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

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Abstract

We examine how informed option traders allocate attention and process information when firm-specific earnings announcements coincide with macroeconomic news. Leveraging high-frequency trade data, we find that sophisticated traders incorporate firm-specific information more efficiently when these events coincide, enhancing the predictive accuracy of directional option trades for stock returns. This effect is strongest when option markets' effective bid-ask spreads are low, earnings surprises are large, and stock volatility is high. Our results support information choice models, showing that traders prioritize acquiring and processing firm-specific signals when benefits outweigh costs. These findings provide new insights into informed trading and market efficiency.

Keywords: Informed option trading, earnings announcements, macroeconomic news, investor attention, information asymmetry
JEL Codes: G12, G13, G14, G41, M41

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1 Introduction

How does news become incorporated into asset prices? It has long been recognized that scheduled information events possess informational value and drive stock returns as well as risk premia (Savor and Wilson, 2013, 2016; Ben-Rephael, Da, and Israelsen, 2017; Ben-Rephael, Carlin, Da, and Israelsen, 2021). If a market faces multiple signals, such as economy-wide and firm-specific news, these can act as both substitutes or complements. Macroeconomic news seems to distract attention-constrained investors from processing firm-specific news. Recent empirical findings, however, also point to a reinforcing effect for institutional equity investors (see, Hirshleifer and Sheng, 2022; Liu, Peng, and Tang, 2023). Findings in this literature suggest that the complementary relationship between macro-news and earnings announcements is linked to the attention of institutional investors. Increased institutional investors' attention, for example, manifests itself in increased searching and reading activities on Bloomberg terminals (Ben-Rephael, Da, and Israelsen, 2017). Such activities give rise to the expectation that institutional investors will then translate their newly acquired information into trading strategies. However, it is not apparent from these measures of attention to what extent investors' increased attention translates into trading activity. Prior literature also does not investigate whether increased trading activity actually originates from institutional investors, who are considered the main users of Bloomberg terminals. Nor does it reveal whether trading activity anticipates the direction of company-specific news when macro news arrives at the same time.[1]

In this paper, we use intraday transaction-level options data to capture the directional trading activity of institutional investors. Building on Easley, O'Hara, and Srinivas (1998), we conjecture an informational role of derivatives and shed light on several important questions: Do options traders increasingly buy calls or sell puts ahead of corporate earnings

[1]Neilson (2022) emphasises that measures of investor attention and information gathering, like Bloomberg searches, are endogenously linked to post-announcement uncertainty. This suggests that increased information gathering may reflect heightened uncertainty rather than predict higher returns, complicating the interpretation of such measures even further.

announcements when the events come with positive earnings surprises and thus favourable stock returns? If so, how does the concurrent arrival of macroeconomic news affect the predictive capability of signed option volume regarding the stock price response to earnings news?

Empirically, we demonstrate that options trading exhibits a distinctive pattern surrounding earnings announcements: Leading up to the events, the directional imbalance in options orders suggests trading in anticipation of the earnings surprise (see also Weinbaum, Fodor, Muravyev, and Cremers, 2023). On the day of the event, previously opened option positions tend to be closed. This pattern becomes even more pronounced when earnings announcements and macroeconomic news coincide. Such a pattern of options trading likely serves as a reliable indicator of informed trading around earnings releases, especially evident on days featuring macroeconomic news. We formally assess the extent to which options trading predicts stock returns by regressing abnormal post-announcement returns on directional options order imbalance and examining the impact of macro news on the stock price reaction. If options investors are attracted to macroeconomic events, process company-specific news more effectively during these times, and incorporate them into trading strategies, the ability of options trading to predict stock returns before macroeconomic news days should increase.

We find that macroeconomic releases on earnings announcement days significantly improve the predictive ability of directional options trading for stock returns. This effect is economically significant, with the coefficient being 3.6 times higher than for earnings news releases alone, without accompanying macroeconomic news. Interestingly, the predictive power of option order imbalance on earnings news days without significant macroeconomic announcements disappears when we include the macro-news indicator in our regression model.

Our findings indicate that option traders process firm-specific private information more efficiently when earnings announcements coincide with macroeconomic news, compared to earnings days without such releases. This supports the theory of a complementary relationship between macro-news and earnings announcements, a subject widely debated in the

literature, as highlighted by Hirshleifer and Sheng (2022).

By leveraging transaction-level data, we are able to identify specific investor types and their informed trading behavior, which allows us to extend prior work in two key ways. First, we establish this complementary effect within options markets. Second, we emphasize the role of explicit trading activity, rather than focusing solely on institutional investor attention (e.g., Hirshleifer and Sheng, 2022; Liu, Peng, and Tang, 2023). Moreover, our results show that when macroeconomic and earnings information coincide, directional options trading indicators possess significant predictive power for short-term excess returns around earnings announcements, offering valuable insight into the behavior of informed investors in these contexts.

To delve deeper into this finding, we aim to identify channels through which the increase in predictability due to macro news can be understood. We explore whether the observed options trading behavior and predictability align with predictions from information choice models. Broadly, depending on whether investors prioritize information due to limited attention capacity (Peng and Xiong, 2006; Kacperczyk, Van Nieuwerburgh, and Veldkamp, 2016) or acquire information when its utility surpasses a threshold (Andrei, Friedman, and Ozel, 2023), macro news can either decrease or increase the marginal utility of firm-specific news. If we classify sophisticated options investors into the latter group, as suggested by our empirical results, the logical next step is to assess whether our findings are consistent with the cost-benefit rationale outlined by Andrei, Friedman, and Ozel (2023). In their model, investors face a cost when seeking information. Generally, information is most valuable for the most uncertain outcomes. Therefore, overall attention increases during periods of economic uncertainty. Specifically, the model posits that earnings news encompasses both firm-specific (idiosyncratic) and systematic components. As economic uncertainty rises, uncertainty surrounding earnings news also increases, amplifying the advantage of being informed about upcoming company events. Consequently, investors pay more attention to this specific news during uncertain times. A rational evaluation by options investors would thus entail deter-

mining whether the benefit of obtaining information outweighs its cost.

Three findings support the notion that the effect we observe can be attributed to a cost-benefit rationale. Firstly, we discover that the predictive power of option order imbalance on stock returns is distinctive to options with low effective bid-ask spreads when macroeconomic and earnings information coincide. Secondly, the effect is magnified by higher absolute earnings surprises. When comparing stocks with the lowest effective spreads and highest earnings surprises to the entire sample, the coefficient on the interaction term in our regressions (indicating the macro-news effect) is four times higher. Thirdly, predictability rises with exposure to systematic risk and idiosyncratic volatility. All three results align with the concept of a cost-benefit analysis by options market investors. A high earnings surprise and high ex ante uncertainty amplify the benefit of gathering information, while liquid options markets reduce its cost. Both factors incentivize options investors to seek out information.

Our findings exhibit remarkable consistency across a range of order imbalance measures, highlighting their robustness. Specifically, we observe a clear amplification of the impact of macroeconomic releases on various order imbalance metrics, including volume-weighted, out-of-the-money[2], delta-weighted, and buyer-initiated indicators. Interestingly, but perhaps not entirely surprising, when constructing buyer-initiated option order imbalances for calls following positive earnings surprises and for puts following negative earnings surprises, this forward-looking measure exhibits even stronger and more significant predictive patterns. It's worth noting that this measure does not differentiate between volatility trading and informed trading. Thus, this result not only confirms our initial findings but also suggests that on days with macroeconomic news announcements, hedging against increased volatility intensifies.[3]

Related literature: Our paper is related to several strands of the literature on investor attention. It builds on a long tradition of research on attention limits and attention allocation (Kahneman, 1973; Sims, 2003; Peng and Xiong, 2006; Hirshleifer, Lim, and Teoh,

[2]In line with Hu (2014), we find that out-of-the-money options do not exhibit greater predictive power compared to the overall universe of options.

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

2009; Kacperczyk, Van Nieuwerburgh, and Veldkamp, 2016), among many others. Recent work has revisited rational inattention approaches, leveraging new technologies to measure attention. In particular, measures like Google search volume (Da, Engelberg, and Gao, 2011) or Bloomberg user access data (Ben-Rephael, Da, and Israelsen, 2017) have been shown to significantly impact stock prices (Andrei and Hasler, 2015; Chen, Tang, Yao, and Zhou, 2022). We examine options order flow, thus ultimately focusing on the aspect of options investor attention that directly translates into trading positions.

