Trading Volume and Open Interest from Options Markets as Measures of the Effect of IT Announcements

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Abstract

We explore how using trading volume and open interest data on IT investment announcements from options markets provide improved information to investors relative to trading volume from stock markets. We first establish through investigating changes in trading volume and open interest in the option market, and changes in trading volume in the stock market, that IT announcements are informative to investors such that they act on the underlying securities. Second, we find that the option market captures such informativeness earlier than the stock market, and that the option market generates a greater response to information from IT announcements than the stock market. Third, the option market's response allows us to distinguish investors' response in the short and long terms: we find IT announcements mainly convey information about expected firm value in the short term, and less in the long term. Finally, we show that good-news IT announcements are more informative than bad-news and no-news announcements. Thus, for firms with options, using option market trading volume and open interest dominates stock market trading volume when examining the effects of IT announcements.

1 Introduction

In the context of securities markets, anything, outside of random liquidity driven trades, that causes investors to act can be regarded as information (Beaver 1968; Sun 2003). If an information technology investment announcement (hereafter IT announcement) is informative, that is, it has information content, then investors' will revise their beliefs about firm value, and optimally adjust their portfolios to reflect these beliefs. The optimal adjustment may include buying/selling the firm's securities, opening or closing an option contract written on the firm's stock, etc., any of which will induce trading volume in the respective securities.

We can infer the informativeness of such IT announcements from investors' actions surrounding the announcement days. These actions would, as described above, be reflected in the abnormal trading volume (Beaver 1968), which has been widely adopted as a measure used in event studies, and several articles have used trading volume to determine if an event is informative (e.g., Foster 1973; Karpoff 1986; Ajinkya and Jain 1989; Sanders and Zdanowicz 1992; Donders, Kouwenberg and Vorst 2000; Jayaraman, Frye and Sabherwal 2001; Nofsinger and Prucyk 2003; Arnold, Erwin, Nail, and Nixon 2006). In fact, the strength of event studies based on the observation of market reactions lies in the fact that it captures the overall actions by a large number of investors upon receiving new information from announcements. The idea is follows from the basic present value equation, when an announcement is made, investors evaluate the information contained in the announcement and then re-adjust their beliefs about the expected cash flows and discount rates/uncertainty of the announcing firm.

According to the semi-strong version of the efficient market hypothesis (Fama 1970), investors' beliefs about the expected value that any announcement brings to the firm are immediately transformed to trading actions on the firm's securities, and thus may cause trading volume on the announcement day to be "abnormal" relative to a non announcement day. For example, McDonalds Corporation (NYSE:MCD) has an average trading volume of

7.58 million shares per day. On December 17, 2002, they announced a warning and reduction of expected earnings (Sun 2003). The news led to trading of 35.17 million shares that day, about five times the average. Such an event is informative, and the informativeness of the event is exactly captured by the abnormal trading volume on the event day.

Assuming traders are rational and they trade to maximize their utility function, a trading transaction becomes possible because the potential buyer and the potential seller have different beliefs about the value of the underlying securities. There are several distinct ways through which announcements affect trading volume. First, trading volume would be higher if investors have divergent priors. Second, receiving slightly different information increases trading volume. Third, even if investors have the same prior expectations and receive the same information, they may differ in the way they interpret the information and thus volume is further increased. For example, investors may differ in their beliefs about whether the information is favorable or unfavorable; or, they could disagree on the extent to which the information is important. Finally, if investors receive the information sequentially, then trading volume increases because of potential information asymmetry among investors. It is worthwhile to notice that change in trading volume gives no information about the direction of investors' valuation of the events. It just tells us that investors are reacting to the announcement, and the announcements are informative.

We introduce two separate measures from the options market, trading volume and open interest on the option market as an alternative to trading volume on the stock market to study whether IT announcements are informative. Open interest refers to the total number of outstanding option contracts for a specific underlying stock on a certain date. If an announcement is informative, then investors would adjust their beliefs about firm value and take actions including opening (or closing) option contracts written on the firm's stock, leading to increased (or decreased) open interest. For example, if the information increases (or decreases) demand for the underlying stock, then we should at least expect an increase in

the open positions for call (or put) option contracts. If the information causes the investors to lose interest in the firm, then we would expect a lower level of open positions. Intuitively, increasing open interest indicates additional money coming and interest generated in the underlying stock; whereas decreasing open interest represents a lower interest level and money flowing out of the related securities of the firm. Note that option contracts can be traded without a change in open interest, which is why we also use option trading volume as an additional approach to measure the informativeness of the IT announcements.

Specifically, we argue that the option market can capture the informativeness of an IT announcement earlier than the stock market, and that it is able to process the information more efficiently than the stock market. In addition, we argue that the option market has an advantage in capturing changes in investors' beliefs (due to the IT announcements) about short-term vs long-term future firm values. There are several reasons to believe that option market measures may be more informative, timely, and efficient than those from the stock market, and because technology is rapidly changing, informativeness and timeliness can be critical when examining reactions to IT announcements.

