Asymmetric Uncertainty Around Earnings Announcements: Evidence from Options Markets

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ABSTRACT

We use the Indian stock options market to study the evolution of uncertainty and asymmetric uncertainty around earnings announcements (EAs). We find that uncertainty (implied volatility) and asymmetric uncertainty (options skew) increase monotonically before the EA day and decrease after EA. Options volume (relative to spot and to futures) also exhibits similar behavior, suggesting that informed investors prefer options markets to spot and futures markets. Both options skew and put-to-call volume ratio can predict the sign of the EA surprise one day before EA, indicating that price discovery and information assimilation happen in the options market.

KEYWORDS

Earnings Announcements, Volatility Smile, Earnings Surprise, Options Volume, Emerging Markets

JEL Classification: G13, G14

INTRODUCTION

Beginning with Ball and Brown (1968) and Beaver (1968), extensive literature documents that earnings announcements (EAs) have significant information content for investors. In addition, recent studies such as Beaver et al. (2018, 2020) have demonstrated a significant increase in the information content of EA in the 21st century. It is found that uncertainty builds up ahead of the scheduled EA and is resolved by the announcement. Accordingly, the implied volatility (IV) of stock options increases before EA, peaks on the eve of the announcement, and decreases after the EA (Donders and Vorst, 1996; Patell & Wolfson, 1979, 1981). However, the literature is relatively sparse regarding the use of the full richness of information about asymmetric risks in the options market. Asymmetric risks are essential for EA because it is well established in the literature that not all EAs have the same level of risk associated with it (Lu & Ray, 2016). For some EAs, the expected left-tail risk is high, while for others, the risk can be high at the right-tail. In both cases, the risk is realized sometimes and not realized at

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other times.[1] The options market can capture this asymmetric risk associated with EA, as investors can strategically position themselves through asymmetric bets using put and call options with strikes substantially away from the current market price. These informed asymmetric bets manifest in the options smile (or smirk), characterized by higher volatility for out-of-the-money (OTM) puts than for OTM calls. Hence, this paper delves into the examination of the evolution of uncertainty and asymmetric uncertainty around EA using options prices and volume.

Most of the literature on options markets and EAs is focused on the US market, and there is very little work on emerging markets. India boasts one of the world's largest single stock options (SSO) markets (Acworth, 2020). What sets it apart is the presence of a liquid single stock futures (SSF) market, offering an attractive avenue for informed traders with strong directional views. SSF, known for their cost-effectiveness, provides embedded leverage without the need for delta rebalancing (Jain et al., 2019a). While both SSF as well as SSO markets provide leverage benefits, the SSO market provides an additional benefit of asymmetric payoff and downside protection. Consequently, for investors with strong directional preferences, SSF may be the preferred market, whereas investors with uncertain directional preferences may prefer the options market. India, therefore, serves as an ideal context for studying the evolution of asymmetric uncertainty around EAs.

We study the dynamics of the IV smile and volume around all the EAs made during the 2015 to 2019 period by firms with derivatives contracts written on them. For estimating the options smile parameters, we use a rigorous methodology that avoids calculating the dividend yield and cost of carry and uses high-frequency trade data to alleviate the concern of asynchronous trading. We also analyze relative volume changes in the SSO market with spot and futures markets to assess the change in the investors' preference over the last five years, when the Indian market noticed a significant increase in the options volume relative to the futures volume.

Our key results are as follows. First, we notice a significant increase in the volatility levels during the EA month. Second, there is a gradual increase in the volatility across different strikes, causing an upward shift of the volatility smile before EA. The smile comes down after EA. This result is consistent with the theoretical argument that the uncertainty is high in the EA months and the uncertainty gets resolved after the EA (Ball and Brown, 1968; Beaver, 1968; Lu & Ray, 2016; Truong et al., 2012). Third, we notice an increase in the options volume relative to the futures volume (*O/F* ratio) and to the spot volume (*O/S* ratio) leading to EA and a subsequent fall in both the measures after EA. The pattern of *O/S* and *O/F* ratios show this pattern in India because the SSO market in India is highly liquid (Futures Industry Association, 2021). For example, while the average *O/S* ratio around EA is more than one in India, it is less than one in the US market (Roll et al., 2010).

Lastly, while the IV at the center of the smile (*ATM-IV*) does not predict the earnings surprises, the skew of the options smile (*RR-IV*) and the volume of the put options relative to the volume of the call options (*P/C* ratio) predict the directions of the impending earnings surprises. We find that the predictive power increases as we move closer to the EA day. There can be multiple reasons why the Indian options market can predict the sign of EA surprise very close to the EA date. First, in India derivatives contracts are allowed only for the largest and most liquid stocks that are widely followed and researched. This is likely to cause the option market to incorporate the impending EA surprises. Second, in the Indian options market, retail investors are allowed to write options easily. Thus, when the risks are one-sided there is a large potential supply of option writing on the other side where the risks are

[1] For EAs where investors expect poor earnings numbers, the anticipated left-tail risk is high. However, if the firms announce earnings that beat the market expectations, the expected left-tail risk does not materialize. Similarly, for EAs where investors anticipate good earnings numbers, the expected right-tail risk is high. Yet, if the firms' announced earnings fall short of expectations, the anticipated right-tail risk does not materialize.

low.[2] This makes the slope of options smile sharper than in countries where the dealers' balance sheets may constrain the supply of options. Third, insider trading in the options market near to the EA may result in an improved ability of the options market to predict EA. Anecdotal evidence also suggests that in India insiders trade in the options market to profit from unpublished price-sensitive information.[3]

Overall, our results confirm the forward-looking nature of the options market. Our results may also be construed as options markets being used by informed traders to benefit from private information. Our study also provides evidence of derivatives trading being motivated by views about future price movements, thereby providing support to the growing literature that derivatives markets don't just act as hedging tool but also help in the price discovery process.

To the best of our knowledge, this is the first study that investigates the options pricing and volume dynamics around EA in the Indian market, which has noticed a significant increase in the SSO volume during the last decade. We examine the dynamics of the IV smile along with the *P/C* ratio to understand the behavior of asymmetric bets in the options market around EA and test whether they can predict EA surprise. The Indian SSO market has noticed a significant rise in volume after 2015 both in absolute terms as well as relative to the other (SSF and Spot) markets (see Figure A1), thereby making it attractive for informed traders (Easley et al., 1998). Our findings are useful for regulators and the surveillance arm of exchanges to identify instances of trading based on unpublished price-sensitive information so that they can be taken up for detailed investigation.

The remaining part of our paper is structured as follows. Section 2 provides a brief review of the relevant literature along with the research questions. In Section 3, we present our research methodology along with the details of the variables used in the study. Section 4 provides the data sources and the descriptive statistics of the sample. Sections 5 and 6 show our main results and those from the battery of robustness tests, respectively. Section 7 concludes.

LITERATURE REVIEW AND RESEARCH QUESTIONS

Recent literature has documented an increase in the information content of EA (Beaver et al., 2018, 2020). Past studies have found that the investors' ex-ante belief of stock price volatility, as implied by the options prices, increases before EA and decreases after the EA (Donders and Vorst, 1996; Patell & Wolfson, 1979, 1981). The Options IV increases significantly during the pre-event period and reaches a maximum on the eve of EA. It then (post the EA) drops sharply and gradually moves back to its long-run level (Donders and Vorst, 1996). Recent papers (Rogers et al., 2009; Truong et al., 2012) have examined the differential impact of good and bad news released during EA and its effect on the IV buildup and change during EA. Lu & Ray (2016) study the residual uncertainty in the system after EA using risk-neutral density (RND) derived from options contracts and find that very good news does not reduce uncertainty. However, most of the papers in this domain have used the IV of at-the-money (ATM) options, thus missing out on the full richness of information (such as asymmetric risks) that the IV smile provides. For example, the skewness of the IV smile (*RR-IV*) captures the extent of asymmetric bets by investors in the options market.

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[2] For example if the market expects a positive surprise in the EA, the supply of call options will reduce as writing a call becomes risky, whereas the supply of put options will increase because writing a put is relatively less risky. This makes the calls more expensive than puts thus increasing the slope of the volatility smile.

[3] For example, a recent SEBI (Indian capital market regulator) order in the matter of insider trading has the following notes, ". . . over the years, the derivatives segment of the market has become multiple times the size of the cash segment and Futures and Options (F&O) have become an even bigger opportunity for an insider to make profit using UPSI. In fact, the F&O segment gives the insider a very "efficient" route to making unlawful gains . . . ". SEBI Order No WTM/MB/ISD/13519/2021-22. Retrieved from https://www.sebi.gov.in/enforcement/orders/sep-2021/interim-order-in-the-matter-of-i nsider-trading-by-employees-of-infosys-limited-and-wipro-limited-in-the-shares-of-in fosys-limited 52968.html

Several studies focus on options volume around EA. Past studies have compared the stock market reaction to EA for stocks acting as underlying for derivatives contracts and other stocks. However, there is mixed evidence about the impact of the availability of options contracts on the market reaction to EA. While studies by Skinner (1990) and Ho (1993) demonstrate that the stock market reaction to EA is smaller for firms having listed options, Truong et al. (2012), using a different subsample, find no difference in the immediate price response from the two groups of stocks.

Recent papers have used variations in the options volume (Truong, 2012) and the options-to-stock volume (*O/S*) ratio (Rai and Tartaroglu, 2015) to explain the cross- sectional variation in the market reaction to EA. However, there is limited usage of the relative volume of put and call options (*P/C* ratio) in predicting earnings surprises. Additionally, because of the absence of a liquid SSF market, one relatively unexplored area is the behavior of the SSO-to-SSF volume (*O/F* ratio) around EA.[4] In our first research question, we attempt to fill this gap in the literature. Specifically, we analyze the volatility and volume of options around EA in the Indian financial market. While doing so, we make two important departures from the literature. First, while examining volatility, we consider the entire IV smile drawn using the IV of options across the full range of strikes and examine how an EA surprise differentially influences the IV smile. Second, we supplement our options volume analysis with *O/S*, *O/F* , and *P/C* ratios around EA. We also examine the differential impact of the EA surprise on *P/C*.

Options markets are known to be a preferred venue for information-based trading (Easley et al., 1998) for various reasons such as short-sale constraints (Johnson & So, 2012), leverage effect (Ge et al., 2016), information asymmetry, and difference in opinions (Cao & Ou-Yang, 2008). Past studies have examined the ability of the options market (using both IV and volume) to explain future stock returns and provided evidence in its favor. The options prices, denominated by IV spread (Cremers & Weinbaum, 2010), options skew (Xing et al., 2010), *O/S* ratio (Johnson & So, 2012; Roll et al., 2010), and *P/C* ratio (Pan & Poteshman, 2006) are known to predict stock returns in general. Studies have also found a higher predictive power of the options market (volume and IV) before information events such as EA (Jin et al., 2012) and M&A (Cao & Ou-Yang, 2008; Chan et al., 2015). Motivated by this line of literature, in our second research question, we analyze whether the variations in the *ATM -IV* , *RR-IV* , and *P/C* ratio leading to the EA day predict the EA surprise. Our investigation would inform us about the extent of informed trading in the Indian SSO market.

Like that most emerging market peers, the literature on options market behavior around EA pertaining to the Indian market is very scant. Past studies have focused on establishing the existence of post-earnings-announcement drift (PEAD) in the Indian market and examining market efficiency around EA (Sen, 2009; Harshita et al., 2018). Jain et al. (2019a) examine the pattern of the option-to-spot volume (*O/S*) and the future-to- spot volume (*F/S*) around EA using a sample spanning 2008 to 2015 and find that SSF is preferred to SSO by informed traders before EA. However, the study did not examine the IV and *P/C* dynamics around EA that could help us in understanding the behavior of asymmetric bets in the options market and whether they can predict EA surprise. Asymmetric bets would reflect in the skewness of the IV curve and put-to-call ratio but not in the relative derivatives to spot volume.[5] Our study aims to fill this gap in the literature using a more recent dataset that includes the period when the Indian market has experienced a marked increase in the options volume (Figure A1).

[4] Also, the literature on options markets dynamics around EA is mainly focused on the US and other developed markets, and there is very little work on the emerging economies.

