2) in Table 3 reveal predictive power of our informed trading measure, abnormal option order imbalance (OI), on cumulative abnormal stock returns on announcement days and the following day ($CAR[0,1]$). This predictability points towards information

Table 3: Predictive Power of Option Trading before Earnings News on Stock Return

This table reports the regression results from the abnormal cumulative stock return on option order imbalance, the macro news day dummy and their product. The sample period is from January 2004 to October 2017. CAR[0,1] is the cumulative abnormal return on the announcement day and the following day. OI is the order imbalance on the day prior to earnings announcements. $MD_{\tau+d}$ is the macro news day dummy variable and $d = 0$. Control variables include market capitalization, share turnover, the number of analysts, the number of earnings announcements on the same day, lag return and return volatility of the last 21 trading days. Heteroscedasticity-consistent (White (1980)) standard errors are in brackets. ***, ** and * note statistical significance of coefficients at the 1%, 5% and 10% level, respectively.

	CAR[0,1]			
	(1)	(2)	(3)	(4)
$OI_{\tau-1}$	0.0078*	0.0073*	0.0033	0.0025
	(0.0045)	(0.0045)	(0.0050)	(0.005)
$MD_{\tau+d}$			-0.0004	-0.0004
			(0.0115)	(0.0113)
$OI_{\tau-1} \times MD_{\tau+d}$			0.0250**	0.0269**
			(0.0118)	(0.0118)
Share turnover		-0.1509***		-0.1509***
		(0.0045)		(0.0132)
Market cap		-0.0166***		-0.0165***
		(0.0047)		(0.0032)
Analysts		0.0224***		0.0223***
		(0.0047)		(0.0048)
Earnings news		-0.0147***		-0.0148***
		(0.0044)		(0.0044)
Lag return		-0.0299***		-0.0299***
		(0.0044)		(0.0058)
Return volatility		0.0282***		0.0283***
		(0.0045)		(0.0073)
Constant	0.00004	0.0002	0.0001	0.0003
	(0.0044)	(0.0004)	(0.0049)	(0.0048)
Controls	No	Yes	No	Yes
Observations	51,522	51,522	51,522	51,522
Adj. R^2	0.00004	0.0223	0.00009	0.0224

advantages of option traders about upcoming micro news. In the last two columns, we include the interaction term of order imbalance and the macro-dummy ($OI_{\tau-1} \times MD_{\tau}$). Remarkably, the coefficient of the interaction term (β_3) is positive and significant[13] and the coefficient of

[13] p-value = 2.2%

OI (β_1) turns insignificant. This result reveals that all of the predictive power of OI (Column (1) and Column (2)) is driven by news days where micro and macro news announcements coincide. Quantifying the macro news effect shows that the predictive power of order imbalance in the model of Equation (8), presented in Column (3) (0.025+0.0033=0.0283), is 3.6 times as high as that in the model without interaction term (0.0078) in Column (1). This improvement of the efficiency of processing firm-specific news by sophisticated investors in the option market on macro news days is consistent with the attention allocation theory of Andrei, Friedman, and Ozel (2020). Before macro releases investors face heightened uncertainty not only about a firm's future cash-flow stream but also about discount rates.[14] Thus, uncertainty about the future stock price movement is higher and according to Andrei, Friedman, and Ozel (2020), investors' incentive to gather information increases, consistent with the increased predictive power we document. Hirshleifer and Sheng (2019) find that macro releases increase immediate stock markets reaction to earnings news. Note that informed option trading could rely to some extent on such efficient stock prices reactions. If earnings information released on macro-news days does in fact feed into stock prices more quickly,[15] informed option trading on the day before earnings news becomes more profitable. For sophisticated option investors who are aware of this attention-trigger effect in the stock market, this should be an additional incentive to process their proprietary information to the option market the day before earnings are released.

Heightened uncertainty due to upcoming macro news is not exclusively limited to days with simultaneous occurrence of firm-specific and macro-news events. We redefine our Macro-day indicator and examine cases in Table 4 where macro news is released one day before and one day after earnings announcements.[16] We expect that macro events one day before

[14]There is a clear relation between the discount rate and our macroeconomic event types. E.g. FOMC decisions are naturally linked to the discount factor, Nonfarm Payroll employment is linked through the Taylor rule, and Personal Consumption Expenditure though consumption-based asset pricing.

[15]In the appendix we repeat the analysis of Hirshleifer and Sheng (2019) for our sample (stocks that are underlying assets of options) and also find increased immediate stock return reaction on macro news days.

[16]Usually, FOMC decisions and Nonfarm Payroll news are released after 2 p.m., while ISM PMI and Personal Consumption news are released in the morning.

Table 4: Predictive Power of Option Trading and Lead/Lag Effects of Macro-News

This table reports the regression results from the abnormal cumulative stock return on option order imbalance, the macro news day dummy and their product. The sample period is from January 2004 to October 2017. CAR[0,1] is the cumulative abnormal return on the announcement day and the following day. OI is the order imbalance on the day prior to earnings announcements. MD$[\tau + d]$ is the macro news day dummy variable, where d indicates the occurrence of macro news relative to the micro-event day ($d = 0$). Control variables include market capitalization, share turnover, the number of analysts, the number of earnings announcements on the same day, lag return and return volatility of the last 21 trading days. Heteroscedasticity-consistent (White (1980)) standard errors are in brackets. ***, ** and * note statistical significance of coefficients at the 1%, 5% and 10% level, respectively.

	CAR[0,1]				
	MD[d=-1]	MD[d=-1,0]	MD[d=-1,0,1]	MD[d=0,1]	MD[d=1]
	(1)	(2)	(3)	(4)	(5)
$OI_{\tau-1}$	0.0014	-0.0018	-0.0038	0.0035	0.0070
	(0.0051)	(0.0055)	(0.0059)	(0.0053)	(0.0049)
$MD_{\tau+d}$	0.0100	0.0030	0.0060	0.0055	0.0156
	(0.0108)	(0.0094)	(0.0091)	(0.0100)	(0.0123)
$OI_{\tau-1} \times MD_{\tau+d}$	0.0268**	0.0274***	0.0271***	0.0143	0.0026
	(0.0109)	(0.0096)	(0.0092)	(0.0101)	(0.0122)
Constant	-0.0020	-0.0009	-0.0023	-0.0013	-0.0022
	(0.0049)	(0.0053)	(0.0056)	(0.0050)	(0.0047)
Controls	Yes	Yes	Yes	Yes	Yes
Observations	51,522	51,522	51,522	51,522	51,522
Adj. R^2	0.0224	0.0225	0.02247	0.0223	0.0224

earnings announcements likewise contribute to an increased ex ante uncertainty regarding the future stock price reaction. On the other hand, macro news released after the actual earnings announcement should no longer be that relevant, since the stock price reaction to earnings news already took place. Table 4 Column (1) shows that macro news that are released one day before earnings announcements indeed increase the predictive power of order imbalance on stock returns. The combination of macro releases on the day before ($d = -1$) and on the same day ($d = 0$) as micro news in Column (2) yields the highest and most significant (1%-level) interaction term among all specifications. This specification additionally has the advantage that it provides a broader set of release days that enter the interaction term ($OI_{\tau-1} \times MD_{\tau+d}$). Particularly, its predictability is 1.86% higher compared to macro releases only at ($d = 0$) and 2.24% higher relative to macro news at day ($d = -1$). As expected and reinforcing the uncertainty channel, we cannot find any predictability if macro news is released the day after micro news.[17]

In the following sections, we repeat the predictive regression analysis of our strongest result so far, namely that of Table 4 Column (2) with $MD[d = -1, 0]$, for various subgroups to examine where the predictive power of order imbalance is concentrated in.