First, Rogers, Douglas and Van Buskirk (2009) classify a forecast announcement as regular "if the forecasting firm issued a forecast in at least 3 of the 4 calendar quarters preceding the current forecast quarter, and are otherwise classified as sporadic" (pg. 98). By this definition and because IT investment announcements are not pre-scheduled events such as earnings forecasts, the IT announcements in our dataset should be treated as sporadic. In fact, there is much uncertainty associated with an IT investment such as price, medium of exchange and likelihood of success, the IT announcements in our sample should not be anticipated in terms of both time and content. Therefore, any significant trading activities prior to the announcement dates should be attributed to informed trading.

Secondly, prior literature in finance have shown that option market traders tend to be more informed than those in the stock market (Easley, O'Hara, and Srinivas 1998;

Chakravarty, Gulen and Mayhew 2004), and that informed traders prefer to trade in the option market as opposed to the equity market because investments in options offers them more leverage and thus a larger potential return (Black 1975; Cao, Chen, and Griffin 2003). In other words, investors that have private information about these unanticipated IT announcements would be more likely to trade in the option market, given the high leverage and the built-in downside protection with options. This is why the option market may capture the informativeness of IT announcements prior to the announcement dates, and thus earlier than the stock market.

Thirdly, once the IT announcements are publicly made, investors would act on the underlying securities if these announcements are indeed informative. Prior literature suggest that investors' judgement of the same information may be different (e.g., Kim and Verrecchia 1994; Jin, Livnat, and Zhang 2012). In fact, Jin et al. (2012) argues that option traders on average have superior ability over equity traders on processing less-anticipated information. Given the unanticipated nature of our IT announcements, we expect the option traders can process the informativeness of these announcements more efficiently. Moreover, option trading is more complicated than stock trading because traders have to consider not only price, but also other factors such as exercise price, expiration time and volatility risk. Im et al. (2001) suggest that stock market investors on average may have difficulties in interpreting the importance of IT announcements. The quantitative and analytical skills required for option traders could be an advantage when it comes to efficiently evaluating the increasingly complex IT investments.

Lastly, option traders could design contracts that match their expectations of risk and cash flows, which is not possible when trading equities. Each option contract has an expiration date which defines when the contract expires. The length between trading date and expiration date is defined as the expiration length. Option contracts with longer (shorter) expiration lengths represent investors' beliefs about the firm's future value in the long (short)

run. Therefore, by studying option market's response to IT announcements, we can provide new insights on whether IT announcements are more informative to investors about the long-run value or the short-run value of the firms.

The literature on the value of IT has taken three distinct approaches. The first is the productivity approach where IT capital was found to be productive (e.g., Brynjolffson and Hitt 1996) and subsequent work using this approach focused on understanding how such as Cheng and Nault (2007, 2012) on IT spillovers; Dewan and Min (1997), Chwelos et al. (2010) and Zhang et al. (2015) on elasticities of substitution; Zhang et al. (2019) on capacity. The second approach is a process approach characterizing the business value of IT such as Barua et al. (1995) on capacity utilization and inventory turnover, Nault and Dexter (1995) on prices, and Mukopadhyay et al. (1997) on mail sorting output and quality.

The third approach is the one taken in this work where the value IT is inferred by responses to IT investment in the securities market through event studies. The event study method has been fruitfully applied in the information systems literature to study the impact of general IT investments (e.g., Dos Santos, Peffers, and Mauer 1993; Brynjolfsson and Yang 1997; Im, Dow, and Grover 2001; Subramani and Walden 2001; Chatterjee, Pacini, and Sambamurthy 2002; Dewan and Ren 2007; Otim, Dow, Grover, and Wong 2012; Yang, Lin, Oh, Animesh, and Pinsonneault 2012; Zhang and Nault 2019). However, few have concentrated on volume. Drawing upon a sample in the early 1990s, Chatterjee et al. (2002) find significant positive abnormal trading volume associated with IT infrastructure investment announcements. Im et al. (2001) find insignificant abnormal trading volume for IT investment announcements, and suggest that this may be due to the fact that stock market investors on average have difficulties in interpreting the importance of IT announcements. Indeed, this supports our argument that a lack of understanding about the true value of IT investments among equity market participants may cause stock market investors to under-value IT investment and thus are not able to capture the information conveyed by IT announcements.

From this perspective, changes in trading volume in response to IT announcements can be interpreted as a measure of investors' lack of agreement about the value of these events (Im et al. 2001).

Supporting the use of volume reactions to announcements in the option market, Easley et al. (1998) show both theoretically and empirically that option volumes can lead price movements in equity markets. Pan and Poteshman (2006) provide evidence that put-call ratios in the option market predict price movements in equity markets. Moreover, abnormal trading volume has been used to detect insider trading and information leakage prior to actual announcement days (e.g., Keown and Pinkerton 1981; Sanders and Zdanowicz 1992). Open interest increases when there are new option contracts created on the underlying stock, and decreases when the existing option contracts expire or are closed out by investors. Option contracts can be traded without a change in open interest. In contrast, changes in open interest require contracts to be traded, except in the case of expirations. Open interest is often used as an indicator of the intensity of trading, and of the revealing of new information (Jayaraman et al. 2001). Compared with stock shares outstanding which are issued by firms, open interest is endogenous in the sense that all option contracts are initiated by investors.

