Retrieving Aggregate Information from Option Volume

William T. Lin[a,d], Shih-Chuan Tsai[1,b], Zhenlong Zheng[c], Shuai Qiao[c]

[a] *Department of Banking & Finance, Tamkang University, No.151, Yingzhuan Road, Tamsui District, New Taipei City 25137, Taiwan*

[b] *Graduate Institute of Management, National Taiwan Normal University, No. 162, Section 1, Heping East Road, Taipei City 106, Taiwan*

[c] *Department of Finance, Xiamen University, No. 422, Siming South Road, Xiamen, Fujian Province 361005, China*

[d] *Academy of Financial Research, Zhejiang University, No. 866, Yuhangtang Road, Hangzhou, Zhejiang Province 310058, China*

Abstract

This paper studies how to retrieve aggregate information from the trading volume of Taiwan composite stock index options (TXO) with better quality by applying the two option-information aggregation methods introduced in Holowczak et al. (2014), namely maturity discount and strike discount. To study an emerging market such as the Taiwan futures market, whose major players are retail investors, we follow Holowczak et al. (2014) in giving greater consideration to trading distribution in terms of option market depth, liquidity, leverage and investors' trading purposes other than option moneyness and time to maturity. Retail investors have traded mainly nearby TXO options with expiration less than one month. Furthermore, both institutions and retail investors have traded more at near-the-money TXO options, and as a result the weights of in-the-money options and out-of-the-money options are smaller than those shown in Holowczak et al. (2014). In addition, we find that there is a dichotomy in the information roles of out-of-the-money options: the information content of their trades is higher (lower) when market volatility increases (falls). Based on this finding, we establish a VIX-adjusted put-call ratio which increases (decreases) the weight of out-of-the-money options when the market VIX is larger (smaller) than the average level. Our model, as revised for an emerging market such as the Taiwan futures market, has outperformed in explaining contemporaneous price changes and it has shown very good predictive ability of large downside market moves.

Keywords: Aggregating option volume; Distribution of option trades across strikes; Emerging futures market; Retail trading; Volatility

[1] Corresponding author: Tsai, +886-96306 6678(mobile), chuant@ntnu.edu.tw.

a, c,d: yungshuncn@hotmail.com, Tel.: +886-972185955, zlzheng@xmu.edu.cn, Tel.: +86-13906038903, qiaoshuaiwelcomeyou@hotmail.com, Tel.: +86-15606092198.

I Introduction

This paper focuses on the differential information roles of options of different strikes and expirations. Option trading conveys information about the price changes of the underlying stock because of the presence of informed trading. However, informed traders seldom randomly choose an option contract to realize their information advantage. Their choices must account for market depth, liquidity, as well as leverage inherent in options (Holowczak et al., 2014). This fact further creates the challenge of how to effectively aggregate information from the trading volume of different options.

An economically appealing approach is the mechanism proposed by Holowczak et al. (2014). They use options on QQQQ, the NASDAQ 100 tracking index, and introduce maturity discount and strike discount methods in which nearby options with maturities of one or less month and near-the-money (ATM) options have a weight of one, while the weights of options with increasing standardized moneyness and increasing maturity decline exponentially with a constant decay rate. Their idea is simple. To mitigate against market impact and to reduce transaction costs, informed traders are prone to choose most actively traded options with short maturities and ATM options. In the meantime, they also consider investors' trading purpose, as deep out-of-the-money (DOTM) options and options with very long maturities are often used to hedge specific risk exposure, thus containing little directional information. Nevertheless, the two categories of options deserve the least weight.

We propose two additional considerations that contribute to enhancing the effectiveness of the two aforementioned aggregation methods (maturity discount and strike discount) when applied to Taiwan composite stock index options (TXO) on the Taiwan Stock Exchange. The daily average TXO trading volume was more than 400,000 contracts during the sample period of July 1, 2009 to November 30, 2012, accounting for 68% of the daily total market trading volume in the Taiwan futures market. In this emerging futures market, retail investors, who represent nearly 60 percent trading volume in the sample period, have been often considered to be noise investors[2]. The time to maturity of TXO contracts traded by all types of investors is usually one month or less, with this pattern being extremely strong for retail investors. On the other hand, intermediate horizon options are most actively traded by foreign and domestic institutional investors. Han and Kumar (2013) found that stock markets with a high retail trading proportion are likely to be overpriced, thus showing a significantly negative alpha. Moreover, given that the concentration of informed traders is closely associated with the information content of option trading (Easley et al., 1998; Pan and Poteshman, 2006), our conjecture is that assigning the maximum weight of one to intermediate horizon TXO, rather than nearby ones, would generate superior performance when applying the maturity discount method to study the TXO market.

Second, according to the liquidity hypothesis, the extent to which how evenly investors allocate their trades among option contracts with varying moneyness determines their relative weight in aggregation. In the weighting scheme of Holowczak et al. (2014), ATM options have a weight of one, and the weight of in-the-money (ITM) and out-of-the-money (OTM) options decline exponentially at a constant decay rate of 1/2 with increasing standardized moneyness in absolute magnitude. This relatively small decay rate is able to match the relative trading volume of each option contract with the weight assigned to it, because investors in the QQQQ options market distribute option trades more evenly among ITM, ATM and OTM options. However, investors in the TXO market distribute their trades less evenly, mostly concentrating at ATM options, which makes a decay rate of 1/2 unreasonable. For example, according to the

[2]See, for example, Chang et al. (2009).

weighting scheme in Holowczak et al. (2014), options with moneyness equal to 1.10 have a weight of 0.9955, which is less than the maximum weight of one by only 0.45%. However, their trading volume accounts for less than 10% of that for ATM options. These contrasting results imply that a decay rate of 1/2 overestimates the information roles of ITM and OTM options, according to liquidity considerations. Mathematically, a larger decay rate is called for in order to apply the strike discount method in the TXO market.

In addition to the two aforementioned considerations, we argue that volatility also has an impact on strike discount aggregation methods. Our argument stems from the numerous empirical findings that provide supporting evidence that informed investors behave differently in bear markets (Chan et al., 2009). In the TXO market, the trading behavior of institutional investors supports our claim. The proportion of OTM and deep OTM options trades increased by 13.93% and 15.12% for foreign institutions and domestic institutions, respectively, during a downward trending period from August 5, 2011 to January 13, 2012. Moreover, the overall market trading volume for OTM and DOTM options grew from 40.43% to 62.19%, exceeding that for ATM options, which indicates that OTM options were most actively traded in this period. In addition, OTM options provide investors with higher leverage. These two factors together make OTM options more appealing to informed traders. Therefore, their corresponding information roles should be augmented when applying the strike discount method during a downward trending period.

We construct put-call ratios using the maturity discount and strike discount methods, respectively, with open-buy TXO trade data, initiated by a buyer to open a new option position. We focus on both contemporaneous relationships and the protracted effect of options trading activity on price changes in the underlying index, following Chan et al.