3.3 Transaction costs and informed trading

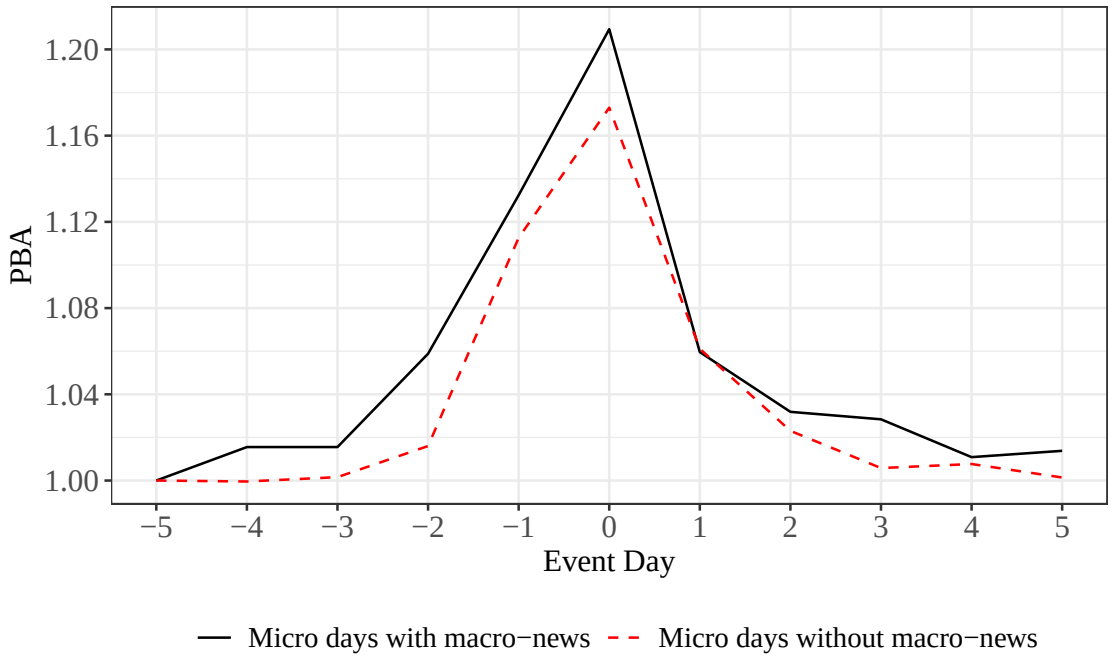
It is well documented in the literature that part of the option bid-ask spread (according to Ahn, Kang, and Ryu (2008) approximately one-third) can be accounted for by information asymmetry costs. Market makers raise the bid-ask spread in case they anticipate informed traders to be prevalent. Thus, we expect to see an increase in bid-ask spreads around news events, and the increase to be even more severe on days with macro-effects. Figure 4 confirms our expectation. Quoted bid-ask spreads[18] of equity options sharply increase around announcement days. Furthermore, the level of information asymmetry is higher on macro

[17] We also analyzed predictive regressions for MD up to five days away from the event day and did not find predictable patterns. Results can be provided upon request.

[18] The quoted bid-ask spread is defined as the difference of the best ask and the best bid price scaled by the midpoint.

Figure 4: Quoted Bid-Ask Spread of Options around Earnings Days

This figure shows the median daily quoted bid-ask spread of options from 5 days before to 5 days after earnings news days with (solid line) and without (dashed line) macro news on the same day. The sample period of option data is from January 2004 to October 2017. For the dashed line, none of the macroeconomic releases FOMC (Federal Open Market Committee) decision, Nonfarm Payroll, ISM PMI (Institute of Supply Management, Purchasing Managers' Index) or Personal Consumption is announced on the earnings release day. For the solid line, at least one of the four macroeconomic releases is announced on the earnings release day.



news days.[19] The difference between bid-ask spreads before micro news with macro news on the same day and that around micro news without macro news on the same day increases until the event day and suddenly drops on the day after the announcement. In detail, we find mean differences of 3.64 percentage points on the event day ($d = 0$). This implies that market makers expect macro news to attract the attention of informed equity option traders or enhances option traders' reaction to earnings news. After news is announced, information asymmetry shrinks, and thus, market makers adjust spreads downwards. The higher the distance from the event, the higher the probability that the macro-effect is confound through other effects. Thus, the difference between the two lines at $t = 3$ should not be

[19]Using the option effective spread instead yields similar, but less severe differences.

Table 5: Predictive Power of Option Trading and Bid-Ask Spread

This table reports the regression results from the abnormal cumulative stock return on option order imbalance, the macro news day dummy and their product. We sort event-stock observations by their effective bid-ask spread into five groups. Columns (1) and (2) present the results for stocks in the highest effective option bid-ask spread group, Columns (3) and (4) for stocks in the lowest effective option bid-ask spread group. The sample period is from January 2004 to October 2017. CAR[0,1] is the cumulative abnormal return on the earnings release day and the following day. OI is the order imbalance on the day prior to earnings announcements. $MD_{\tau+d}$ is the macro news day dummy variable and $d = -1, 0$. Control variables include market capitalization, share turnover, the number of analysts, the number of earnings announcements on the same day, lag return and return volatility of the last 21 trading days. Heteroscedasticity-consistent (White (1980)) standard errors are in brackets. ***, ** and * note statistical significance of coefficients at the 1%, 5% and 10% level, respectively.

	CAR[0,1]			
	High EBA		Low EBA	
	(1)	(2)	(3)	(4)
$OI_{\tau-1}$	0.0177*	0.0174*	-0.0077	-0.0076
	(0.0099)	(0.0099)	(0.0156)	(0.0152)
$MD_{\tau+d}$	-0.0010	-0.0012	-0.0113	-0.0084
	(0.0227)	(0.0230)	(0.0181)	(0.0180)
$OI_{\tau-1} \times MD_{\tau+d}$	0.0005	0.0014	0.0560*	0.0562*
	(0.0169)	(0.0168)	(0.0304)	(0.0300)
Constant	0.0137	0.0053	0.0072	0.0211*
	(0.0138)	(0.0171)	(0.0095)	(0.0109)
Controls	No	Yes	No	Yes
Observations	10,183	10,183	10,337	10,337
Adj. R^2	0.0002	0.0065	0.0002	0.0263

overinterpreted.