Latest studies bring investor type to the forefront of their analyses of the determinants of investor attention. Investors are susceptible to distractions in their reactions to earnings announcements, and this susceptibility depends on the type of investor. It appears that less sophisticated investors, rather than more experienced institutional investors, are most susceptible to competing stimuli when processing corporate information (Da, Hua, Hung, and Peng, 2023; Israeli, Kasznik, and Sridharan, 2022; Liu, Peng, and Tang, 2023). We can directly attribute the attention we measure to experienced market participants. Our results show an enhanced effect of informed option trading once earnings news coincide with scheduled releases of key macroeconomic indicators.[4] Our findings substantiate previous results on investor type, make them concrete for option investors, and are consistent with a rational information calculus on the part of these investors (Andrei, Friedman, and Ozel, 2023).[5]

Our paper also connects to the literature addressing informed trading in option markets.

[4]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. However, 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 (2021) 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.

[5]Recent literature, including studies by Bryzgalova, Pavlova, and Sikorskaya (2023) and Hendershott, Khan, and Riordan (2024) emphasizes the increasing focus on retail participation in options trading during the pandemic. Our data are from the pre-pandemic period, which was characterized by a stronger prevalence of institutional investors in this market.

According to Black (1975) and many subsequent studies[6] option markets are an ideal trading venue for informed investors due to their embedded leverage, their built-in downside protection, absence of shorting constraints, and margin reasons. Recent literature even shows that option trading increases the overall underlying stock price informativeness (Cao, Goyal, Ke, and Zhan, 2024). They explain this result by linking option trading to increased information acquisition behavior by both option and stock investors, which aligns with the theoretical framework of Goldstein and Yang (2015) and is related to our finding that macroeconomic releases on earnings announcement days enhance the predictive power of directional option trading on stock returns.

A large empirical literature provides evidence of sophisticated, privately-informed investors in the options market whose activities create predictability for future stock returns. A broad part of this literature measures informed trading with option pricing measures[7]. Since Easley, O'Hara, and Srinivas (1998) an important focus has been on option trades rather than option prices. Well-known examples include buyer-initiated put/call ratios (Pan and Poteshman, 2006) and imbalance measures based on the hedging activity by option market makers (Hu, 2014). Stock return predictability from order imbalance measures is also prominent around news announcements such as takeover announcements (Cao, Chen, and Griffin, 2005), earnings announcements (Hu, 2014), and, more generally scheduled and unscheduled news events (Weinbaum, Fodor, Muravyev, and Cremers, 2023). The latter is one of the few studies that looks at the behavior of informed option market investors with the main finding that informed traders use short (long) option positions before scheduled (unscheduled) news announcements. Our study adds to the scarce empirical literature that analyzes the information content of *option order imbalance* around news announcements.

[6]E.g. John, Koticha, and Narayanan (2003), Chakravarty, Gulen, and Mayhew (2004), Boyer and Vorkink (2014), Ge, Lin, and Pearson (2016), Chordia, Lin, and Xiang (2021), and Muravyev and Bondarenko (2023).

[7]E.g. Cremers and Weinbaum (2010), Muravyev, Pearson, and Broussard (2013), and Jones, Mo, and Wang (2018), among others. They interpret implied volatility spreads, i.e. the difference in implied volatilities of call and put options, as a proxy for price pressure in the options market that arises from informed trading. Du, Fung, and Loveland (2018) and Chordia, Lin, and Xiang (2021) 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 options markets.

We provide new evidence on the prevalence, the origin, and the observed investment behavior of informed traders in the option market. Specifically, our results support informed trading ahead of corporate news events, suggesting that such trading is largely triggered by the interaction of micro and macro days, and that the trading behavior of informed options traders follows a cost-benefit rationale.

2 Conceptual Framework

2.1 Information Content of News Announcements

Various types of information are regularly made public and thereby incorporated into prices. In this study, we focus on two types of information disclosure events: earnings announcements and macroeconomic announcements.

Scheduled *macroeconomic announcements* are among the most significant news events for the stock market (see, Savor and Wilson, 2013). These events include announcements about unemployment or interest rates and provide signals that allow investors to update their expectations about the current state of the economy. *Earnings announcements*, on the other hand, are official statements of a company's profitability for a specific period. The information contained in earnings announcements goes beyond just the current success of a company; it includes details on the firm's riskiness, such as types of investments made and financial liquidity (see, Smith and So, 2022). Additionally, Beaver, McNichols, and Wang (2020) find that information on management guidance, analyst forecasts, and financial statement line items is disclosed concurrently with earnings. Following earnings announcements, investors and analysts adjust their expectations regarding future cash flows and simultaneously update the firm's discount rate (see, Smith and So, 2022).

Savor and Wilson (2016), Ben-Rephael, Carlin, Da, and Israelsen (2021), and Andrei, Friedman, and Ozel (2023) suggest spillover-effects between firm-specific and macroeconomic information contents. In addition to firm-specific information, earnings news about a firm

also conveys essential information for peer companies and the economy as a whole. To sharpen the subsequent discussion, let us consider a firm i that pays a risky dividend

$$D_i = \beta_i f + e_i \tag{1}$$

consisting of a firm-specific component e_i and a systematic component f as in the model of Andrei, Friedman, and Ozel (2023). In its simplest version, the model considers f to be a normally distributed random variable $f \sim \mathcal{N}(0, U^2)$, where U represents the investors' pre-announcement uncertainty about the macroeconomic fundamentals.[8] An earnings announcement of firm i provides a noisy signal about the dividend D_i. The extent to which investors pay attention to this signal crucially depends on the uncertainty U. This is because this signal also reveals market-wide information.

Formally, for this mechanism to hold, two conditions must be met: first, β_i must not be zero, as a zero value would imply no connection between earnings announcements and macroeconomic events; and second, the macroeconomic events we consider must be related to the systematic component f, which reflects the overall state of the economy. When both conditions are met, this ultimately suggests that earnings announcements reflect information about the economy.[9] The assessment that β_i is not zero aligns with the existing literature (see e.g. Lambert, Leuz, and Verrecchia (2007)). Additionally, it is highly plausible that the macroeconomic events we consider are associated with the systematic component f.

Now, let's take these considerations one step further and consider a macro announcement

[8]While Andrei, Friedman, and Ozel (2023) and Benamar, Foucault, and Vega (2021) offer valuable insights into how macroeconomic uncertainty influences investor information gathering, Neilson (2022) empirically investigates the endogenous relationship between firm-level uncertainty and firm-specific information acquisition.

[9]Earnings reports, for instance, can illustrate how economic trends, such as FOMC interest rate changes, affect companies and, conversely, provide insights into future economic conditions and policy decisions. Earnings from labor-intensive sectors may signal employment trends (e.g., Nonfarm Payrolls), while those from consumer goods companies can reveal consumption patterns linked to Personal Consumption Expenditures (PCE). Additionally, results from the manufacturing sector provide indirect signals about overall economic health, aligning with the ISM PMI. While some macroeconomic events may show this interaction more clearly than others, any lack of interaction would likely reduce the observed effect, making it more probable that we observe no effect at all. In this sense, our empirical results are more likely biased toward finding no significant effects, which actually strengthens the robustness of our conclusions.

simultaneously with the earnings announcement. A macroeconomic announcement offers a noisy signal about the macroeconomic fundamentals f, but also prompts market participants to update their cash-flow estimates for firm i. Importantly, both scheduled events share the characteristic that risk measures increase in the run-up to the event and decrease afterward. In the case of earnings announcements Patell and Wolfson (1979) and Dubinsky, Johannes, Kaeck, and Seeger (2019) find an anticipated increase in stock price volatility ahead of earnings announcements. Similarly, event-induced hightened uncertainty prior to macroeconomic announcements is well-documented in existing literature (see, Savor and Wilson, 2013; Hu, Pan, Wang, and Zhu, 2022). E.g., Savor and Wilson (2013) argue that investors expect scheduled economic announcements to reveal crucial information about the state of the economy. Consequently, they anticipate higher systematic risk and an increased risk of expectations not aligning with the announcements. As uncertainty U is the key variable that determines investors' attention allocation decisions, heightened uncertainty induced by scheduled macroeconomic news events should translate into higher attention to firm-specific news.

For the sake of simplicity, the setup considered so far assumed a known and constant parameter β_i in Equation (1). However, in reality, the exposure to the systematic component and, thus, the interaction between firm-specific and economy-wide news is likely to be much more complex. β_i itself could be a random variable, introducing additional uncertainty regarding its market impact on top of the uncertainty about the macro variable.[10] The extra uncertainty is likely to amplify the significance of the macroeconomic news event in allocating investor attention and transmitting information regarding firm i's earnings announcement.

[10]Note that this form of uncertainty is closely related to the impact uncertainty introduced in Hu, Pan, Wang, and Zhu (2022) in addition to the news risk of macroeconomic events. While their model does not specify what drives the resolution of the impact uncertainty, informed option trading prior to earnings announcements (as documented in Table 2) may contribute to this aspect.