Motivated by what we present above, we explore how using changes in trading volume and open interest from the options market resulting from IT announcements provide improved information to investors relative to changes in trading volume from the stock market. Our contribution is one of measures and methods applied to IT announcements. First, we establish that IT announcements are informative to investors such that they act on the underlying securities. Second, we examine whether the options market measures capture the informational content of IT announcements earlier and with greater magnitude that stock market volume. Third, we study whether information conveyed by IT announcements differentially affect investors' beliefs about short-term and long-term future firm values. Finally, we identify what types of IT announcements are more informative.

We approach these questions by calculating abnormal trading volume and open interest around IT announcement days in the option market using a previously-published set of electronic commerce announcements in the 1996-2002 time frame. For purpose of comparison, we also calculate abnormal trading volume for the stock market for the same set of IT announcements. The remainder of the article proceeds as follows. In the next section we present our model to calculate the abnormal trading volume and open interest. After that, we introduce our datasets and the specifications regarding estimation and calculation. Following that, we present our main results. The last section discusses our findings and contributions.

2 A Model of Abnormal Volume

We calculate the abnormal volume for the days in the event window to capture the response of financial markets to the IT announcements. The calculation of abnormal open interest follows the same procedure.

As raw trading volume data are by construction non-negative and highly non-normal, we begin by constructing a transformed volume variable,

$$V_{i,t}^{m} \;=\; ln(1 \;+\; volume_{i,t}^{m}),$$

where $volume_{i,t}$ is the total trading volume for the announcing firm in event i on day t. The superscript $m \in \{e, o\}$ represents the equity market (e) or the option market (o). Because the model is the same for the two markets, we do not address the meaning of m for the rest of this section unless necessary. We define $t = 0$ as the day when IT announcement i is made (e.g., the event day), $t < 0$ a day prior to the event day and $t > 0$ a day after the event day. The event window $[t_1,t_0]$ $(t_1 \leq 0 \leq t_0)$ is the window of consecutive trading days immediately around the event day (including the event day). The estimation window $[t_3,t_2]$

($t_3 < t_2 < t_1$; t_1, t_2, t_3 are negative integers) is the window of consecutive trading days before the event window.

Following a standard approach to calculate abnormal volume (Ajinkya and Jain 1989, Sanders and Zdanowicz 1992, Arnold et al. 2006), we first estimate the following form for each event over its estimation window:

$$\Delta V_{i,t}^m \;=\; \alpha_i^m \;+\; \beta_i^m \Delta V_{i,t-1}^m + \epsilon_{i,t}, \tag{1}$$

where $\Delta V_{i,t}^m = V_{i,t}^m - V_{i,t-1}^m$, and $t \in [t_3, t_2]$. α_i is the average change in trading volume between two consecutive trading days in the estimation window for event i, β_i is the one-year lag effect, and $\epsilon_{i,t}$ is the mean zero error term, that is assumed normally distributed, for the announcing firm in event i on day t. For the announcing firm in each event, we define the abnormal trading volume for each day in the event window, which is the difference between the actual volume and the predicted volume:

$$AV_{i,h}^m \;=\; \Delta V_{i,h}^m \;-\; [\hat{\alpha_i^m} \;+\; \hat{\beta_i^m} \Delta V_{i,h-1}^m], \tag{2}$$

where $h \in [t_1, t_0]$. $AV_{i,h}$ is the abnormal trading volume in day h in the event window for the announcing firm in event i. $\hat{\alpha_i}$ and $\hat{\beta_i}$ are estimates of α and β from (**??**). The variance of $AV_{i,h}$ is calculated as (Judge et al. 1998, pg.170; Subramani and Walden 2001, pg.144):

$$var(AV_{i,h}^m) \;=\; S_i^2 \Big[1 \;+\; \frac{1}{T} \;+ \frac{[\Delta V_{i,h-1}^m \;-\; \overline{\Delta V_i^m}]^2}{\sum_{t=t_3}^{t_2} [\Delta V_{i,t-1}^m \;-\; \overline{\Delta V_i^m}]^2} \Big], \tag{3}$$

where S_i^2 is the variance of the error term from (**??**), T is the number of trading days in the estimation window (i.e., $[t_3, t_2]$), $\overline{\Delta V_i}$ is the mean value of $\Delta V_{i,t-1}$ over the event window. From (**??**) we can see that the variance of the abnormal return by our definition depends

on the length of the estimation interval, as well as the distance between the current value of the predictor and its mean value over the event window.