The high quoted spreads around news events are consistent with high asymmetric information, which is further amplified when the two news events coincide. At the same time, however, we know that informed investors prefer lower cost assets to ensure profitability of their trading. Fairly high bid-ask spreads around earnings news are thus a plausible explanation for the rather low predictive power of OI on stock returns during earnings release days compared to a full time-series analysis of predictability like in Hu (2014). Taking the even higher transaction costs on macroeconomic days into account, the result that predictive

power is higher on these days is even more impressive.

Lin and Lu (2015) conduct a regression test and find that the predictive power of option trading on index returns drops with the bid-ask spread of options. Andrei, Friedman, and Ozel (2020) also point out that the benefit of collecting information needs to outweigh its costs to induce investors to acquire information and trade on them. Inspired by their finding, we evaluate our expectation that informed investors prefer lower cost assets to ensure profitability of their trading.

The quoted bid-ask spread we analyze in Figure 4 represents market makers' opinion about information asymmetry in the market and includes also information on non-traded option prices from the order book. Muravyev and Pearson (2020) point out that actual option trading costs are lower than shown by such a conventional measure. The effective bid-ask spread (EBA)[20] is a more realistic and more accurate measure of actually paid transaction costs as it takes transaction prices into account. In the following, we use the effective bid-ask spread to approximate trading costs of option investors on the day prior to the earnings announcement day. We divide our observations into five groups based on effective option bid-ask spread on the day prior to the event.[21] Then, we repeat the predictive regression analysis for the highest and lowest EBA group.

Table 5 shows the regression results for the 1$^{\text{st}}$ (Low EBA) and 5$^{\text{th}}$ (High EBA) quintile of EBA. The coefficient of $\text{OI}_{\tau-1}\times\text{MD}_{\tau-1,\tau}$ in Columns (1) and (2) is not significant when the EBA of options is high. For the group with low EBA, the coefficient of the interaction term is statistically and economically significant. Columns (3) and (4) suggest a higher predictive power of order imbalance for stocks with highly liquid options. The coefficient increases by

[20]EBA is defined as the absolute difference of the transaction price and the midpoint scaled by the midpoint.

[21]For all event days occurring in the same week we calculate quintiles based on the mean effective option spread per stock and based on this we divide our sample into five groups. We choose a weekly basis to account for time-dependent changes in spreads, as well as, to ensure a balanced sample of macro and non-macro days in the groups. Using this procedure yields a similar percentage of macro days per group compared to the percentage of all macro days in our sample as shown in Table 1. For our sample a weekly basis is clearly preferable to a daily sorting basis, because daily grouping excludes announcement days with less than 5 stock-event observations.

more than 100% compared to our full sample result in Table 4 Column (2).[22] Beyond that, and in contrast to our previous findings, for the group with high EBA the coefficient of OI on non-macro days is statistically significant. A possible explanation is that due to the positive correlation between the effective and quoted bid-ask spread, high EBA also points towards high asymmetric information. The result of significant predictability on non-macro days compared to insignificant predictability on macro days in the low EBA group, could imply that due to relatively lower spreads on non-macro days informed trading is still profitable. In sum, our results imply that informed traders prefer liquid options to trade on their private information.

3.4 Predictability of stock returns and potential profit

After we established a relationship between transaction costs and informed trading, we now come to potential profit. We use absolute earnings surprises to approximate potential profit for informed traders. In the same way as in the previous section, we divide our sample into five groups, this time, based on absolute earnings surprise quintiles.

Columns (1) and (2) in Table 6 report the predictive regression results of option order imbalance on stock returns for the lowest quintile of absolute earnings surprises |ES|, Columns (3) and (4) for the highest quintile. For low |ES|, the coefficient of $\mathrm{OI}_{\tau-1}\times\mathrm{MD}_{\tau+d}$ is not significant, while for high |ES| the interaction term has significant predictive power. For example, Column (4) indicates that for the subsample of trading on valuable information the predictive regression coefficient of the interaction term more than doubles (compared to Table 4 Column (2)). Summing up, our finding suggests that informed traders trade only on valuable private information.

Finally, to test the hypothesis that informed investors only trade when their information is profitable enough after costs, we conduct conditional double sorts: In the first stage, we sort micro news events into tertile groups based on the absolute earnings surprise; in the

[22]The lower statistical significance in Table 5 Column (4) compared to Table 4 Column (2) can probably be traced back to the five times lower number of observations in the quintile regressions.

Table 6: Predictive Power of Option Trading and Absolute Earnings Surprise

This table reports the regression results from the abnormal cumulative stock return on option order imbalance, the macro news day dummy and their product. We sort each stock-event observation on a weekly basis by the absolute earnings surprise into five groups. Columns (1) and (2) present the results for stocks in the lowest absolute earnings surprise group, Columns (3) and (4) for stocks in the highest absolute earnings surprise group. The sample period is from January 2004 to October 2017. CAR[0,1] is the cumulative abnormal return on the earnings release day and the following day. OI is the order imbalance on the day prior to earnings announcements. $MD_{\tau+d}$ is the macro news day dummy variable and $d = -1, 0$. Control variables include market capitalization, share turnover, the number of analysts, the number of earnings announcements on the same day, lag return and return volatility of the last 21 trading days. Heteroscedasticity-consistent (White (1980)) standard errors are in brackets. ***, ** and * note statistical significance of coefficients at the 1%, 5% and 10% level, respectively.

	CAR[0,1]			
	Low |ES|		High |ES|	
	(1)	(2)	(3)	(4)
$OI_{\tau-1}$	-0.0053	-0.0074	0.0155	0.0153
	(0.0087)	(0.0083)	(0.0141)	(0.0141)
$MD_{\tau+d}$	-0.0141	-0.0159	0.0658*	0.0617*
	(0.0210)	(0.0198)	(0.0336)	(0.0337)
$OI_{\tau-1} \times MD_{\tau+d}$	0.0337	0.0289	0.0578*	0.0565*
	(0.0210)	(0.0200)	(0.0316)	(0.0315)
Constant	-0.1252***	-0.1539***	0.0040	0.0385**
	(0.0088)	(0.0109)	(0.0147)	(0.0166)
Controls	No	Yes	No	Yes
Observations	10,323	10,323	10,284	10,284
Adj. R^2	0.00003	0.1101	0.0009	0.0366

second stage, we sort stocks, within each |ES|-tertile, into tertile groups based on the average option effective spread (EBA). Again, we construct weekly rolling window groups.