2.2 Informed Trading in the Option Market

The notion that experienced and informed traders are prevalent in option markets due to options offering high leverage, simultaneously limiting downside risk, and circumventing short sale constraints, is well-documented by academics, as seen in early references such as Black (1975) and Back (1993). However, measuring the extent of informed trading in the options market is challenging because the timing of informed trades and the identity of investors are unobservable.

We aim to address this challenge by, firstly, examining time periods characterized by asymmetric information and likely informed trading, such as before corporate and macroeconomic news announcements, and secondly, utilizing option order imbalance as a proxy for 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 carries information about future underlying stock prices.

Only a few studies utilize option transaction data to measure informed trading. Hu (2014) stands out as one of the rare studies directly assessing informed trading through (delta-weighted) option order imbalances. Similarly, Pan and Poteshman (2006) rely on high-frequency trading data to analyze buyer-initiated option volume and identify predictable patterns in stock returns. Ni, Pan, and Poteshman (2008) study informed trading with a focus on predicting realized volatility. Fortunately, we also have access to high-frequency option trading data. Therefore, our primary measure of informed trading is the option order imbalance, calculated as the difference between the volumes of option purchases and sales divided by the total volume of option transactions (refer to Section 3.4.1 for detailed calculations). In robustness analyses, we also examine a range of different specifications of the option order imbalance.

3 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, for a single stock to be included in our analysis, it must have data available in all three databases. The information on the timing of macroeconomic news is collected from Bloomberg. Appendix A.1 provides variable details.

3.1 Stock and Option Data

Our primary data source, LiveVol, provides real-time transaction-level data for all U.S.-listed individual equity options. Our sample period spans from January 2004 to October 2017, constrained by LiveVol's availability. We focus on American-style options with underlying assets as common stock. Daily data on options' delta and underlying assets, including stock prices, trading volumes, and shares outstanding, are obtained from the OptionMetrics Ivy database. The trade data from LiveVol lacks transaction direction but includes matched quote prices. We employ a modified Lee-Ready algorithm to categorize buyer-initiated put and call option trades. Utilizing the quote rule, a trade is deemed buyer-initiated if it surpasses the midpoint of the best bid-ask spread. For trades occurring exactly at this midpoint, further classification is based on detailed exchange information from LiveVol, comparing the trade price to the bid and ask prices of the respective exchange. Trades unable to be classified are excluded from the sample. According to Savickas and Wilson (2003), 88.65% of equity option trades can be correctly classified using the quote rule.

We implement filters similar to prior studies such as Goyal and Saretto (2009) and Cao and Han (2013) to mitigate recording errors. We remove option observations violating no-arbitrage conditions. Observations with zero option bid prices and bid-ask spreads smaller than the minimum tick size (e.g., \$0.05 for options trading below \$3, \$0.1 for others) are excluded. Options lacking implied volatility or delta are dropped. Following Hirshleifer and

Sheng (2022), observations with stock prices under one dollar are also excluded.

3.2 Earnings News of Companies

We utilize I/B/E/S for firm-specific data on actual earnings and earnings forecasts, including timestamps of the announcements. Forecasts within the last 30 calendar days preceding the forthcoming quarterly earnings release are incorporated. If multiple forecasts exist for the same stock within the same quarter within this timeframe, we retain the most recent one. To ensure data accuracy, earnings news with actual or estimated earnings per share exceeding the stock price are excluded. To merge actual earnings news announcements published outside trading hours with stock and option data, we use the NYSE (New York Stock Exchange) closing time of 4 p.m. Eastern as a cutoff, as suggested by Weinbaum, Fodor, Muravyev, and Cremers (2023). Earnings news released after 4 p.m. is 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.[11]

3.3 Macroeconomic News Announcements

We concentrate on significant macroeconomic news announcements, as suggested by Savor and Wilson (2013) and Hirshleifer and Sheng (2022). These events include FOMC (Federal Open Market Committee) decisions, Nonfarm Payroll employment, ISM PMI (Institute of Supply Management, Purchasing Managers' Index), and Personal Consumption Expenditure. We obtain release dates for these announcements from Bloomberg Econoday and define a dummy variable for macro news days (MD), where $MD = 1$ if at least one of these four announcements is released on that day, otherwise $MD = 0$.[12] In our sample, 15.8%

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

[12]In our sample, eight days with macroeconomic announcements are non-trading days for stocks and options. In such instances, we designate the following trading day as a macro news day ($MD = 1$).

of trading days are macro news days. On days when earnings announcements occur, 16.2% coincide with macro news days.

3.4 Variable Construction

3.4.1 Option Order Imbalance

We compute the total order imbalance (TOI) of options on stock k on day j using option transaction data. TOI is determined as the difference between buy and sell trading volumes divided by the total volume of option trades on day j:

$$TOI_{k,j} = \frac{\sum_{i=1}^{n} sign_{k,j,i} \cdot size_{k,j,i}}{\sum_{i=1}^{n} size_{k,j,i}}, \tag{2}$$

where $sign_{k,j,i}$ denotes the information signal of an option trade i. For buyer-initiated call option trades, $sign_{k,j,i} = 1$, and for seller-initiated call option trades, $sign_{k,j,i} = -1$. Conversely, for buyer-initiated put options, $sign_{k,j,i} = -1$, and for seller-initiated put options, $sign_{k,j,i} = 1$. $size_{k,j,i}$ represents the trade size of trade i.

We filter stocks to include only those with a minimum of 10 call or put option contracts traded per day. Additionally, we exclude options in the highest effective spread decile to mitigate biases arising from illiquid option trading.[13] Inspired by Bernile, Hu, and Tang (2016), our final measure of informed trading regarding a specific announcement date (τ) is the difference in market activity at day $\tau - j$ compared to the mean TOI of non-announcement days

$$OI_{k,\tau-j} = TOI_{k,\tau-j} - \overline{TOI}_{k,\tau-40\to\tau-10}, \tag{3}$$

where $\overline{TOI}_{k,\tau-40\to\tau-10}$ is the mean TOI of non-announcement days spanning from 40 trading

[13] We compute effective spread deciles weekly to account for variations in spreads over time and between macro and non-macro news days. This approach ensures there are enough observations to divide into 10 groups and addresses the impact of macro news on information processing in option markets beyond the same day.

days to 10 trading days before the current earnings announcement.[14] Positive private information on stock k prompts informed option traders to buy call options or sell put options, thereby increasing option order imbalance (OI_k), while negative information leads them to buy put options or sell call options, reducing order imbalance. When testing whether informed trading is more prevalent on days when macroeconomic and earnings announcements coincide, we aim to ensure that our measure of informed trading is not biased by hedging strategies. To address hedging activities formed independently of the event, we subtract order imbalance during normal times (40 to 10 trading days before the event). Earnings announcements drive up stock price volatility, prompting the use of options to hedge against volatility in either other options or the underlying stock. Employing straddles is a commonly adopted approach for mitigating volatility in the underlying stock. Even if the proportion of straddles increases, our OI-measure remains constant. Hence, this volatility hedging strategy should not cause worry and will not skew our results toward greater predictive power. The remaining options bought for hedging purposes may introduce noise to our informed trading measure and bias results towards rejecting the null hypothesis of prevalent informed trading in the option market.

3.4.2 Earnings Surprise of Companies

Following Hirshleifer, Lim, and Teoh (2009) and Hirshleifer and Sheng (2022), we calculate earnings surprise (ES) as the difference between actual earnings ($actual$) for the quarter and the median estimate ($medest$) from the latest forecasts, normalized by the stock price at the end of the forecast quarter:

$$ES = \frac{actual - medest}{price}. \tag{4}$$

[14] We opt for a broader non-announcement period compared to Bernile, Hu, and Tang (2016), given that we are dealing with single equity options, which are generally less liquid than index options examined by Bernile, Hu, and Tang (2016). In the rare occurrence of another micro event within this timeframe, we exclude the five days before and after the event.

3.4.3 Stock Return and Volume Reaction

Cumulative abnormal stock returns ($CAR[h, H]$) following 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:[15]

$$\begin{aligned} CAR[h, H] =& [\prod_{j=\tau+h}^{\tau+H}(1 + R_{j,k}) - \prod_{j=\tau+h}^{\tau+H}(1 + r_j)] \\ & - \hat{\beta}_{t,k}[\prod_{j=\tau+h}^{\tau+H}(1 + R_{j,m}) - \prod_{j=\tau+h}^{\tau+H}(1 + r_j)], \end{aligned} \tag{5}$$

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.