Following Sanders and Zdanowicz (1992), we then calculate the average daily abnormal volume across all events:

$$AAV_h^m \;=\; \frac{\sum_{i=1}^{N}\Big[AV_{i,h}^m \;/\; var(AV_{i,h}^m)\Big]}{\sum_{i=1}^{N}\Big[1 \;/\; var(AV_{i,h}^m)\Big]}, \tag{4}$$

where AAV_h is the average abnormal trading volume for day h ($h \in [t_1, 0]$) across events, N is the total number of events. The variance of AAV_h is:

$$var(AAV_h^m) \;=\; \frac{\sum_{i=1}^{N}\Big[(AV_{i,h}^m \;-\; AAV_h^m)^2 \;/\; var(AV_{i,h}^m)\Big]}{[N \;-\; 1]\sum_{i=1}^{N}\Big[1 \;/\; var(AV_{i,h}^m)\Big]}. \tag{5}$$

With (**??**) and (**??**), we are able to examine the statistical significance of the average abnormal volume using a student's t test, which is of the form:

$$\frac{AAV_h^m}{\sqrt{var(AAV_h^m)}} \sim t_{(N-1)}. \tag{6}$$

Then, we can use (**??**) and (**??**) to calculate the cumulative average abnormal volume (CAAV) for the event window or its sub-periods:

$$CAAV^m \;=\; \sum_{h=a}^{z} AAV_h^m, \tag{7}$$

where a and z are, respectively, the first and last days of the accumulation period in the event window or the sub-periods. $CAAV$ is the cumulative average abnormal volume over the days in the accumulation period. We can examine the statistical significance of the

$CAAV$ using the statistic:

$$\frac{CAAV_h^m}{\sqrt{\sum_{h=a}^{z} var(AAV_h^m)}} \sim t_{(N-1)}. \tag{8}$$

Finally, in order to test if the difference between the $CAAVs$ for options and stocks is statistically greater than zero, we use the following student's t test:

$$\frac{CAAV_h^o \ - \ CAAV_h^e}{\sqrt{\frac{var(CAAV_h^o) \ + \ var(CAAV_h^e)}{N}}} \sim t_{(N-1)}. \tag{9}$$

Following the same procedure, we also calculate the cumulative average abnormal open interest, $CAAO^m$.

3 Data

For our IT announcements we use the same list of 640 electronic commerce announcements as in Dewan and Ren (2007), and thank Sanjeev Dewan and Fei Ren for sharing this data. This data is collected from PR Newswire and BusinessWire in Lexis-Nexis, and from four distinct years: 1996, 1998, 2000, and 2002. Events that have confounding factors such as earnings announcements and lawsuits have already been eliminated from the list. For a detailed description of the making of the event list see Dewan and Ren (2007), pg. 378.

Notice that in this list one firm can only make one announcement on one day, but can have several announcements on different days. In addition, one announcement only corresponds to one announcing firm on a particular day. Each announcement is treated as one event in our analysis. For the announcing firm in each event, we collect daily stock trading volume over the period beginning 120 trading days before the announcement date and ending 5 trading days after the announcement date. If the announcement day is a public holiday, we use the next immediate trading day as the event day. For the same period and each event, we collect

data on trading volume and open interest for option contracts written on the underlying firm's stock. On a specific day each firm may have multiple contracts written with different expiration lengths and exercise prices. We aggregate the trading volume and open interest over all option contracts written on a firm on every day in the sample period.

The stock data is obtained from the Center for Research in Security Prices (CRSP), and the option data from the OptionMetrics database. The option data includes both put and call American options (European options are not traded on equities in the US.). We drop events that either do not have corresponding traded options at all or do not satisfy our continuity test, which is done separately for the pre-announcement windows and the event windows. We drop events for which the pre-announcement windows have missing volume data for more than 30 trading days, or where two consecutive trading days are more than three calendar weeks apart, or if the total calendar duration for the window is more than 200 calendar days. We also drop events for which the event window contains missing volume data for more than 4 trading days, or where two consecutive trading days are more than three calendar days apart. Only events that satisfy these continuity tests for pre-announcement and event windows are selected into our final sample. The purpose of the continuity test is to further ensure our results are not driven by unobserved factors that may affect market's response to the IT announcements. Our final dataset is a balanced panel of 424 IT announcement events (49 in 1996, 86 in 1998, 150 in 2000, and 139 in 2002) across 126 relative trading days. A further description of the full sample is provided in Table 1.

4 Results

In order to test whether the IT announcements are informative to investors prior to the announcement days and if the volume response persists after the events, we include trading days both prior to and after the event day in the event window. Therefore, we adopt an event

window starting ten trading days before (Dewan and Ren 2007) and ending five trading days after the announcement date (i.e., (-10,5)). The estimation window consists of the trading days prior to the event window (i.e., (-120,-11)). We do not include more trading days after the event day in the event window because we believe five trading days is enough for investors to incorporate the information from announcements and behave accordingly. Moreover, the longer the window, the more confounding factors there may be that could bias our results. We divide the event window into four measurement windows and calculate the cumulative abnormal volume ($CAAV$) and cumulative abnormal open interest ($CAAO$) over each measurement window: (-10,-6), (-5,-1), 0, and (1,5), where (-10,-6) and (-5,-1) are two pre-announcement measurement windows, 0 is the event-day measurement window, and (1,5) is the post-announcement measurement window. We report $CAAV$ and $CAAO$ for each of the four measurement windows in our results tables, Table 2 through 6. .