Table 7 shows that OI on macro-days is only informative when absolute earnings surprise is high and transaction costs are low. In this case, the coefficient of the interaction term doubles compared to the single group sorts (Table 5 and 6) and is four times higher than in the full sample (Table 4). In the cases of low earnings surprise with low spreads and low earnings surprise with high spreads, order imbalance has no significant predictive power on stock returns at all. Interestingly, order imbalance turns significant on event days without

Table 7: Predictive Power of Option Trading and Profit after Costs

This table reports the regression results from the abnormal cumulative stock return on option order imbalance, the macro news day dummy and their product. We perform conditional double sorts per week. First, we sort each stock-event observation on a weekly basis by the absolute earnings surprise (|ES|) into three groups. Second, we sort stocks based on the effective option bid-ask spread (EBA) into three groups. Column (1) presents the results for the highest |ES| tertile and the lowest EBA tertile, (2) presents the results for the lowest |ES| tertile and the lowest EBA tertile, (3) presents the results for the highest |ES| tertile and the highest EBA tertile and (4) presents the results for the lowest |ES| tertile and the highest EBA tertile. The sample period is from January 2004 to October 2017. CAR[0,1] is the cumulative abnormal return on the earnings release day and the following day. OI is the order imbalance on the day prior to earnings announcements. $MD_{\tau+d}$ is the macro news day dummy variable and $d = -1, 0$. Control variables include market capitalization, share turnover, the number of analysts, the number of earnings announcements on the same day, lag return and return volatility of the last 21 trading days. Heteroscedasticity-consistent (White (1980)) standard errors are in brackets. ***, ** and * note statistical significance of coefficients at the 1%, 5% and 10% level, respectively.

	CAR[0,1]			
	High |ES| Low EBA	Low |ES| Low EBA	High |ES| High EBA	Low |ES| High EBA
	(1)	(2)	(3)	(4)
$OI_{\tau-1}$	-0.0126	0.0048	0.0289*	0.0047
	(0.0217)	(0.0167)	(0.0167)	(0.0102)
$MD_{\tau+d}$	0.0002	-0.0064	-0.0068	-0.0005
	(0.0311)	(0.0211)	(0.0367)	(0.0234)
$OI_{\tau-1} \times MD_{\tau+d}$	0.1103***	-0.0274	0.0028	-0.0003
	(0.0418)	(0.0308)	(0.0274)	(0.0178)
Constant	0.0985***	-0.0853***	0.0938***	-0.1075***
	(0.0159)	(0.0155)	(0.0333)	(0.0241)
Controls	Yes	Yes	Yes	Yes
Observations	5,743	5,743	5,662	5,716
Adj. R^2	0.0035	0.0950	0.0047	0.0449

macro news when earnings surprise is high and the effective spread is high. A possible explanation is that higher effective spreads also point towards more informed trading in the market and therefore option markets lead stock markets. At the same time, due to much higher spreads on macro news days (as Figure 4 shows) the profitability of informed trading is absorbed by costs (represented by an insignificant interaction term).

3.5 Systematic and idiosyncratic risk and informed trading

Besides option trading cost and earnings surprise, the level of systematic and idiosyncratic uncertainty are further cross-sectional differences that might affect the cost/benefit ratio of information gathering. In the model of Andrei, Friedman, and Ozel (2020) a firm's payoff consists of a systematic and idiosyncratic component. If two firms (only) differ in their market beta, the model suggests that investors find the information on the earnings announcement of the higher beta firm more valuable. Also, the benefit of information is relatively greater for firms with higher idiosyncratic volatility.

To further explore this issue, we analyze the trading preferences of informed option investors with regard to stock characteristics, specifically a stock's market beta and idiosyncratic volatility. In doing so, we want to investigate whether more risky stocks lead to a higher fraction of potentially informed investors and particularly so on macro days. Using the same sorting procedure as before, we divide our observations into five groups based on a stocks' market beta and idiosyncratic volatility, respectively. Tables 8 and 9 confirm the intuition of the model of Andrei, Friedman, and Ozel (2020). Table 8 reports the regression result of option order imbalance on future stock returns for the lowest market beta quintile (Columns 1 and 2) and for the highest market beta quintile (Columns 3 and 4). Comparing high to low market beta regression results yields that the predictability of order imbalance more than doubles on macro release days for firms with larger exposures to systematic risk.[23] Columns (1) and (2) in Table 9 show regression results for stocks in the lowest idiosyncratic volatility quintile, Columns (3) and (4) for the highest idiosyncratic volatility quintile. For stocks with low idiosyncratic volatility, the coefficient of $\mathrm{OI}_{\tau-1}\times\mathrm{MD}_{\tau}$ is not significant, while for stocks with high idiosyncratic volatility the interaction term has significant predictive power.

[23]Note that for this analysis we look only at macro releases that occur on the day of the earnings announcement (MD_{τ}) to ensure that systematic uncertainty is high enough to be in accordance with the model of Andrei, Friedman, and Ozel (2020). The model suggests that differences in stock's market betas between two firms are more valuable to investors if macroeconomic uncertainty is high. Including also $MD_{\tau-1}$ into the interaction term still reveals higher coefficients for high market beta groups compared to low market beta groups but the difference is less severe.

Table 8: Predictive Power of Option Trading and Systematic Risk

This table reports the regression results from the abnormal cumulative stock return on option order imbalance, the macro news day dummy and their product. We sort each stock-event observation on a weekly basis by the absolute earnings surprise into five groups. Columns (1) and (2) present the results for stocks in the lowest market beta group, Columns (3) and (4) for stocks in the highest market beta group. Market beta is estimated using the market model (see Chapter 2.5.3 for more details). The sample period is from January 2004 to October 2017. CAR[0,1] is the cumulative abnormal return on the earnings release day and the following day. OI is the order imbalance on the day prior to earnings announcements. $MD_{\tau+d}$ is the macro news day dummy variable and $d = -1, 0$. Control variables include market capitalization, share turnover, the number of analysts, the number of earnings announcements on the same day, lag return and return volatility of the last 21 trading days. Heteroscedasticity-consistent (White (1980)) standard errors are in brackets. ***, ** and * note statistical significance of coefficients at the 1%, 5% and 10% level, respectively.

	CAR[0,1]			
	Low Market Beta		High Market Beta	
	(1)	(2)	(3)	(4)
$OI_{\tau-1}$	-0.0043	-0.0034	-0.0041	-0.0079
	(0.0093)	(0.0091)	(0.0143)	(0.0142)
MD_{τ}	0.0167	0.0152	-0.0225	-0.0265
	(0.0197)	(0.0197)	(0.0318)	(0.0316)
$OI_{\tau-1} \times MD_{\tau}$	0.0418**	0.0383**	0.0885***	0.0968***
	(0.0188)	(0.0186)	(0.0343)	(0.034)
Constant	0.0031	-0.0283	-0.0113	0.0277**
	(0.0088)	(0.0146)	(0.0136)	(0.0124)
Controls	No	Yes	No	Yes
Observations	10017	10017	10180	10180
Adj. R^2	0.0000	0.0287	0.0005	0.0214

This former subsample analyses indicate that the predictive power of option order imbalance is concentrated in firms with a high exposure to systematic risk and high idiosyncratic volatility.

