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Whose option ratios contain information about future stock prices?

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Abstract

Using the next-day and next-week returns of stocks in the Korean market, we examine the association of option volume ratios – i.e. the option-to-stock (O/S) ratio, which is the total volume of put options and call options scaled by total underlying equity volume, and the put-call (P/C) ratio, which is the put volume scaled by total put and call volume – with future returns. We find that O/S ratios are positively related to future returns, but P/C ratios have no significant association with returns. We calculate individual, institutional, and foreign investors' option ratios to determine which ratios are significantly related to future returns and find that, for all investors, higher O/S ratios predict higher future returns. The predictability of P/C depends on the investors: institutional and individual investors' P/C ratios are not related to returns, but foreign P/C predicts negative next-day returns. For net-buying O/S ratios, institutional net-buying put-to-stock ratios consistently predict negative future returns. Institutions' buying and selling put ratios also predict returns. In short, institutional put-to-share ratios predict future returns when we use various option ratios, but individual option ratios do not.

Keywords Option-to-stock volume ratio, Put-call ratio, Return predictability, Investor type, Net buying volume

Paper type Research paper

1. Introduction

Recent empirical studies argue that option ratios that are based on trading volume contain information for future underlying equity prices, so they predict future returns. Pan and Poteshman (2006) examine the put-call volume ratio (P/C ratio), a buyer-initiated put volume scaled by total put and call volume and find that stocks with low P/C ratios outperform stocks with high P/C ratios at the daily level. This finding suggests that P/C ratios predict future underlying stock returns. Meanwhile, Johnson and So (2012) show the return predictability of option-to-stock (O/S) volume ratios – i.e. the total volume of put options and call options scaled by total underlying equity volume – based on their results that weekly O/S ratios are negatively related to next-week returns. Ge *et al.* (2016) also find that the O/S ratio is negatively related to the subsequent week's stock returns. Blau *et al.* (2014) demonstrate that both P/C ratios and O/S ratios predict negative future stock returns, but the predictability in P/C ratios is temporary, on the daily and weekly levels. O/S ratios are significantly negatively related to daily, weekly, and monthly returns [1].

JEL Classification — G12, G13, G14, G15

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The studies' results are due to private information held by informed traders, which derivatives markets may have more than equity markets do. Pan and Poteshman (2006) document that the economic source of predictability of P/C ratios is nonpublic information possessed by options traders and find that these ratios have greater predictability for stocks with higher concentrations of informed traders. Roll *et al.* (2010) examine O/S ratios around earnings announcements and find that post-announcement absolute returns are positively related to the pre-announcement O/S ratio, indicating that at least part of the pre-announcement options trading is informed. Johnson and So (2012) also find that the O/S ratio predicts the sign and magnitude of earnings surprises and abnormal returns at quarterly earnings announcements in the following week, suggesting that the O/S ratio reflects private information and that the information is incorporated into stock prices following a subsequent public disclosure of the news. They argue that the informativeness of the O/S ratio reflecting private information is induced by more participation of informed investors in options markets. Their model shows that short-sale costs in equity markets make option markets an attractive venue for traders with negative news; as a result, stocks with higher O/S ratios, which may be driven by increased put option volume from informed traders, have lower returns in the future.

The explanation for these relationships that informed traders prefer the option market is supported by the theoretical literature. Black (1975) explains that informed traders prefer to trade instruments in option markets that provide more leverage opportunities. In an asymmetric information model from Easley *et al.* (1998), informed traders choose to trade in both option and equity markets and suggest that informed investors prefer to trade in options markets when the leverage that is implicit in options is larger [2]. Chen *et al.* (2005) find evidence for the argument that informed traders' trade in both the equity and options markets and show that some informed traders are probably attracted to out-of-the-money options because of these options' higher liquidity, lower premiums, and higher delta-to-premium ratios. Similarly, Diamond and Verrecchia (1987) and Danielsen and Sorescu (2001) argue that informed investors favor option trading because of constraints to short sales in stock markets. In addition, An *et al.* (2014) and Chung *et al.* (2018) support this argument that options markets can attract informed traders due to greater liquidity, higher leverage effects, and lower transaction costs.

Since informed traders prefer the options markets, option trades may contain information. Easley *et al.* (1998) examine whether information flows into equity prices through the options market such that certain options transactions contain information. Cremers and Weinbaum (2010) find that option price deviations related to put-call parity contain information not yet incorporated in the prices of the underlying stocks. Their empirical results support the theoretical prediction that directional option volume signals private information that is not yet reflected in equity prices. In a related study, Chakravarty *et al.* (2004) find evidence of significant stock price discovery in the options market and that options markets tend to be more informative when the options trading volume is high and when the stock volume is low. Kacperczyk and Pagnotta (2019) argue that the options volume includes more private information than equity volume does. Other articles also support the view that options trading conveys stock price information (DeTemple and Jorion, 1990; Figlewski and Webb, 1993; Kumar *et al.*, 1998; Chan *et al.*, 2002; Cao *et al.*, 2005; Battalio and Schultz, 2006; Roll *et al.*, 2009; Cao and Wei, 2010; Hao *et al.*, 2013; Hu, 2014).

However, many individual investors participate in Korean options markets as well as equity markets. Individual traders' option volume accounted for an average of 24.6% of the total options volume in the Korean market from 2015 through 2021,[3] so their high trading volume means that the options market has many noise traders, making option trades in the Korean market less informative. On the other hand, as Kim (2007) argues, individual investors in the Korean market intend not to hedge their risk but to bet on price movement, so

the association between future returns and option volume ratios may differ from that of other markets. Prior studies do not show consistent results for the association between the option volume of individual stocks and the future stock return. For example, Woo and Kim (2021) analyze the trading volume of options before the preliminary announcement of the underlying stocks' performance on the Korean market and stock price responses to the announcement and find that the O/S ratio is negatively related to future returns for firms with good news events and positively related to future returns for firms with bad news.