We focus on the significance of the pre-announcement trading activities and less on signs and magnitude because until the announcements become public traders continue acquiring private information and updating their beliefs. Thus there remains uncertainty before the announcements as to how accurate the traders' opinions are (Ederington and Lee 1996). We pay attention to significance, sign, as well as magnitude on and after the announcement days, assuming that the information conveyed by the announcements has been absorbed by investors and is reflected in their trading activities.

4.1 Baseline Results

Our baseline results are reported in Table 2, where the $CAAVs$ and $CAAOs$ are calculated using the full sample of 424 events. The trading volume for options are aggregated over all existing option contracts. The $CAAV$ is positive and significant on day 0 for the stocks ($CAAV = 0.064$, $t = 3.06$, $p < 0.01$), while the $CAAVs$ are not significant for call or put options. This suggests that, using the full sample, IT announcements are only informative

Table 1 - Summary Statistics

Variable	Obs	Mean	Median	Std. Dev.	Min	Max
Equity trading volume	55968	4475885	1379000	8662028	0	1.78E+08
Put option trading volume	55968	3084.152	166	8865.358	0	256554
Call option trading volume	55968	4528.843	434	11268.87	0	216281
Put option open interest	55968	81617.2	7389	195310.6	0	1431576
Call option open interest	55968	123177.9	14158	307085.4	0	2039523

Note. Summary statistics on the full sample with 424 events, covering four years: 1996, 1998, 2000, and 2002. The unit of measure is in number of shares (for volume) or number of contracts (for options).

Table 2 - Base Results (on Full Sample)

Abnormal Variable	Security type	Expiration Length	Number of events	Measurement Window			
				(-10, -6)	(-5, -1)	0	(1,5)
CAAV	Stock	Full Sample	424	0.043 (0.85)	-0.075 (-1.52)	0.064*** (3.06)	-0.052 (-1.06)
	Call	1-1000	424	0.073 (0.07)	-0.136 (-1.36)	0.004 (0.11)	0.017 (0.18)
	Put	1-1000	424	-0.081 (-0.71)	-.118 (-1.05)	0.048 (0.87)	-0.053 (-0.47)
CAAO	Call	1-1000	424	-0.034*** (-3.11)	0.002 (0.29)	-0.000 (-0.07)	-0.010 (-1.24)
	Put	1-1000	424	-0.036*** (-3.22)	0.009 (1.05)	0.003 (0.68)	-0.001 (-0.07)

Note. CAAO (Cumulative Average Abnormal Open Interest) and CAAV (Cumulative Average Abnormal Volume) are calculated for the measurement windows. The estimation window is (-120,-11).
Significance Level (two-tailed): *** 0.01 ** 0.05 * 0.10

to stock traders on the event day. We do not observe significant response from the option market, likely because option traders only act on certain types of option contracts. Unlike stock shares, the option market traders may choose or even design the optimal contract that fits their beliefs about future expected return of the firm. This may lead to an uneven distribution of trading volume on different option contracts, and an insignificant aggregate response.

The $CAAOs$ are negative and significant for the two-week pre-announcement window (-10,-6) ($Call : CAAO = -0.034$, $t = -3.11$, $p < 0.01$; $Put : CAAO = -0.036$, $t = -3.22$, $p < 0.01$), and insignificant for the windows after. This indicates that the option market is able to capture the informational content of IT announcements prior to the event day, likely

because informed traders choose to trade in the option market (Easley et al. 1998), and they close out their positions at least 5 days prior to the event day.

4.2 Short Term, Mid Term, and Long Term

The results on $CAAV$ by expiration lengths are presented in Table 3, where trading volume is aggregated over different expiration lengths. The most interesting finding is that the $CAAVs$ are mainly positive and significant for the options expiring between 1 to 30 days ($Call : CAAV = 0.120$, $t = 1.84$, $p < 0.1$; $Put : CAAV = 0.112$, $t = 1.76$, $p < 0.1$). This implies that IT announcements mainly affect investors' beliefs about short-term firm value, instead of long-term firm value. The reason may be that investors do not believe that most IT investments fundamentally change the nature and management of firms. It could also be a result of the time coverage of our datasets: the dot-com bubble burst towards the end of year 2000 adding more uncertainty to long-run expected firm value. Using the same list of 349 events, the $CAAV$ for stocks is also significant on the event day but with a much smaller magnitude ($CAAV = 0.063$, $t = 2.75$, $p < 0.01$), indicating that the option market is responding to IT announcements with a greater magnitude. We believe this is because option traders can better interpret the information content of IT announcements.