[5] While the Jain et al. (2019a) study uses data till 2015, the Indian SSO market has noticed a significant rise in volume after 2015 both in absolute terms as well as relative to the other (SSF and Spot) markets (see Figure A1), thereby making it attractive for informed trader (Easley et al., 1998). The increased liquidity of the SSO market post-2015 may have also altered the investors' preference across markets.

RESEARCH METHOD

ESTIMATING VOLATILITY SMILE

We use time-matched high-frequency data of SSO and SSF markets to estimate the volatility smile. The presence of a liquid SSF market along with SSO allows us to use the Black (1976) model for estimating IV. The use of time-matched high-frequency data and the Black (1976) model addresses the problems induced by asynchronous trading, stale prices, estimation of dividend yield, and the cost of carry (Black & Scholes, 1973; Jain et al., 2019b). Our IV smile estimation method is broadly similar to that used by Jain et al. (2019b). We apply various liquidity filters because some of the SSO contracts traded in the Indian market are illiquid and there is evidence of manipulations in such contracts (Jain et al., 2019b). We exclude all SSO contracts traded for less than five minutes in a day and remove all options contracts whose market prices lay outside the Black's model arbitrage bound. Following Jain et al. (2019b), we fit quadratic volatility smiles for all SSO-day pairs using contracts that satisfy our filter conditions. We use the 91-day T-Bill rate, obtained from the Reserve Bank of India's (RBI) website, as the risk-free rate for estimating the IV.

To ensure that sufficient data points are available for fitting the IV curve, we exclude SSO-day pairs having less than seven different SSO contracts trading on the day and not having at least one call, and one put SSO contract. A quadratic function is fitted for every SSO-day pair to estimate the IV curve. Specifically, we use $IV = a\Delta^2 + b\Delta + c$, where Δ is the call delta of the options contract, to estimate the IV curve of each SSO-day pair. Many previous studies have used a similar functional form to estimate the IV curve in the Indian context (Agarwalla et al., 2021a,c; Jain et al., 2019b). For fitting the smile, the Δ of put options is converted into the Δ of call options so that the Δ ranges between [0,1]. To ensure that IV always lies above the X-axis between [0, 1], we estimate the *a*, *b*, and *c* parameters with the restriction that *a* and *c* are non-negative. For this, *c* is shifted by $b^2/4a$ when $-b/2a \in [0, 1]$; else, *c* is shifted by $min(0, a + b)$. Deviating from Jain et al. (2019b), we aim to minimize the weighted mean-squared errors (WMSEs), using the log of the traded value as weights between the options market price and the estimated prices recursively. Also, the optimization is done by the Nelder–Mead (Nelder & Mead, 1965) simplex optimization function.

The above exercise gives us the values of *a*, *b*, and *c* for every SSO-day pair. The values are then used to estimate four parameters that characterize the options smile, hereafter referred to as 'smile parameters.' The four parameters are defined as follows. (a) *ATM-IV*: the IV of options having delta equal to 0.5 ($IV_{\Delta=0.5}$). (b) $IV_{\Delta=0.75}$: the IV of options having delta equal to 0.75. (c) $IV_{\Delta=0.25}$: the IV of options having delta equal to 0.25. (d) Risk-Reversal (*RR-IV*): the difference of the IV of options having delta equal to 0.25 and 0.75 ($IV_{\Delta=0.25} - IV_{\Delta=0.75}$). *RR-IV* becomes positive (negative) when OTM calls are more (less) expensive than OTM puts. The parameter has been used extensively in the literature as a measure of the skewness of the IV curve.

ESTIMATING EARNINGS SURPRISES

We use two measures of earnings surprise in the study. The first measure is the earnings surprise reported in the summary files of the IBES database, which we refer to as *IBES_Surprise*. Many previous studies have used IBES data to estimate earnings surprise (Hirshleifer et al., 2009; DellaVigna & Pollet, 2009; Truong & Corrado, 2014). The IBES database uses the following formula to estimate this surprise:

$$IBES\_Surprise = \frac{X_{i,q} - F_{i,q}}{F_{i,q}} \quad (1)$$

where $X_{i,q}$ is the reported earnings per share (EPS) by firm *i* in quarter *q* and $F_{i,q}$ is the mean value of the latest analysts' earnings estimates for firm *i* in quarter *q*. Our second measure of the EA surprise is the widely used standardized unexpected earnings (*SUE*) (Ball and Bartov, 1996), estimated using the following equation:

$$SUE_{i,q} = \frac{X_{i,q} - \mathrm{E}(X_{i,q})}{\sigma_{i,q}} \quad (2)$$

where $X_{i,q}$ is the actual EPS before extraordinary item, $E(X_{i,q})$ is the expected EPS, and $\sigma_{i,q}$ is the standard deviation of earnings surprises during the previous eight quarters. We use a seasonal random walk with a drift model to estimate expected earnings. Specifically, we use the following equation to estimate $E(X_{i,q})$:

$$\mathrm{E}(X_{i,q}) = X_{i,q-4} + \mu_{i,q} \quad (3)$$

$$\mu_{i,q} = \frac{\sum_{n=1}^{8}(X_{i,q-n} - X_{i,q-n-4})}{8} \quad (4)$$

ASYMMETRIC UNCERTAINTY AND OPTIONS SMILE

In this section, we present a hypothetical illustration demonstrating how asymmetric uncertainty around EA can influence the shape of the options smile curve. For our illustration, we assume that the expected stock price after the EA is a linear combination of the three lognormal normal distributions (φ_1, φ_2, and φ_3). We define φ_1, φ_2, and φ_3 as lognormal distributions with mean 100, 110, and 90 respectively, and with a standard deviation of 0.25. Hence, φ_1, φ_2, and φ_3 show a no surprise, positive surprise, and negative surprise scenario. The stock price follows a distribution that is a weighted average of these three lognormal distributions. The option price is also a weighted average of option prices from the three component distributions. This is because of the risk-neutral nature of option pricing and expectations being linear. Additionally, we assume a one-week time to maturity for the options contract (i.e., 1/52), and for simplicity, consider the risk-free rate and dividend yield to be zero.

With the aforementioned assumptions, we calculate the implied volatility of at- the-money options (*ATM -IV*), in-the-money options (*ITM -IV*), and out-of-the-money option (*OTM -IV*) under three conditions: an EA without surprise, an EA with a 10 percent probability of positive surprise, and an EA with a 10 percent probability of negative surprise. We determine the slope of the IV curve (*RR-IV*) in all three scenarios by subtracting *ITM-IV* from *OTM-IV* (*RR-IV = OTM-IV –ITM-IV*). In each case, we first estimate the *ATM-IV* by taking the strike price equal to the stock price under each of the three scenarios. Then, we use estimated *ATM – IV* to set the strike price of the *ITM (OTM)* option as the spot price divided (multiplied) by one plus *ATM -IV* /52.[6]

In the case of an EA with no surprise, the stock price follows the first lognormal distribution, denoted as φ_1, as there is no surprise weight given to the other two distributions (φ_1 and φ_2) is zero. In this scenario, the spot price is 100. The estimated *ATM -IV* using the Black & Scholes (1973) in this case is 25 % (the input parameters are Stock Price = 100, T = 1/52, R_f = 0, Div Yield = 0, Premium = 1.38). Using the estimated *ATM -IV* , we then set the strike price of ITM, and OTM options as 99.52 (100/(1+0.25/52)), and 100.48 (100 × (1+0.25/52)), respectively. Employing the assumptions outlined in the previous paragraph, we estimate the implied volatility (*ITM -IV* , and *OTM -IV*) using the Black & Scholes (1973) model. Column (1) of Table 1 presents the estimated im- plied volatility. Notably, *ATM -IV* is 25%, and *RR-IV* is zero. This

[6] We divide *ATM – IV* by 52 to convert it into weekly volatility from annual volatility.

example illustrates that the absence of asymmetry in the direction of EA surprise does not impact the slope of the options smile.

Next, in the case of an EA with an expected positive surprise, the stock price follows a distribution that is the weighted average of φ_1 and φ_2 with weights of 0.9 and 0.1, respectively, the weight given to φ_3 is zero. Consequently, in this scenario, the spot price is 101 (calculated as 0.9 × 100 + 0.1 × 110). The estimated *ATM-IV* using the Black & Scholes (1973) in this case is 31.37 % (the input parameters are Stock Price = 101, T = 1/52, R_f = 0, Div Yield = 0, Premium = 1.75). Consequently, the strike prices for ITM and OTM options are 100.39 (101/(1+0.3137/52)), and 101.61 (101 × (1+0.3137/52)), respectively. Using other assumptions outlined in the initial paragraph, we estimate the implied volatility (*ITM-IV*, and *OTM-IV*) using the Black & Scholes (1973) model. Column (2) of Table 1 reports the estimated implied volatility, revealing that *ATM-IV* is 31.37% and *RR-IV* is 1.08. This example shows that the presence of asymmetric risk (in this case it is in the right tail) during EA affects the slope of IV curve.

Lastly, in the third scenario, i.e., an EA with a negative expected surprise, the stock price follows a distribution that is the weighted average of φ_1 and φ_3 with weights of 0.9 and 0.1, respectively, the weight given to φ_2 is zero. Consequently, in this scenario, the spot price is 99 (calculated as 0.9 × 100 + 0.1 × 90). The estimated *ATM-IV* using the Black & Scholes (1973) in this case is 31.78 % (the input parameters are Stock Price = 99, T = 1/52, R_f = 0, Div Yield = 0, Premium = 1.74). Consequently, the strike prices for ITM and OTM options are 98.40 (99/(1+0.3178/52)), and 99.61 (99 × (1+0.3137/52)), respectively. Using other assumptions outlined in the initial paragraph, we estimate the implied volatility (*ITM-IV*, and *OTM-IV*) using the Black & Scholes (1973) model. Column (3) of Table 1 reports the estimated implied volatility, revealing that *ATM-IV* is 31.78% and *RR-IV* is −1.23. Taken together, both examples demonstrate that the presence of asymmetry in the direction of EA surprise significantly impacts the slope of the options smile.

Table 1. Asymmetric Uncertainty and Options Smile: An Illustration

	EA Without Surprise (1)	EA With Positive Surprise (2)	EA With Negative Surprise (3)
Spot Price	*100.00*	*101.00*	*99.00*
ITM Strike Price	*99.52*	*100.39*	*98.40*
ITM Premium	*1.63*	*2.04*	*2.09*
ITM-IV	*25.00 %*	*30.86 %*	*32.43 %*
ATM Strike Price	*100.00*	*101.00*	*99.00*
ATM Premium	*1.38*	*1.75*	*1.74*
ATM-IV	*25.00 %*	*31.37 %*	*31.78%*
OTM Strike Price	*100.48*	*101.61*	*99.61*
OTM Premium	*1.16*	*1.50*	*1.43*
OTM-IV	*25.00%*	*31.94 %*	*31.20%*
RR-IV (OTM-IV - ITM-IV)	*0.00*	*1.08*	*−1.23*

Note: The table reports the estimated implied volatility of *ITM*, *ATM*, and *OTM* options under three scenarios, EA without surprise, EA with positive surprise, and EA with negative surprise. All the assumptions made for the estimation are mentioned in subsection, Asymmetric Uncertainty and Options Smile.

SMILE PARAMETERS DYNAMICS AROUND EA

We first examine the behavior of options smile parameters in months having EA and months not having EA. We compare the mean value of the smile parameters (*ATM -IV* , $IV_{\Delta=0.75}$, and $IV_{\Delta=0.25}$) for the EA month with the values for other months using the difference-in-mean (*t*-test) test to verify the statistical significance of the variation in the mean values of smile parameters.

Second, to examine the behavior of the options smile around EA, we plot the daily mean value of the smile parameters for the period starting from 10 days before (*t*= −10) to 10 days after (*t*= +10) EA. We have normalized the smile parameters using the average of the daily values during the previous trading month.

Next, we analyze the behavior of the smile parameters around EA after categorizing the EA into three groups on the basis of the magnitude and sign of the surprise. The EAs are split into three quantiles on the basis of the EA surprise and are categorized as large negative, small positive/negative, and large positive (quantiles 1 to 3, respectively). We then plot the mean value of *ATM -IV* and *RR-IV* for ±10 days period around EA separately for the three categories of surprise. Our choice of the two parameters is influenced by past studies (Diavatopoulos et al., 2012; Truong et al., 2012) that have documented differential increases in these two parameters before EA, depending on the magnitude and sign of earnings surprises.