3.5 Summary Statistics

Table 1 presents summary statistics of our sample. Panel A covers all earnings news days. We have a total of 2,628 news days and 3,986 stocks in our sample, with a median of 12.5 firms announcing earnings per day.[16] Positive earnings surprises occur approximately 2.2 times more frequently than negative surprises during our sample period. The median ES is slightly positive, close to zero. The negative mean of ES suggests the occurrence of some unexpected negative events with high surprises during our sample period. Consequently, the average cumulative abnormal return (CAR) post-event is slightly negative.

Our main explanatory variable, abnormal order imbalance OI, exhibits negative mean and median values on the day preceding earnings announcements. This suggests that, prior

[15] Similar results are available using the Fama-French three-factor model, provided upon request.

[16] Our daily stock data are sourced from OptionMetrics, ensuring that all stocks are underlying assets of equity options. These stocks, being generally larger than the universe of all exchange-traded stocks, exhibit higher market capitalization, share turnover, and analyst coverage compared to those in Hirshleifer and Sheng (2022).

Table 1: **Summary statistics**

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

Panel A: Full sample

	N	Mean	SD	25%	50%	75%
ES	51,503	−0.03	3.67	−0.03	0.05	0.20
$OI_{\tau-1}$ %	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 %	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
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
ES	42,248	9,255	−0.04	−0.03	3.65	3.80
$OI_{\tau-1}$ %	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 %	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
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

to news events, investors, on average, sell more calls than they buy and hold more long puts than short puts. The quoted bid-ask spread (QBA) and effective bid-ask spread (EBA) for put and call options are relatively high compared to stock market spreads, as documented in the literature, e.g., Christoffersen, Goyenko, Jacobs, and Karoui (2018).

In Panel B, mean values and standard deviations are compared between macro news days and other days. On earnings days with macro releases share turnover is higher. Sock volatility exhibits a similar pattern. These initial observations suggest that the dissemination of economy-wide news draws investors' focus to the single stock market, a phenomenon we will investigate further in subsequent sections. We incorporate the summary statistics variables as control variables in our prediction model to address differences in characteristics between macro news days and other days.

4 Empirical Analysis

In this section, we investigate option investors' attention allocation and information transmission in an event-study framework, comparing news days with both micro and macro announcements to those with only earnings releases. Unlike many other studies on informed trading in the option market, we benefit from high-frequency transaction-based option volume data spanning over 14 years. This long time series allows us to examine how efficiently firm-specific information is incorporated into market prices. Initially, we assess the informativeness of options order flows regarding upcoming earnings surprises.[17] Subsequently, we investigate the informational content of option trading for future movements in underlying stock prices. Lastly, we analyze the preferences of informed option investors. Focusing on the simultaneous occurrence of micro and macroeconomic news, our findings indicate a preference for liquid option markets, events with high earnings surprises, and stocks with high market beta and idiosyncratic volatility, aligning with a cost-benefit rationale.

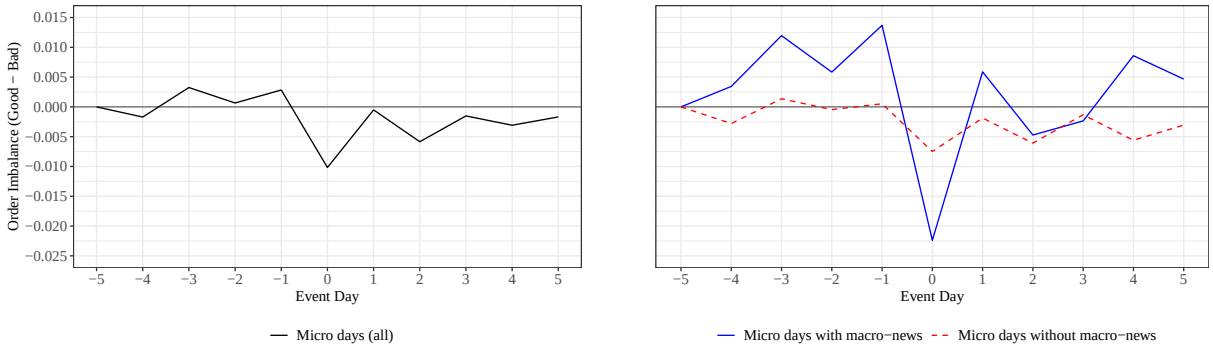
[17] In Appendix A.2, we present results from a pre-analysis examining the presence of a macro-effect in abnormal trading volumes around news events.

Figure 1: **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), classified as good news in the 10th and 11th quantiles and bad news in the 1st and 2nd quantiles, are depicted. We combine good and bad ES days as follows: $OI^{good-bad}_{\tau-j} = OI^{good}_{\tau-j} - OI^{bad}_{\tau-j}$. Thus, regardless of the type of news, positive $OI^{good-bad}$ indicates informed trading. The sample period spans from January 2004 to October 2017.

(a) All event days

(b) Event day subsamples with and without macroeconomic news



4.1 Macro News Effect and Trading Behavior

4.1.1 Option Order Imbalance

To assess the informativeness of option market trades, we employ option order imbalance as our main predictive variable. To gauge its effectiveness in anticipating upcoming events, we use earnings surprise as a proxy for the information signal of these events. In Figure 1, we depict option order imbalance accounting for good and bad news as follows:

$$OI^{good-bad}_{\tau-j} = OI^{good}_{\tau-j} - OI^{bad}_{\tau-j}, \tag{6}$$

where $OI^{good}\tau - j$ ($OI^{bad}_{\tau-j}$) represents the option order imbalance of events in the 10th and 11th (1st and 2nd) earnings surprise quantile. This yields a directional measure independent of news type (good or bad), which should be positive before the event day if informed trading prevails.

In Figure 1, Panel (a) presents the mean daily $OI^{good-bad}$ from 5 days before to 5 days

after earnings announcements.[18] In the days leading up to earnings news releases, there appears to be a positive and modestly increasing option order imbalance, suggesting potential informativeness of options order flows regarding the forthcoming earnings surprise. It seems that options traders may be executing orders in anticipation of the event. On the announcement day, option order imbalance becomes strongly negative, suggesting investors close their positions after earnings news is released. In the days following news announcements, option order imbalance reverts back towards zero but remains slightly negative. This pattern suggests that, on average, option traders may have some ability to anticipate whether actual earnings will exceed or fall short of expectations.

Having established an initial empirical relationship between order imbalance and informed trading in general, we now address the central question of whether macroeconomic releases influence the pattern of order imbalance around earnings announcements. As before, we categorize earnings surprises as positive and negative, and then assess the alignment of option trades with the information content of firm-specific news. Figure 1 (b) illustrates option order imbalance $OI^{good-bad}$ around micro news *with macro releases* on the same day, compared to the corresponding measure around micro news *without macro releases* on the same day. The graph illustrates that before earnings announcement days with macro news, option order imbalance is notably higher, suggesting more effective trading driven by information. This supports the idea that macro releases motivate option investors to seek firm-specific information. Building on this motivation, we next formally test whether option order imbalance holds predictive power for stock returns around earnings announcements and delve into the role of macro news days in this process.

[18] We winsorize the data at the 5th and 95th percentiles, with similar results observed when calculating the median option order imbalance.

4.2 Macro News Effect and Predictive Power of Options on Stock Returns

How does macro news arrival change the predictive power of option order flow on stock returns? We take the view that if the predictive power of option trading on stock returns rises before macro news days, it indicates that option investors have been attracted by the macro event and hence enhance information processing of firm-specific news. Conversely, if predictability decreases, the macro event distracts option investors. We therefore examine the predictive power of option order imbalance for subsequent stock returns both for earnings announcements on days with and without macro news.

We utilize option order imbalance from the day before earnings announcements to gauge informed trading in the option market. Initially, we regress the immediate stock return response $CAR[0,1]$ solely on OI for reference. Then, we proceed to regress $CAR[0,1]$ on OI, MD, and their product:

$$CAR[0,1] = \alpha + \beta_1 OI_{\tau-1} + \beta_2 MD_{\tau+d} + \beta_3 (OI_{\tau-1} \times MD_{\tau+d}) + \sum_{i=1}^{n} b_i X_i + \varepsilon_\tau, \tag{7}$$

where $OI_{\tau-1}$ represents option order imbalance on the day prior to the earnings announcement. MD is a dummy variable with a value of 1 if macro news (such as FOMC decision, Nonfarm Payroll, ISM PMI, or Personal Consumption) coincides with micro news. To mitigate omitted variable bias, we include control variables that influence stock market reactions to earnings news. Following Hirshleifer and Sheng (2022), we incorporate absolute earnings surprise quantile[19], market capitalization, share turnover, number of analysts, 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. The coefficient of primary interest is β_3, indicating how the arrival of macro news alters the predictive power of option market trading on stock

[19]Following Hirshleifer and Sheng (2022), the absolute earnings surprise quantile is a categorical variable ranging from 1 to 11, indicating the quantile of absolute earnings surprises. It measures the magnitude of the difference between actual and expected earnings.

returns.