4 Robustness Checks

We perform a number of robustness checks to ensure that our results are not driven by the specific design of our option order imbalance measure. We find that our main results are robust to a variety of option order imbalance measures.

Table 9: Predictive Power of Option Trading and Idiosyncratic Volatility

This table reports the regression results from the abnormal cumulative stock return on option order imbalance, the macro news day dummy and their product. We sort each stock-event observation on a weekly basis by the absolute earnings surprise into five groups. Columns (1) and (2) present the results for stocks in the lowest idiosyncratic volatility group, Columns (3) and (4) for stocks in the highest idiosyncratic volatility group. Idiosyncratic volatility (IVOL) is the standard deviation of the residuals of the market model estimated using daily stock returns (see Chapter 2.5.3 for more details). The sample period is from January 2004 to October 2017. CAR[0,1] is the cumulative abnormal return on the earnings release day and the following day. OI is the order imbalance on the day prior to earnings announcements. $\text{MD}_{\tau+d}$ is the macro news day dummy variable and $d = -1, 0$. Control variables include market capitalization, share turnover, the number of analysts, the number of earnings announcements on the same day, lag return and return volatility of the last 21 trading days. Heteroscedasticity-consistent (White (1980)) standard errors are in brackets. ***, ** and * note statistical significance of coefficients at the 1%, 5% and 10% level, respectively.

	CAR[0,1]			
	Low IVOL		High IVOL	
	(1)	(2)	(3)	(4)
$\text{OI}_{\tau-1}$	0.0037	0.0038	0.0159	0.0118
	(0.007)	(0.0068)	(0.0172)	(0.0173)
$\text{MD}_{\tau+d}$	-0.0002	0.0069	0.0258	0.0146
	(0.0115)	(0.0116)	(0.0298)	(0.0298)
$\text{OI}_{\tau-1} \times \text{MD}_{\tau+d}$	0.0098	0.0091	0.0638**	0.0679**
	(0.0123)	(0.0121)	(0.0298)	(0.0297)
Constant	0.0054	-0.0659**	-0.0458***	0.0515***
	(0.0065)	(0.0285)	(0.0172)	(0.0191)
Controls	No	Yes	No	Yes
Observations	10019	10019	10167	10167
Adj. R^2	0.0000	0.02424	0.00097	0.02118

4.1 Dollar-volume-weighted option order imbalance

First, we check the robustness of our main order imbalance measure (see Equation (7)) by multiplying each transaction additionally with the respective option price:

$$VOI_{k,j} = \frac{\sum_{i=1}^{n} sign_{k,j,i} \cdot size_{k,j,i} \cdot O_{k,j,i}}{\sum_{i=1}^{n} size_{k,j,i} \cdot O_{k,j,i}}, \tag{9}$$

where $sign_{k,j,i}$ represents the informational signal of an option trade i of the underlying stock k on day j. $size$ is the number of traded contracts and O corresponds to the option

Table 10: Predictive Power of Volume-Weighted Option Order Imbalance

This table reports the regression results from the abnormal cumulative stock return on option order imbalance, the macro news day dummy and their product. Columns (1) and (2) present predictive regression results for the whole sample. Columns (3) and (4) present the results of the conditional double sort: In the first stage, we sort micro news events into tertile groups based on the absolute earnings surprise; in the second stage, we sort stocks, within each |ES|-tertile, into tertile groups based on the average option effective bid-ask spread (EBA). Columns (3) and (4) summarize the results for high |ES| events and low EBA. The sample period is from January 2004 to October 2017. CAR[0,1] is the cumulative abnormal return on the earnings release day and the following day. VOI is the dollar volume-weighted order imbalance on the day prior earnings announcements. $MD_{\tau+d}$ is the macro news day dummy variable and $d = -1, 0$. Control variables include market capitalization, share turnover, the number of analysts, the number of earnings announcements on the same day, lag return and return volatility of the last 21 trading days. Heteroscedasticity-consistent (White (1980)) standard errors are in brackets. ***, ** and * note statistical significance of coefficients at the 1%, 5% and 10% level, respectively.

	CAR[0,1]			
	ALL		High |ES| & Low EBA	
	(1)	(2)	(3)	(4)
$VOI_{\tau-1}$	0.0000	-0.0011	-0.0335	-0.0358
	(0.0050)	(0.0050)	(0.0218)	(0.0220)
$MD_{\tau+d}$	-0.0004	-0.0004	0.0526	0.0479
	(0.0115)	(0.0113)	(0.0413)	(0.0415)
$VOI_{\tau-1} \times MD_{\tau+d}$	0.0253**	0.0253**	0.1390***	0.1396***
	(0.0120)	(0.0118)	(0.0512)	(0.0513)
Constant	0.0001	0.0003	0.0438***	0.0523***
	(0.0049)	(0.0048)	(0.0162)	(0.0143)
Controls	No	Yes	No	Yes
Observations	51,522	51,522	5,740	5,740
Adj. R^2	0.0001	0.0224	0.0011	0.0059

transaction price.

We perform the regression analysis as in Equation (8) for the full sample and additionally look at the sample split into high |ES| and low EBA as in Table 7 using dollar-volume weighted option order imbalance (VOI). Table 10 shows regression results when the dollar-volume-weighted measure of option order imbalance is used as predictive variable. Compared to Table 4 Column (2), Columns (1) and (2) exhibit similar predictive power of option trading on stock returns when micro and macro news coincide. Our double-sorting results

by profitability and costs are presented in Columns (3) and (4). Again, the results suggest that our main analysis is robust to dollar-volume weighting order imbalance.

4.2 Out-of-the-money option order imbalance

Informed traders may prefer out-of-the-money options to other options due to higher liquidity and higher leverage, indicating that out-of-the-money options reveal more information on stock prices than other options (see, for instance, Pan and Poteshman (2006)).

We follow Christoffersen, Goyenko, Jacobs, and Karoui (2017), Driessen, Maenhout, and Vilkov (2009), and Bollen and Whaley (2004) and define out-of-the-money options according to its delta that we take from OptionMetrics by $|\text{delta}^{OTM}| < 0.375$. Then we calculate order imbalance as in Equation (7) with a subset of our option data that contains only out-of-the-money options.

Table 11 reports the results of the robustness check repeating the regressions of Table 4 Column (2) and Table 7 by using out-of-the-money option order imbalance (OTM-OI). Table 11 confirms that macroeconomic news enhances the predictive power of out-of-the-money options on stock returns. However, the coefficient of the interaction term OTM-$\text{OI}_{\tau-1}\times\text{MD}_{\tau}$ is statistically and economically slightly lower than the coefficient in Table 3 and Table 4, suggesting that out-of-the-money options do not carry a higher information content compared to in-the-money and at-the-money options. This is consistent with the results of Hu (2014) who finds that in his setting, return predictability does not stem from OTM options at all and only ITM and ATM options carry information. Hu explains that OTM options are used by sophisticated investors for hedging purposes in volatility trading and this adds noise to the informed trading measure.