In this paper, we use individual stocks in the Korean market to examine the determinants of O/S ratios and P/C ratios and the relations between these ratios and future returns. Our evidence indicates that market-adjusted returns on the observation day of O/S and P/C ratios have significant positive relations with the options ratio. That is, the O/S volume and the P/C volume are larger when the underlying stock returns that are in excess of market returns are higher. Size has a positive association and the book-to-market ratio has a negative association with the O/S ratio after controlling for other variables. Stocks in the higher O/S ratio have lower trading volume and short-selling volume and stocks with higher P/C ratios have significantly larger sizes.

We investigate the relation between O/S ratios and P/C ratios and future returns in regression analyses and use the next-day and next-week raw and market-adjusted returns as the future return. We find a positive relation between O/S ratios and future returns but no significant relation between P/C ratios and future returns.

We also calculate individual, institutional, and foreign investors' option ratios and investigate which ratios have a significant association with future returns based on institutional traders being informed investors and individual investors being uninformed. Ryu and Yang (2018) use the KOSPI 200 index options in Korea to document that foreign investment firms' options trading volume predicts the next-day spot returns. Their study suggests that information in the options volume depends on the characteristics of its traders. The influence of retail investors in the equity and derivatives markets is growing in many countries, including the USA, so our study contributes to understanding the changing market circumstances. We use the O/S ratios and net buying O/S ratios of investors in our regressions. The net buying O/S ratio is the net buying option volume (calls or puts) scaled by total share volume for each individual, institutional, and foreign investor. Many studies use the overall option volume ratios, but the types of information that calls and puts reflect differ depending on the investor's option position (Ge *et al.*, 2016; Ryu and Yang, 2018). We expect that the net buying O/S ratios show more clearly than the total option volume whether investors' information is good or bad.

We find that higher O/S ratios of all investors predict higher future returns but that institutional and individual investors' P/C ratios have no significant association with returns. Foreign investors' P/C ratio predicts negative next-day raw and market-adjusted returns. When we use investors' net buying O/S ratios as the explanatory variables in our regressions, institutional investors' net buying put-to-stock ratios consistently predict negative future returns, but other investors' net buying O/S ratios do not. In our additional tests, institutional investors' buying and selling put volume ratios predict future returns. In short, institutional investors' put-to-share volume ratios predict future returns when we use various option ratios in our analyses, but individual investors' option volume ratios do not.

Our contribution is as follows. The literature on the association between the option volume ratio and the future return argues that as the higher option ratio indicates relatively high informed trading in the option market, it contains larger information for future prices and so predicts future returns. Although the empirical studies partially find evidence supporting this argument, they do not directly reveal whether the significant relation between the option ratio and the future return is due to informed trading. Almost all studies regarding option ratios of individual stocks use total trading volume for the option volume, not the volume of

the type of investors. However, we use the option ratios of the type of investors and test their return predictability, to examine whether informed investors trade securities using their information more in option markets. In general, institutional traders have more information than individual traders who are regarded as noise traders. Most of the foreigners in Korean markets are also institutional traders, so have more information than retail traders. Therefore, our study contributes to filling this gap in the literature by showing the direct effect of informed volume in option markets on future stock returns, distinguishing from noise trading volume.

Moreover, we examine the buying, selling, and net buying O/S ratios for each of the call and put option of each investor, while the O/S ratio in the literature is calculated using the total volume of put options and call options. We find that the buying, selling, and net buying put-to-share ratios of institutional traders significantly predict future returns but any ratios of individual traders do not. These results indicate that informed traders involving institutional investors buy (sell) more put options when they have negative (positive) news, supporting the expectation of the literature. Thus, our study also contributes to the literature by finding which option the informed traders prefer and trade with information.

The rest of the paper is organized as follows. Section 2 describes the data and defines the variables used in our study. Section 3 shows the characteristics of five portfolios based on option volume ratios and the determinants of option ratios. Section 4 examines option volume ratios and future returns. Section 5 concludes the study.

2. Data and variables

The data used in our study come from DataGuide and the Market Data System of the Korea Exchange. We obtain from DataGuide the daily volume for all call options and put options. DataGuide also provides the trading volume, returns, market capitalization, volatility, and other firm fundamentals, including the accounting data of underlying stock. From the Market Data System we gather the daily option volume of individual, institutional, and foreign traders. The sample period begins in November 2013, when the Korean option market system was reorganized and reopened and ends in May 2022. We exclude the stock-day observations with zero call or zero put contracts to reduce the measurement problems that are associated with illiquid option markets, as in Blau *et al.* (2014). Transactions that occur within five days (i.e., one week) before the option's exercise date are excluded because option volume may increase heavily close to the option position. Our final sample consists of 37 firms and 42,750 stock-day observations.

We calculate O/S ratios and P/C ratios. The O/S ratio is defined as the total option volume (calls and puts) scaled by the total share volume over the day. The P/C ratio is defined as the total put volume scaled by the total option volume over the day. We also compute these two ratios for individual, institutional, and foreign investors. The O/S ratio of investor j (O/S_j) is defined as investor j's option volume divided by the investor j's share volume, where j is an individual investor (ind), an institutional investor (inst), or a foreign investor (forg). The P/C of investor j (P/C_j) is investor j's put option volume divided by the investor j's option volume. Since one contract of an individual stock option consists of ten stocks in Korea, we multiply the option volume by 10 when using stock volume to make option ratios.

In measuring call option ratios and put option ratios, the C/S ratio is defined as the call option volume scaled by the total share volume and the P/S ratio is the put option volume scaled by the total share volume. For investors, The C/S and P/S of investor j (C/S_j and P/S_j) are investor j's call option volume and put option volume, respectively, divided by investor j's share volume.

To take into account investors' net buying option volume, we define Net C/S_j as the difference between investor j's buying and selling call volume, scaled by investor j's share

volume. Net P/S_j is defined as the difference between investor j's buying and selling put volume, scaled by investor j's share volume.