VOLUME DYNAMICS AROUND EA

To identify the investors' preferences across the three markets, we analyze the change in the trading volume around EA in all the three markets —spot, options, and futures. We calculate the *O/S* and *O/F* ratios for each firm at a daily frequency. The trend of *O/S* and *O/F* ratios around EA will give us an idea about the volume pickup in the options market relative to the spot and futures markets. If the options market is the investors' preferred market, we will notice an increase in the *O/S* and *O/F* ratios in the days leading to the EA and a fall afterward.

We supplement our volume analysis by examining the trend of the *P/C* ratio. Past studies have suggested that the *P/C* ratio impounds information about future stock prices (Pan & Poteshman, 2006). If this is true, we can expect the *P/C* ratio around EA to be sensitive to the EA surprise. To check this, we plot the mean value of *P/C* separately for the three categories of earnings surprises (large negative, small positive/negative, and large positive).

REGRESSION MODELS

To examine the extent of informed trading in the options market before EA, we analyze the predictive power of IV curve parameters (*ATM -IV* and *RR-IV*) and *P/C*. Specifically, we use pre-EA *RR-IV* , *ATM -IV* , and *P/C* to predict the surprise of the impending EA. Following the literature, we control for analysts' coverage, analysts' dispersion, stock beta, the proportion of institutional shareholding in the firm, momentum, size, and pre-EA buy-and-hold return (*BHAR*). Our main regression model is given below:

$$Surprise_{i,q} = \beta_1 RR - IV_{t-n,i,q} + \beta_2 - P/C_{t-n,i,q} + \beta_3 ATM - IV_{t-n,i,q} + \lambda X_{i,q} + \delta_i + \gamma_q + \mathrm{E}_{i,q} \quad (5)$$

where $Surprise_{i,q}$ is the earnings surprise of firm *i*'s EA for quarter *q* estimated using two separate measures —*IBES surprise* and *SUE*. $RR\text{-}IV_{t-n,i,q}$ is the value of firm *i*'s *RR-IV* *n* number of days before the EA of quarter *q*. $ATM\text{-}IV_{t-n,i,q}$ is the value of *i*th firm ATM-IV *n* number of days before quarter *q*'s EA. X_{iq}

is a vector of control, and λ is the vector of coefficients. We include the following controls. *Analyst Coverage*$_{i,q}$ is measured as *log*(1+*p*), where *p* is the number of analysts following firm *i* during quarter *q*. *Analyst Dispersion*$_{i,q}$ is firm *i*'s ratio of the standard deviation of the analysts' forecast and mean of analysts' consensus during the quarter. *Beta*$_{m-1,i,q}$ is the beta of firm *i*'s stock lagged by one month (*m* is the result month). *Institutional pct*$_{i,q-1}$ is the percentage of institutional holding in firm *i* lagged by a quarter. *Momentum*$_{i,q}$ is the return of the last 11 months leading to the quarterly EA of stock *i*. *Size*$_{m-1,i,q}$ is the average market capitalization of stock *i* lagged by a month. $P/C_{t-n,i,q}$ is firm *i*'s ratio of put options volume to call options volume *n* number of days before a particular quarter EA. $BHAR_{t-10,t-2,i,q}$ is firm *i*'s buy-and-hold return for the period $t = -10$ day to $t = -2$. δ_i and γ_q are firm-level and year-quarter fixed effects, respectively.

While estimating the above regression to predict earnings surprises, we use three different values of *n* = 1, 2, and 3. This use of the lag values of the options smile parameters helps us test the extent of informed trading in the options market during each of the three days before EA.

DATA AND DESCRIPTIVE ANALYSIS

INDIAN DERIVATIVES MARKET

The Indian capital market is well-regulated and liquid, with multiple well-functioning exchanges. The National Stock Exchange (NSE) is the main exchange and accounts for 99.9% of the derivatives contracts in India by volume. It ranks among the largest options markets in the world (Acworth, 2020). The Indian financial market is unique in many ways. First, unlike in the US, where spot and derivatives contracts trade at different exchanges, in India, the underlying stocks and all their derivatives products (Index options, Index futures, SSO, and SSF) trade at the same exchange. Second, the existence of a liquid SSF market along with a liquid SSO market improves the efficiency of the Indian derivatives market (Jain et al., 2019b). Third, the Indian regulator allows the derivatives trading of large and liquid stocks that many analysts also follow. Though Jain et al. (2019b) finds that the Indian SSO market is micro efficient with a low pricing error, many past studies have found huge expiry-day effects (Agarwalla & Pandey, 2013; Vipul, 2005) and the use of illiquid SSO/SSF products for market manipulation (Jain et al., 2019b).

These unique features can influence the market efficiency and information asymmetry of the underlying assets. Both SSO and SSF contracts provide embedded leverage to the traders that incentivizes them to acquire private information. This, in turn, improves the efficiency of the underlying assets and reduces the information asymmetry, as noted by Jain et al. (2019a). Moreover, the concurrent trading of SSF and SSO on the same platform attracts informed traders. Their trading activities generate public information about the fundamentals of the underlying assets, thereby contributing to the efficiency of the spot market by reducing information asymmetry (Easley et al., 1998). The SSF market also makes it easier for options traders to delta hedge their positions without worrying about leverage and short-selling constraints in the spot market.

DATA

We consider all EAs made from January 2015 to December 2019 by firms whose stocks act as underlying for derivatives contracts. Our sample selection period is motivated by the fact that the options volume in India increased significantly from 2015 (see Figure A1). We deliberately end our sample in the last quarter of 2019 to avoid the confounding effect of the COVID-19 crisis, which has been found to have a significant effect on the Indian stock market (Agarwalla et al., 2021b,c).

The data used in the study is taken from various sources. The exact broadcast time of the quarterly EA is taken from the respective firm's corporate announcement web pages on the NSE website. The EA dates are also cross-matched with the EA dates provided by the IBES database. The exact time of EA helps us categorize EAs into during-the- market-hours (DMH) and after-the-market-hours (AMH) announcements. We adjust the event date of AMH-EA to the next trading date, as suggested by Berkman & Truong (2009). Thus, for AMH-EA, the next trading date is considered as day zero.

The SSO and SSF data (both price and volume) used in the study are taken from the trading books and bhav copy of the NSE. As the near-month contracts are the most liquid, we consider only the near-month options series that expire after the EA date. As the Indian options market is known to exhibit huge expiry-day effects (Vipul, 2005; Agarwalla & Pandey, 2013), we remove EAs made less than three days before the expiry day of the near-month options series. The information relating to the spot market (returns and volume) and institutional shareholding in a firm is obtained from the CMIE Prowess database. Analysts' related information, such as coverage, mean, and standard deviation of the estimates, is obtained from the IBES database. See Table 2 for individual variables' sources. Our final dataset consists of 2,081 firm-quarter observations of 191 unique firms. As information relating to various dependent and independent variables is sourced from different datasets, the number of observations varies from analysis to analysis, depending on data availability. All the variables used in the study are winsorized at the 5 and 95 percentiles.

Table 2. Variable Construction Details

Variable Name	Variable Definition	Source
ATM -IV	*For every SSO-day pair, the IV of at-the-money options, i.e., $\Delta = 0.5$, divided by the mean value of ATM -IV of the month preceding the EA month.*	*NSE Trade Book*
$IV_{\Delta=0.75}$	*For every SSO-day pair, the IV of the options having $\Delta = 0.75$ divided by the mean value of $IV_{\Delta=0.75}$ of the month preceding the EA month.*	*NSE Trade Book*
$IV_{\Delta=0.25}$	*For every SSO-day pair, the IV of the options having $\Delta = 0.25$ divided by the mean value of $IV_{\Delta=0.25}$ of the month preceding the EA month.*	*NSE Trade Book*
RR-IV	*For every SSO-day pair, the difference of the IV of options having delta equal to 0.25 and 0.75 ($IV_{\Delta=0.25}IV_{\Delta=0.75}$).*	*NSE Trade Book*
Analyst_Coverage	*log(1+the number of analysts following the firm)*	*IBES*
Beta	*Estimate $r_{jt} = \alpha_j + \beta_j r_{mt} + c_{jt}$, where r_{jt} and r_{mt} are the returns for the stock j and the market at time t, respectively. We estimate a 60-month rolling window regression for each stock.*	*CMIE Prowess*
Institutional_pct	*Percentage of institutional shareholding in a firm*	*CMIE Prowess*
Analyst_Dispersion	*Ratio of the standard deviation of analyst's EPS forecast and the mean of analysts' EPS consensus*	*IBES*
Momentum	*Month t momentum of a stock is its return over the t – 12 to t – 1 months*	*CMIE Prowess*
Size	*Log of the average market capitalization of the stock in the pre-EA month.*	*CMIE Prowess*

Table 2. Continued

Variable Name	Variable Definition	Source
O/S	*Ratio of the daily trading volume of options and stocks*	*NSE Bhav Copy & CMIE Prowess*
O/F	*Ratio of the daily trading volume of options and futures*	*NSE Bhav Copy*
P/C	*Ratio of the daily trading volume of put options and call options*	*NSE Bhav Copy*
$BHAR_{t-10,t-2}$	*Buy-and-hold return from −10 to −2 days before EA*	*CMIE Prowess*

DESCRIPTIVE STATISTICS

Table 3 provides the summary statistics. Table 4 provides the correlation coefficients of surprise measures and our variables of interest. $RR\text{-}IV_{t-1,i,q}$, $RR\text{-}IV_{t-2,i,q}$, and $RR\text{-}IV_{t-3,i,q}$ are, on average, negative (−0.011, −0.007, −0.006), indicating that the OTM puts are more expensive than OTM calls just before EAs. Our two measures of earnings surprise—*SUE* and *IBES Surprise*—are positively correlated (0.17), as expected. The correlation coefficients of $RR\text{-}IV_{t-1,i,q}$ and $P/C_{t-1,i,q}$ (−0.228), $RR\text{-}IV_{t-2,i,q}$ and $P/C_{t-2,i,q}$ (−0.205), and $RR\text{-}IV_{t-3,i,q}$ and $P/C_{t-3,i,q}$ (−0.019) are negative, as expected (high put options demand increases the *P/C* ratio and decreases *RR-IV*), but the magnitude is very small. So, both the variables can be used in the same model without the issue of multicollinearity. As we move closer to EA, the correlation between the surprise measures and *RR-IV* increases in magnitude. The correlation between *SUE* (*IBES Surprise*) and *RR-IV* increases monotonically from 0.078 to 0.162 (0.052 to 0.157) from *t*= −3 to *t*= −1. As we come close to EA, we see a similar trend in the correlation between the *P/C* ratio and surprise measures. The correlation between *SUE* (*IBES Surprise*) and *P/C* decreases monotonically from −0.056 to −0.11 (−0.161 to −0.224) from *t*= −3 to *t*= −1. As expected, the correlation between *ATM -IV* and surprise measures does not show any clear pattern.