Table 11: Predictive Power of Out-Of-The-Money Options

This table reports the regression results from the abnormal cumulative stock return on option order imbalance, the macro news day dummy and their product. Columns (1) and (2) present predictive regression results for the whole sample. Columns (3) and (4) present the results of the conditional double sort: In the first stage, we sort micro news events into tertile groups based on the absolute earnings surprise; in the second stage, we sort stocks, within each |ES|-tertile, into tertile groups based on the average option effective spread (EBA). Columns (3) and (4) summarize the results for high |ES| events and low EBA. The sample period is from January 2004 to October 2017. CAR[0,1] is the cumulative abnormal return on the earnings release day and the following day. OTM-OI is the out-of-money order imbalance on the day prior to earnings announcements. $\text{MD}_{\tau+d}$ is the macro news day dummy variable and $d = -1, 0$. Control variables include market capitalization, share turnover, the number of analysts, the number of earnings announcements on the same day, lag return and return volatility of the last 21 trading days. Heteroscedasticity-consistent (White (1980)) standard errors are in brackets. ***, ** and * note statistical significance of coefficients at the 1%, 5% and 10% level, respectively.

	CAR[0,1]			
	ALL		high |ES| & Low EBA	
	(1)	(2)	(3)	(4)
$\text{OTM-OI}_{\tau-1}$	-0.0036	-0.0052	-0.0206	-0.0245
	(0.0049)	(0.0049)	(0.0180)	(0.0180)
$\text{MD}_{\tau+d}$	-0.0026	-0.0014	0.0507	0.0459
	(0.0116)	(0.0115)	(0.0415)	(0.0417)
$\text{OTM-OI}_{\tau-1} \times \text{MD}_{\tau+d}$	0.0207*	0.0201*	0.0825*	0.0818*
	(0.0116)	(0.0115)	(0.0423)	(0.0422)
Constant	0.0003	0.0258	0.0459***	0.0552***
	(0.0049)	(0.0049)	(0.0163)	(0.0145)
Controls	No	Yes	No	Yes
Observations	49,863	49,863	5,642	5,642
Adj. R^2	0.0000	0.0226	0.0003	0.0050

4.3 Delta-weighted option order imbalance

Inspired by Hu (2014) we test the predictive power of a measure of order imbalance that considers the exposure to the underlying stock price in the following way:

$$DOI_{k,j} = \frac{\sum_{i=1}^{n} sign_{k,j,i} \cdot |\Delta_{k,j,i}| \cdot size_{k,j,i}}{\sum_{i=1}^{n} |\Delta_{k,j,i}| \cdot size_{k,j,i}}, \tag{10}$$

Table 12: Predictive Power of Delta-Weighted Option Order Imbalance

This table reports the regression results from the abnormal cumulative stock return on option order imbalance, the macro news day dummy and their product. Columns (1) and (2) present predictive regression results for the whole sample. Columns (3) and (4) present the results of the conditional double sort: In the first stage, we sort micro news events into tertile groups based on the absolute earnings surprise; in the second stage, we sort stocks, within each |ES|-tertile, into tertile groups based on the average option effective spread (EBA). Columns (3) and (4) summarize the results for high |ES| events and low EBA. The sample period is from January 2004 to October 2017. CAR[0,1] is the cumulative abnormal return on the earnings release day and the following day. *DOI* is the delta-weighted order imbalance on the day prior to earnings announcements. $\text{MD}_{\tau+d}$ is the macro news day dummy variable and $d = -1, 0$. Control variables include market capitalization, share turnover, the number of analysts, the number of earnings announcements on the same day, lag return and return volatility of the last 21 trading days. Heteroscedasticity-consistent (White (1980)) standard errors are in brackets. ***, ** and * note statistical significance of coefficients at the 1%, 5% and 10% level, respectively.

	CAR[0,1]			
	ALL		high |ES| & Low EBA	
	(1)	(2)	(3)	(4)
$\text{DOI}_{\tau-1}$	0.0062	0.0054	-0.0331	-0.0346
	(0.0050)	(0.0050)	(0.0222)	(0.0221)
$\text{MD}_{\tau+d}$	-0.0002	-0.0003	0.0561	0.0514
	(0.0115)	(0.0113)	(0.0411)	(0.0412)
$\text{DOI}_{\tau-1} \times \text{MD}_{\tau+d}$	0.0189	0.0202*	0.1346**	0.1353**
	(0.0119)	(0.0118)	(0.0555)	(0.0553)
Constant	0.0000	0.0002	0.0432***	0.0516***
	(0.0049)	(0.0048)	(0.0162)	(0.0143)
Controls	No	Yes	No	Yes
Observations	51,480	51,480	5,739	5,739
Adj. R^2	0.0001	0.0225	0.0010	0.0059

where $DOI_{k,j}$ is the delta-weighted order imbalance of stock k on day j and $sign_{k,j,i}$ is a dummy variable equal to one if the i-th option trade is a buyer-initiated call or seller-initiated put and negative one if it is a seller-initiated call or buyer-initiated put. The $\Delta_{k,j,i}$ is an options' delta and $size_{k,j,i}$ denotes the trade size. The net delta position of option traders is represented by the numerator, while the denominator scales the position by the delta-weighted total number of trades.

Table 12 yields only little predictive power of delta-weighted order imbalance if the whole

sample is considered, which is in line with the event-based results of Hu (2014). If profitable investments with high absolute earnings surprise and low costs are considered, the coefficient of DOI is almost four times as high as in the full sample ($(0.1353-0.0346)/(0.0202+0.0054)$). Thus, our main results are also robust towards delta-weighting order imbalance.

4.4 Buyer- initiated option order imbalance

As discussed by Frazzini and Pedersen (2012), investors prefer buying options to short-selling because short positions are associated with large margin requirements, whereas the long positions limit the potential loss to minus 100%. We follow the existing literature (see for instance Pan and Poteshman (2006) or Ge, Lin, and Pearson (2016)) and assume that buyer-initiated option trades are more informative than seller-initiated option trades. Correspondingly, the last variation we use to check the robustness of our main results is order imbalance of call options before positive earnings surprises and the order imbalance of put options before negative earnings surprises:[24]

$$BI\text{-}OI_{\tau-1} = \begin{cases} OI_{call,\tau-1}, & \text{if } ES_\tau > 0, \\ OI_{put,\tau-1}, & \text{if } ES_\tau < 0. \end{cases} \tag{11}$$

Thus, we construct a forward looking measure and assume informed traders are aware of the realization of tomorrows earnings news. We measure the potential information content of informed investors by earnings surprise (ES), which is the difference between I/B/E/S median earnings estimates and actual released earnings. Then, we assume an informed investor will take the most cost-efficient way of trading her private information. In particular, she will buy a call option if she has positive information and buy put options in the case she has bad information about a company.[25]

[24]Note that we calculate buyer-initiated order imbalance by the number of trades. Using volume-weighted order imbalance yields similar results.