To ensure that our forecasting results are not influenced by the higher standard deviation of stock returns on macro news days compared to earnings news days without macro news, we standardize all variables separately for macro and non-macro news days before conducting the predictive regression. It is worth noting that our results tend to become more significant when we do not standardize our variables in this manner.

Columns (1) and (2) in Table 2 demonstrate the 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 suggests information advantages of option traders regarding upcoming micro news. In the last two columns, we introduce the interaction term of order imbalance and the macro-dummy ($OI_{\tau-1} \times MD_{\tau}$). Notably, the coefficient of the interaction term (β_3) is positive and significant[20], while the coefficient of OI (β_1) becomes insignificant. This indicates that all of the predictive power of OI (Columns (1) and (2)) is driven by days where micro and macro news announcements coincide. Quantifying the macro news effect, the predictive power of order imbalance in the model of Equation (7), presented in Column (3) (0.025+0.0033=0.0283), is 3.6 times as high as that in the model without the interaction term (0.0078) in Column (1). Adding controls does not alter the results.

The enhancement in the efficiency of processing firm-specific news by sophisticated investors in the option market on macro news days aligns with the attention allocation theory proposed by Andrei, Friedman, and Ozel (2023). Heightened uncertainty surrounding the upcoming macro event leads to increased uncertainty about a firm's future cash-flow stream and discount rates.[21] This, in turn, elevates uncertainty about future stock price movements and incentivizes investors to gather information, consistent with the increased predictive power we observe. Hirshleifer and Sheng (2022) demonstrate that macro releases amplify

[20] p-value = 2.2%

[21] Our macroeconomic event types have a direct relationship with the discount rate. For instance, FOMC decisions are naturally tied to the discount factor, Nonfarm Payroll employment is connected through the Taylor rule, and Personal Consumption Expenditure is associated with consumption-based asset pricing.

Table 2: **Predictive power of option trading before earnings news on stock returns**

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 per news-day		-0.0147***		-0.0148***
		(0.0044)		(0.0044)
Lag return		-0.0299***		-0.0299***
		(0.0044)		(0.0058)
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

immediate stock market reactions to earnings news. Notably, informed option trading may partly rely on these efficient stock price reactions. If earnings information released on macro-news days indeed influences stock prices more rapidly,[22] informed option trading on the day before earnings news becomes more profitable. This serves as an additional incentive for sophisticated option investors to process private information to the option market the day before earnings are released.

We expand our analysis beyond simultaneous occurrences of firm-specific and macro-news events, as heightened uncertainty due to upcoming macro news is not exclusive[23] to these days. Redefining our Macroday indicator, we investigate cases where macro news is released one day before and one day after earnings announcements.[24] We expect that macro events one day before earnings announcements also contribute to increased ex ante uncertainty regarding future stock price reactions. Conversely, macro news released after the actual earnings announcement should be less relevant, as the stock price reaction to earnings news would have already occurred.

Table 3, Column (1), indicates that macro news released one day before earnings announcements increases 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 also benefits from a broader set of release days entering the interaction term ($OI_{\tau-1} \times MD_{\tau+d}$). Its predictability is notably 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, no predictability is found if macro news is released the day after micro news.

[22] In Table A3 in the appendix, we replicate the analysis conducted by Hirshleifer and Sheng (2022) for our sample, which consists of stocks underlying options. We also observe an amplified immediate stock return reaction on macro news days.

[23] Andrei, Friedman, and Ozel (2023) and Hirshleifer and Sheng (2022) also suggest that trading on the event can happen before the announcement day.

[24] FOMC decisions and Nonfarm Payroll news are typically released after 2 p.m., whereas ISM PMI and Personal Consumption news are released in the morning.

Table 3: **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

In the upcoming sections, we will revisit the predictive regression analysis, focusing specifically on the setup outlined in Table 3, Column (2), utilizing $MD[d = -1, 0]$. Our aim is to examine various subgroups more closely to identify where the predictive strength of order imbalance is most pronounced.

4.3 Transaction Costs and Informed Trading

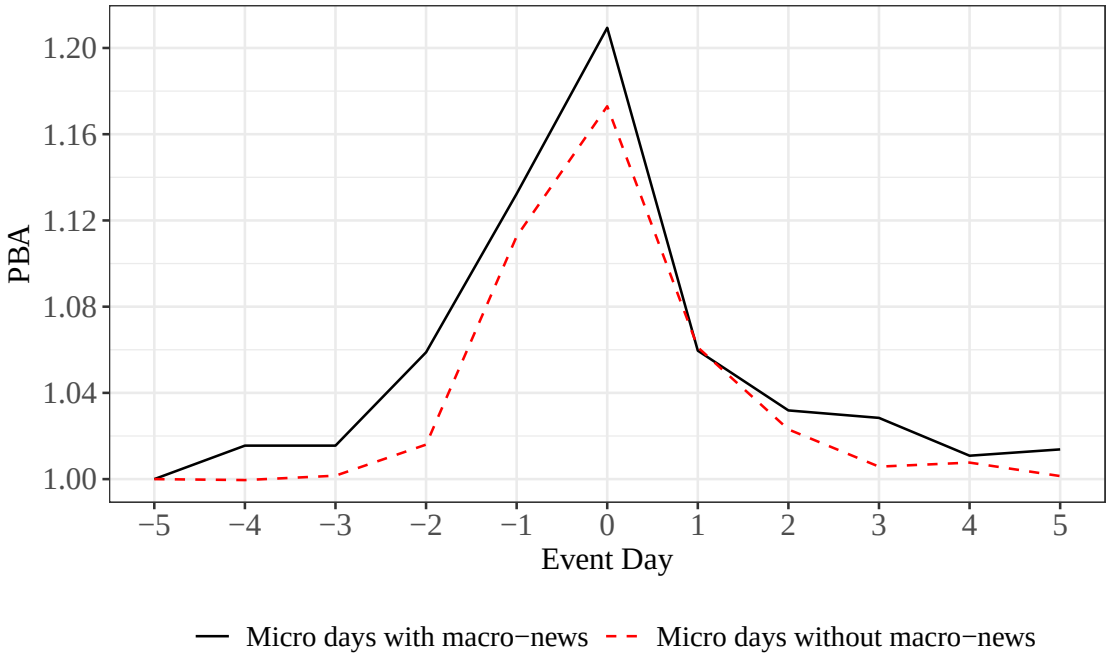
It's widely acknowledged in the literature that a portion of the option bid-ask spread, estimated at approximately one-third according to Ahn, Kang, and Ryu (2008), can be attributed to information asymmetry costs. Market makers tend to widen the bid-ask spread when they anticipate the presence of informed traders. Consequently, we anticipate observing an increase in bid-ask spreads around news events, particularly on days with macroeconomic effects. Figure 2 confirms our expectation. Quoted bid-ask spreads[25] for equity options indeed surge around announcement days, and the level of information asymmetry is typically higher on macro news days. In particular, before micro news days with concurrent macroeconomic news, bid-ask spreads tend to be higher compared to micro news days without macroeconomic events. This difference decreases abruptly on the day following the announcement. On the event day ($d = 0$), we observe a mean difference of 3.64 percentage points. This aligns with the notion that market makers anticipate macroeconomic news to attract informed equity option traders' attention or enhance their reaction to earnings news. On the day following the news announcement, the event-related information asymmetry is resolved. Consistently, lower spreads are observed, with virtually no differences remaining. The further away from the event, the greater the likelihood that other factors confound the macro-effect.

On one hand, the heightened bid-ask spreads during news events suggest increased asymmetric information, especially when both types of news events coincide. On the other hand, informed investors typically prefer lower-cost assets to maximize the profitability of their

[25]The quoted bid-ask spread is defined as the difference of the best ask and the best bid price scaled by the midpoint. Using the option effective spread instead yields similar, but less severe differences.

Figure 2: **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.



trades. The relatively high bid-ask spreads during earnings announcement days could explain the limited predictive power of OI for stock returns compared to studies like Hu (2014), which analyze predictability over the entire time series. Remarkably, despite the even higher transaction costs on macroeconomic days, there is an increased predictive power of option order imbalance OI.