(2002), Schlag and Stoll (2005), and Holowczak et al. (2014). Empirically, an erroneous price reversal pattern may signal liquidity or hedging effects rather than informed trading. As our study involves parameter optimizing, we further partition our entire sample into two parts with a ratio of 3:1 and separately conduct in-sample and out-of-sample tests to examine whether our results are robust across different periods.

Our three findings provide insights into the role of retail trading, as well as how investors allocate trades and volatility in retrieving aggregate information from option volume. First, the maturity discounted put-call ratios with intermediate horizon options rather than nearby options assigned to a weight of one generate the largest negative contemporaneous coefficients in magnitude, and this result is robust for out-of-sample tests.

However, by contrast with Holowczak et al. (2014), our results are consistent with Chang et al. (2009) that the information content of intermediate horizon options is higher. Furthermore, our results also confirm the conclusion of Han and Kumar (2013) that retail trading in options markets also affects the option prices.

Second, the contemporaneous coefficients for strike discounted put-call ratios form a bell-shaped curve and reach their summit when we adopt a larger decay rate of 1,000. This means that, in order to enhance the effectiveness of the strike discount aggregation method, option contracts should be discounted with a far smaller weight than that in Holowczak et al. (2014). Our findings accord with the liquidity hypothesis in that the weight of each option contract ultimately depends on its relative proportion of trading volume. In addition, our predictive analysis shows that both the maturity discounted put-call ratio and the strike discounted put-call ratio provide little evidence of predicting the future price changes of the underlying index, which is consistent with Chiu et al. (2014). This finding also confirms that the contemporaneous price impacts are permanent because there is little evidence of price reversal as per Schlag and Stoll (2005).

Finally, we find that the aggregated put-call ratios with greater weight assigned to OTM option contracts show incremental explanatory power only when VIX, an indicator of market volatility, exceeds 25. This finding is consistent with what is documented in Chan et al. (2009), who claim that the differing behavior of investors during this period is responsible for this effect. Motivated by this implication, we establish a new type of information variable, the VIX-adjusted put-call ratio, which increases (decreases) the weight of OTM options when the market VIX is greater (smaller) than the sample average level. It performs better in predicting large downward movements in the underlying index.

Collectively, the aggregation of options trading volume based on their information roles is poised to become a prevailing norm. In the meantime, there is not a universally applicable weighting scheme. The optimal scheme depends not only on liquidity, market depth and trading purposes as documented in Holowczak et al. (2014), but also on actual market characteristics, which are of great importance for emerging options markets.

An overview of this paper is as follows. Section II describes our data and its corresponding descriptive statistics. Section III introduces our empirical design and modifications of the strike discount and maturity discount methods. We present empirical analysis in section IV. Finally, section V presents our conclusions.

II Data

Our paper uses intraday trade data from the TXO and Taiwan composite stock index futures (TX) markets for the period from July 1, 2009 to November 30, 2012. Each trade record includes the product type, expiration, strike, buy-sell indicator, indicator of opening or closing position, quantity, price, and trader type (retail traders, foreign institutions, domestic institutions, and market makers). For the purposes of this paper, we exclude trades by market makers and those with expiration of less than 3 days. Following Chang et al. (2009) and Pan and Poteshman (2006), we use only open-buy trading volume, because informed investors tend to open new positions to realize their information.

In our sample period, the new open-buy daily volume of TXO options averaged approximately 150,000, and its daily trade volume did more than 400,000 contracts, representing more than 60 percent of the total trading volume in the Taiwan futures market. In our sample, 52% of the total trading volume of the TXO were call options, and the rest were put options; this is contrasted with those shown in both Holowczak et al. (2014) and Pan and Poteshman (2006), where index put options prevailed in developed options markets.

We partition both call and put options into five categories of moneyness, including deep in-the-money (DITM), in-the-money (ITM), near-the-money (ATM), out-of-the-money (OTM) and deep out-of-the-money (DOTM) options, using 3% and 10% as cutoffs. The option trading volumes by different investor classes and categories of moneyness are reported in Panel A of Table 2.1. Overall, investors distribute trades more unevenly among DITM, ITM, ATM, OTM, and DOTM options. The first row shows that their corresponding proportions are 0.06%, 1.09%, 58.42%, 33.82%, and 6.61%. In Holowczak et al. (2014), 18.58% of the option volume is in-the-money, 44.19% is near-the-money, and 37.23% is out-of-the-money. A comparison with those in the QQQQ options market shows that investors in TXO options show a stronger preference for ATM options.

Analyzing each investor class separately, we find that this pattern is even stronger for retail investors and domestic institutions. This indicates that liquidity is the main consideration of such investors when choosing option contracts. By comparison, foreign institutions distribute trades more evenly.

We further summarize the proportion of option trading volume by categorizing in terms of time to expiration. The first row shows that 79.24% of options traded by investors have an expiration of less than 30 days, a proportion which is far greater than in the QQQQ options market. This indicates that investors are more likely to trade most liquid nearby options. To analyze the trading patterns of different classes of investors, we decompose the option trades in each category of expiration into those traded by retail investors, by foreign institutions and by domestic institutions, respectively. We find that nearby options are mostly traded by retail investors, with a proportion of 69.37%, while institutions, including both foreign and domestic institutions, take a majority in intermediate horizon and long term options.

Table 2.1

Option trading volume by investor class, moneyness and expirations.

This table describes options market activities between July 1, 2009 and November 30, 2012. We exclude option trades by market makers and those with an expiration of less than three days. Panel A provides the trading volume breakdown as percentages of the total option volume by the option moneyness and investor class. Panel B shows the corresponding statistics by the option time to expiration and investor class.

Panel A: Option trading volume for different moneyness categories and investor classes

	DITM	ITM	ATM	OTM	DOTM
Overall Market	0.06%	1.09%	58.42%	33.82%	6.61%
Retail Investors	0.01%	0.66%	60.94%	32.59%	5.80%
Foreign Institutions	0.22%	1.30%	46.36%	38.85%	13.26%
Domestic Institutions	0.09%	2.43%	58.65%	34.35%	4.47%

Panel B: Option time to expiration by different classes of investors

	Under 30 days	30-59 days	60-119 days	120 days or more	Total
Overall Market	79.24%	18.29%	1.77%	0.71%	100%
Retail Investors	69.37%	54.51%	21.53%	15.74%	
Foreign Institutions	10.48%	27.33%	67.72%	76.43%	
Domestic Institutions	20.14%	18.16%	10.75%	7.84%	
Total	100%	100%	100%	100%	

III Methodology

3.1 Primary empirical specifications

In this section, we introduce the main empirical design and explain how to compute put-call ratios using four weighting schemes: the strike discount, maturity discount, equal weighted and one pair methods.