Table 3. Summary Statistics

Statistic	N	Mean	St. Dev.	Min	Pctl(25)	Median	Pctl(75)	Max
SUE Surprise	1,831	0.052	1.089	-2.678	-0.604	0.106	0.753	2.742
IBES Surprise	1,460	-0.170	1.154	-7.248	-0.212	-0.026	0.086	3.504
$RR\text{-}IV_{t-1,i,q}$	2,081	-0.011	0.060	-1.440	-0.031	-0.003	0.017	0.324
$ATM\text{-}IV_{t-1,i,q}$	2,081	0.455	0.142	0.226	0.363	0.430	0.520	1.053
$P/C_{t-1,i,q}$	2,081	0.124	0.184	0.002	0.025	0.060	0.145	1.153
$RR\text{-}IV_{t-2,i,q}$	1,768	-0.007	0.110	-4.171	-0.022	0.0003	0.018	0.403
$ATM\text{-}IV_{t-2,i,q}$	1,768	0.448	0.157	0.138	0.355	0.422	0.502	1.947
$P/C_{t-2,i,q}$	1,768	0.105	0.237	0.000	0.024	0.053	0.118	7.383
$RR\text{-}IV_{t-3,i,q}$	1,578	-0.006	0.149	-5.700	-0.019	-0.0001	0.017	0.187
$ATM\text{-}IV_{t-3,i,q}$	1,578	0.437	0.160	0.168	0.347	0.410	0.491	2.433
$P/C_{t-3,i,q}$	1,578	0.099	0.171	0.000	0.022	0.050	0.117	3.803
$Analyst\ Coverage_{i,q}$	2,055	2.835	0.903	0.000	2.398	3.091	3.526	3.951
$Beta_{m-1,i,q}$	1,971	1.265	0.595	0.050	0.842	1.245	1.690	2.827

Table 3. Continued

Statistic	N	Mean	St. Dev.	Min	Pctl(25)	Median	Pctl(75)	Max
Institutional $pct_{i,q-1}$	2,081	34.226	14.708	7.586	23.380	32.416	42.971	86.689
Analyst $Dispersion_{i,q}$	2,002	0.101	0.229	-1.163	0.046	0.082	0.143	0.993
$Momentum_{i,q}$	2,080	0.028	0.393	-0.835	-0.220	-0.003	0.250	1.243
$Size_{m-1,i,q}$	2,081	12.493	1.269	9.996	11.538	12.463	13.379	15.452
$BHAR_{t-10,t-2,i,q}$	2,081	-0.003	0.056	-0.149	-0.037	-0.004	0.029	0.191

Note: The table reports the summary statistics of the variables used in the study. $RR\text{-}IV_{t-1,i,q}$, $RR\text{-}IV_{t-2,i,q}$, and $RR\text{-}IV_{t-3,i,q}$ are the difference between implied volatility (IV) of options having delta equal to 0.25 and 0.75, one, two, and three days before the earnings announcement, respectively. $ATM\text{-}IV_{t-1,i,q}$, $ATM\text{-}IV_{t-2,i,q}$, and $ATM\text{-}IV_{t-3,i,q}$ are the IV of at-the-money options one, two, and three days before the earnings announcement, respectively. $P/C_{t-1,i,q}$, $P/C_{t-2,i,q}$, and $P/C_{t-3,i,q}$ are the ratio of put to call trading volume one, two, and three days before the earnings announcement, respectively. All other variables mentioned in the table are defined in Table 2. The sample period spans from January 2015 to December 2019.

Table 4. Correlation Table

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
SUE	1									
IBES Surprise	0.17	1								
$RR\text{-}IV_{t-1,i,q}$	0.162	0.157	1							
$ATM\text{-}IV_{t-1,i,q}$	−0.061	−0.233	−0.305	1						
$P/C_{t-1,i,q}$	−0.11	−0.224	−0.228	0.371	1					
$RR\text{-}IV_{t-2,i,q}$	0.091	0.113	0.559	−0.267	−0.162	1				
$ATM\text{-}IV_{t-2,i,q}$	−0.089	−0.249	−0.279	0.915	0.354	−0.273	1			
$P/C_{t-2,i,q}$	−0.082	−0.203	−0.177	0.368	0.882	−0.205	0.351	1		
$RR\text{-}IV_{t-3,i,q}$	0.078	0.052	0.469	−0.158	0.047	0.591	−0.141	0.038	1	
$ATM\text{-}IV_{t-3,i,q}$	−0.075	−0.227	−0.25	0.881	0.355	−0.253	0.964	0.347	−0.136	1
$P/C_{t-3,i,q}$	−0.056	−0.161	−0.154	0.367	0.81	−0.171	0.345	0.841	−0.019	0.348

Note: The table reports the correlation between the main independent and dependent variables used in the study. The sample period spans from January 2015 to December 2019. $RR\text{-}IV_{t-1,i,q}$, $RR\text{-}IV_{t-2,i,q}$, and $RR\text{-}IV_{t-3,i,q}$ are the difference between implied volatility (IV) of options having delta equal to 0.25 and 0.75, one, two, and three days before the earnings announcement, respectively. $ATM\text{-}IV_{t-1,i,q}$, $ATM\text{-}IV_{t-2,i,q}$, and $ATM\text{-}IV_{t-3,i,q}$ are the IV of at-the-money options one, two, and three days before the earnings announcement, respectively. $P/C_{t-1,i,q}$, $P/C_{t-2,i,q}$, and $P/C_{t-3,i,q}$ are the ratio of put to call trading volume one, two, and three days before the earnings announcement, respectively. All other variables mentioned in the table are defined in Table 2.

RESULTS AND DISCUSSION

OPTIONS SMILE DYNAMICS AROUND EA

As discussed in Section, *Smile Parameters Dynamics Around EA*, we first examine the behavior of options smiles in the EA and non-EA months. Table 5 shows the results of our analysis. We find that all the three smile parameters (*ATM -IV* , $IV_{\Delta=0.75}$, and $IV_{\Delta=0.25}$) are elevated in the months having EA than in the other months. The difference between the mean of the smile parameters in the EA months and the mean in pre- and post-EA months is statistically significant. The upward shift of the smile curve may reflect the increased volatility that the market expects in the price discovery process of the high information contents of EA. The price discovery process will lead to higher volatility, irrespective of the sign of the earnings surprises. Thus, our analysis provides evidence of elevated smiles in the months having EA than in the months without EA.

Table 5. Differences Between the Mean Values of IV Curve Parameters

IV Parameters	Pre-EA Month (1)	EA Month (2)	Post-EA Month (3)	(2)–(1) (*t*-stats) (4)	(2)–(3) (*t*-stats) (5)
ATM-IV	*0.383*	*0.411*	*0.372*	*0.028 (6.70)*	*0.038 (10.84)*
$IV_{\Delta=0.75}$	*0.397*	*0.427*	*0.391*	*0.030 (6.42)*	*0.036 (9.13)*
$IV_{\Delta=0.25}$	*0.397*	*0.422*	*0.388*	*0.024 (5.59)*	*0.034 (9.21)*

Note: Columns (1) to (3) report the mean value of IV curve parameters (*ATM-IV*, $IV_{\Delta=0.75}$, and $IV_{\Delta=0.25}$) for the month before the EA month, for the EA month, and for the month after the EA month. Columns (4) and (5) report the differences between the mean values of the EA month and the mean values of the month before the EA month and after the EA month, respectively, along with the *t*-statistics of the difference in the mean test.

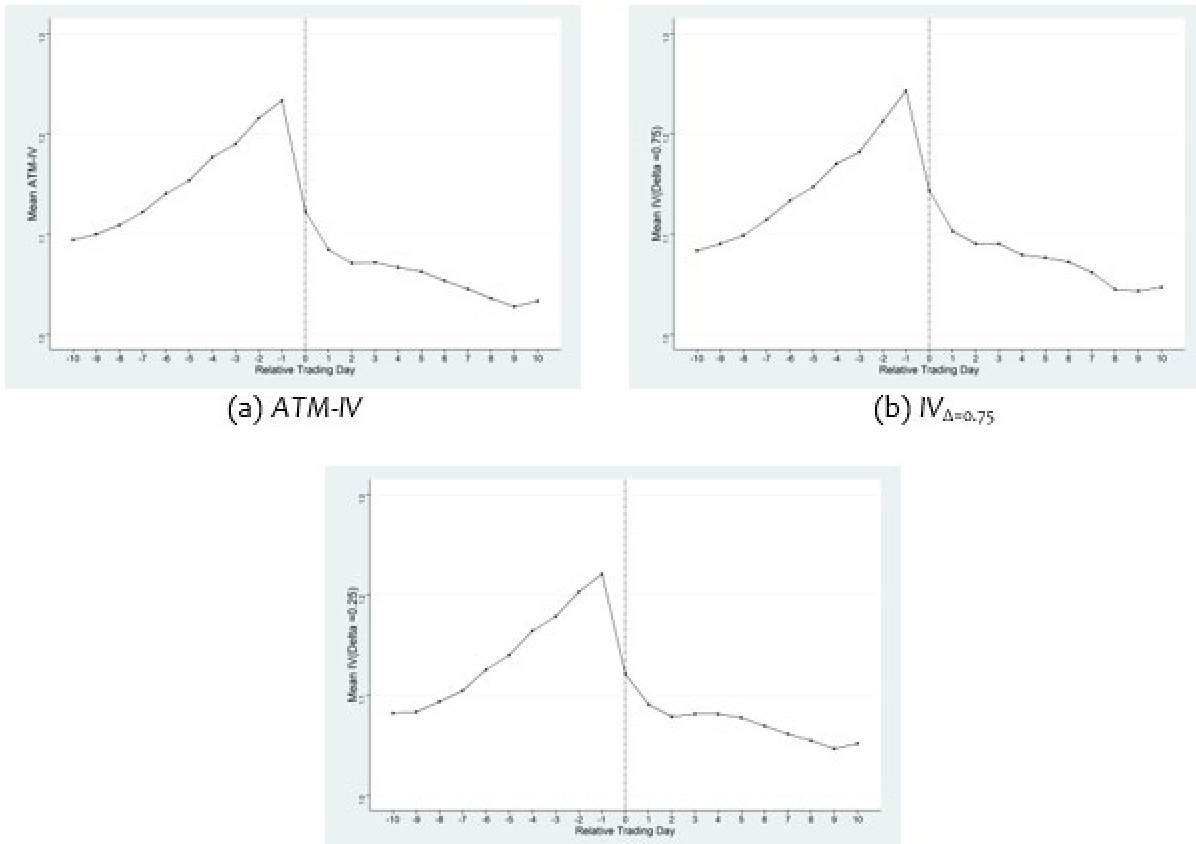
SMILE PARAMETERS AROUND EA

We examine the behavior of the option smiles around EA by first plotting the daily mean value of the options smile parameters around the EA day. Figure 1 shows the pattern of mean *ATM -IV* (plot a), $IV_{\Delta=0.75}$ (plot b), and $IV_{\Delta=0.25}$ (plot c). The figures highlight two key points. First, all the three smile parameters show a monotonic increase leading to EA, signifying a buildup of uncertainty before EA. Second, all three parameters experience a sharp fall immediately after EA, signifying the resolution of the uncertainty post-EA. These results confirm the uncertainty resolution role of EA, which is in line with the findings from other countries (Truong et al., 2012).

SMILE DYNAMICS AROUND EA CLASSIFIED ON THE BASIS OF EARNINGS SURPRISES

A. ATM -IV AND EARNINGS SURPRISES

Past studies have reported differences in the increase in *ATM -IV* before EA, depending on the sign of earnings surprises (Truong et al., 2012). However, the unique setting of the Indian market provides us with an opportunity to explore the pricing of the uncertainty in the options market in the presence of a liquid SSF market. While both SSF and SSO contracts provide leverage benefits, the SSO market provides additional benefits to investors seeking protection against downside risks (Jain et al., 2019b). The high information content of EA will make the options more expensive before EA to compensate for the expected increase in volatility of the underlying stocks because of the impending earnings information. To examine whether the increase in *ATM -IV* depends on the surprise, we plot the mean value of *ATM -IV* around EA classified separately on the basis of the earnings surprises.