In investigating the predictability of option ratios, our main variable is the return (Ret_t) on date t. In our regression analyses, we add other variables to control for firm characteristics that may affect stock returns: $LogSize_t$ is the log of the total number of common shares outstanding, multiplied by the closing stock price on date t; and BM_t is the book value of common equity scaled by the market value of the common stock (i.e., Size) on date t (the book value of equity is from the latest available accounting statement). We also control for the prior returns, volatilities, and trading volume that might be related to returns and trading activities: the return on date t-1 (Ret_{t-1}), the standard deviation of the stock return estimated from daily returns during the year before date t (STD_t), and the log of 1 plus the total trading volume of the stock on date t ($LogTV_t$). In addition, short-selling volume is the log of 1 plus the total short-selling volume of the stock on date t($LogShrtTV_t$). Table 1 defines the main variables used in this paper.

Table 2 presents the summary statistics of the main variables, and Table 3 reports the correlation coefficients among the variables using daily data. As foreign investors rarely traded before October 2021 in the Korean option market, the sample period for the variables related to foreign option trading begins in October 2021 in Tables 2 and 3 This period is too short, but we use the statistics for the measures for foreign investors' option volume ratios to compare with other investors' results. Table 2 shows that the average stock has an O/S ratio of 0.063, a P/C ratio of 0.463, and a daily option (calls and puts) volume of 2,499.6 contracts. As the average of P/C ratios is less than 0.5, the trading volume of put options is smaller than that of call options. The O/S ratios are heavily right skewed, which is consistent with Johnson and So's (2012) and Blau *et al.*'s (2014) samples. Following Johnson and So (2012) and Blau *et al.*

Table 1.
Variable definitions

Variable	Definition
Variables for option volume ratio	
O/S	(Call volume + Put volume)/total share trading volume
P/C	Put volume/(Call volume + Put volume)
C/S	Call volume/total share trading volume
P/S	Put volume/total share trading volume
Variables for investor j's option volume ratio	
O/S_j	(Call volume for j + Put volume for j)/share volume for j, where j is an individual (ind), institutional (inst), or foreign (forg) investor.
P/C_j	Put volume for j/(Call volume for j + Put volume for j), where j is an individual (ind), institutional (inst), or foreign (forg) investor.
C/S_j	Call volume for j/share volume for j, where j is an individual (ind), institutional (inst), or foreign (forg) investor.
P/S_j	Put volume for j/share volume for j, where j is an individual (ind), institutional (inst), or foreign (forg) investor.
Net C/S_j	(Buying call volume for j – selling call volume for j)/share volume for j, where j is an individual (ind), institutional (inst), or foreign (forg) investor.
Net P/S_j	(Buying put volume for j – selling put volume for j)/share volume for j, where j is an individual (ind), institutional (inst), or foreign (forg) investor.
Variables related to firm characteristics	
Ret	Daily raw return
LogSize	Log(1+ total number of common shares outstanding × market value of the common stock)
BM	Book value of common equity/market value of the common stock
STD	The standard deviation of the daily stock return during the year before the date
LogTV	Log(1+ total trading volume of the stock)
LogShrtTV	Log(1+ total short selling volume of the stock)

	N	Mean	STD	Q1	Median	Q3
Panel A: Option ratios and firm fundamentals						
O/S	42,742	0.063	0.156	0.003	0.017	0.062
P/C	41,877	0.463	0.203	0.349	0.471	0.574
Option volume	42,743	2,499.6	4,176.8	268	1,146	3,117
C/S	42,742	0.033	0.082	0.002	0.009	0.032
P/S	42,743	0.030	0.080	0.001	0.008	0.028
Ret	42,750	0.024	2.274	−1.20	0	1.12
LogSize	42,750	30.335	1.071	29.740	30.420	30.834
BM	42,750	1.323	0.942	0.596	1.151	1.854
STD	42,705	0.022	0.006	0.018	0.021	0.025
LogTV	42,750	24.724	1.113	24.051	24.624	25.302
Panel B: Option ratios for institutional investors						
O/S_inst	42,741	0.185	0.541	0.009	0.047	0.170
P/C_inst	41,821	0.463	0.205	0.348	0.470	0.574
C/S_inst	42,741	0.096	0.274	0.004	0.024	0.089
P/S_inst	42,741	0.088	0.288	0.003	0.020	0.077
Net C/S_inst	42,741	−0.006	0.540	−0.009	0	0.010
Net P/S_inst	42,742	0.005	0.104	−0.002	0	0.003
Panel C: Option ratios for individual investors						
O/S_ind	42,742	0.052	0.170	0.001	0.009	0.040
P/S_ind	42,742	0.025	0.087	0.000	0.003	0.018
C/S_ind	42,742	0.027	0.093	0.000	0.004	0.020
P/S_ind	42,742	0.025	0.087	0.000	0.003	0.018
Net C/S_ind	42,741	−0.003	0.652	−0.008	0	0.009
Net P/S_ind	42,742	0.005	0.120	−0.002	0	0.002
Panel D: Option ratios for foreign investors						
O/S_forg	5,295	0.062	0.099	0.010	0.028	0.071
P/C_forg	5,192	0.471	0.186	0.366	0.472	0.580
C/S_forg	5,295	0.032	0.053	0.005	0.014	0.037
P/S_forg	5,295	0.029	0.050	0.004	0.013	0.033
Net C/S_forg	5,295	−0.002	0.044	−0.006	0	0.005
Net P/S_forg	5,295	0.0001	0.042	−0.006	0	0.006

Note(s): This table reports the summary statistics of the main variables using daily data. The sample period for Panels A and B is from November 2014 to May 2022. The sample period for Panel C is from October 2021 to May 2022

Table 2. Summary statistics for the main variables

(2014), we rank option ratios into quintiles and use the ranking indicator instead of the actual value in later analyses. The average O/S ratio for institutional traders is 0.185, which is higher than that for individual traders, 0.052. In fact, while individuals trade stocks in the Korea stock markets more than institutions do, institutions trade options in the option market more than individuals do. Institutional investors' net buying option volumes for institutional traders have negative averages because some of them act as liquidity providers, but their medians are zero. Individual traders' net buying option volumes have positive averages because their trading is not generally intended to hedge their risk but to bet on the price movement, but their medians are zero. Although the sample period for the variables related to foreign investors' option trading is not short, we present the summary statistics to compare with other investors' transactions. The average foreign investor's P/C ratio is 0.471, which is the highest among the three types of investors, and their net buying ratios of calls and puts are the closest to zero.