To measure the effectiveness of our aggregation methods, we examine both contemporaneous and predictive relations between various put-call ratios and price changes of the underlying index as Holowczak et al. (2014). In addition to examining whether there is extra information in the aggregated put-call ratio, our predictive analysis also provides a channel to assess whether their contemporaneous relations stem from a liquidity or hedging pressures which is characterized by price reversal as suggested in Schlag and Stoll (2005). Therefore, if market-wide informed traders prefer to realize information in an options market, we would expect a negative relationship between the aforementioned put-call ratios and future price movement in the underlying index. The specification is as follows:

$$R_{t+\tau} = \alpha + \beta X_t + Control_t + \varepsilon_{t+\tau} \qquad \tau = 0,1 \tag{3.1}$$

where $R_{t+\tau} = \log\left(\frac{P_{t+\tau}}{P_{t-1+\tau}}\right) \times 100\%$ ($\tau = 0,1$) represents the logarithmic spot index daily return and X_t represent put-call ratios calculated by above four aggregation methods.

Following Chang et al. (2009) and Pan and Poteshman (2006), we select a set of control variables comprised of the daily options trading volume, the cumulative return over the past five trading days, and the lagged one-day Nasdaq 100 index return to control for the effect of liquidity, price reversal and the correlation between the U.S. and Taiwan markets[3].

The put-call ratios calculated from equations (3.2) and (3.3) are aggregated via the maturity discount (MD) and strike discount (KD) weighting schemes, respectively. Additionally, we compute two benchmark aggregated put-call ratios via equal weighting (EW) and one pair (OP) to gauge whether the maturity discount and strike discount methods contribute to retrieving aggregate information from option trading with better quality.

$$X_t^{MD} = \frac{\sum_{j=1}^{N} e^{-\left(M_j - C_1\right)^2} P(K_j, T_j)}{\sum_{j=1}^{N} e^{-\left(M_j - C_1\right)^2} P(K_j, T_j) + \sum_{j=1}^{N} e^{-\left(M_j - C_1\right)^2} C(K_j, T_j)} \tag{3.2}$$

[3] To have profound coefficients on independent variables, we multiply the return series of the underlying index $R_{t+\tau}$, the cumulative return over the past five trading days, and the lagged one-day Nasdaq 100 index return by 100 and scale the daily option trading volume by 1,000.

where $C(K_j,T_j)$ and $P(K_j,T_j)$ are the trading volume for the specified option contract on day t and $M_j = \max(1, T_j \times 12)$ is the time to expiration for each option contract measured in months. In this paper, we floor all maturities to integer months. For example, we set M_j to two for option contracts with time to expiration in the range [2.0, 3.0). Equation (3.2) stipulates that option contracts with maturity equal to C_1 share a weight of one, while the weight for the remaining decay exponentially.

$$X_{\mathrm{t}}^{KD} = \frac{\sum_{j=1}^{N} e^{-d_j^2 \cdot \mathrm{C}_2} P(K_j,T_j)}{\sum_{j=1}^{N} e^{-d_j^2 \cdot \mathrm{C}_2} P(K_j,T_j) + \sum_{j=1}^{N} e^{-d_j^2 \cdot \mathrm{C}_2} C(K_j,T_j)} \tag{3.3}$$

where $d_j = \log\left(\frac{K_{j,t}}{F_t}\right)$ represents the moneyness for the specified option contract, F_t [4] is the price of the nearby TX contract on day t. From (3.3), we infer that ATM options have the largest weight of one.

$$X_t^{EW} = \frac{\sum_{j=1}^{N} 1 \cdot P(K_j,T_j)}{\sum_{j=1}^{N} 1 \cdot P(K_j,T_j) + \sum_{j=1}^{N} 1 \cdot C(K_j,T_j)} \tag{3.4}$$

Equal weighting the put-call ratio is the typical method employed in Chang et al. (2009) and Pan and Poteshman (2006), who assign equal weight to each option contract. In fact, this weigh assignment implies that informed traders randomly choose options to realize their information.

$$X_{\mathrm{t}}^{OP} = \frac{P^{Max}(K_j,T_j)}{P^{Max}(K_j,T_j) + C^{Max}(K_j,T_j)} \tag{3.5}$$

Referring to Chan et al. (2002) and Lin et al. (2016), we choose the option contract with the daily maximum trading volume. $P^{Max}(K_j,T_j)$ and $C^{Max}(K_j,T_j)$ represent the trading

[4] To obtain a more precise moneyness measure, we choose the first trade price of the nearby TX in every minute denoted as F_t.

volume of the selected put and call option contracts on day t , respectively.

We adjust the maturity discount and strike discount methods by introducing one additional parameter, respectively. The two parameters determine the weighting schemes for different options contracts. Unlike in a developed options market, the majority of participants in TXO are retail traders; in addition, investors in the TXO seem to distribute trades more unevenly among options with varying moneyness. The differences in the characteristics of the options market play an important role in the optimal weighting schemes.

3.2 Optimizing the maturity discount and strike discount methods in the TXO market

We define the free parameter C_1 in equation (3.2) as the location parameter, which determines which set of options have a weight of one. Holowczak, Hu, and Wu assume C_1=0, meaning that nearby options with a maturity of one and less than one month have a weight of one in the QQQQ options market, in which the majority of participants are institutions.

However, retail trading, which is often regarded as noise trading (Chang et al. 2009), accounts for more than half of the trading volume of the TXO, a representative emerging options market. At the same time, retail investors exhibit a stronger preference for nearby options, accounting for nearly 70 percent of all nearby options trading, while foreign institutions and domestic institutions, the well-known market-oriented informed investors (Lin et al. 2016), take a majority in intermediate horizon and long-term options trading. According to the implication of information-based models, retail traders' concentration could weaken the information roles of nearby options. Moreover, Holowczak et al. (2014) suggest that investors trade long-term contracts primarily for hedging purposes irrespective of information.

Empirically, Chang et al. (2009) provide evidence that the information content of intermediate horizon options by foreign institutions is highest in the TXO market. Han et al. (2009) find that retail investors dominating nearby options trading lose more money. Together, these findings suggest that retail trading, particular in emerging option markets, affects the way that we aggregate options trading volume to retrieve information with better quality. To examine their effect on the maturity discount aggregation method, we specify the following regressions.

$$R_{t+\tau} = \alpha + \beta X_t^{MD\_In/Out} + Control_t + \varepsilon_{t+\tau} \quad \tau=0,1 \tag{3.6}$$

Our procedure involves three steps. First, we partition our sample into two periods for in-sample and out-of-sample tests. Second, a sample simulation analysis specified in (3.6) is run separately for integer location parameters ranging from 1 to 6. Third, we conduct a similar analysis for out-of-sample tests using $X_t^{MD\_Out}$. The parameter that performs best in both in-sample and out-of-sample tests will be optimal.

With respect to strike discount one, we introduce the shape parameter C_2 in equation (3.3). The shape parameter describes how quickly the weights for ITM options and OTM options decline as standardized moneyness increases in absolute magnitude. Its value further depends on how evenly investors distribute trades among options with varying moneyness according to the liquidity hypothesis.