There are a few significant results on $CAAV$ prior to the announcement days ($CallOptions1-30on(-10,-6) : CAAV = 0.275$, $t = 2.07$, $p < 0.05$; $CallOptions301 - 600on(-5,-1) : CAAV = -0.690$, $t = -1.76$, $p < 0.1$; $PutOptions101 - 300on(-10,-6) : CAAV = -0.332$, $t = -2.34$, $p < 0.05$), but no significant responses from the stock market in the pre-announcement windows. This again suggests that the option market captures the information from IT announcements ahead of the stock market. No result in the post-announcement window is significant, which means there is no delay in investors' actions upon observing the announcements.

Table 4 reports the results on $CAAO$ by expiration length. Overall, there is more signif-

Table 3 - CAAV by Expiration Lengths

Security type	Expiration Length	Number of events	Measurement Window			
			(-10, -6)	(-5, -1)	0	(1,5)
Stock	Matching Option 1-30	349	0.052 (0.94)	-0.059 (-1.11)	0.063*** (2.75)	-0.064 (-1.23)
Call	1-30	349	0.275** (2.07)	-0.160 (-1.27)	0.120* (1.84)	0.135 (1.06)
	31-100	365	0.026 (0.19)	0.030 (0.23)	0.070 (1.13)	-0.003 (-0.02)
	101-300	420	-0.096 (-0.72)	-0.123 (-0.95)	-0.054 (-0.96)	0.038 (-0.28)
	301-600	49	0.142 (0.37)	-0.690* (-1.76)	0.291 (1.60)	0.068 (0.17)
	601-1000	147	0.015 (0.07)	-0.141 (-0.69)	0.049 (0.54)	0.009 (0.04)
Put	1-30	349	0.065 (0.49)	-0.145 (-1.15)	0.112* (1.76)	0.034 (0.26)
	31-100	365	0.082 (0.57)	0.108 (0.73)	-0.101 (-1.2)	-0.072 (-0.50)
	101-300	420	-0.332** (-2.34)	-0.125 (-1.00)	-0.028 (-0.57)	-0.018 (-0.15)
	301-600	49	-0.151 (-0.29)	-0.633 (-1.15)	0.165 (0.62)	0.519 (0.88)
	601-1000	143	0.004 (0.01)	-0.139 (-0.50)	-0.018 (-0.16)	-0.061 (-0.21)

Note. CAAV (Cumulative Average Abnormal Volume) are calculated for the measurement windows.
The estimation window is (-120,-11).
Significance Level (two-tailed): *** 0.01 ** 0.05 * 0.10

icance in all the measurement windows than in Table 3, although the main message is the same. The response on the event day remains strongest in the short term, and gradually weakens in magnitude as the expiration lengths get longer, suggesting that IT announcements are more informative to investors about short-term firm value than about long-term firm value. We observe significant $CAAOs$ for options with longer expiration lengths likely because creating new long-run positions is more beneficial to investors than trading existing long-run contracts. Moreover, there is strong evidence of informed trading prior to the event days, as well as significant changes in trading activities after the event days. The significant $CAAOs$ and insignificant $CAAVs$ in the post-announcement window imply that there

is continued interest in the IT investment decisions announced, which is, however, mainly attributable to new positions opened and old positions closed out. Overall, our results on $CAAO$ provide even stronger evidence about the informativeness of IT announcements than the $CAAV$ results. This is because open interest is an endogenous measure and thus able to give additional insights about investors' responses (Jayaraman et al. 2001).

Table 4 - CAAO by Expiration Lengths

Security type	Expiration Length	Number of events	Measurement Window			
			(-10, -6)	(-5, -1)	0	(1,5)
Call	1-30	349	-0.227** (-2.45)	0.138** (2.30)	0.09** (2.28)	0.072 (1.17)
	31-100	365	-0.071 (-0.59)	0.352*** (8.44)	0.065*** (2.96)	0.226*** (4.69)
	101-300	420	-0.321*** (-8.69)	-0.078*** (-2.80)	0.012* (1.92)	-0.325*** (-8.33)
	301-600	49	0.017** (2.19)	-0.002 (-0.22)	-0.001 (-0.75)	0.003 (0.72)
	601-1000	147	0.092*** (4.02)	0.082*** (4.92)	0.002 (0.68)	0.036** (2.15)
Put	1-30	349	-0.127 (-1.42)	0.080 (1.29)	0.084*** (2.57)	0.112* (1.83)
	31-100	365	-0.125 (-0.85)	0.422*** (8.65)	0.060*** (2.23)	0.231*** (4.10)
	101-300	420	-0.277*** (-7.77)	-0.264*** (-6.90)	-0.056*** (-3.37)	-0.397*** (-8.27)
	301-600	49	-0.003 (-0.50)	-0.012** (-2.09)	-0.006*** (-3.66)	-0.003 (-0.50)
	601-1000	143	0.113*** (4.44)	0.146*** (9.10)	-0.003 (-0.92)	0.040 (3.47)

Note. CAAO (Cumulative Average Open Interest) are calculated for the measurement windows.
The estimation window is (-120,-11).
Significance Level (two-tailed): *** 0.01 ** 0.05 * 0.10