In Table 3, the O/S ratio is highly correlated with institutional, individual, and foreign investors' O/S, call-to-stock (C/S), and put-to-stock (P/S) ratios. The P/C ratio is also highly correlated with all investors' O/S, C/S, and P/S ratios. The correlations between the C/S ratios

Table 3.
Correlation coefficients of the variables

Panel A: Main option ratios and firm fundamentals

	O/S	P/C	C/S	P/S	Ret	LogSize	BM	STD	LogTV
O/S	1.000								
P/C	0.029	1.000							
C/S	0.967	−0.050	1.000						
P/S	0.965	0.108	0.867	1.000					
Ret	−0.008	0.017	0.006	−0.022	1.000				
LogSize	−0.070	0.033	−0.069	−0.066	0.020	1.000			
BM	−0.095	−0.008	−0.092	−0.091	−0.021	−0.126	1.000		
STD	−0.076	−0.049	−0.072	−0.075	0.024	−0.323	−0.256	1.000	
LogTV	−0.221	0.015	−0.217	−0.210	0.060	0.744	−0.201	0.040	1.000

Panel B: Option ratios for investors

	O/S	P/C	O/S_inst	O/S_indi	P/C_inst	P/C_indi	C/S_inst	C/S_ind	P/S_inst	P/S_indi	Net_C/S_ inst	Net_P/S_ inst	Net_C/S_ indi	Net_C/S_ indi
O/S	1.000													
P/C	0.029	1.000												
O/S_inst	0.884	0.025	1.000											
O/S_indi	0.635	0.028	0.363	1.000										
P/C_inst	0.031	0.973	0.027	0.030	1.000									
P/C_indi	0.013	0.705	0.004	0.028	0.601	1.000								
C/S_inst	0.868	−0.041	0.960	0.361	−0.040	−0.032	1.000							
C/S_ind	0.600	−0.043	0.342	0.950	−0.028	−0.058	0.366	1.000						
P/S_inst	0.833	0.086	0.963	0.337	0.089	0.038	0.849	0.293	1.000					
P/S_indi	0.601	0.100	0.345	0.942	0.088	0.116	0.315	0.790	0.347	1.000				
Net_C/S_inst	−0.297	0.004	−0.345	−0.043	0.004	0.001	−0.316	−0.041	−0.346	−0.040	1.000			
Net_P/S_inst	−0.281	0.004	−0.340	−0.040	0.004	0.000	−0.300	−0.037	−0.353	−0.039	0.943	1.000		
Net_C/S_indi	0.133	−0.013	0.065	0.274	−0.014	−0.009	0.075	0.270	0.050	0.249	−0.086	−0.057	1.000	
Net_C/S_indi	0.114	0.016	0.045	0.266	0.010	0.024	0.047	0.208	0.040	0.298	−0.058	−0.067	0.725	1.000

Note(s): This table reports the correlation coefficients of the main variables used in the analysis. The sample period is from November 2014 to May 2022

and the P/S ratios are high. An investor's net buying call option ratio is also highly correlated with the investor's net buying put option ratio. Therefore, an investor's option trading may be associated with other investors' trading and an investor's call option trading activity may be associated with the investor's put option trading activity. Since foreign investors rarely traded in the Korean options market before October 2021, our sample period for the foreign option ratios begins in October 2021 and ends in May 2022. This period is too short, thus, we do not include the correlation coefficients for the foreigner's variables in Table 3, but they are correlated with institutional investors' variables.

3. Characteristics of portfolios based on option volume ratios

To investigate the relations between the two option ratios and other variables, we sort stocks by O/S ratios or P/C ratios and construct five portfolios. Then we calculate the means of the variables for each of the five option ratio quintiles. Table 4 shows the means of the variables for the O/S ratio quintiles and the P/C ratio quintiles. The variables in the first and second rows are the return and market-adjusted return on the observation day of the option ratios. The market-adjusted return is calculated as the difference between the stock return and the return on the index, with the latter including all stocks in the market in which the stock is listed. Stocks with the lowest O/S ratio have higher market-adjusted returns (and returns) than those with the highest O/S on the same day, but the difference is insignificant. However, stocks with the highest P/C ratios have significantly higher market-adjusted returns; that is, investors trade put options more than they do call options when the underlying stock returns are far higher than the market returns.

Table 4 shows that firms whose stocks have the highest O/S ratio are likely to be smaller firms (LogSize) and to have lower book-to-market (BM) ratios, lower one-year volatility of daily returns (STD), lower trading volumes (LogTV) and lower short-selling volumes (LogShrtTV). Stocks that are in the highest O/S ratio quintile have significantly lower P/C ratios than those in the lowest O/S ratio quintile do. The institutional investors' P/C (P/C_inst) in the highest O/S quintile is also significantly lower than it is in the lowest O/S quintile, which suggests that institutional investors trade call options more often when the volume of option trading is large. Institutions are net sellers of both calls and puts only when the O/S ratio is in the highest quintile. Overall, in the highest O/S quintile, institutional traders tend to sell more calls. However, individual investors' P/C ratios (P/C_indi) does not change with O/S ratios, but their net buying option ratios (Net C/S_indi and Net P/S_indi) increase with their O/S ratios. This result suggests that, when individual traders demand more options and option volume increases as a result, some institutions sell options as liquidity suppliers. In addition, foreign investors' P/C ratio in the lowest O/S quintile is significantly lower than it is in the highest O/S quintile, which means that foreign investors trade more put options when the option trading volume is larger.

Table 4 also shows that the firms whose stocks have the highest P/C ratios are likely to be larger firms and to have lower BM ratios, lower volatility, and higher trading volumes. For the O/S ratio across the P/C quintiles, stocks in the highest P/C, P/C_inst, and P/C_indi ratio quintiles have significantly higher O/S ratios than those in the lowest P/C ratio quintile, but the association is not a monotonic linear relationship. For investors' net buying option volume ratios, the net P/S ratios of stocks with the highest P/C ratios are significantly higher than those with the lowest P/C ratios and the net C/S ratios of stocks with the highest P/C ratios are significantly lower. However, other investors' net buying option volume ratios do not monotonically change with the P/C ratio quintiles.