The constant one, 1/2, used in Holowczak et al. (2014) fails to match the trading volume of option contracts with their corresponding weights. Figure 1 below shows the shapes of the weight distribution for options with different moneyness with varying decay rates. When setting C_2 to 1/2, options with moneyness 1.1 gain weight 0.9955, which is less than that for ATM options by only 0.45%. When it comes to actual trading volume, the difference amounts to 90%. This contrasting difference suggests that we need a larger decay rate when applying the strike discount method to the TXO market.

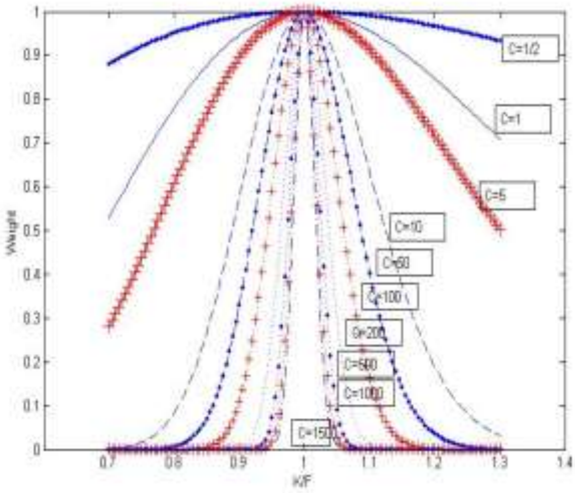

Figure 1. The weight distribution for options with respect to moneyness for different C_2

To obtain the appropriate decay rate, we conduct a similar simulation analysis as before by estimating the following equation:

$$R_{t+\tau} = \alpha + \beta X_t^{KD\_In/Out} + Control_t + \varepsilon_{t+\tau} \quad \tau=0,1 \tag{3.7}$$

where $X_t^{KD\_In/out}$ is our new strike discounted put-call ratio calculated using in-sample and out-of-sample data, respectively. The decay rate ranges from 1/2 to 1500.

Given the optimal parameters for the maturity discount and strike discount methods, we calculate the put-call ratios in equations (3.2)-(3.5) using our entire sample data and subsequently run the regressions specified in equation (3.1) separately for the four types of put-call ratios to examine whether the maturity discount and strike discount methods contribute to retrieving aggregate information from option trading volume.

3.3 Do OTM options trades contain more information?

Information-based models suggest that leverage affects informed traders' choice of trading venues. The results of Blasco et al. (2010) and Pan and Poteshman (2006) support this assertion and subsequently provide evidence that directional information is essentially realized through OTM options providing the highest leverage.

However, there are also exceptions. Chang et al. (2009) show that intermediate horizon ATM options, rather than OTM options, of foreign institutions exhibit significant predictability. Moreover, Hu (2014) finds that only the order imbalance calculated from OTM options exhibits little predictive power.

If the only concern of informed investors in selecting an option contract to trade is leverage, OTM options deserve more weight. Motivated by this implication, we use the following equations to determine whether OTM options contain more information:

$$R_{t+\tau} = \alpha + \beta X_t^{KD\_OTM\_In/Out} + Control_t + \varepsilon_{t+\tau} \quad \tau=0,1 \tag{3.8}$$

and

$$X_t^{KD\_OTM\_In/Out} = \frac{\sum_{j=1}^{N} e^{-\left(d_j+C^*\right)^2 * C_2} P(K_j,T_j)}{\sum_{j=1}^{N} e^{-\left(d_j+C^*\right)^2 * C_2} P(K_j,T_j) + \sum_{j=1}^{N} e^{-\left(d_j+C^*\right)^2 * C_2} C(K_j,T_j)} \tag{3.9}$$

where $C^* \in \{-0.05,-0.04,-0.03,-0.02,-0.01,0,0.01,0.02,0.03,0.04,0.05\}$. Compared with equation (3.3), we introduce another location parameter *C** which determines which category of option contracts share maximum weight. A positive (negative) *C** means shifting the weighting distribution line in figure 1 to the left (right), thus assigning less (more) weight to OTM options. Therefore, if leverage is the only consideration for informed traders, we would expect a 'larger' β for negative *C**.

3.4 Revisiting the information roles of OTM options in extreme conditions

Although few researchers have studied the theoretical relationship between the information roles of options with varying moneyness and market volatility, some empirical studies provide compelling evidence. Chan et al. (2009) find that OTM options are more attractive to informed traders in a bear market with a surge in market volatility, and therefore OTM option trades lead equity return. They attribute this to the incremental difficulty of short sales in an equity market. Hu (2014) also confirms that short-sale constraints enhance the informational role of stock option trading.

The Taiwan futures exchange publishes an index of implied volatility, the VIX. As a measure of apprehension, a surge in the VIX is always accompanied by a large downward movement in the market. Subsequently, we summarize the option trading volume of different categories of moneyness when the market experiences a downward movement when the VIX exceeds 25. Our results suggest that institutions behave in a different manner: namely, they allocate more trades to OTM options. Thus, the information content of OTM options is greater when combined with the high leverage inherent in OTM options. To incorporate the effect of market volatility, we construct the following VIX-adjusted put-call ratio.

$$X_t^{KD\_VIX} = \frac{\sum_{j=1}^{N} e^{-\left(d_j - \tilde{VIX}\right)^2 * C_1} P(K_j, T_j)}{\sum_{j=1}^{N} e^{-\left(d_j - \tilde{VIX}\right)^2 * C_1} P(K_j, T_j) + \sum_{j=1}^{N} e^{-\left(d_j - \tilde{VIX}\right)^2 * C_1} C(K_j, T_j)} \qquad (3.10)$$

In this equation $\tilde{VIX}$ is a standardized VIX obtained by subtracting its sample mean and dividing the difference by the sample standard deviation; to match the magnitude of d_j, we further divide $\tilde{VIX}$ by 100. Therefore, when the VIX exceeds the sample mean level, we have a positive $\tilde{VIX}$; and this modification is equivalent to shifting the weight distribution line in Figure 1 to the right.

To gauge whether the VIX-adjusted put-call ratio outperforms in a bear market, we design two specifications. The first examines whether it provides more information about the large negative price changes of the underlying index.

$$R_t^{Neg} = \alpha + \beta X_{t-\tau}^{KD\_VIX} + Control_t + \varepsilon_t \quad \tau = 0,1 \qquad (3.11)$$

where R_t^{Neg} represents the selected return series with a value less than the median level of all negative returns in our sample, and $X_{t-\tau}^{KD\_VIX}$ represents the VIX-adjusted put-call ratios computed by option trades on days *t* and *t-1* to obtain their contemporaneous and predictive coefficients, respectively.

The second concentrates on market downtrend period when VIX continuously exceeds 25. This subsample period covers from August 5, 2011 to January 13, 2012. We then calculate the series of VIX adjusted put-call ratios using this subsample data and run regressions as specified in equation (3.1). Given that investors trade more OTM options when the VIX exceeds 25, we might expect informed traders to prefer to realize their information through OTM options due to liquidity considerations. In addition, OTM options provide the greatest leverage. Therefore, we expect more significant coefficients on the VIX-adjusted put-call ratio in a bear market.