In a broader sense, Blankespoor, deHaan, and Marinovic (2020) offer an overview of research concerning information gathering and processing. They highlight recent findings suggesting that accessing corporate disclosures can be costly even for professional investors and that investors earn competitive returns on their costly disclosure processing activities. Andrei, Friedman, and Ozel (2023) emphasize that the benefit of gathering information

Table 4: **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, while Columns (3) and (4) present results 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. $\text{MD}_{\tau+d}$ 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]			
	High EBA		Low EBA	
	(1)	(2)	(3)	(4)
$\text{OI}_{\tau-1}$	0.0177*	0.0174*	-0.0077	-0.0076
	(0.0099)	(0.0099)	(0.0156)	(0.0152)
$\text{MD}_{\tau+d}$	-0.0010	-0.0012	-0.0113	-0.0084
	(0.0227)	(0.0230)	(0.0181)	(0.0180)
$\text{OI}_{\tau-1}\times\text{MD}_{\tau+d}$	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

must outweigh its costs to motivate investors to acquire and trade on it. Also, Lin and Lu (2015) conducted a regression test and found that the predictive power of option trading on index returns decreases as the bid-ask spread of options widens. Expanding on these insights, we assess whether informed options investors prioritize lower-cost assets to enhance the profitability of their trades.

The quoted bid-ask spreads analyzed in Figure 2 reflect market makers' perceptions of information asymmetry and also include information on non-traded option prices from the order book. Muravyev and Ni (2020) highlight that actual option trading costs are lower than indicated by this conventional measure. The effective bid-ask spread (EBA), calculated as the absolute difference between the transaction price and the midpoint, scaled by the

midpoint, provides a more realistic measure of transaction costs. Therefore, we use EBA to capture the trading costs of option investors on the day prior to earnings announcement.

We group our observations into five quintiles based on the effective bid-ask spread of options on the day before the event.[26] We then repeat the predictive regression analysis for the groups with the highest and lowest EBA.

Table 4 shows the regression results for the 1st (Low EBA) and 5th (High EBA) quintile of EBA. The interaction term coefficient ($OI_{\tau-1} \times MD_{\tau-1,\tau}$) in Columns (1) and (2) lacks significance with high EBA options. Conversely, for low EBA, this coefficient is both statistically and economically significant. Columns (3) and (4) indicate heightened predictive power of order imbalance on macro days for stocks with highly liquid options, with the coefficient increasing by over 100% compared to our full sample results in Table 3, Column (2).[27] Additionally, contrary to our previous findings, the OI coefficient on non-macro days is statistically significant for the high EBA group, suggesting a possible link to the positive correlation between effective and quoted bid-ask spreads, indicative of high asymmetric information at high EBA levels. The significant predictability on non-macro days compared to the insignificant predictability on macro days in the high EBA group suggests that informed trading may remain profitable due to the relatively lower spreads on non-macro days. In summary, our results suggest that informed traders prefer liquid options for trading on their private information.

[26] We calculate quintiles for all event days occurring within the same week based on the mean effective option spread per stock. Using this information, we divide our sample into five groups. Opting for a weekly basis allows us to accommodate time-dependent changes in spreads and ensures a balanced distribution of macro and non-macro days across the groups. This approach results in a similar percentage of macro days per group compared to the overall percentage in our sample, as illustrated in Table 1. A weekly basis is clearly preferred over daily sorting because daily grouping would exclude announcement days with fewer than 5 stock-event observations.

[27] The reduced statistical significance in Table 4, Column (4) compared to Table 3, Column (2) may stem from the lower number of observations in the quintile regressions.

Table 5: **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, while Columns (3) and (4) present results 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

4.4 Predictability of Stock Returns and Potential Profit

Having established a connection between transaction costs and informed trading, we now turn to potential profits. We utilize absolute earnings surprises to estimate potential profits for informed traders. Similar to the previous section, we divide our sample into five groups, this time based on absolute earnings surprise quintiles.

Columns (1) and (2) of Table 5 display the predictive regression results of option order imbalance on stock returns for the lowest quintile of absolute earnings surprises |ES|, while Columns (3) and (4) pertain to the highest quintile. In the case of low |ES|, the coefficient of $OI_{\tau-1}\times MD_{\tau+d}$ is not significant, whereas for high |ES|, the interaction term exhibits significant predictive power. Notably, in Column (4), the predictive regression coefficient of

Table 6: **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

the interaction term more than doubles compared to Table 3 Column (2), suggesting that informed traders primarily act 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. First, we sort micro news events into tertile groups based on the absolute earnings surprise. Then, within each |ES|-tertile, we sort stocks into tertile groups based on the average option effective spread (EBA). Again, these groups are constructed using weekly rolling windows.

Table 6 highlights 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 single group sorts (Table 4 and 5), and is four times higher than in the full sample (Table 3). Conversely, when earnings surprise is low and spreads are either low or high, order imbalance lacks significant predictive power on stock returns. Similar to the findings observed in Table 4 for high effective spreads, order imbalance becomes significant on event days without macro news when combined with high earnings surprise. A possible explanation could be that increased effective spreads may indicate greater informed trading activity in the market, causing option markets to lead stock markets. However, on macro news days, characterized by even higher spreads (as depicted in Figure 2), the profitability of informed trading is diminished by expenses, resulting in an insignificant interaction term.

4.5 Systematic and Idiosyncratic Risk and Informed Trading

In addition to option trading costs and earnings surprise, differences in systematic and idiosyncratic uncertainty across firms may further affect the cost-benefit ratio of information gathering. In the model proposed by Andrei, Friedman, and Ozel (2023), a firm's payoff comprises both systematic and idiosyncratic components. When two firms differ solely in their market beta, the model suggests that investors perceive the information regarding the earnings announcement of the higher beta firm as more valuable. Additionally, the benefit of information is relatively greater for firms with higher idiosyncratic volatility.

To delve deeper into this matter, we examine the trading preferences of informed option investors concerning stock characteristics, particularly a stock's market beta and idiosyncratic volatility. Our aim is to ascertain whether riskier stocks attract a higher proportion of potentially informed investors, especially on macro days. Employing the same sorting procedure as previously described, we categorize our observations into five groups based on a stock's market beta and idiosyncratic volatility, respectively. Tables 7 and 8 validate the insights of the model proposed by Andrei, Friedman, and Ozel (2023). In Table 7, regression results depict the relationship between option order imbalance and future stock returns for

Table 7: **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 3.4.3 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 Market Beta		High Market Beta	
	(1)	(2)	(3)	(4)
$\text{OI}_{\tau-1}$	-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)
$\text{OI}_{\tau-1}\times\text{MD}_{\tau}$	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

the lowest market beta quintile (Columns 1 and 2) and the highest market beta quintile (Columns 3 and 4). A comparison of regression results between high and low market beta groups indicates that the predictability of order imbalance more than doubles on macro release days for firms with greater exposure to systematic risk.[28] Columns (1) and (2) in Table 8 display regression results for stocks in the lowest idiosyncratic volatility quintile, while Columns (3) and (4) show results for the highest idiosyncratic volatility quintile. For stocks with low idiosyncratic volatility, the coefficient of $OI_{\tau-1}\times\text{MD}_{\tau}$ is not significant. However,

[28]Note that for this analysis, we only consider macro releases that coincide with the day of the earnings announcement (MD_{τ}) to ensure that systematic uncertainty aligns with the assumptions of Andrei, Friedman, and Ozel (2023). The model suggests that differences in stock market betas between two firms are more valuable to investors when macroeconomic uncertainty is high. Including $MD_{\tau-1}$ in the interaction term still shows higher coefficients for high market beta groups compared to low market beta groups, although the difference is less pronounced.

Table 8: **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 3.4.3 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 IVOL		High IVOL	
	(1)	(2)	(3)	(4)
$OI_{\tau-1}$	0.0037	0.0038	0.0159	0.0118
	(0.007)	(0.0068)	(0.0172)	(0.0173)
$MD_{\tau+d}$	-0.0002	0.0069	0.0258	0.0146
	(0.0115)	(0.0116)	(0.0298)	(0.0298)
$OI_{\tau-1} \times MD_{\tau+d}$	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

for stocks with high idiosyncratic volatility, the interaction term exhibits significant predictive power.

Overall, the evidence from this subsection indicates that the predictive power of option order imbalance is concentrated in firms with high exposure to systematic risk and high idiosyncratic volatility. This finding further supports the notion from earlier subsections that heightened uncertainty leads to increased attention among option investors.

5 Robustness Checks

We conduct several robustness checks to ensure that our findings are not influenced by the particular design of our option order imbalance measure. While our approach of utilizing abnormal order imbalance (as defined in Equation 3) is reasonable, it is not widely used in existing literature. Therefore, in the robustness section, we consider a variety of total order imbalance measures. Our key results remain consistent across each of these alternative specifications.