To examine the determinants of option ratio quintiles while controlling the effects of other variables, we perform regressions of the O/S ratio quintile and the P/C ratio rank and report results in Table 5. Following Johnson and So (2012) and Blau *et al.* (2014), we estimate

Table 4. Averages of the variables in five option ratio portfolios

Panel A: O/S quintile							Panel B: P/C quintile						
	Low	2	3	4	High	High -low		Low	2	3	4	High	High -low
Ret	0.022	0.035	0.051	0.034	−0.027	−0.048	Ret	0.028	0.057	0.031	0.017	0.012	0.016
	(0.76)	(1.35)	(2.13)	(1.49)	(−1.23)	(−1.35)		(1.03)	(2.47)	(1.36)	(0.72)	(0.42)	(0.41)
Mrk-adj Ret	0.152	0.202	0.191	0.165	0.050	−0.102	Mrk-adj Ret	−0.047	0.075	0.214	0.253	0.248	−0.295***
	(2.49)	(3.66)	(3.75)	(3.44)	(1.10)	(−1.35)		(−0.82)	(1.49)	(4.29)	(5.00)	(4.49)	(−3.71)
LogSize	30.331	30.388	30.333	30.371	30.248	−0.083***	LogSize	30.199	30.364	30.371	30.405	30.359	−0.160***
						(−4.43)							(−9.04)
BM	1.346	1.383	1.392	1.333	1.152	−0.194***	BM	1.301	1.312	1.347	1.337	1.276	0.026*
						(−13.86)							(1.71)
STD	0.023	0.022	0.022	0.022	0.021	−0.002***	STD	0.023	0.022	0.022	0.022	0.022	0.001***
						(−17.05)							(7.45)
LogTV	24.920	24.937	24.788	24.683	24.295	−0.624***	LogTV	24.682	24.735	24.711	24.755	24.762	−0.081***
						(−33.38)							(−4.49)
LogShrtTV	20.917	20.982	20.842	20.737	20.494	−0.423***	LogShrtTV	20.813	20.901	20.810	20.868	20.878	−0.065
						(−8.35)							(−1.25)
P/C	0.468	0.472	0.465	0.457	0.456	−0.012***	O/S	0.053	0.070	0.070	0.064	0.063	0.010***
						(−3.46)							(4.39)
P/C_inst	0.467	0.471	0.464	0.457	0.456	−0.010***	O/S_inst	0.158	0.203	0.204	0.185	0.189	0.031***
						(−3.03)							(3.53)
P/C_indi	0.455	0.464	0.467	0.453	0.452	−0.003	O/S_indi	0.044	0.054	0.055	0.053	0.054	0.010***
						(−0.68)							(3.98)
P/C_forg	0.458	0.477	0.471	0.474	0.475	0.017*	O/S_forg	0.006	0.008	0.010	0.008	0.006	−0.0004
						(1.84)							(−0.75)
Net C/S_inst	0.039	0.075	0.101	0.072	−3.434	−3.473**	Net C/S_inst	−1.158	−1.074	0.111	−1.191	0.189	1.347**
						(−2.50)							(2.29)
Net P/S_inst	0.053	0.085	0.174	0.404	−2.497	−2.550	Net P/S_inst	−0.511	−0.555	0.194	−1.446	0.647	1.158
						(−1.52)							(1.28)
Net C/S_indi	0.001	0.038	0.110	0.356	2.097	2.087***	Net C/S_indi	0.774	0.964	0.294	0.378	0.223	−0.551***
						(8.23)							(−3.93)
Net P/S_indi	−0.001	0.069	0.196	0.416	2.000	2.001***	Net P/S_indi	0.256	0.612	0.373	0.638	0.814	0.558***
						(6.86)							(3.04)
Net C/S_forg	−0.0003	0.014	−0.002	−0.015	−0.119	−0.119***	Net C/S_forg	−0.006	−0.028	−0.049	−0.024	−0.010	−0.003
						(−3.70)							(−0.15)
Net P/S_forg	−0.001	0.010	0.027	0.009	−0.042	−0.041	Net P/S_forg	0.012	0.003	−0.026	0.010	0.010	−0.002
						(−1.30)							(−0.08)

Note(s): This table reports the averages of the variables for the five portfolios based on the O/S (Panel A) and P/C (Panel B) ratios. Net buying option volume ratios are rescaled by multiplying by 1,000. For the difference between the highest and lowest quintiles, ***, ** and * denote statistical significance at the 1%, 5% and 10% levels, respectively. The sample period is from November 2014 to May 2022. The sample period for O/S_forg, P/C_forg, C/S_forg, P/S_forg, Net C/S_forg and Net P/S_forg is from October 2021 to May 2022

Dependent variable	O/S(Q) (1)	(2)	P/C(Q) (3)	(4)
Ret	0.006		−0.003	
	(1.59)		(−0.22)	
Mrk-adj Ret		0.007***		0.007**
		(3.26)		(2.16)
LogSize	0.392***	0.394***	0.066***	0.070***
	(3.20)	(3.22)	(2.73)	(2.88)
BM	−0.205**	−0.204**	−0.018	−0.017
	(−2.31)	(−2.30)	(−0.77)	(−0.75)
STD	−10.687	−10.788	−6.339	−6.416
	(−0.70)	(−0.71)	(−1.36)	(−1.38)
LogTV	−0.608***	−0.612***	−0.026	−0.033
	(−5.58)	(−5.62)	(−1.23)	(−1.54)
LogShrtTV	−0.024**	−0.023**	−0.005	−0.005
	(−2.27)	(−2.23)	(−0.97)	(−0.83)
O/S(Q)			−0.021**	−0.022**
			(−2.39)	(−2.47)
P/C(Q)	−0.019**	−0.019**		
	(−2.31)	(−2.39)		
Constant	6.227*	6.257*	0.971	1.011
	(1.78)	(1.79)	(1.51)	(1.59)
Year dummy	Yes	Yes	Yes	Yes
Observations	41,841	41,841	41,841	41,841
Adjusted R^2	0.106	0.106	0.003	0.003