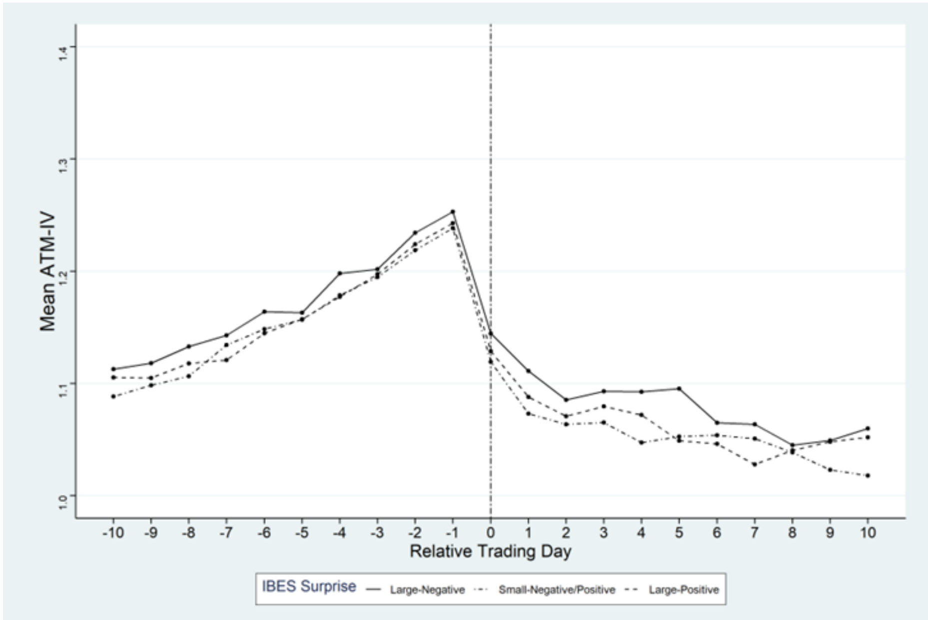
(a) *ATM-IV* (b) $IV_{\Delta=0.75}$

(c) $IV_{\Delta=0.25}$

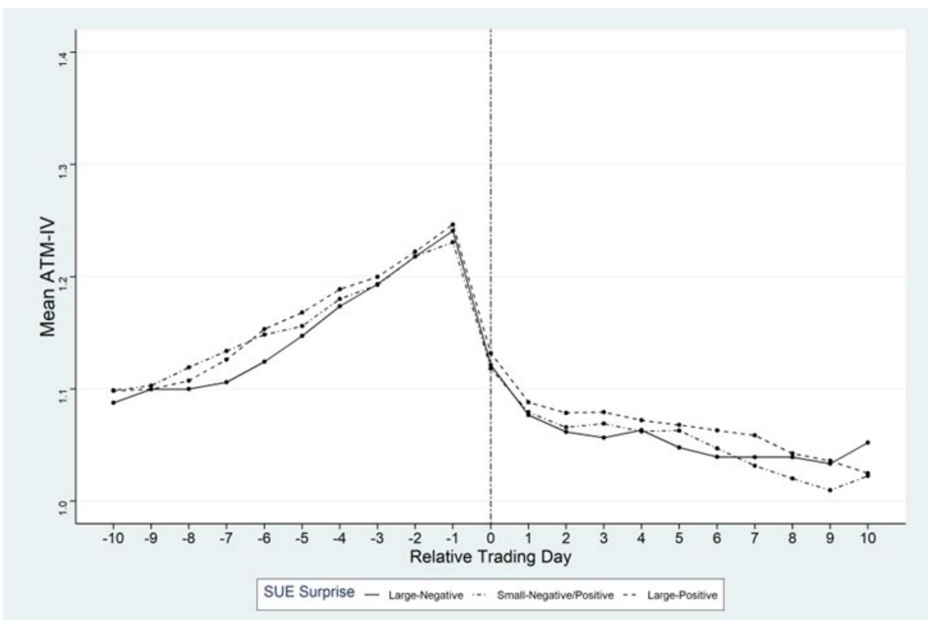
Figure 1. IV Parameter Dynamics Around EA

Note: The panels show the mean value of the normalized smile parameters (*ATM-IV*, $IV_{\Delta=0.75}$, and $IV_{\Delta=0.25}$) for a ±10-day window across the EA day. The vertical lines indicate EA days.

Figure 2 shows the trend of *ATM -IV* during the ±10-day window around EA classified on the basis of earnings surprises estimated using *IBES Surprise* (plot a) and *SUE* (plot b). Consistent with our expectations, we find that *ATM -IV* increases in the few days before EA, but the increase is not dependent on the EA surprise. The increase in *ATM -IV* reflects the increase in the options cost to compensate for the expected increase in the volatility by the impending earnings release. The increased options costs compensate for the additional benefit of the nonlinear payoff that SSO contracts provide over SSF contracts. Our findings diverge from those observed in the US market, where changes in the ATM-IV around EA are contingent upon the sign of the surprise. However, our results indicate that in the presence of an SSF market, investors mostly use ATM options (both call and put) to hedge against increased volatility risk during EA. This is because investors can take a leveraged directional position in the SSF market. Also, the lever- age and short-selling constraints are absorbed by the SSF market in India, the IV smile (computed off futures prices) is free of the effect of short-selling constraints. In markets without SSF, the smile would be impacted by these constraints. Consequently, in the presence of a liquid SSF market, the ATM-IV does not contain meaningful information about the EA surprise in the Indian market.



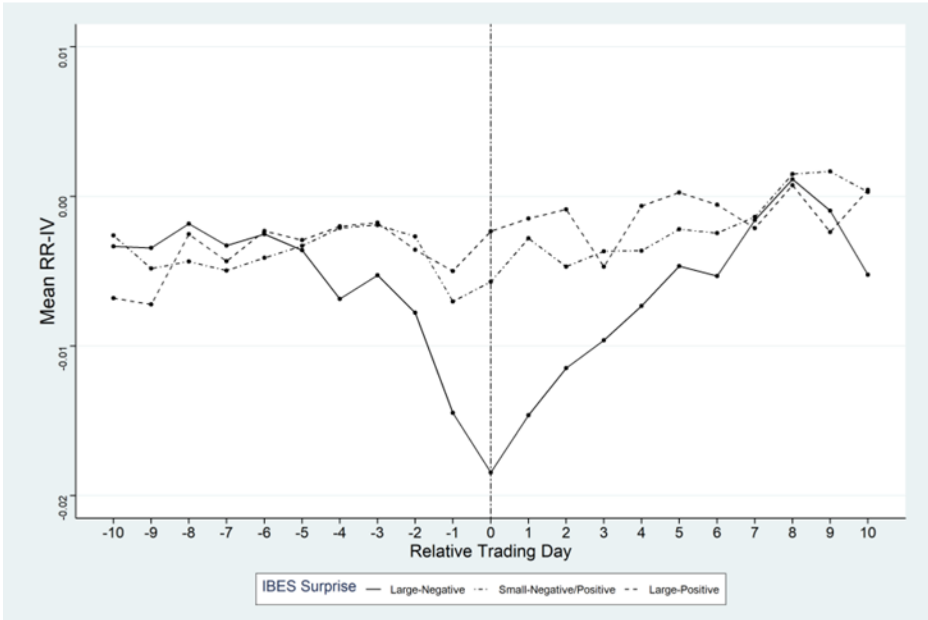
(a) IBES Surprise



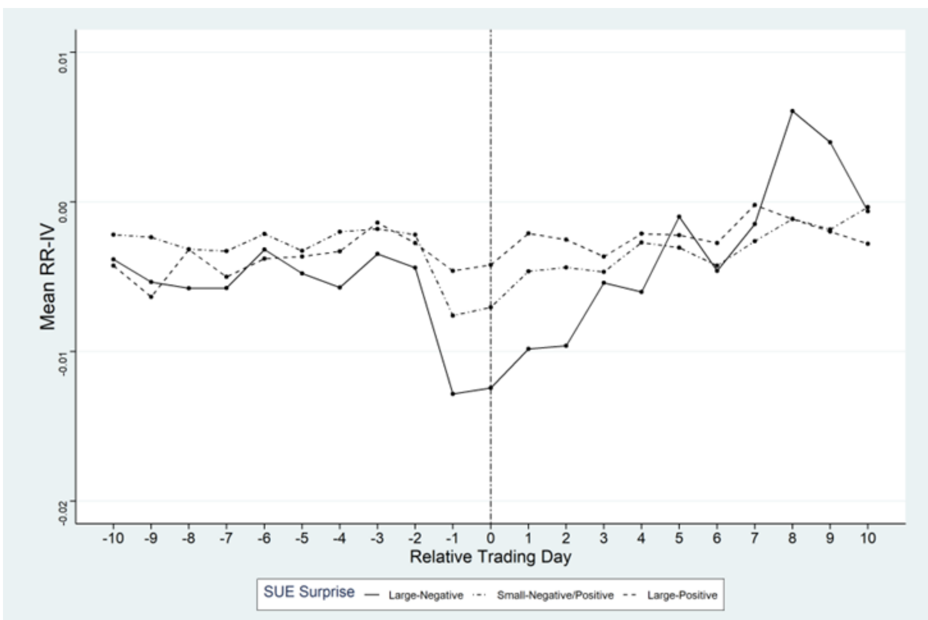
(b) SUE Surprise

Figure 2. ATM -IV and Surprise

Note: The panels show the pattern of adjusted *ATM -IV* categorized on the basis of earnings surprise, measured using (a) IBES-reported surprise and (b) standardized unexpected earnings. All EAs are categorized into large negative, small positive/negative, and large positive, by dividing the surprise measure into three quantiles. The vertical lines indicate EA days.



(a) IBES Surprise



(b) SUE Surprise

Figure 3. *RR-IV* and Surprise

Note: The panels show the pattern of the skew of the IV smile ($RR\text{-}IV = IV_{\Delta=0.25} - IV_{\Delta=0.75}$) categorized on the basis of earnings surprise, measured using (a) IBES-reported surprise and (b) standardized unexpected earnings. All EAs are categorized into large negative, small positive/negative and large positive, by dividing the surprise measure into three quantiles. The vertical lines indicate EA days.

B. RR-IV AND EARNINGS SURPRISES

RR-IV , defined as the difference between $IV_{\Delta=0.25}$ and $IV_{\Delta=0.75}$, measures the risk of a large price increase or price crash. The use of options contracts before EA to hedge against the downside risk will increase the demand for put options relative to call options, causing *RR-IV* to be negative. A negative *RR-IV* indicates that $IV_{\Delta=0.25}$ is lower than $IV_{\Delta=0.75}$, which is the case when OTM puts are costlier than OTM call options. We also expect *RR-IV* to be more negative in the case of EA having a large-negative surprise than in other cases. Past studies have found evidence of options trading being motivated by views about the direction of future stock prices (Lakonishok et al., 2007). An expected negative earnings surprise will increase the demand for put options than for call options, leading to negative *RR-IV* .

Figure 3 shows the trend of *RR-IV* for the two surprise measures —*IBES Surprise* (plot a) and *SUE* (plot b) —in a ±10-day window around EAs after classifying them into three groups on the basis of earnings surprises as before. We find that *RR-IV* is negative before EA. It becomes more negative before EA, with a large-negative surprise than that of the other two categories. This indicates that the options market could predict negative surprises very close to the event as insiders and informed traders trade on their private information closer to the announcement event. While insiders could benefit from taking positions in both options and futures markets, options contracts offer advantages such as a nonlinear payoff, greater leverage, and possibly lower costs. While the options contract buyers will have to pay the option premium (which would be lower for OTM contracts), the futures contract buyers will have to deposit margin money. The costs for the buyer of an options contract would mainly be the cost of option decay, which may be low for a very short period (given the investor holds the option only until EA).

VOLUME DYNAMICS AROUND EA

O/S AND O/F AROUND EA

While past research has already established that the *O/S* ratio increases leading to EA, little is known for markets where both SSO and SSF contracts trade simultaneously. The Indian financial market provides us with a unique setting wherein we can examine the investor's preference among the different markets (SSO, SSF, or spot) before EA. For this, we plotted the daily mean values of *O/S* and *O/F* for ±10 days around EA. Figure 4 shows that both *O/S* (plot a) and *O/F* (plot b) increase monotonically leading to EA. The two plots suggest that the investors prefer SSO markets to the spot and SSF markets, as suggested by the relatively high buildup in SSO volumes than in SSF and spot volumes. The high SSO volume may be explained by the fact that while both futures and options provide leverage and short-selling benefits, the downside protection (nonlinear payoff) is only provided by the options contracts.

P/C RATIO AND EARNINGS SURPRISES

Our previous analysis suggests that investors prefer the SSO market to the SSF and spot markets, and one possible reason is the presence of insurance-seeking or informed investors. The presence of insurance-seeking investors will lead to an increase in the *P/C* ratio before EA, and the presence of informed investors would cause a differential increase, depending on the surprise embedded in the impending EA. To test our conjecture, we plot the daily mean *P/C* ratio around EA after classifying EAs into three groups on the basis of earnings surprises, as explained in Section, *Volume Dynamics Around EA.* Figure 5 shows the trend of *P/C* in a ±10-day window around EA classified on the basis of the two measures of earnings surprises —*IBES Surprise* (plot a) and *SUE* (plot b). Consistent with our expectations, we find that the *P/C* ratio increases a few days before EA, indicating the use of options for hedging purposes. Regarding the information content of the options activity, we find that the increase in the *P/C* ratio is the highest in the case of large-negative surprises and the lowest in the case of large-positive surprises. The trend indicates that the options markets attract informed investors who trade on the basis of expected earnings surprises. In fact, taken along with the increase in the *O/F* ratio close to the EA day, one may also conjecture informed investors' preference for SSO over SSF contracts close to the EA day—a major information content release event.