5.1 Dollar-Volume-Weighted Option Order Imbalance

First, we check the robustness of our main order imbalance measure (see Equation (2)) by multiplying each transaction additionally with the respective option price:

$$VOI_{k,j} = \frac{\sum_{i=1}^{n} sign_{k,j,i} \cdot size_{k,j,i} \cdot O_{k,j,i}}{\sum_{i=1}^{n} size_{k,j,i} \cdot O_{k,j,i}}, \tag{8}$$

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 transaction price.

We conduct regression analysis similar to Equation (7) for the full sample, and we also examine the sample split into high |ES| and low EBA as shown in Table 6, using dollar-volume weighted option order imbalance (VOI). Table 9 presents regression results when the dollar-volume-weighted measure of option order imbalance is utilized as the predictive variable. Compared to Column (2) of Table 3, 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 depicted in Columns (3) and (4). Once again, the results suggest that our main analysis remains robust to dollar-volume weighting of order imbalance.

Table 9: **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. $\text{MD}_{\tau+d}$ 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)
$\text{VOI}_{\tau-1}$	0.0000	-0.0011	-0.0335	-0.0358
	(0.0050)	(0.0050)	(0.0218)	(0.0220)
$\text{MD}_{\tau+d}$	-0.0004	-0.0004	0.0526	0.0479
	(0.0115)	(0.0113)	(0.0413)	(0.0415)
$\text{VOI}_{\tau-1} \times \text{MD}_{\tau+d}$	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

5.2 Out-of-the-Money Option Order Imbalance

Informed traders may favor out-of-the-money options over other options because of their higher liquidity and greater leverage. This preference suggests that out-of-the-money options may convey more information about stock prices compared to other options, as discussed in studies such as Pan and Poteshman (2006).

Following the approach of Christoffersen, Goyenko, Jacobs, and Karoui (2018), Driessen, Maenhout, and Vilkov (2009), and Bollen and Whaley (2004), we define out-of-the-money options based on their delta obtained from OptionMetrics, specifically by selecting options with $|\text{delta}^{OTM}| < 0.375$. We then compute order imbalance as described in Equation (2),

Table 10: **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. $MD_{\tau+d}$ 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)
OTM-OI$_{\tau-1}$	-0.0036	-0.0052	-0.0206	-0.0245
	(0.0049)	(0.0049)	(0.0180)	(0.0180)
MD$_{\tau+d}$	-0.0026	-0.0014	0.0507	0.0459
	(0.0116)	(0.0115)	(0.0415)	(0.0417)
OTM-OI$_{\tau-1}$×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

utilizing a subset of our option data that includes only out-of-the-money options.

Table 10 presents the results of the robustness check, repeating the regressions conducted in Table 3, Column (2), and Table 6, utilizing out-of-the-money option order imbalance (OTM-OI).

The findings in Table 10 confirm that macroeconomic news enhances the predictive power of out-of-the-money options on stock returns. However, the coefficient of the interaction term OTM-OI$_{\tau-1}$×MD$_{\tau}$ is slightly lower, both statistically and economically, compared to the coefficient in Table 2 and Table 3. This suggests that in our setting, out-of-the-money options do not convey higher information content compared to in-the-money and at-the-

money options. This observation is in line with the results of Hu (2014), who finds that in his setting, return predictability does not originate from out-of-the-money options, but rather from in-the-money and at-the-money options. Hu explains that out-of-the-money options are primarily utilized by sophisticated investors for hedging purposes in volatility trading, which introduces noise into the informed trading measure.

5.3 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 manner:

$$DOI_{k,j} = \frac{\sum_{i=1}^{n} sign_{k,j,i} \cdot |\Delta_{k,j,i}| \cdot size_{k,j,i}}{\sum_{i=1}^{n} |\Delta_{k,j,i}| \cdot size_{k,j,i}}, \tag{9}$$

where $DOI_{k,j}$ represents the delta-weighted order imbalance of stock k on day j. $sign_{k,j,i}$ 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. $\Delta_{k,j,i}$ denotes the delta of the option, and $size_{k,j,i}$ indicates the trade size. The numerator represents the net delta position of option traders, while the denominator scales the position by the delta-weighted total number of trades.

Table 11 shows that delta-weighted order imbalance has limited predictive power when considering the entire sample, consistent with the (event-based) findings of Hu (2014). However, when focusing on profitable investments with high absolute earnings surprise and low costs, the coefficient of DOI is nearly four times higher than in the full sample $((0.1353 - 0.0346)/(0.0202 + 0.0054))$. Therefore, our main results remain robust even when using delta-weighted order imbalance.

Table 11: **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

5.4 Buyer-Initiated Option Order Imbalance

As discussed by Frazzini and Pedersen (2022), investors prefer buying options to short selling due to the large margin requirements associated with short positions, while long positions limit potential losses to minus 100%. Following the literature, such as Pan and Poteshman (2006) and Ge, Lin, and Pearson (2016), we adopt the assumption that buyer-initiated option trades convey more information than seller-initiated option trades. To further test the robustness of our main results, we examine the order imbalance of call options before positive earnings surprises and the order imbalance of put options before negative earnings

Table 12: **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. $\text{MD}_{\tau+d}$ 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)
$\text{BI-OI}_{\tau-1}$	0.0546***	0.0630***	0.0678***	0.0747***
	(0.0053)	(0.0054)	(0.0224)	(0.0224)
$\text{MD}_{\tau+d}$	-0.0000	0.0000	0.0005	-0.0017
	(0.0127)	(0.0126)	(0.0330)	(0.0330)
$\text{BI-OI}_{\tau-1} \times \text{MD}_{\tau+d}$	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

surprises:[29]

$$BI\text{-}OI_{\tau-1} = \begin{cases} OI_{call,\tau-1}, & \text{if } ES_\tau > 0, \\ OI_{put,\tau-1}, & \text{if } ES_\tau < 0. \end{cases} \tag{10}$$

Thus, we construct a forward-looking measure under the assumption that informed traders are aware of tomorrow's earnings news. To gauge the potential information content of informed investors, we utilize earnings surprise (ES), defined as the difference between

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

I/B/E/S median earnings estimates and actual released earnings. Informed investors are presumed to opt for the most cost-efficient way of trading their private information. Specifically, they will buy call options in the case of positive information and purchase put options if they have negative information about a company.

Measuring order imbalance in this manner provides a combined measure of volatility hedging and informed trading. If an investor is not trading based on private information but rather forming straddles to trade on volatility, this action will increase the order imbalance of both call and put options in the direction of informative trading. However, to the best of our knowledge, the effects of economy-wide news announcements on volatility hedging in equity option markets have not been documented. Therefore, this combined measure merits further investigation.

We observe that macroeconomic news amplifies the coefficient of buyer-initiated option order imbalance. The results presented in Table 12 overall demonstrate that buyer-initiated option order imbalance yields statistically and economically more significant results compared to the classical measure of order imbalance. Notably, in contrast to all other specifications, buyer-initiated option order imbalance significantly predicts stock returns on earnings announcement days without macroeconomic releases. However, it remains an interesting question for future research to determine whether this stronger effect is driven by enhanced volatility hedging or informed trading before news releases.

In summary, four alternative measures of option order imbalance consistently show that the estimated coefficient β_3 in Equation (7) remains economically and statistically significant. This suggests that option trading contains information about future underlying stock values around earnings days, particularly when investor attention is heightened by macro news.

6 Conclusion

Our study contributes to the existing literature by examining the impact of economy-wide (macro) news releases on informed option traders' attention. This complements research on informed option trading and investor attention.

Macro releases attract the attention of privately informed option traders to firm-specific news content by increasing the incentive to gather firm-specific information. This, in turn, enhances the efficiency of information processing into the option market on the day before news announcements. We demonstrate 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 versus micro news days without macro news. We find that increased attention due to macro news is the primary driver of the predictive power of option order imbalance on stock price reactions to micro news.

Furthermore, we illuminate the trading preferences of informed option investors. Our analyses indicate that informed investors favor options with low effective bid-ask spreads and news days characterized by high absolute earnings surprises. Consistent with existing literature, we find that informed investors trade stocks with high market beta and high idiosyncratic volatility. These findings are robust across various option order imbalance measures.

However, our results are subject to several limitations. The order imbalance measure relies on estimated trading directions of buyer and seller-initiated option trades, leading to a noisy measure of informed trading. Enhancing our results with data providing signed option trading information would be insightful. Moreover, investor attention is influenced not only by macro releases but also by other economically relevant events such as elections or political tensions. Exploring these open questions remains a topic for future research.