IV Empirical Analysis

4.1 Optimizing the maturity discount and strike discount methods in the TXO market

In this section, we examine the effect of retail trading on the optimal choice of the category of options, in terms of expiration, to give a weight of one when applying the maturity discount method to the TXO market. Specifically, we run both in-sample and out-of-sample regressions as specified in equation (3.6), and the results are reported in Panel A and B, respectively, of Table 4.1. For the sake of brevity, we only present the coefficients and t-statistics for the put-call ratios. The first two rows of Panel A show that when C_1=1, the contemporaneous coefficient for the maturity discounted put-call ratio is insignificant, indicating that it provides little information about the prices of the underlying index by assigning a weight of one to nearby options. Although this finding contradicts Holowczak et al. (2014) and the general intuition that the information content of nearby options with the largest share of option trades should be greater, it is consistent with Han and Kumar (2013) in that option contracts with a high retail trading proportion tend to contain little useful information.

For the other values of C_1=2, 3, 4, and 5, the corresponding coefficients become significantly negative, reaching their peak of -1.68 (t-statistic = -1.72) at C_1=2. However, the estimated results for out-of-sample tests show that these contemporaneous coefficients are all insignificant except for the one when C_1=3, indicating only by setting C_1 to 3 can we have the best and most robust results. This finding also suggests that intermediate horizon options with scarce retail trading, especially those with an expiration close to three months, contain more information about the price changes of the underlying index. This finding accords with Chang et al. (2009), who find that intermediate horizon options by foreign institutions perform better. However, when C_1=6, which indicates that the long-term options with the lowest retail trading proportion have a weight of one, the contemporaneous coefficient becomes insignificant again. One possible explanation is that the primary purpose of trading long-term options is protection against market crashes, and thus information in long-term option trades is not reflective of daily price movements (Holowczak et al., 2014). Furthermore, long-term option transactions account for only a minority of all TXO trades, and therefore the inherent information in their trades is necessarily limited.

The last two rows in Panel A reveal the results of the predictive analysis. Consistent with Chiu et al. (2014), our results provide evidence in support of market efficiency, as there is little predictive power over the next day. This also supports the conclusion that the contemporaneous impacts are permanent, as there is little evidence of price reversal as per Schlag and Stoll (2005).

Collectively, our findings suggest that retail trading, the purpose of trading, and liquidity all affect the information content of option trades in each category. In the TXO market, intermediate horizon options yield the best balance.

Table 4.1

Regression results for maturity discounted put-call ratios with varying location parameters.

This table reports the regression results of the following equation:

$$R_{t+\tau} = \alpha + \beta X_t^{MD\_In/Out} + Control_t + \varepsilon_{t+\tau} \quad \tau=0,1$$

$R_{t+\tau}$ is the daily logarithmic spot index return. $X_t^{MD\_In/Out}$ represents two groups of maturity discounted put-call ratios computed by in-sample data (July 1, 2009-January 31, 2012) and out-of-sample data (February 1, 2012-November 30, 2012), respectively. For each group, we compute the maturity discounted put-call ratios with varying location parameters C_1 specified in equation (3.2). $Control_t$ is comprised of the daily option trading volume, the cumulative return of the spot index over the past five trading days, and the lagged one-day Nasdaq 100 index return. Panels A and B show the empirical results for in-sample tests and out-of-sample tests, respectively. The resulting t-statistics are reported in parentheses. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels.

C_1	1	2	3	4	5	6
Panel A: In-sample tests (July 1, 2009-January 31, 2012)						
τ=0	-0.5	-1.68*	-1.38**	-0.85***	-0.4*	-0.2
	(-0.49)	(-1.72)	(-2.47)	(-2.74)	(-1.89)	(-1.05)
τ=1	1.51	0.67	-0.22	0.11	-0.04	-0.2
	(1.49)	(0.69)	(-0.39)	(0.36)	(-0.18)	(-1.01)
Panel B: Out-of-sample tests (February 1, 2012-November 30, 2012)						
τ=0	0.00	-1.75	-2.04**	-0.80	-0.40	-0.33
	(0.00)	(-1.03)	(-2.35)	(-1.61)	(-1.02)	(-0.92)
τ=1	3.48*	1.94	-0.87	-0.73	-0.54	-0.18
	(1.99)	(1.15)	(-1.01)	(-1.48)	(-1.38)	(-0.51)

As detailed in section 3.2, investors in the TXO allocate more trades at near-the-money options, and thus the weight of in-the-money and out-of-the-money options should be further discounted. We propose a larger weight decay rate as defined in equation (3.3) is associated with a 'bigger' estimated coefficient. To test our proposal, we run equation (3.7) separately for different decay rates ranging from 1/2 (used in Holowczak et al. 2014) to 1500. Panels A and B report the estimated coefficients for in-sample and out-of-sample tests, which again for the sake of simplicity omit the coefficients for the other control variables.

Panel A shows that the contemporaneous coefficient of the strike discounted put-call ratio, -3.09, is significant when C_2=1/2. However, their relationship becomes insignificant for the out-of-sample test. The contrasting findings suggest that the decay rate in Holowczak et al. (2014) does not apply to the TXO market. For the other values of C_2 ranging from 1 to 1,500, the magnitudes of the contemporaneous coefficients rise, peak, and fall in a bell-shaped curve, reaching their summit when C_2 =1,000. Moreover, this result is robust for the out-of-sample tests. This finding is consistent with our expectation that assigning less weight to in-the-money and out-of-the-money options would generate better results in the TXO market.

However, the positive relationship between the decay rate and information quality is not perpetual. A larger C_2 in excess of 1,000 ultimately generates lower-quality aggregate information. The economic explanation is simple. Consider an extreme case in which C_2 tends to infinite, which means that we choose only the options with moneyness of zero because the weight for the other option contracts is zero. Because we have abandoned the information contained in those discarded option contracts, the quality of the aggregate information from the option volume declines correspondingly. In addition, the coefficients for the put-call ratios are insignificant for regressions at lag 1, indicating that the contemporaneous price impacts are permanent due to the limited number of price reversals. One important implication of our results is that when using the strike discount aggregation method, we should consider the actual distribution of option trading volume in terms of option moneyness.

Table 4.2

Regression results for strike discounted put-call ratios with varying weight decay rates.

This table reports the regression results of the following equation:

$$R_{t+\tau} = \alpha + \beta X_t^{KD\_In/Out} + Control_t + \varepsilon_{t+\tau} \quad \tau=0,1$$

$R_{t+\tau}$ is the daily logarithmic spot index return. $X_t^{KD\_In/out}$ represents two groups of strike discounted put-call ratios computed by in-sample data (July 1, 2009-January 31, 2012) and out-of-sample data (February 1, 2012-November 30, 2012), respectively. For each group, we compute the strike discounted put-call ratios with varying weight decay rates C_2 as specified in equation (3.3). $Control_t$ is comprised of the daily option trading volume, the cumulative return of the spot index over the past five trading days, and the lagged one-day Nasdaq 100 index return. Panels A and B show the empirical results for in-sample tests and out-of-sample tests, respectively. The resulting t-statistics are reported in parentheses. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels.