Note(s): This table reports the results from regressions of the option volume ratio quintiles, the O/S(Q) and the P/C(Q). t-statistics are based on standard errors adjusted for a firm-clustering effect and are in parentheses. ***, ** and * denote statistical significance at the 1%, 5% and 10% levels, respectively. The sample period is from November 2014 to May 2022

Table 5.
Determinants of option volume ratios

regressions using the quintile rank of the O/S and P/C ratios, O/S(Q) and P/C(Q), as opposed to the option ratios themselves, since the option ratios are right-skewed. We expect that this approach will reduce the outlier effect. Standard errors are adjusted for the firm-clustering effect and year dummies are included. The explanatory variables are the raw return (Ret) or market-adjusted return (Mrk-adj Ret) on the same day as the observation of option ratios, firm size (LogSize), the BM ratio, the one-year volatility of daily returns (STD), the trading volume (LogTV), and the short-selling volume (LogShrtTV).

The results indicate that returns on the observation day of the O/S and P/C ratios have a significant relationship with the option ratio quintiles, but the market-adjusted returns are higher when the O/S and P/C ratios are higher. That is, the O/S volume and the P/C volume are larger when underlying stock returns in excess of market returns are higher. Size and BM ratio have a positive association and a negative association with the O/S ratio rank, respectively, after controlling other variables. Stocks in the highest O/S ratio quintile have lower trading volumes and short-selling volumes, probably because the denominator of the dependent variable is stock volume. Stocks in the highest P/C ratio quintile have significantly larger sizes, but other variables have no significant association. The relations between the O/S and P/C ratio quintiles are significantly negative.

4. Option volume ratios and future returns

4.1 Full sample

To examine the return predictability of the option volume ratios, we regress the future return on the option volume ratios, controlling for the effect on firms' stock returns of firm

characteristics like size, BM ratio, volatility, and stock trading volume. The dependent variables are the next-day raw return (Ret_{t+1}) and the next-day market-adjusted return (Mrk-adj Ret_{t+1}). The main explanatory variables of interest are the O/S ratio quintile (O/S(Q)) and the P/C ratio quintile (P/C(Q)) on day *t*. All control variables are used for the observations on day *t*. We also add the stock return on day *t* as a control variable to control for firm characteristics that may affect the next-day return. Our regressions adjust standard errors for the firm-clustering effect and include year dummies. Table 6 reports the results of the regressions.

When we use the next-day raw return as the dependent variable (regressions 1, 2, and 3), the O/S quintiles have a significantly positive association with the next-day return, but the P/C quintile has no significant association with future returns. This result is opposed to those of prior studies like Johnson and So (2012), Ge *et al.* (2016), and Blau *et al.* (2014), who find a negative relation between option ratios and future returns in the U.S. In Korea, a representative emerging market, the O/S volume ratio predicts positive future returns. We also use the next-day market-adjusted return as a dependent variable, reporting the results in regressions 4, 5, and 6 in Table 6. The coefficient of the O/S quintile is significantly positive when the O/S quintile is used as the explanatory variable, but not when the P/C quintile is used, as the previous results from regressions using the raw return as the dependent variable (regressions 1, 2, and 3) show. Therefore, stocks with higher O/S ratios outperform the market return. However, when we use both the O/S ratio quintile and the P/C ratio quintile as explanatory variables, the significance of the O/S ratio quintile's coefficient decreases, although the coefficient is still positive.

To determine whether the predictability of option ratios, especially the O/S ratio, persist over a week, we run equivalent regressions but use the next week's raw return ($Ret_{t+1,\ t+5}$) and market-adjusted return (Mrk-adj $Ret_{t+1,\ t+5}$) as the dependent variables. The results are reported in Table 7. In regressions 1, 2, and 3, the return predictability of the O/S quintile persists for a week, and the coefficients of the P/C quintiles are insignificant. The coefficients of the O/S quintiles are also insignificant when we use the next-week market-adjusted return as the dependent variable.

Since individual traders, who are generally regarded as noise traders, participate heavily in the Korean option market, we divide the total option volume ratios into institutional, individual, and foreign option ratios and investigate their return predictability.

4.2 Institutional investors

Institutional traders are known to be more informed investors than individual traders are, so we examine whether institutional traders' option volume ratios predict future returns. First, we perform the regressions as in Section 4.1 but revise the main explanatory variables such that the two main explanatory variables are the institutional investors' O/S quintile and P/C_inst quintile, instead of the overall O/S ratio quintile and the P/C ratio quintile. To identify institutional investors' O/S quintile and P/C_inst quintile, we rank institutional investors' option ratios (O/S and P/C_inst) into quintiles and use the quantile number as their values of the O/S_inst(Q) and P/C_inst(Q). We also include institutional investors' net buying option volume ratios of institutional traders, Net C/S_inst and Net P/S_inst as explanatory variables because investors' large net buying call volume means that they expect it to outperform the stock, and the large net buying put volume means that they expect it to underperform the stock. Thus, when we test the net buying option volume, we can more directly determine whether investors have information.

For our tests, we rank institutional investors' net buying O/S ratios (Net C/S_inst and Net P/S_inst) into quintiles and use the quantile numbers, Net C/S_inst(Q) and Net P/S_inst(Q). Since institutional investors' O/S ratios are scaled by their stock volume, we use the stock volume