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A Appendix

A.1 Variables Definitions

Table A1 provides detailed definitions of the main variables including all control variables used in the analysis.

A.2 Stock and Option Trading Volume

We investigate the stock dollar volume reaction to earnings news using the immediate abnormal trading volume ($AVOL$) measure introduced by DellaVigna and Pollet (2009) and Hirshleifer and Sheng (2022):

$$\begin{aligned} AVOL[j, j+1] &= \frac{AVOL[j] + AVOL[j+1]}{2}, \\ AVOL[j] &= \ln(V_{\tau+j} + 1) - \frac{1}{15} \sum_{k=\tau-20}^{\tau-6} \ln(V_k + 1), \end{aligned} \tag{11}$$

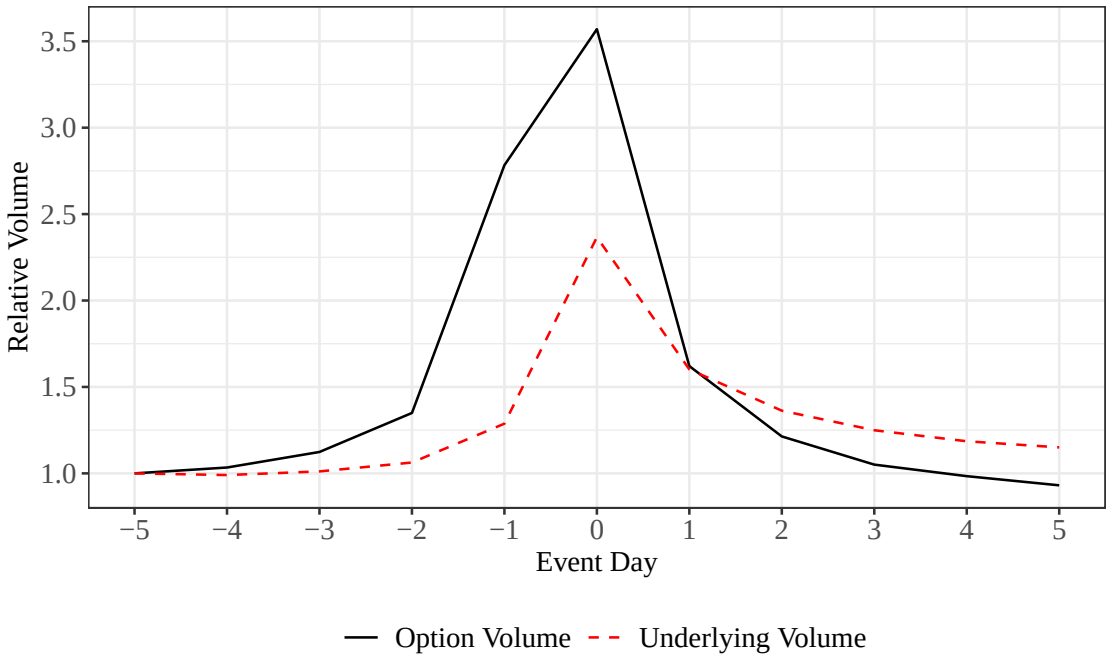
where $V_{\tau+j}$ is the dollar amount of the trading volume on the day $\tau+j$. Similar to Hirshleifer and Sheng (2022), we use the period from $\tau - 20$ to $\tau - 6$ as a benchmark. The abnormal option dollar volume is calculated similarly, but only considering the period from $\tau - 5$ to $\tau - 3$ to avoid potential volume increases stemming from maturity-dependent portfolio adjustments expected in longer time windows.

Figure A1 illustrates an increase in both option and stock volumes around earnings announcement days. Notably, the day before the news announcements, the option volume rises more than twofold compared to the previous day, while stock volume experiences a sudden increase on the day of the news announcement. These findings suggest that certain participants in the option market may possess relevant, potentially private information about the impending event.

Next, we analyze option trading volume on days with both micro and macro announcements compared to days with only earnings announcements. We formally investigate whether

Figure A1: **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.



macro releases boost investors' attention, resulting in heightened option trading volume. We assess the abnormal option volume (OAVOL) responses to micro and macro news the following regressions:

$$OAVOL[-1,0] = \alpha + \beta_1 MD_\tau + \sum_{i=1}^{n} b_i X_i + \varepsilon, \tag{12}$$

where our main explanatory variable, MD, is a dummy variable equal to 1 when macroeconomic news (such as the FOMC decision, Nonfarm Payroll, ISM PMI, or Personal Consumption) coincides with microeconomic news.[30] All the other variables are the same as in Equation (7).

[30]We use the period from $\tau - 5$ to $\tau - 3$ as a benchmark for the abnormal option dollar volume. We have similar results when using the trading volume instead of the dollar volume.

Table A2 displays the results of the regression in Equation (12). Abnormal dollar volumes for options (OAVOL[-1,0]) are significantly higher on macro news days compared to days without macro news. Our results remain robust with the inclusion of additional controls. This indicates that macroeconomic news amplifies investor attention and reaction to microeconomic news among option traders in the days leading up to earnings announcements.

A.3 Stock Market's Ability to Incorporate News

We replicate the attention trigger effect documented by Hirshleifer and Sheng (2022) using our sample of optionable stocks. Similar to Section 3.4.3, we employ the market-adjusted cumulative abnormal return $CAR[0,1]$ to assess the immediate stock market reaction, and $CAR[2,61]$ to gauge the post-earnings announcement drift. We analyze the impact of macro news on stock return response to earnings news with the following regression:

$$CAR = \alpha + \beta_1 ESqtl + \beta_2 MD + \beta_3 (ESqtl \times MD) + \sum_{i=1}^{n} b_i X_i + \varepsilon, \tag{13}$$

where variables follow the same definitions as Equation (12), and according to Hirshleifer and Sheng (2022), $ESqtl$ represents earnings surprises quintiles ranging from 1 to 11. The coefficient β_3 holds particular interest as it indicates the nature of the relationship between micro and macro news announcements, whether complementary or substitutionary.

Table A3 presents the regression results from Equation (13). The estimated $\hat{\beta}_3$ for the immediate stock return reaction is positive and significant at the 10% level. This implies that also in our sample, where all stocks serve as underlying assets for options, micro and macro news releases are complementary. On earnings news days, macro news increases the immediate stock return reaction by 8.86% compared to earnings release days without macro news releases.

Regarding the post-earnings announcement drift, we find no significant interaction between micro and macro news. The adjusted R^2 of 0.0005% in Column (3) indicates that,

relative to Hirshleifer and Sheng (2022) (see their Table 2), less 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.

Table A1: **Variables Definitions**

Variable Name	Description
ES	The earnings surprise, measured as the difference between reported earnings and analysts' expectations (median estimate), normalized by the stock price at the end of the forecast quarter.
OI$_{\tau-1}$	The option order imbalance before earnings news, calculated as difference in market activity on day $\tau - 1$ relative to the average order imbalance over non-announcement days from 40 to 10 trading days prior to the current earnings announcement.
CAR[h,H]	The cumulative excess return from the h-th to the H-th day after earnings announcements.
Volatility	The return volatility is the standard deviation of the stock return over the last 21 trading days.
QBA	The quoted bid-ask spread, defined as difference of the best ask and the best bid price scaled by the midpoint.
EBA	The effective bid-ask spread, defined as twice the difference between the transaction price and the midpoint, scaled by the midpoint.
Share turnover	A measure of stock liquidity, calculated as the proportion of shares traded relative to the total number of outstanding shares.
Market capitalization	A metric for assessing the total value of a company, calculated as the current share price multiplied by the total number of outstanding shares.
#Analysts	The number of financial analysts providing estimates for the company. Data is sourced from OptionMetrics.
#Earnings per news-day	The total number of earnings announcements for companies in the sample on a specific day.
MD	A dummy variable equal to 1 if macroeconomic news, such as FOMC decisions, Nonfarm Payroll, ISM PMI, or Personal Consumption data, coincides with the release of firm-specific (micro) news.
VOI, OTM-OI, DOI, BI-OI	Dollar-volume-weighted, out-of-the-money, delta-weighted, and buyer-initiated option order imbalance measures, as discussed in Sections 5.1–5.4 of the robustness section.

Table A2: **Option volume reaction to micro and macro news**

This table reports the regression results from the abnormal dollar volume of 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.

	Option AVOL[-1,0]	
	(1)	(2)
MD_τ	0.0294**	0.0349***
	(0.0127)	(0.0123)
Constant	1.0592***	1.3450***
	(0.0054)	(0.0171)
Controls	No	Yes
Observations	58,516	58,516
Adj. R^2	0.0001	0.0760

Table A3: **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