C_2	½	1	10	50	100	200	500	600	700	1000	1100	1200	1500
Panel A: In-sample tests (July 1, 2009-January 31, 2012)													
τ=0	-3.09*	-3.12*	-3.50**	-4.78***	-5.47***	-6.83***	-7.92***	-8.01***	-8.05***	-8.05***	-8.03***	-8.01***	-7.93***
	(-1.83)	(-1.85)	(-2.06)	(-2.88)	(-6.02)	(-8.43)	(-11.79)	(-12.36)	(-12.80)	(-13.66)	(-13.85)	(-14.01)	(-14.36)
τ=1	2.01*	2.02*	2.04*	1.93*	1.73*	1.46	1.15	1.09	1.04	0.94	0.93	0.90	0.85
	(1.88)	(1.88)	(1.89)	(1.90)	(1.72)	(1.55)	(1.36)	(1.33)	(1.31)	(1.24)	(1.22)	(1.21)	(1.17)
Panel B: Out-of-sample tests (February 1, 2012-November 30, 2012)													
τ=0	-0.87	-0.88	-1.16	-2.31	-3.36*	-4.59***	-5.67***	-5.76***	-5.79***	-5.79***	-5.77***	-5.74***	-5.65***
	(-0.50)	(-0.50)	(-0.66)	(-1.31)	(-1.99)	(-2.98)	(-4.51)	(-4.78)	(-5.00)	(-5.45)	(-5.55)	(-5.64)	(-5.84)
τ=1	0.79	1.79	0.91	1.22	1.56	2.03	2.61	2.69*	2.75*	2.84*	2.85**	2.85**	2.85**
	(0.43)	(0.43)	(0.49)	(0.66)	(0.85)	(0.85)	(1.62)	(1.71)	(1.79)	(1.96)	(2.00)	(2.03)	(2.06)

To gauge the effectiveness of the maturity discount, strike discount, equal weighting and one pair methods, we run separate regressions as specified in equation (3.1) for four put-call ratios constructed from equations (3.2)-(3.5) using our entire sample data. Here we use the optimal parameters found in the previous section when calculating the maturity discounted put-call ratios and the strike discounted put-call ratios. The empirical results are reported in Table 4.3. Consistent with our expectation, the equal weighting of the put-call ratios provides the poorest performance. Although its contemporaneous coefficient, -0.96, has the expected sign, its corresponding t-statistic (-1.08) fails to reject the null hypothesis.

However, the other three present a different picture. When τ=0, the coefficient for the put-call ratio is -8.33 (t-statistic = -7.52) when aggregated with the strike discount method, -1.43 (t-statistic = -3.06) when aggregated with the maturity method, and -3.08 (t-statistic = -6.16) when aggregated with one pair of call and put options. Moreover, we find that the four put-call ratios show little predictive ability at lag 1, as none of their coefficients are significant. This also indicates that significant contemporaneous price impacts arise from information rather than from liquidity pressure. The significantly negative contemporaneous coefficients show that the trading volume of the TXO, as a whole, does carry information about price changes of the underlying index on a daily basis. In addition, it shows that, when studying price discovery between options and spot markets, in addition to paying attention to information issues as Holowczak et al. (2014) suggest, the method of aggregating trading information of different options is also important.

We further consider the difference in magnitude between the above three significant coefficients. Compared with the one pair related put-call ratio, the strike discounted put-call ratio reveals incremental explanatory power. The difference possibly comes from the discarded option contracts when using only one pair of call and put options. Surprisingly, the coefficient for the one pair related put-call ratio is larger than that for the maturity discounted put-call ratio, which also incorporates all option contracts. The possible reason is that we assign less weight to nearby options. According to the liquidity hypothesis, nearby options rather than intermediate horizon options should have a weight of one because they are most actively traded. However, they are also exposed to the most noise trading. These offsetting effects cause the maturity discount put-call ratio, which assigns the maximum weight of one to intermediate horizon options, to exhibit weaker explanatory power. Additionally, the superior performance of the one pair method provides compelling empirical evidence in support of Chan et al. (2002) and Lin et al. (2016), who select only one pair of call and put options for analysis. Although not perfect, it offers a convenient way to handle option issues.

Table 4.3
Regression results for four aggregating methods.

This table reports the regression results of the following equation:

$$R_{t+\tau} = \alpha + \beta X_t + Control_t + \varepsilon_{t+\tau} \qquad \tau = 0, 1$$

$R_{t+\tau}$ is the daily logarithmic spot index return. X_t represents the strike discounted put-call ratio (KD) specified in equation (3.3) with the optimal decay rate, C_2, equals to 1,000, the maturity discounted put-call ratio (MD) as specified in equation (3.2) with the optimal location parameter, C_1, equals to 3, the equal weighting put-call ratio (EW) as specified in equation (3.4), and the one pair put-call ratio as specified in equation (3.5), respectively. When calculating the four types of put-call ratios, we use the entire sample data (July 1, 2009-November 30, 2012). $Control_t$ is comprised of the daily option trading volume, the cumulative return of the spot index over the past five trading days, and the lagged one-day Nasdaq 100 index return. The resulting t-statistics are reported in parentheses. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels.

		KD	MD	EW	OP
	β	-8.33***	-1.43***	-0.96	-3.08***
τ=0	t	(-7.52)	(-3.06)	(-1.08)	(-6.16)
	R^2	0.2319	0.019	0.0096	0.0504
	β	-0.22	-0.36	1.63*	-0.75
τ=1	t	(-0.13)	(-0.77)	(1.85)	(-1.46)
	R^2	0.0095	0.0084	0.0119	0.0108

4.2 Do OTM option trades contain more information?

Table 4.4 presents the results of eleven regressions when we choose different values of C^* as specified in equation (3.9). A negative C^* means increasing the weight of OTM options, while a positive C^* means increasing the weight of ITM options. The estimated coefficients for in-sample tests are reported in Panel A. Overall, the variation in the contemporaneous coefficients for the put-call ratios suggests that ITM options and OTM options contain differential information about the changes in the underlying index.

We first focus on the results of the contemporaneous analysis when τ=0 in Panel A. The weights for OTM options are in decreasing order from left to right. We choose the coefficients for C^*=0 as a benchmark, which implies that ITM and OTM options are equally informational. For all negative values of C^*= -0.01,-0.02,-0.03,-0.04, and -0.05, their corresponding coefficients decrease continuously in magnitude and its sign becomes positive when C^*=-0.05. On the other hand, the coefficients first reach their peak at C^*=0.01 (coefficient = -8.31, t-statistic = -15.99) and begin to fall monotonously when moving to the right. Panel B shows similar results for the out-of-sample analysis. This finding is consistent with Chang et al. (2009), De Jong et al. (2006), and Hu (2014) in the sense that ITM and ATM options seem to contain more information than OTM options. In addition to the significant contemporaneous relations, our information variables fail to predict the future prices of the underlying index, supporting the claim that the TXO market as a whole is sufficient, which accords with Chiu et al. (2014).