EVIDENCE OF INFORMED TRADING—REGRESSION RESULTS

As discussed in Section, *Regression Models*, we use the regression specification in model 5 to examine the evidence of informed trading. We separately estimate the regression coefficients using different lag values of the smile parameters. The results are shown in Tables 6 and 7. Columns (1) and (2) present the estimated coefficients with *SUE* as the dependent variable, and columns (3) and (4) present the coefficients for the model that uses *IBES Surprise* as the dependent variable. Our variables of interest are the coefficients of the smile parameters (*RR-IV* and *ATM-IV*) and the *P/C* ratio.

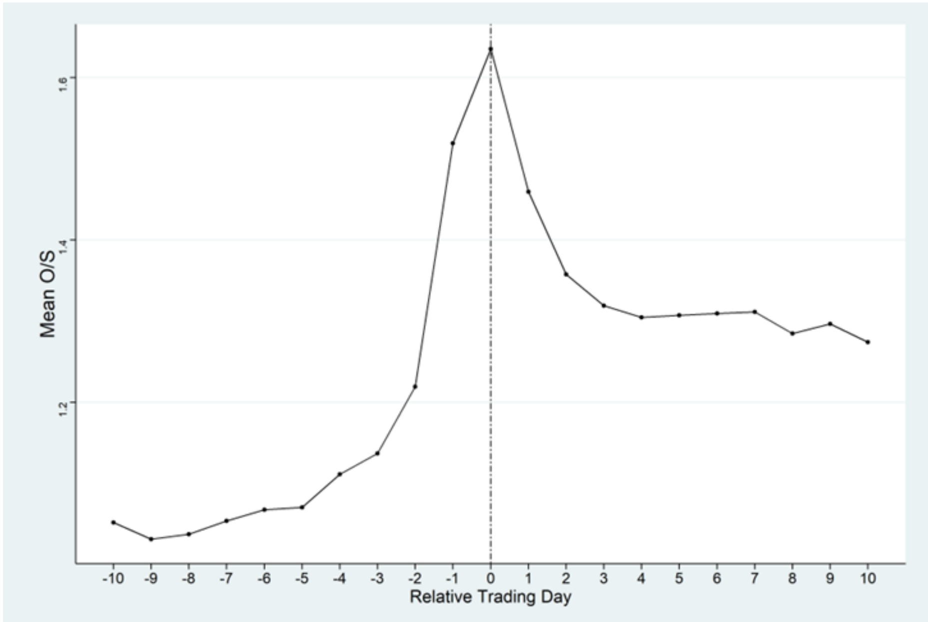
Table 6 shows the results of our regression model 5 when n =1. The estimated coefficient for $RR\text{-}IV_{t-1,i,q}$ is positive and significant, and that for $P/C_{t-1,i,q}$ is negative and significant. The coefficient estimate for $ATM\text{-}IV_{t-1,i,q}$ is statistically nonsignificant, which is consistent with our expectations. Specifically, we find that the level of *RR-IV* on the trading day immediately before EA can predict the sign of the EA surprise and that the result remains robust for two alternative measures of surprises. Similarly, the level of *P/C* one day before EA predicts the sign of the EA surprise, with a high value of *P/C* predicting a negative surprise. We find that the level of *ATM -IV* one day before EA does not predict the sign of EA surprises. Our results indicate the presence of informed traders in the SSO market one day before EA.

Table 7 shows the results of our regression model 5 when *n* = 2 and 3. Corroborating our expectations, we find that the two- and three-day lag values of our first variables of interest ($RR\text{-}IV_{t-2,i,q}$ and $RR\text{-}IV_{t-3,i,q}$) load positively on both the measures of surprise but are nonsignificant. Our second variable of interest, *P/C*, shows similar results. $P/C_{t-2,i,q}$ and $P/C_{t-3,i,q}$ load negatively on both the surprise measures but are nonsignificant. Coupling the results shown in Tables 6 and 7, we can infer that the predictive power of *RR-IV* and *P/C* increases as we come closer to the EA date. Thus, our regression analysis provides evidence that the options market can distinguish between the forthcoming positive and negative earnings surprises closer to the announcement date.

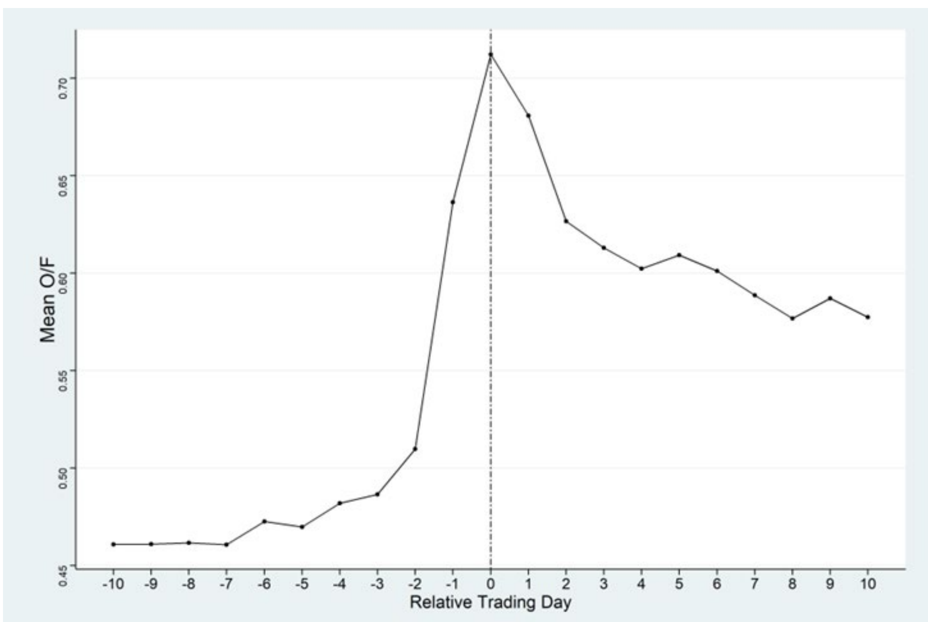
The extant literature provides evidence indicating that informed traders prefer trading in the options market before EA (Chakravarty et al., 2004; Augustin et al., 2016; Bondarenko & Muravyev, 2022). However, the extent to which informed trading intensity varies in the options market before EA remains less explored. Our analysis reveals that the options market can effectively predict the direction of the earnings surprise only very close to the EA, specifically one day before the announcement. Our finding holds significance for regulatory surveillance efforts, as it suggests that insiders may be utilizing the options market to trade based on unpublished price-sensitive information during periods very close to EA.

ROBUSTNESS

To test the robustness of our results, we use an alternative way to estimate smile parameters (*ATM - IV and RR-IV*). Instead of fitting quadratic volatility smiles, we use the moneyness of the options contract to categorize them into OTM, ATM, and ITM. Following Xing et al. (2010), we categorize a call



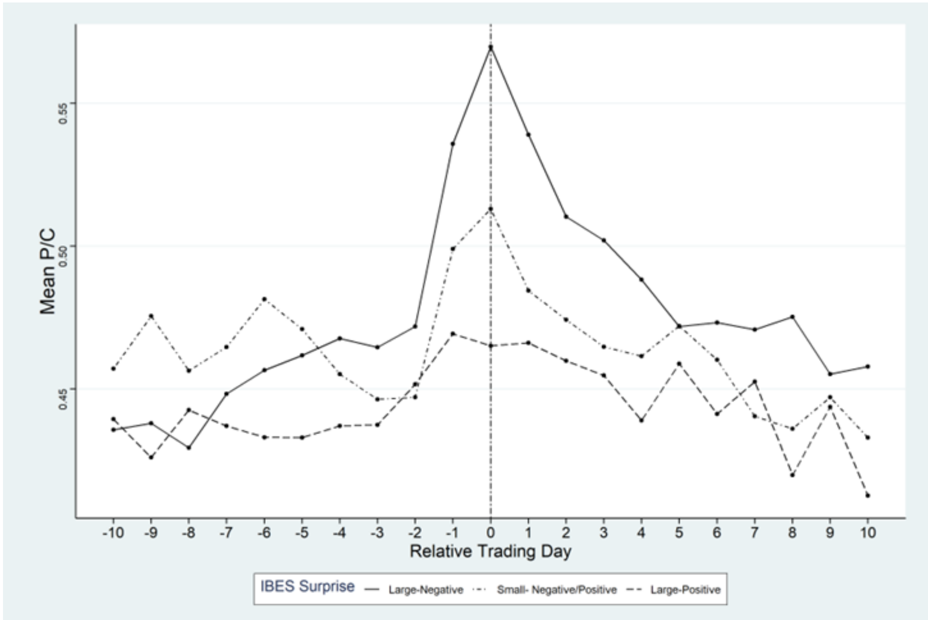
(a) *O/S*



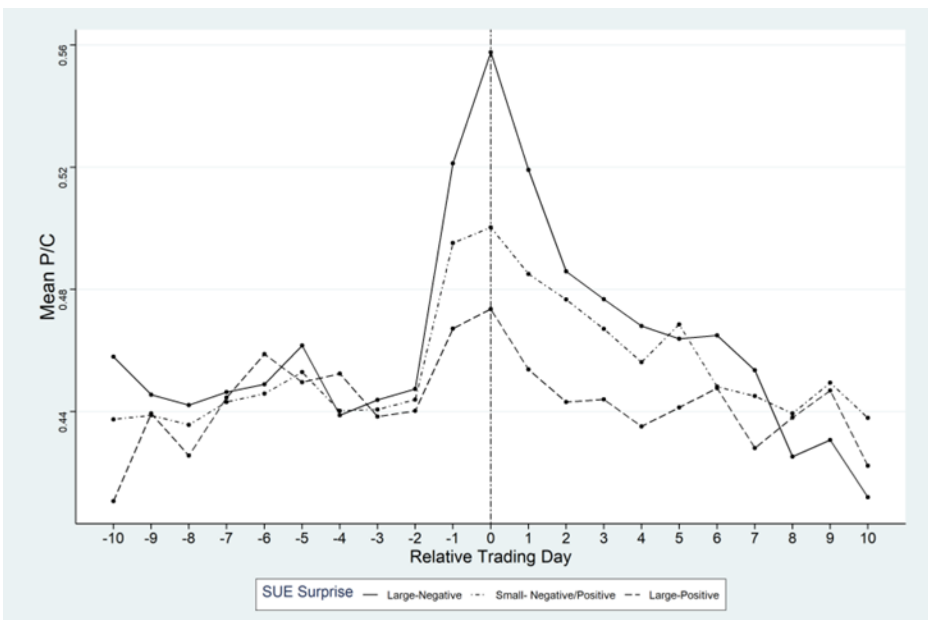
(b) *O/F*

Figure 4. Relative Volume and EA

Note: The panels show the mean value of the options-volume-to-stock-volume ratio (*O/S*) and the options-volume-to-SSF-volume ratio (*O/F*) for the ±10-day window around EA days (indicated by the vertical lines).



(a) IBES Surprise



(b) SUE Surprise

Figure 5. Put-to-Call Ratio and Surprise

Note: The panels show the pattern of the ratio of the volume of put options to the volume of call options (*P/C*) categorized on the basis of earnings surprise, measured using (a) IBES- reported surprise and (b) standardized unexpected earnings. All EAs are categorized into large negative, small positive/negative, and large positive, by dividing the surprise measure into three quantiles. The vertical lines indicate EA days.