[25]For the sake of completeness, we also consider seller-initiated order imbalance in the Appendix. Weinbaum, Fodor, Muravyev, and Cremers (2020) show in a theoretical setting that informed traders will prefer

Table 13: Predictive Power of Buyer-Initiated Option Order Imbalance

This table reports the regression results from the abnormal cumulative stock return on option order imbalance, the macro news day dummy and their product. Columns (1) and (2) present predictive regression results for the whole sample. Columns (3) and (4) present the results of the conditional double sort: In the first stage, we sort micro news events into tertile groups based on the absolute earnings surprise; in the second stage, we sort stocks, within each |ES|-tertile, into tertile groups based on the average option effective bid-ask spread (EBA). Columns (3) and (4) summarize the results for high |ES| events and low EBA. The sample period is from January 2004 to October 2017. CAR[0,1] is the cumulative abnormal return on the earnings release day and the following day. BI-OI is the buyer-initiated order imbalance of calls (puts) on the day prior to positive (negative) earnings announcements. $MD_{\tau+d}$ is the macro news day dummy variable and $d = -1, 0$. Control variables include market capitalization, share turnover, the number of analysts, the number of earnings announcements on the same day, lag return and return volatility of the last 21 trading days. Heteroscedasticity-consistent (White (1980)) standard errors are in brackets. ***, ** and * note statistical significance of coefficients at the 1%, 5% and 10% level, respectively.

	CAR[0,1]			
	ALL		high |ES| & Low EBA	
	(1)	(2)	(3)	(4)
BI-OI$_{\tau-1}$	0.0546***	0.0630***	0.0678***	0.0747***
	(0.0053)	(0.0054)	(0.0224)	(0.0224)
$MD_{\tau+d}$	-0.0000	0.0000	0.0005	-0.0017
	(0.0127)	(0.0126)	(0.0330)	(0.0330)
BI-OI$_{\tau-1}\times MD_{\tau+d}$	0.0246*	0.0218*	0.0809**	0.07920**
	(0.0133)	(0.0130)	(0.0373)	(0.0373)
Constant	-0.0000	-0.0000	0.0263	0.0356**
	(0.0054)	(0.0053)	(0.0187)	(0.0167)
Controls	No	Yes	No	Yes
Observations	41,990	41,990	5,321	5,321
Adj. R^2	0.0035	0.02385	0.0058	0.00123

Measuring order imbalance in this way yields a combined measure of volatility hedging and informed trading. In the case an investor is not trading on his private information, but forming straddles to trade on volatility, this will increase the order imbalance of call and put options in the direction of informative trading. However, to the best of our knowledge, effects of economy-wide news announcements on volatility hedging in equity option markets

short option positions ahead of scheduled news releases. In the Appendix A.2 we provide regression results for seller-initiated order imbalance in Table A2. For the full sample, we find that seller-initiated order imbalance in general has predictive power on abnormal stock returns. However, macro news do not seem to play an important role in the case of seller-initiated order imbalance.

is also not yet documented and, thus, this combined measure is worth looking at.

We find that macroeconomic news enhances the coefficient of buyer-initiated option order imbalance. In general, the results reported in Table 13 are statistically and economically more significant than the results with the classical measure of order imbalance. In contrast to all other specifications, buyer-initiated option order imbalance significantly predicts stock returns on earnings announcement days without macro releases. We cannot say whether this is caused by enhanced volatility hedging or informed trading before news releases.

In summary, four alternative measures of option order imbalance maintain that the estimated coefficient β_3 in Equation (8) is economically and statistically significant. This indicates that around earnings days, option trading contains information about future underlying stock values, when investor attention is increased by macro news.

5 Conclusions

We contribute to the existing literature by analyzing the attention effects that economy-wide (macro) news releases have on informed option traders. Thus, our paper complements the literature on informed option trading and investor attention.

Macro releases attract the attention of privately informed option traders to the firm-specific news content through rising the incentive to collect firm-specific information. Thereby, macro releases increase the efficiency of information processing into the option market on the day prior to news announcements. We show this by comparing the predictive power of option order imbalance on cumulative stock returns when firm-specific earnings (micro) news is released on macro news days to the predictive power on micro news days without macro news. We find that the increased attention by macro news is the main driver of the predictive power of option order imbalance on stock price reactions to micro news.

Furthermore, we shed light on the trading preferences of informed option investors. Our analyses indicate that informed investors prefer options with low effective bid-ask spreads

and news days on which the unexpected news part (absolute earnings surprise) is high. In accordance with the current literature, we find that informed investors trade stocks with high market beta and high idiosyncratic volatility. Our results are robust to a variety of different option order imbalance measures.

The results of this paper are subject to a number of limitations. The order imbalance measure relies on the estimation of buyer and seller-initiated option trades. This, of course, yields a noisy measure of informed trading. It would be interesting to see how our results could be enhanced with data that provides signed option trading information. Clearly, investor attention is not only driven by macro releases. There must be other economically relevant events worth exploring, such as elections or political tensions. These open questions are left for future work.

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A Appendix

A.1 Stock return around micro and macro news days

Increasing option trading on earnings release days is severe. The sign of the order imbalance even turns to the opposite side after peeking (slumping) on the preceding day. This might be a result of the stock price reaction to earnings news such that options are not so profitable any more as on the days prior to the news releases. Apart from the stock volume, we also examine the stock return response to micro and macro news. First, we graphically look at the mean stock return from 5 days before to 5 days after good and bad earnings news with and without macro news on the same day.