Table 6.
Option volume ratios and one-day future returns

Dependent variable	Ret_{t+1}			Mrk-adj Ret_{t+1}		
	(1)	(2)	(3)	(4)	(5)	(6)
$O/S(Q)_t$	0.022**		0.020**	0.013*		0.011
	(2.54)		(2.27)	(1.78)		(1.46)
$P/C(Q)_t$		0.004	0.005		0.004	0.004
		(0.52)	(0.56)		(0.49)	(0.52)
$LogSize_t$	−0.025	−0.020	−0.028	−0.018	−0.013	−0.017
	(−0.94)	(−0.75)	(−1.13)	(−0.82)	(−0.60)	(−0.86)
BM_t	0.052***	0.053***	0.057***	0.018	0.017	0.019
	(3.02)	(3.12)	(3.38)	(1.21)	(1.17)	(1.31)
STD_t	9.745***	9.599***	9.754***	2.254	2.358	2.445
	(3.36)	(3.04)	(3.21)	(0.94)	(0.89)	(0.94)
$LogTV_t$	0.054**	0.045*	0.057**	0.022	0.015	0.022
	(2.42)	(1.84)	(2.62)	(1.16)	(0.74)	(1.18)
Ret_t	−0.030***	−0.030***	−0.030***	−0.024***	−0.023***	−0.023***
	(−3.90)	(−3.80)	(−3.82)	(−3.61)	(−3.45)	(−3.47)
Constant	−0.913*	−0.755*	−0.872*	−0.083	0.008	−0.057
	(−1.99)	(−1.69)	(−1.93)	(−0.23)	(0.02)	(−0.17)
Year dummy	Yes	Yes	Yes	Yes	Yes	Yes
Observations	42,697	41,841	41,841	42,697	41,841	41,841
Adjusted R2	0.003	0.003	0.003	0.001	0.001	0.001

Note(s): This table reports the results from regressions of one-day future returns on the option volume ratio quintiles, the O/S(Q) and the P/C(Q). The dependent variable is the next-day raw return and the next-day market-adjusted return. *t*-statistics are based on standard errors adjusted for a firm-clustering effect and are in parentheses. ***, ** and * denote statistical significance at the 1%, 5% and 10% levels, respectively. The sample period is from November 2014 to May 2022

Table 7.
Option volume ratios and one-week future returns

Dependent variable	$Ret_{t+1, t+5}$ (1)	(2)	(3)	(4)	Mrk-adj $Ret_{t+1, t+5}$ (5)	(6)
$O/S(Q)_t$	0.061**		0.061**	0.026		0.023
	(2.22)		(2.29)	(1.07)		(0.99)
$P/C(Q)_t$		0.014	0.015		0.011	0.012
		(0.52)	(0.57)		(0.50)	(0.52)
$LogSize_t$	−0.003	0.016	−0.008	−0.041	−0.023	−0.032
	(−0.02)	(0.15)	(−0.07)	(−0.49)	(−0.26)	(−0.38)
BM_t	0.190***	0.188**	0.200***	0.062	0.061	0.065
	(2.83)	(2.68)	(2.97)	(1.07)	(1.02)	(1.11)
STD_t	56.785***	55.810***	56.271***	15.166	15.133	15.310
	(3.87)	(3.57)	(3.70)	(1.37)	(1.28)	(1.31)
$LogTV_t$	0.147*	0.113	0.151*	0.062	0.037	0.051
	(1.85)	(1.30)	(1.83)	(1.01)	(0.53)	(0.80)
Ret_t	−0.037***	−0.036***	−0.037***	−0.048***	−0.044***	−0.044***
	(−3.17)	(−3.13)	(−3.19)	(−4.12)	(−3.89)	(−3.93)
Constant	−5.147**	−4.777**	−5.132**	−0.446	−0.285	−0.421
	(−2.48)	(−2.23)	(−2.44)	(−0.29)	(−0.18)	(−0.27)
Year dummy	Yes	Yes	Yes	Yes	Yes	Yes
Observations	42,556	41,700	41,700	42,556	41,700	41,700
Adjusted R^2	0.010	0.010	0.010	0.001	0.001	0.001

Note(s): This table reports the results from regressions of one-week future returns on the option volume ratio quintiles, O/S(Q) and P/C(Q). The dependent variable is the next-week raw return and the next-week market-adjusted return. t-statistics are based on standard errors adjusted for firm-clustering effect and are in parentheses. ***, ** and * denote statistical significance at the 1%, 5% and 10% levels, respectively. The sample period is from November 2014 to May 2022

(LogTV_inst) instead of the total trading volume (LogTV). We calculate the stock volume, $LogTV\_inst_t$, as the log of 1 plus the institutional trading volume of the stock on date t. Our regressions adjust standard errors for the firm-clustering effect and include year dummies.

Table 8 presents the results from regressions that use institutional investors' option ratios, both with the next-day raw return as the dependent variable and with the next-day market-adjusted return as the dependent variable. When we use the next-day raw return and use only one option ratio variable of institutional traders as the explanatory variable (regressions 1, 2, 3, and 4), the O/S quintile has a positive association with the next day's return and the P/C ratio does not have a significant association, which is like the result when we use the total O/S quintile (Table 6). The coefficients of institutional investors' net buying option ratios are significantly negative. Regression 5 uses four option ratio variables as the explanatory variables, and only the O/S_inst quintile and net buying put volume ratios (Net P/S_inst(Q)) have a significant association with the future return. Higher net buying put volume means that investors buy more put options than they sell, perhaps because they expect a decrease in the stock price. These findings suggest that institutional investors' net buying put volume ratios contain information that predicts future returns. Although the coefficient of the net buying call volume ratio (Net C/S_inst(Q)) is significantly negative when other option ratio variables are not included (regression 3), it is no longer significant when all option ratio variables are included (regression 5).

When we use one option ratio variable as the explanatory variable (regressions 6, 7, 8, and 9) and use the next-day market-adjusted return as the dependent variable, the results are similar to those when we use the next-day raw return as the dependent variable. In regression 10, which uses all option volume ratios, the coefficients of the Net P/S_inst quintile are still significantly negative. Thus, stocks in higher Net P/S_inst quintiles are likely to underperform the market return. However, the coefficient of the institutional investors' O/S quintile is insignificant in regression 10. The coefficient of the Net C/S_inst quintile is also significantly negative, but these trades do not predict future returns.

To test whether the predictability of institutional investors' option ratios continues after a week, we replicate previous regressions but use the next week's raw and market-adjusted return as the dependent variables. The results are reported in Table 9. The results using raw returns parallel those in Table 6 that use the next-day raw returns as the dependent variable. The institutional investors' O/S and Net P/S ratio quintiles are significantly positively and negatively related to future returns, so their ability to predict returns persists for a week. When we use the market-adjusted return as the dependent variable, the significance of the institutional investors' O/S quintile disappears but net buying put volume ratios are still significantly associated with the next-week future returns. Overall, then, the results suggest that institutional investors' Net P/S_inst contains information about future returns.