Table 6. *RR-IV*, *P/C*, and EA Surprise (*n* = 1)

	SUE		IBES Surprise	
Dependent Variable	**(1)**	**(2)**	**(3)**	**(4)**
$RR\text{-}IV_{t-1,i,q}$	*2.168**** *(0.594)*	*2.514**** *(0.634)*	*0.750**** *(0.242)*	*0.824**** *(0.258)*
$P/C_{t-1,i,q}$	*-1.078**** *(0.388)*	*-1.149**** *(0.397)*	*-0.575**** *(0.157)*	*-0.570**** *(0.162)*
$ATM\text{-}IV_{t-1,i,q}$	*0.649** *(0.336)*	*0.416* *(0.362)*	*-0.069* *(0.134)*	*-0.135* *(0.145)*
$Analyst\_Coverage_{i,q}$	*-0.272*** *(0.107)*	*-0.204** *(0.113)*	*0.044* *(0.058)*	*0.060* *(0.061)*
$Beta_{m-1,i,q}$	*0.144* *(0.142)*	*0.185* *(0.148)*	*0.032* *(0.054)*	*0.046* *(0.056)*
$Institutional\_pct_{i,q-1}$	*0.016** *(0.009)*	*0.011* *(0.009)*	*0.001* *(0.004)*	*0.0001* *(0.004)*
$Analyst\_Dispersion_{i,q}$	*-0.396* *(0.398)*	*-0.361* *(0.402)*	*0.072* *(0.156)*	*0.045* *(0.159)*
$Momentum_{i,q}$	*-0.140** *(0.085)*	*-0.039* *(0.094)*	*0.053* *(0.035)*	*0.077** *(0.040)*
$Size_{m-1,i,q}$	*0.305**** *(0.110)*	*0.190* *(0.121)*	*-0.099*** *(0.045)*	*-0.086** *(0.049)*
$BHAR_{t-10,t-2,i,q}$	*1.074** *(0.547)*	*0.760* *(0.552)*	*0.052* *(0.218)*	*0.037* *(0.221)*
Firm-Level Fixed Effect	*Yes*	*Yes*	*Yes*	*Yes*
Year-Quarter Fixed Effect	*No*	*Yes*	*No*	*Yes*
Observations	*1,729*	*1,729*	*1,390*	*1,390*
Adjusted R^2	*0.028*	*0.038*	*0.140*	*0.142*

Note: The table reports the regression coefficients of equation 5 estimated using one day before EA $RR\text{-}IV_{t-1,i,q}$, $P/C_{t-1,i,q}$, and $ATM\text{-}IV_{t-1,i,q}$ as independent variables. The dependent variables are *SUE Surprise* in columns (1) and (2) and *IBES Surprise* in columns (3) and (4). The standard errors are reported in the parenthesis. ***, **, and * reflect the significance at 1, 5, and 10% levels, respectively.

(put) option as OTM if the option's strike price by futures price (futures price by strike price) is between 1.05 and 1.20. A call (put) option is categorized as ATM if the option's strike price by futures price (futures by strike price) is between 0.95 and 1.05. When there are multiple ATM and OTM options for a particular stock day, we estimate the volume-weighted IV of all the options contracts to arrive at one IV value for ATM and OTM for each SSO-day pair. Finally, we use the volume-weighted IV of ATM and OTM options of each SSO-day pair to calculate the RR-IV of the respective stock day. We use the following formula to estimate RR-IV:

$$Alt\ RR\text{-}IV = IV_{OTMCall} - IV_{OTMPut}$$

Table 7. *RR–IV* , *P/C*, and EA Surprise (*n* = 2 and 3)

	SUE		IBES Surprise	
Dependent Variable	**(1)**	**(2)**	**(3)**	**(4)**
$RR\text{-}IV_{t-2,i,q}$	*0.673*		*0.400*	
	(1.026)		*(0.413)*	
$P/C_{t-2,i,q}$	*-0.700*		*-0.096*	
	(0.590)		*(0.232)*	
$ATM\text{ -}IV_{t-2,i,q}$	*0.107*		*-0.292*	
	(0.464)		*(0.183)*	
$RR\text{-}IV_{t-3,i,q}$		*1.809*		*0.667*
		(1.240)		*(0.499)*
$P/C_{t-3,i,q}$		*-0.274*		*-0.373*
		(0.669)		*(0.258)*
$ATM\text{ -}IV_{t-3,i,q}$		*0.575*		*-0.110*
		(0.532)		*(0.209)*
$Analyst\_Coverage_{i,q}$	*-0.173*	*-0.203*	*0.114**	*0.076*
	(0.128)	*(0.141)*	*(0.068)*	*(0.074)*
$Beta_{m-1,i,q}$	*0.233*	*0.340**	*0.030*	*0.072*
	(0.162)	*(0.175)*	*(0.061)*	*(0.064)*
$Institutional\_pct_{i,q-1}$	*0.004*	*0.008*	*-0.0002*	*0.003*
	(0.011)	*(0.011)*	*(0.004)*	*(0.004)*
$Analyst\_Dispersion_{i,q}$	*-0.607*	*-0.627*	*0.087*	*0.0092*
	(0.442)	*(0.466)*	*(0.174)*	*(0.184)*
$Momentum_{i,q}$	*0.021*	*0.044*	*0.073**	*0.065*
	(0.103)	*(0.112)*	*(0.044)*	*(0.047)*
$Size_{m-1,i,q}$	*0.215*	*0.270**	*-0.083*	*-0.054*
	(0.135)	*(0.145)*	*(0.055)*	*(0.058)*
$BHAR_{t-10,t-2,i,q}$	*1.257***	*1.337***	*0.152*	*-0.118*
	(0.612)	*(0.666)*	*(0.243)*	*(0.259)*
Firm-Level Fixed Effect	*Yes*	*Yes*	*Yes*	*Yes*
Year-Quarter Fixed Effect	*Yes*	*Yes*	*Yes*	*Yes*
Observations	*1,474*	*1,320*	*1,210*	*1,074*
Adjusted R^2	*0.014*	*0.014*	*0.126*	*0.126*

Note: The table reports the regression coefficients of equation 5, with standard errors in parenthesis. The dependent variables are *SUE Surprise* in columns (1) and (2) and *IBES Surprise* in columns (3) and (4). In columns (1) and (3) two days before EA $RR\text{-}IV_{t-2,i,q}$, $P/C_{t-2,i,q}$, and $ATM\text{ -}IV_{t-2,i,q}$ are independent variables. In columns (2) and (4) three days before EA $RR\text{-}IV_{t-3,i,q}$, $P/C_{t-3,i,q}$, and $ATM\text{ -}IV_{t-3,i,q}$ are independent variables. ***, **, and * reflect the significance at 1, 5, and 10% levels, respectively.

where $IV_{OTMCall}$ is the volume-weighted IV of all the OTM call options and IV_{OTMPut} is the volume-weighted IV of all the OTM put options. The above exercise gives a single value of ATM and OTM call and put options for every SSO-day pair. For the sake of clarity, we call them *Alt ATM -IV* and *Alt RR-IV*. In our robustness test, we use *Alt ATM -IV* and *Alt RR-IV* in our regression equation 5. The results reported in Tables 8 and 9 show that our main results remain qualitatively similar even if we use the alternate definitions of ATM-IV and RR-IV.

Table 8. Alternate Estimate of IV: *RR-IV*, *P/C*, and EA Surprise (*n* = 1)

Dependent Variable	SUE (1)	SUE (2)	IBES Surprise (3)	IBES Surprise (4)
Alt RR-IV$_{t-1,i,q}$	*1.844**** *(0.656)*	*2.386**** *(0.699)*	*0.428** *(0.256)*	*0.483** *(0.271)*
P/C$_{t-1,i,q}$	*-0.635**** *(0.142)*	*-0.620**** *(0.145)*	*-0.188**** *(0.055)*	*-0.205**** *(0.057)*
Alt ATM -IV$_{t-1,i,q}$	*0.718*** *(0.337)*	*0.432* *(0.362)*	*-0.061* *(0.134)*	*-0.115* *(0.143)*
Analyst_Coverage$_{i,q}$	*-0.252*** *(0.110)*	*-0.170* *(0.117)*	*-0.013* *(0.060)*	*-0.004* *(0.065)*
Beta$_{m-1,i,q}$	*0.168* *(0.144)*	*0.234* *(0.150)*	*0.076* *(0.054)*	*0.095** *(0.055)*
Institutional_pct$_{i,q-1}$	*0.015* *(0.009)*	*0.009* *(0.009)*	*0.001* *(0.004)*	*0.0001* *(0.004)*
Analyst_Dispersion$_{i,q}$	*-0.597* *(0.400)*	*-0.594* *(0.405)*	*0.032* *(0.156)*	*0.013* *(0.159)*
Momentum$_{i,q}$	*-0.082* *(0.086)*	*0.035* *(0.096)*	*0.063** *(0.035)*	*0.086*** *(0.040)*
Size$_{m-1,i,q}$	*0.343**** *(0.110)*	*0.229** *(0.122)*	*-0.091*** *(0.045)*	*-0.072* *(0.049)*
BHAR$_{t-10,t-2,i,q}$	*1.107*** *(0.548)*	*0.863* *(0.553)*	*0.243* *(0.216)*	*0.234* *(0.218)*
Firm-Level Fixed Effect	*Yes*	*Yes*	*Yes*	*Yes*
Year-Quarter Fixed Effect	*No*	*Yes*	*No*	*Yes*
Observations	*1,672*	*1,672*	*1,334*	*1,334*
Adjusted R^2	*0.034*	*0.043*	*0.150*	*0.158*

Note: The table reports the regression coefficients of equation 5 estimated using one day before EA *Alt RR-IV*$_{t-1,i,q}$, *P/C*$_{t-1,i,q}$, and *Alt ATM -IV*$_{t-1,i,q}$ as independent variables. The dependent variables are *SUE Surprise* in columns (1) and (2) and *IBES Surprise* in columns (3) and (4). The standard errors are reported in the parenthesis. ***, **, and * reflect the significance at 1, 5, and 10% levels, respectively.

CONCLUSION

We examine the price and volume dynamics in the options market before EAs to study how they reflect the asymmetric risks of earnings surprises in the Indian market. India is unique in having liquid options and futures markets in individual stocks and provides an ideal setting to study the evolution of the asymmetric uncertainty around EAs. Our key results are as follows. First, both uncertainty and asymmetric uncertainty are elevated before EA and come down after it. Therefore, option volatility, smirk, and volumes increase before EA and decrease immediately after EA for options expiring after an EA. Second, the markets can differentiate between forthcoming positive and negative earnings surprises only very near to the announcement date. This suggests that firms' internal controls and enforcement of insider trading laws ensure that, by and large, the actual surprise content of EAs remains confidential until perhaps very close to their release. Our results suggest that even in the presence of a liquid SSF market, informed traders are attracted toward the options market, which becomes an important venue for price discovery and the assimilation of information about earnings surprises. Our paper adds to the larger debate on the options market's role in helping price discovery and assimilation of private information.

Table 9. Alternate Estimate of IV: *RR-IV*, *P/C*, and EA Surprise (*n* = 2 and 3)

	SUE		IBES Surprise	
Dependent Variable	(1)	(2)	(3)	(4)
Alt RR-IV$_{t-2,i,q}$	*3.010****		*-0.167*	
	(1.037)		*(0.415)*	
P/C$_{t-2,i,q}$	*-0.204*		*-0.108*	
	(0.190)		*(0.076)*	
Alt ATM -IV$_{t-2,i,q}$	*0.102*		*-0.266*	
	(0.471)		*(0.185)*	
Alt RR-IV$_{t-3,i,q}$		*2.314**		*0.215*
		(1.213)		*(0.472)*
P/C$_{t-3,i,q}$		*-0.302*		*-0.057*
		(0.191)		*(0.075)*
ATM -IV$_{t-3,i,q}$		*0.416*		*-0.179*
		(0.531)		*(0.203)*
Analyst_Coverage$_{i,q}$	*-0.152*	*-0.147*	*0.101*	*0.080*
	(0.132)	*(0.143)*	*(0.069)*	*(0.074)*
Beta$_{m-1,i,q}$	*0.344***	*0.394***	*0.061*	*0.075*
	(0.163)	*(0.174)*	*(0.060)*	*(0.062)*
Institutional_pct$_{i,q-1}$	*0.001*	*0.006*	*-0.002*	*0.004*
	(0.011)	*(0.012)*	*(0.004)*	*(0.005)*
Analyst_Dispersion$_{i,q}$	*-0.892***	*-0.712*	*-0.010*	*0.190*
	(0.437)	*(0.472)*	*(0.175)*	*(0.182)*
Momentum$_{i,q}$	*0.070*	*0.076*	*0.099***	*0.077***
	(0.105)	*(0.113)*	*(0.043)*	*(0.046)*
Size$_{m-1,i,q}$	*0.232**	*0.313***	*-0.112***	*-0.044*
	(0.134)	*(0.143)*	*(0.054)*	*(0.056)*
BHAR$_{t-10,t-2,i,q}$	*1.277***	*1.565*	*0.304*	*0.009*
	(0.607)	*(0.653)*	*(0.238)*	*(0.252)*
Firm-Level Fixed Effect	*Yes*	*Yes*	*Yes*	*Yes*
Year-Quarter Fixed Effect	*Yes*	*Yes*	*Yes*	*Yes*
Observations	*1,429*	*1,273*	*1,157*	*1,030*
Adjusted R^2	*0.031*	*0.027*	*0.129*	*0.157*

Note: The table reports the regression coefficients of equation 5, with standard errors in parenthesis. The dependent variables are *SUE Surprise* in columns (1) and (2) and *IBES Surprise* in columns (3) and (4). In columns (1) and (3) two days before EA *Alt RR-IV$_{t-2,i,q}$*, *P/C$_{t-2,i,q}$*, and *Alt ATM -IV$_{t-2,i,q}$* are independent variables. In columns (2) and (4) three days before EA *Alt RR-IV$_{t-3,i,q}$*, *P/C$_{t-3,i,q}$*, and *Alt ATM -IV$_{t-3,i,q}$* are independent variables. ***, **, and * reflect the significance at 1, 5, and 10% levels, respectively.