Figure A1 illustrates that the stock return on good earnings news days with macro news is considerably higher than that on good earnings news days without macro news. Following Hirshleifer and Sheng (2019), we further analyze the effect of macro news on stock return response to earnings news with regressions. As discussed in Section 2.5.3, we use the market-adjusted cumulative abnormal return $CAR[0,1]$ to measure the immediate reaction and use $CAR[2,61]$ to measure the post-earnings announcement drift:

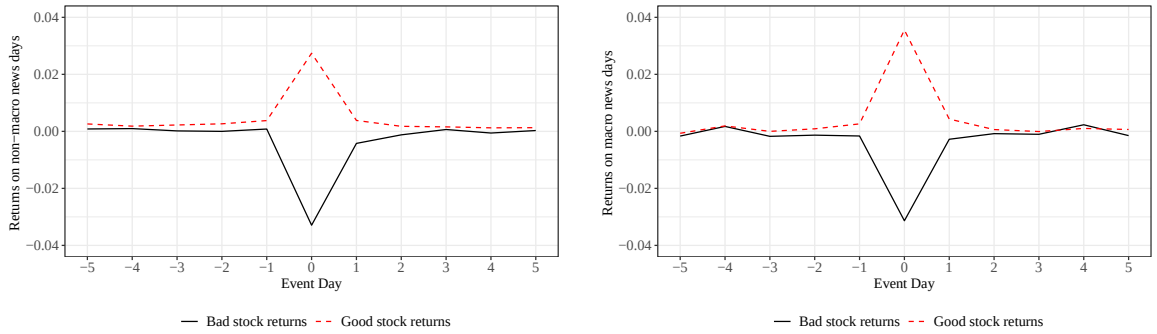
$$CAR = \alpha + \beta_1 ESqtl + \beta_2 MD + \beta_3 (ESqtl \times MD) + \sum_{i=1}^{n} b_i X_i + \varepsilon, \tag{12}$$

where most variables are defined in the same way as in Equation 6, $ESqtl$ is the quintile of earnings surprises with values from 1 to 11. In this regression, β_3 is the coefficient of most interest because it shows whether micro and macro news announcements are complementary or substitutionary.

Table A1 shows the results of the regression in Equation 12. For the immediate stock return reaction, the estimated $\hat{\beta}_3$ is positive and significant at the 10% level, suggesting that in our sample where all stocks are underlying assets of options, the micro and macro news releases are complementary. On earnings news days, the macro news increase the

Figure A1: Stock Return around Earnings Days with or without Macro News

This figure shows the mean daily return of stocks from 5 days before to 5 days after good (solid line) and bad (dashed line) earnings news day with (Panel b) and without (Panel a) macro news on the same day. The sample period of stock data is from February 2014 to October 2017. In Panel (a), none of the macroeconomic releases FOMC (Federal Open Market Committee) decision, Nonfarm Payroll, ISM PMI (Institute of Supply Management, Purchasing Managers' Index) or Personal Consumption is announced on the earnings release day. In Panel (b), at least one of the four macroeconomic releases is announced on the earnings release day.



(a) Earnings day without macro news

(b) Earnings day with macro news

immediate stock return reaction by 8.86% (0.0007/0.0079) compared to earnings release days without macro news releases. For the post-earnings announcement drift, however, we find no significant interaction between micro and macro news. The adjusted R^2 of 0.0005% in Column (3) demonstrates that very little variation in cumulative abnormal returns from $\tau + 2$ to $\tau + 61$ can be explained by the size of earnings surprises or the announcement of macro news.

A.2 Seller- initiated option order imbalance

Recent literature suggests that informed option traders use short positions before scheduled news announcements because those strategies are more profitable (see Weinbaum, Fodor, Muravyev, and Cremers (2020)). Therefore, we conduct the seller-initiated order imbalance

Table A1: Stock Return Reaction to Micro and Macro News

This table reports the regression results from the abnormal cumulative stock return on the earnings surprise quintile and the macro news day dummy. The sample period is from March 1997 to February 2014. CAR[0,1] is the cumulative abnormal return on the earnings release day and the following day. CAR[2,61] measures the post-earnings announcement drift. ESqtl is the quintile of the earnings surprise with values from 1 to 11. MD is the macro news day dummy variable. Control variables include market capitalization, share turnover, the number of analysts, the number of earnings announcements on the same day, lag return and return volatility of the last 21 trading days. Standard errors are in brackets. ***, ** and * note statistical significance of coefficients at the 1%, 5% and 10% level, respectively.

	CAR[0,1]		CAR[2,61]	
	(1)	(2)	(3)	(4)
ESqtl	0.0079***	0.0080***	0.0019***	0.0022***
	(0.0001)	(0.0001)	(0.0002)	(0.0002)
MD	-0.0035**	-0.0036**	0.0013	0.0016
	(0.0015)	(0.0015)	(0.0041)	(0.0040)
ESqtl×MD	0.0007***	0.0007***	-0.0005	-0.0005
	(0.0002)	(0.0002)	(0.0005)	(0.0005)
Constant	-0.0523***	-0.0511***	0.0001	-0.0077***
	(0.0006)	(0.0008)	(0.0017)	(0.0023)
Controls	No	Yes	No	Yes
Observations	154,347	154,347	151,957	151,957
Adj. R^2	0.06625	0.0689	0.0005	0.0052

in the following way:

$$SI\text{-}OI_{\tau-1} = \begin{cases} -OI_{call,\tau-1}, & \text{if } ES_\tau < 0, \\ -OI_{put,\tau-1}, & \text{if } ES_\tau > 0. \end{cases} \tag{13}$$

Table A2 suggests that seller-initiated order imbalance has less predictive power compared to buyer-initiated order imbalance.

Table A2: Predictive Power of Seller-Initiated Option Order Imbalance

This table reports the regression results from the abnormal cumulative stock return on option order imbalance, the macro news day dummy and their product. Columns (1) and (2) present predictive regression results for the whole sample. Columns (3) and (4) present the results of the conditional double sort: In the first stage, we sort micro news events into tertile groups based on the absolute earnings surprise; in the second stage, we sort stocks, within each |ES|-tertile, into tertile groups based on the average option effective bid-ask spread (EBA). Columns (3) and (4) summarize the results for high |ES| events and low EBA. The sample period is from January 2004 to October 2017. CAR[0,1] is the cumulative abnormal return on the earnings release day and the following day. SI-OI is the buyer-initiated order imbalance of calls (puts) on the day prior to positive (negative) earnings announcements. $\text{MD}_{\tau+d}$ is the macro news day dummy variable and $d = -1, 0$. Control variables include market capitalization, share turnover, the number of analysts, the number of earnings announcements on the same day, lag return and return volatility of the last 21 trading days. Heteroscedasticity-consistent (White (1980)) standard errors are in brackets. ***, ** and * note statistical significance of coefficients at the 1%, 5% and 10% level, respectively.

	CAR[0,1]			
	ALL		high |ES| & Low EBA	
	(1)	(2)	(3)	(4)
$\text{SI-OI}_{\tau-1}$	0.0588***	0.0547***	-0.0099	-0.0126
	(0.0058)	(0.0058)	(0.0208)	(0.021)
$\text{MD}_{\tau+d}$	0.0000	0.0000	0.0022	0.0045
	(0.0131)	(0.013)	(0.0327)	(0.033)
$\text{SI-OI}_{\tau-1}\text{x}\text{MD}_{\tau+d}$	0.0082	0.0057	0.0563	0.0524
	(0.013)	(0.0128)	(0.0356)	(0.0356)
Constant	0.0000	0.0000	0.0900***	0.0931***
	(0.0055)	(0.0055)	(0.018)	(0.0168)
Controls	No	Yes	No	Yes
Observations	39430	39430	5147	5147
Adj. R^2	0.0040	0.02849	0.00009	0.00335