Our results seem to contradict the leverage hypothesis that informed investors prefer to trade options that provide higher leverage (Pan and Poteshman, 2006). However, rather than a violation of the leverage hypothesis, our findings suggest some other factors also affect informed investors’ choice. One possible interpretation is that ITM options exhibit greater exposure to the underlying price, so is their corresponding weight according to the logic of Hu (2014). The second relates to the characteristics of option markets. The literature (e.g., Chang et al. 2009; Hu 2014) provides evidence that the option markets in which OTM options underperform share one common feature: the trading volume for OTM calls is larger than that for OTM puts. According to the principle of parameter estimation, an estimated coefficient increases in magnitude when a positive explanatory variable with value less than one decreases in value. In our paper, an increase in the weight of OTM options is equivalent to a decrease in the put-call ratio, thereby generating a smaller coefficient in magnitude, as the put-call ratio is always positive and less than one. Altogether, our results suggest that it is risky to assume that OTM options contain more information than ITM and ATM options. In addition to leverage, informed investors also account for liquidity and the different exposure of option contracts to the movement of the underlying index.

Table 4.4

Regression results for testing the information role of OTM options.

This table reports the regression results of the following equation:

$$R_{t+\tau} = \alpha + \beta X_t^{KD\_OTM\_In/Out} + Control_t + \varepsilon_{t+1} \quad \tau=0,1$$

$R_{t+\tau}$ is the daily logarithmic spot index return. $X_t^{KD\_OTM\_In/Out}$ represents two groups of put-call ratios computed by in-sample data (July 1, 2009-January 31, 2012) and out-of-sample data (February 1, 2012-November 30, 2012), respectively. For each group, we compute the put-call ratios with varying C^* specified in equation (3.9) in which a positive (negative) C^* means decreasing (increasing) the weight of OTM options compared with the weighting scheme of strike discount method. $Control_t$ is comprised of the daily option trading volume, the cumulative return of the spot index over the past five trading days, and the lagged one-day Nasdaq 100 index return. Panels A and B show the empirical results for in-sample tests and out-of-sample tests, respectively. The resulting t-statistics are reported in parentheses. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels.

C^*	-0.05	-0.04	-0.03	-0.02	-0.01	0	0.01	0.02	0.03	0.04	0.05
Panel A: In-sample tests (July 1, 2009-January 31, 2012)											
τ=0	1.46**	-0.65	-3.17***	-5.48***	-7.13***	-8.05***	-8.31***	-8.03***	-7.39***	-6.59***	-5.77***
	(2.23)	(-0.91)	(-4.32)	(-7.72)	(-10.87)	(-13.66)	(-15.99)	(-17.69)	(-18.66)	(-18.91)	(-18.52)
τ=1	0.26	0.34	0.34	0.27	0.18	0.08	-0.02	-0.53	-0.59	-0.70	-0.79
	(0.41)	(0.49)	(0.47)	(0.38)	(0.26)	(0.13)	(-0.04)	(-0.54)	(-0.70)	(-0.99)	(-1.31)
Panel B: Out-of-sample tests (February 1, 2012-November 30, 2012)											
τ=0	6.32***	4.84***	1.28	-2.50*	-4.85***	-5.79***	-5.94***	-5.73***	-5.35***	-4.90***	-4.43***
	(5.29)	(3.36)	(0.82)	(-1.70)	(-3.80)	(-5.45)	(-6.74)	(-7.76)	(-8.53)	(-9.07)	(-9.38)
τ=1	0.47	0.95	1.76	2.39*	2.50**	2.26**	1.90**	1.53**	1.20*	0.91	0.69
	(0.39)	(0.67)	(1.16)	(1.66)	(1.98)	(2.11)	(2.09)	(1.98)	(1.79)	(1.56)	(1.34)

4.3 Revisiting the information roles of OTM options in extreme conditions

In this section, we use the VIX-adjusted put-call ratios to examine whether the information role of OTM options is unresponsive to market volatility. If the preferences of informed investors remain unchanged in a downward trending period, the strike discounted put-call ratios would continue to exhibit superior performance. We first compare the estimated coefficients reported in Panel A of Table 4.5 for the VIX-adjusted put-call ratios and the strike discounted put-call ratios using entire sample data. It seems unnecessary to take market volatility into account when using overall sample data, because the contemporaneous coefficient for the VIX-adjusted put-call ratio is less than that for the strike discounted put-call ratio. Additionally, as mentioned earlier, they both show little predictive ability.

Next, our analysis concentrates on more volatile days with a VIX in excess of 25. As a measure of apprehension, a surge in the VIX is often associated with a sharp decrease in the index. In particular, we choose the trading days when the underlying index experiences a relatively large downward movement, larger than the median level of all downward movements in our sample. To correct for time series correlation in our selected sample data, we use robust standard error. The first two columns of Panel B present contemporaneous coefficients for the VIX-adjusted put-call ratios and the strike adjusted put call ratios, respectively. The former coefficient -3.65 (t-statistic = -3.36) is less than the latter -5.46 (t-statistic = -6.97) in both magnitude and significance level.

We further calculate the above two put-call ratios with trade data from the previous day to determine which can better predict the following day’s large negative price changes; the results are reported in the last two columns of Panel B. Contrary to the results of the contemporaneous impact analysis, the VIX-adjusted put-call ratio shows better forecasting ability. Its calculated coefficient of -3.30 (t-statistic = -3.14) exceeds that of the strike discounted put-call ratio in both magnitude and significance level. Our results accord with Chan et al. (2009) in that the information roles of ITM and OTM options interact with market conditions. Specially, our results reveal that assigning more weight to OTM options when aggregating all option trades contributes to better predictive ability for future downward movements.

Panel C reports the results of their corresponding regressions in a downward trending market. The sample data ranges from August 5, 2011 to January 13, 2012, during which the VIX continually exceeds 25. Our results reveal that the coefficient for the VIX-adjusted put-call ratio is -13.81, which is greater than that of the strike discounted put-call ratio when $\tau=0$. Similarly, no significant price reversal is found in regressions for $\tau=1$. This further supports the claim that OTM options contain more directional information when the market experiences a downward trend with a surge in the VIX. The conclusion is consistent with the leverage hypothesis confirmed in Pan and Poteshman (2006).