Our results carry several policy implications. First, in the current regulatory frame- work, exchanges typically require companies to explain any unusual movement in the stock price to ensure the absence of pending information disclosure. Our results propose an extension to this practice, suggesting that exchanges should also seek explanations for any unusual movement in the slope of the IV smile (*RR-IV*), as such movements are indicative of potential forthcoming earnings surprises. Second, our results advocate for the consideration of *RR-IV* as an additional metric by regulators in monitoring the potential leakage of price-sensitive information around EA. Lastly, recognizing the primal role played by the options market in the price discovery process and improving the efficiency of the market, our results suggest that emerging markets lacking liquid option markets should try to establish them. Moreover, the development of the SSF market is also recommended, as it can alleviate short-selling constraints, thereby improving market efficiency.

REFERENCES

Acworth, W. (2020). *2019 market data - derivatives volume grows BRIC by BRIC*. Futures Industry Association. https://www.fia.org/marketvoice/articles/2019-market-data-derivatives-volume-grows-bric-bric

Agarwalla, S. K. & Pandey, A. (2013). Expiration-day effects and the impact of short trading breaks on intraday volatility: Evidence from the Indian market. *Journal of Futures Markets*, 33, 1046–1070.

Agarwalla, S. K., Saurav, S., & Varma, J.R. (2021a). Lottery and bubble stocks and the cross-section of option-implied tail risks. *Journal of Futures Markets*, 42, 231–249.

Agarwalla, S. K., Varma, J. R., & Virmani, V. (2021b). The impact of COVID-19 on tail risk: Evidence from Nifty index options. *Economics Letters*, 204, 109878.

Agarwalla, S. K., Varma, J. R., & Virmani, V. (2021c). Rational repricing of risk during covid- 19: Evidence from Indian single stock options market. *Journal of Futures Markets*, 41, 1498–1519.

Augustin, P., Brenner, M., Grass, G., & Subrahmanyam, M. G. (2016). How do informed investors trade in the options market?

Ball, R. & Bartov, E. (1996). How naive is the stock market's use of earnings information? *Journal of Accounting and Economics*, 21, 319–337.

Ball, R. & Brown, P. (1968). An empirical evaluation of accounting income numbers. *Journal of Accounting Research,* 6, 159–178.

Beaver, W. H. (1968). The information content of annual earnings announcements. *Journal of Accounting Research* , 6, 67–92.

Beaver, W. H., McNichols, M. F., & Wang, Z. Z. (2018). The information content of earnings announcements: New insights from intertemporal and cross-sectional behavior. *Review of Accounting Studies,* 23, 95–135.

Beaver, W. H., McNichols, M. F., Wang, Z. Z. (2020). Increased market response to earnings announcements in the 21st century: An empirical investigation. *Journal of Accounting and Economics,* 69, 101244.

Berkman, H. & Truong, C. (2009). Event day 0? After-hours earnings announcements. *Journal of Accounting Research*, 47, 71–103.

Black, F. (1976). The pricing of commodity contracts. *Journal of Financial Economics,* 3, 167–179.

Black, F. & Scholes, M. (1973). The pricing of options and corporate liabilities. *Journal of Political Economy,* 81, 637–654.

Bondarenko, O. & Muravyev, D. (2022). *How common is insider trading? Evidence from the options market.* SSRN. https://ssrn.com/abstract=4150768

Cao, H. H. & Ou-Yang, H. (2008). Differences of opinion of public information and speculative trading in stocks and options. *The Review of Financial Studies,* 22, 299–335.

Chakravarty, S., Gulen, H., & Mayhew, S. (2004). Informed trading in stock and option markets. *The Journal of Finance*, 59, 1235–1257.

Chan, K., Ge, L., & Lin, T. C. (2015). Informational content of options trading on acquirer announcement return. *Journal of Financial and Quantitative Analysis*, 50, 1057–1082.

Cremers, M. & Weinbaum, D. (2010). Deviations from put-call parity and stock return predictability. Journal of Financial and Quantitative Analysis 45, 335–367.

DellaVigna, S. & Pollet, J. M. (2009). Investor inattention and Friday earnings announcements. *The Journal of Finance,* 64, 709–749.

Diavatopoulos, D., Doran, J. S., Fodor, A., & Peterson, D. R. (2012). The information content of implied skewness and kurtosis changes prior to earnings announcements for stock and option returns. *Journal of Banking & Finance*, 36, 786–802.

Donders, M. W. & Vorst, T. C. (1996). The impact of firm specific news on implied volatilities. *Journal of Banking & Finance*, 20, 1447–1461.

Easley, D., O'hara, M., & Srinivas, P. S. (1998). Option volume and stock prices: Evidence on where informed traders trade. *The Journal of Finance*, 53, 431–465.

Futures Industry Association. (2021). *Global futures and options trading reaches record level in 2020*. https://www.fia.org/fia/articles/global-futures-and-options-trading-reaches-record-level-2020

Ge, L., Lin, T. C., & Pearson, N. D. (2016). Why does the option to stock volume ratio predict stock returns? *Journal of Financial Economics,* 120, 601–622.

Harshita, Singh, S., & Yadav, S. S. (2018). Post-earnings-announcement drift anomaly in India: A test of market efficiency. *Theoretical Economics Letters,* 8, 3178.

Hirshleifer, D., Lim, S. S., & Teoh, S. H. (2009). Driven to distraction: Extraneous events and underreaction to earnings news. *The Journal of Finance*, 64, 2289–2325.

Ho, L. C. J. (1993). Option trading and the relation between price and earnings: A cross- sectional analysis. *Accounting Review*, 368–384.

Jain, S., Agarwalla, S. K., Varma, J. R., & Pandey, A. (2019a). Informed trading around earnings announcements—spot, futures, or options? *Journal of Futures Markets*, 39, 579–589.

Jain, S., Varma, J. R., & Agarwalla, S. K. (2019b). Indian equity options: Smile, risk premiums, and efficiency. *Journal of Futures Markets*, 39, 150–163.

Jin, W., Livnat, J., & Zhang, Y. (2012). Option prices leading equity prices: Do option traders have an information advantage? *Journal of Accounting Research*, 50, 401– 432.

Johnson, T. L. & So, E. C. (2012). The option to stock volume ratio and future returns. *Journal of Financial Economics*, 106, 262–286.

Lakonishok, J., Lee, I., Pearson, N. D., & Poteshman, A. M. (2007). Option market activity. *The Review of Financial Studies*, 20, 813–857.

Lu, Y. & Ray, S. (2016). Too good to be true? An analysis of the options market's reactions to earnings releases. *Journal of Business Finance & Accounting,* 43, 830–848.

Nelder, J. A., & Mead, R. (1965). A simplex method for function minimization. *The Computer Journal*, 7, 308–313.

Pan, J. & Poteshman, A. M. (2006). The information in option volume for future stock prices. *The Review of Financial Studies,* 19, 871–908.

Patell, J. M. & Wolfson, M. A. (1979). Anticipated information releases reflected in call option prices. *Journal of Accounting and Economics*, 1, 117–140.

Patell, J. M. & Wolfson, M. A. (1981). The ex ante and ex post price effects of quarterly earnings announcements reflected in option and stock prices. *Journal of Accounting Research,* 19, 434–458.

Rai, A. & Tartaroglu, S. (2015). The relative option to stock volume and market response to earnings surprises. *Journal of Accounting, Auditing & Finance,* 30, 431–460.

Rogers, J. L., Skinner, D. J., & Van Buskirk, A. (2009). Earnings guidance and market un- certainty. *Journal of Accounting and Economics,* 48, 90–109.

Roll, R., Schwartz, E., & Subrahmanyam, A. (2010). O/S: The relative trading activity in options and stock. *Journal of Financial Economics*, 96, 1–17.

Sen, K., (2009). Earnings surprise and sophisticated investor preferences in India. *Journal of Contemporary Accounting & Economics*, 5, 1–19.

Skinner, D. J. (1990). Options markets and the information content of accounting earnings releases. *Journal of Accounting and Economics,* 13, 191–211.

Truong, C. (2012). Options trading and the extent that stock prices lead future earnings information. *Journal of Business Finance & Accounting,* 39, 960–996.

Truong, C. & Corrado, C. (2014). Options trading volume and stock price response to earnings announcements. *Review of Accounting Studies,* 19, 161–209.

Truong, C., Corrado, C., & Chen, Y. (2012). The options market response to accounting earnings announcements. *Journal of International Financial Markets, Institutions and Money,* 22, 423–450.

Vipul, V. (2005). Futures and options expiration-day effects: the Indian evidence. *Journal of Futures Markets,* 25, 1045.

Xing, Y., Zhang, X., & Zhao, R. (2010). What does the individual option volatility smirk tell us about future equity returns? *Journal of Financial and Quantitative Analysis*, 45, 641–662.

APPENDIX

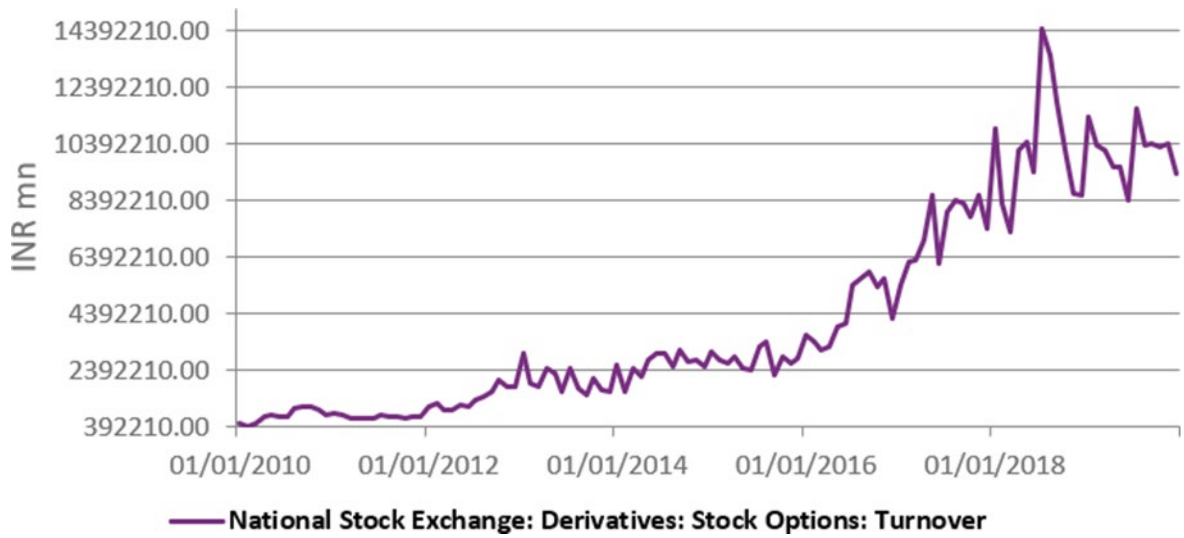


Figure A1. National Stock Exchange Single Stock Options Total Turnover (in INR million)
Source: CEIC (https://www.ceicdata.com/en)