4.3 Good News, Bad News, and No News

Many empirical studies support the hypothesis that investor reactions differ to good and bad news (Schachter 1988). Thus, the observed pattern in volume and open interest around

announcements may be the net effect of investors' anticipations of good or bad news. Zhang and Nault (2019) argue that good-news IT announcements indicate that the "the information conveyed in the announcement is "better" than they expected, thus giving them more confidence about the firm's future returns." (pg. 15); while bad-news announcements negatively surprise investors such that there is more pessimism and uncertainty on future returns. Theoretically, good-news announcements would increase the demand for the stock and cause an increase in price and trading volume; and bad-news announcements, making more investors want to sell, would decrease prices and increase trading volume (Nofsinger and Prucyk 2003). Although both types of announcements could make investors act and thus increase trading volume, which type generates stronger investor reactions is largely an empirical question. In fact, prior research report mixed support and findings on the impact of good vs. bad news announcements, which depends on the type of announcements, state of the economy, cognitive ability of the investors, etc. (Barberis, Shleifer, and Vishny 1998, Veronesi 1999, Donders et al 2000, Nofsinger and Prucyk 2003). Our study contributes to the IS literature by providing empirical evidence on the impact of good vs bad IT announcements on option trading volume.

In order to determine the types of IT announcements that are more informative to investors, we assign each announcement to one of three types: good news, bad news, or no news. Following Campbell, Lo, and MacKinlay (1996), we categorize each announcement using an ex-post measure: the deviation of the actual return from the expected return on the announcement day. The calculation largely follows our model of abnormal volume, except that we use a market model to predict the returns. If the actual exceeds expected by more than 2.5%, then the announcement is designated as good news. If the actual is more than 2.5% less than expected, then the announcement is designated as bad news. Those announcements where the actual returns are in the 5% range centered about the expected returns are designated as no news. Of our 424 announcements, 78 are good news, 92 are bad

news, and the remaining 254 are no news.

Table 5 - CAAV by News Type

News Type	Security type	Number of events	Measurement Window			
			(-10, -6)	(-5, -1)	0	(1,5)
Good News	Call	78	0.054	-0.011	0.432***	-0.407**
			(0.18)	(-0.06)	(5.27)	(-2.09)
	Put		-0.157	-0.068	0.442***	-0.318
			(-0.65)	(-0.30)	(3.12)	(-1.33)
	Stock		-0.039	-0.035	0.335***	-0.347***
			(-0.38)	(-0.36)	(7.44)	(-3.61)
Bad News	Call	92	0.207	-0.310	-0.185**	0.183
			(0.89)	(-1.26)	(-1.98)	(0.80)
	Put		0.024	-0.267	0.061	-0.146
			(0.09)	(-0.99)	(0.57)	(-0.57)
	Stock		0.128	-0.123	0.148***	-0.051
			(1.19)	(-1.20)	(2.95)	(-0.52)
No News	Call	254	0.035	-0.124	-0.099*	0.131
			(-0.25)	(-0.98)	(-1.87)	(1.02)
	Put		-0.087	-0.090	-0.110	0.078
			(-0.58)	(-0.61)	(-1.60)	(0.52)
	Stock		0.030	-0.042	-0.003	0.015
			(0.55)	(-0.76)	(-0.12)	(0.28)

Note. CAAV (Cumulative Average Abnormal Volume) are calculated for the measurement windows.
The estimation window is (-120,-11).
Significance Level (two-tailed): *** 0.01 ** 0.05 * 0.10

Table 6 - CAAO by News Type

News Type	Security type	Number of events	Measurement Window			
			(-10, -6)	(-5, -1)	0	(1,5)
Good News	Call	78	-0.026	0.043***	0.020***	-0.016
			(-1.35)	(3.33)	(3.81)	(-0.76)
	Put		-0.025	0.045***	0.019***	0.014
			(-1.30)	(3.08)	(2.92)	(0.73)
Bad News	Call	92	-0.024	0.008	-0.005	0.015
			(-1.12)	(0.42)	(-0.59)	(1.06)
	Put		-0.022	0.006	0.004	-0.002
			(-0.87)	(0.32)	(0.55)	(-0.14)
No News	Call	254	-0.035**	-0.008	-0.004	-0.016
			(-2.43)	(-0.71)	(-0.70)	(-1.50)
	Put		-0.040***	0.000	-0.002	-0.003
			(-2.73)	(0.07)	(-0.34)	(-0.25)

Note. CAAO (Cumulative Average Abnormal Volume) are calculated for the measurement windows.
The estimation window is (-120,-11).
Significance Level (two-tailed): *** 0.01 ** 0.05 * 0.10