However, the contrasting results in Hu (2014) suggest that leverage is not the only explanation. The other comes from the liquidity hypothesis. Table 4.6 summarizes the trading volume for options with varying moneyness during the above period. Consistent with our expectation, the combined trading volume for OTM options and DOTM options increased by 21.75% to 62.19% as compared with the result in Table 2.1. Moreover, the foreign institutions and domestic institutions also engage in more trades for out-of-the-money options, with incremental portions of 13.92% and 15.12%, respectively. Thus, we argue that leverage and liquidity together augment the information roles of OTM options.

Table 4.5

Regression results for comparing the performance between VIX-adjusted put-call ratios and strike discounted put-call ratios.

In this table, Panel A reports the regression results of the following equation:

$$R_{t+\tau} = \alpha + \beta X_t + Control_t + \varepsilon_{t+\tau}$$

$R_{t+\tau}$ is the daily logarithmic spot index return. X_t represents the VIX-adjusted put-call ratio specified in equation (3.10) in which we increase (decrease) the weight of OTM options when market VIX is larger (less) than its sample mean level and the strike discounted put-call ratio (KD) specified in equation (3.3) in which the optimal decay rate, C_2, equals to 1,000. Panel B presents the regression results of the following equation:

$$R_t^{Neg} = \alpha + \beta X_{t-\tau}^{KD-VIX} + Control_t + \varepsilon_t \quad \tau=0,1$$

R_t^{Neg} is the selected return series with values less than the median level of all negative returns in our sample. $X_{t-\tau}^{KD-VIX}$ represents the VIX-adjusted put-call ratios computed by option trades on day *t* and *t-1*, respectively. Panel C reports the regression results of the same specification in Panel A, while the difference is that we use a subsample data starting from August 5, 2011- January 13, 2012 during which VIX continually exceeds 25. The three specifications share the same control variables: the daily options trading volume, the cumulative return of the spot index over the past five trading days, and the lagged one-day Nasdaq 100 index return. The resulting t-statistics are reported in parentheses. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels.

Panel A: Entire return series				
	τ=0		τ=1	
	VIX_KD	KD	VIX_KD	KD
β	-6.83***	-7.42***	0.68	0.42
t	(-10.53)	(-14.43)	(1.03)	(0.75)
R^2	0.1223	0.2028	0.0057	0.0052
Panel B: Large down movements (Robust standard error)				
	τ=0		τ=1	
	VIX_KD	KD	VIX_KD	KD
β	-3.65***	-5.46***	-3.30***	-2.69***
t	(-3.36)	(-6.97)	(-3.14)	(-3.1)
R^2	0.1257	0.2535	0.1179	0.1169
Panel C: Return series from August 5, 2011- January 13,2012				
	τ=0		τ=1	
	VIX_KD	KD	VIX_KD	KD
β	-13.81***	-13.51***	1.24	0.40
t	(-6.52)	(-8.26)	(0.51)	(0.24)
R^2	0.3146	0.4141	0.0464	0.0446

Table 4.6
Option trading volume by different classes of traders and different moneyness.

This table shows the trading volume breakdown as a percentage of total volume by option moneyness and investor class between August 5, 2011 and January 13, 2012.

	Deep ITM	ITM	ATM	OTM	Deep OTM
Overall Market	0.06%	1.05%	36.71%	43.53%	18.66%
Foreign Institutions	0.10%	1.28%	32.58%	41.13%	24.91%
Domestic Institutions	0.25%	5.72%	40.09%	43.57%	10.37%

V Conclusion

This paper studies how to enhance the effectiveness of two option-information aggregation methods, maturity discount and strike discount, introduced in Holowczak et al. (2014) by considering retail trading and investors' uneven trades among options with varying moneyness, respectively, in the TXO market.

Inconsistent with Holowczak et al. (2014), the contemporaneous coefficients for the maturity discounted put-call ratio are greater in magnitude when assigning the maximum weight of one to intermediate horizon options rather than nearby options. The explanation for this finding is that retail trading, often considered to be noise trading, accounts for a majority of trades in the TXO, and it is primarily concentrated at nearby options with an expiration of less than one month, thus contaminating the information content inherent in their trades. Furthermore, it contributes to retrieving aggregate information with better quality if we reduce the weight of in-the-money and out-of-the-money options when applying the strike discount method, because investors, including institutions and retail investors, tend to trade more near-the-money options compared with that in Holowczak et al. (2014). Consequently, we should weaken the informational roles of in-the-money and out-of-the-money options in accordance with the liquidity consideration.

We also find that the information content of OTM options is related to market volatility. To take volatility into consideration, we establish a VIX-adjusted put-call ratio, increasing (decreasing) the weight of OTM options when the VIX is larger (smaller) than the sample average level. This provides stronger predictability of large downward movements of the underlying index. Rather than a violation of the leverage hypothesis, our findings support the claim that some other factors also affect informed investors' choice of the category of options to realize their information advantage.

Reference

Blasco, N., Corredor, P., & Santamaria, R. (2010). Does informed trading occur in the options market? Some revealing clues. *Accounting & Finance*, 50, 555-579.

Chan, K. C., Chang, Y., & Lung, P. P. (2009). Informed trading under different market conditions and moneyness: Evidence from TXO options. *Pacific-Basin Finance Journal*, 17, 189-208.

Chang, C.C., Hsieh, P.F. & Lai, H.N. (2009). Do informed option investors predict stock returns? Evidence from the Taiwan stock exchange. *Journal of Banking and Finance*, 33, 757–764.

Chan, K., Chung, Y. P., & Fong, W.-M. (2002). The informational role of stock and option volume. *Review of Financial Studies*, 15, 1049–1075.

Chiu W.-C., Lee, H.-H., & Wang, C.-W. (2014). Have domestic institutional investors become as market savvy as foreign investors? Evidence from the Taiwan options market. *Journal of Derivatives*, 21 (4), 63-81.

De Jong, C., Koedijk, K. G., & Schnitzlein, C. R. (2006). Stock market quality in the presence of a traded option. *Journal of Business*, 79(4), 2243-2274.

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

Han, B., & Kumar, A. (2013). Speculative retail trading and asset prices. *Journal of Financial and Quantitative Analysis*, 48(2), 377-404.

Han, B., Lee, Y.-T., & Liu, Y.-J. (2009). Investor trading behavior and performances: Evidence from Taiwan stock index options. McCombs Research Paper Series No. FIN-06-09. Available at SSRN: http://ssrn.com/abstract=1343270.

Holowczak, R., Hu, J., & Wu, L. (2014). Aggregate information in option transactions. *Journal of Derivatives*, 21 (3), 9-23.

Hu, J. (2014). Does option trading convey stock price information? *Journal of Financial Economics*, 111, 625-645.

Lin, W., Tsai, S.-C., & Chiu, P. (2016). Do foreign institutions outperform in the Taiwan options market? *North American Journal of Economics and Finance*, 35, 101-115.

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

Rourke, T. (2014). The delta- and vega- related information content of the near-the-money option market trading activity. *Journal of Financial Markets*, 20, 175–193.

Schlag, C., & Stoll, H. (2005). Price impacts of options volume. *Journal of Financial Markets*, 8, 69-87.