Our results on $CAAV$ by news type are reported in Table 5. There are no significant responses in the pre-announcement windows for any of the news types. However, and most interestingly, we find that the good-news announcements are more informative than both the bad-news and no-news announcements on the event day in terms of having significant and stronger response to the IT announcements ($GoodNewsCall : CAAV = 0.432$, $t = 5.27$, $p < 0.01$; $GoodNewsPut : CAAV = 0.442$, $t = 3.12$, $p < 0.01$; $GoodNewsStock : CAAV = 0.335$, $t = 7.44$, $p < 0.01$; $BadNewsCall : CAAV = -0.185$, $t = -1.98$, $p < 0.05$; $BadNewsStock : CAAV = 0.148$, $t = 2.95$, $p < 0.01$; $NoNewsCall : CAAV = -0.099$, $t = -1.87$, $p < 0.1$). Notice that the $CAAVs$ for options for the good-news announcements are also much greater in magnitude than those for stocks as well as those for the short-term options in Table 3. The strong response to good-news announcements indicate investors' preference towards IT announcements that raise their expectations about expected firm value.

The negative $CAAV$ for call options for the bad-news announcements on the event day ($CAAV = -0.185$, $t = -1.98$, $p < 0.05$) is due to the fact that when investors have negative opinions about IT announcements, they are not enthused about the likelihood of success of these initiatives and would postpone trading call options and hold on to their portfolios. The no-news events barely convey any information so even the stock market traders are indifferent about them. Moreover, the $CAAVs$ are negative and significant for call options and stocks for the good-news announcements on (1,5) ($Call : CAAV = -0.407$, $t = -2.09$, $p < 0.05$; $Stock : CAAV = -0.347$; $t = -3.61$; $p < 0.01$), which is likely because trading activities on event days are too large in magnitude such that the trading volume in the following days drops significantly relative to event days.

Table 6 presents the $CAAO$ results by news type. The main message from the $CAAO$ results is the same as that in Table 5, confirming that good-news IT announcements are more informative on the event day than the other two types of announcements ($Call$:

$CAAO = 0.020$, $t = 3.81$, $p < 0.01$; $Put : CAAO = 0.019$, $t = 2.92$, $p < 0.01$). As before, the $CAAO$ measure is able to capture the informativeness of IT announcements prior to event days ($GoodNewsCallon(-5,-1) : CAAO = 0.043$, $t = 3.33$, $p < 0.01$; $GoodNewsPuton(-5,-1) : CAAO = 0.045$, $t = 3.08$, $p < 0.01$; $NoNewsCallon(-10,-6) : CAAO = -0.035$, $t = -2.43$, $p < 0.05$; $NoNewsPuton(-10,-6) : CAAO = 0.040$, $t = -2.73$, $p < 0.01$). The negative and significant $CAAOs$ in the two-week pre-announcement window (-10,-6) for the no-news type indicate significantly decreased interest in the underlying firm from investors in the option market. This is due to the fact that the no-news IT announcements are not providing information to help better understand future firm values.

4.4 Robustness

We re-ran all of our analyses shrinking the event window to one week on either side of the event (i.e., (-5,5)), and again using the trading days prior to the event window as the estimation window (i.e., (-120,-6)). In particular, we calculate $CAAVs$ and $CAAOs$ for three measurement windows: (-5,-1), 0 , and (1,5). We found that our main qualitative results remain unchanged.

5 Discussion and Conclusions

Using a novel approach to examine the impact of IT investment announcements – trading volume and open interest from options markets, we study whether IT announcements are informative events, whether the options market captures information sooner than the stock market and with greater magnitude, and whether the options market's response allows us to distinguish investors' response to the information for different time periods. We adopt cumulative average abnormal volume (CAAV) and cumulative average abnormal open interest (CAAO) as measures for abnormal levels of trading activities in the option market around

IT announcements.

Our findings are consistent across trading volume and open interest, and across different sub-samples. There are four main messages from our findings. First, IT announcements indeed convey information to investors such that they act on the underlying securities. Such information tends to be captured by the option market prior to the event day, and continues to generate interest in post-announcement trading days. Second, we exploit the fact that options have a term structure. This allows us to show that IT announcements mainly affect investors' expectations about short-term firm value, with less effects on expectations of long-term firm value. This distinction can only be captured by option market trading activities. We note that options of any expiration length incorporate both short- and long-run cash flows, and a stylized fact in the options market is that shorter-dated options are more liquid and heavily traded. Thus, our finding more pronounced empirical results in shorter-dated options does not imply IT investments have only short-term effects.

Third, good-news IT announcements are more informative to investors than bad-news and no-news announcements. Fourth, compared to stock market traders, option market traders respond to IT investment announcements earlier, and with greater magnitude. Our findings can help firm executives and managers better understand the possible responses and assessments from financial markets to their IT investment announcements, and thus may improve firms' decision making regarding IT investments.

Our main contribution is developing and testing an innovative approach of using abnormal trading volume and open interest from option markets as a means to measure the effects of IT announcement, and showing that these measures dominate stock market trading volume when examining the effects of IT announcements. We believe that future research may further exploit the differential response between option markets and stock markets to IT announcements. These differences may contain useful information about disentangling IT's impact on firm risk and firm cash flows.

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