4.3 Individual investors

As many individual traders participate in the Korean option market, we test whether their option transactions hold information for future returns or differ from institutional investors' transactions in this regard. We replicate the previous regressions using as explanatory variables individual option ratio quintiles, the O/S_indi quintile (O/S_indi(Q)), the P/C_indi quintile (P/C_indi(Q)), the Net C/S_indi quintile (Net C/S_indi(Q)), and the Net P/S_indi quintile (Net P/S_indi(Q)). To compute these variables, we also rank individual option ratios into quintiles and use the quantile number as the variable's value. As individual investors' O/S ratios are scaled by their stock volume, that volume (LogTV_indi) is used as the measure for the trading volume. The individual investors' stock volume on day t, $LogTV\_indi_t$, is calculated as the log of 1 plus the individual trading volume of the stock on day t. The results are reported in Table 10.

Table 8.
Institutional option volume ratios and one-day future returns

	Panel A. Dependent variable: Ret_{t+1}					Panel B. Dependent variable: Mrk-adj Ret_{t+1}				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
$O/S\_inst(Q)_t$	0.020**				0.017*	0.013*				0.011
	(2.25)				(2.06)	(1.80)				(1.65)
$P/C\_inst(Q)_t$		0.003			0.003		0.002			0.003
		(0.30)			(0.42)		(0.30)			(0.40)
Net $C/S\_inst(Q)_t$			−0.028***		−0.017			−0.027***		−0.017*
			(−3.16)		(−1.50)			(−4.12)		(−1.88)
Net $P/S\_inst(Q)_t$				−0.030***	−0.023*				−0.028***	−0.018*
				(−2.78)	(−1.66)				(−3.30)	(−1.65)
$LogSize_t$	−0.008	−0.004	−0.007	−0.006	−0.004	−0.005	−0.005	−0.006	−0.006	−0.005
	(−0.47)	(−0.26)	(−0.37)	(−0.36)	(−0.24)	(−0.35)	(−0.36)	(−0.43)	(−0.44)	(−0.40)
BM_t	0.052***	0.052***	0.047**	0.048**	0.056***	0.019	0.016	0.015	0.016	0.019
	(2.79)	(2.93)	(2.65)	(2.68)	(3.11)	(1.17)	(1.10)	(1.01)	(1.06)	(1.24)
STD_t	11.680***	11.272***	11.286***	11.240***	11.546***	2.977	2.984	2.711	2.667	3.189
	(4.34)	(3.99)	(4.10)	(4.07)	(4.10)	(1.42)	(1.28)	(1.29)	(1.27)	(1.37)
$LogTV\_inst_t$	0.042***	0.034*	0.028	0.028	0.040**	0.021	0.013	0.012	0.011	0.016
	(2.74)	(1.80)	(1.64)	(1.63)	(2.35)	(1.61)	(0.85)	(0.79)	(0.79)	(1.14)
Ret_t	−0.029***	−0.030***	−0.033***	−0.034***	−0.035***	−0.024***	−0.023***	−0.027***	−0.028***	−0.028***
	(−3.79)	(−3.64)	(−4.03)	(−3.98)	(−3.92)	(−3.57)	(−3.45)	(−3.99)	(−3.84)	(−3.86)
Constant	−0.640	−0.443	−0.477	−0.467	−0.402	0.050	0.120	0.185	0.190	0.175
	(−1.20)	(−0.83)	(−0.89)	(−0.87)	(−0.76)	(0.13)	(0.30)	(0.45)	(0.46)	(0.45)
Year dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	42,696	41,782	42,696	42,696	41,779	42,696	41,782	42,696	42,696	41,779
Adjusted R^2	0.003	0.003	0.003	0.003	0.003	0.001	0.001	0.001	0.001	0.001

Note(s): This table reports the results from regressions of one-day future returns on the institutional option volume ratio quintiles, that is, O/S_inst(Q), P/C_inst(Q), Net C/S_inst(Q) and Net C/S_inst(Q). The dependent variable in Panel A is the next-day raw return. The dependent variable in Panel B is the next-day market-adjusted return. t-statistics are based on standard errors adjusted for firm-clustering effect and are in parentheses. ***, ** and * denote statistical significance at the 1%, 5% and 10% levels, respectively. The sample period is from November 2014 to May 2022

Table 9. Institutional option volume ratios and one-week future returns

	Panel A. Dependent variable: $Ret_{t+1,\ t+5}$					Panel B. Dependent variable: Mrk-adj $Ret_{t+1,\ t+5}$				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
$O/S\_inst(Q)_t$	0.054**				0.055**	0.030				0.027
	(2.21)				(2.21)	(1.31)				(1.20)
$P/C\_inst(Q)_t$		0.009			0.011		0.005			0.007
		(0.34)			(0.44)		(0.24)			(0.34)
Net $C/S\_inst(Q)_t$			−0.069***		−0.032			−0.077***		−0.038*
			(−3.14)		(−1.44)			(−4.01)		(−1.93)
Net $P/S\_inst(Q)_t$				−0.084***	−0.069**				−0.093***	−0.071***
				(−3.31)	(−2.48)				(−4.28)	(−3.11)
$LogSize_t$	0.082	0.073	0.078	0.077	0.025	−0.032	−0.003	−0.018	−0.017	−0.004
	(1.07)	(0.92)	(1.01)	(1.00)	(0.24)	(−0.41)	(−0.03)	(−0.23)	(−0.21)	(−0.05)
BM_t	0.192**	0.187**	0.177**	0.179**	0.194***	0.062	0.058	0.054	0.056	0.065
	(2.65)	(2.57)	(2.47)	(2.49)	(2.89)	(1.06)	(0.98)	(0.93)	(0.96)	(1.10)
STD_t	61.893***	59.794***	60.828***	60.704***	59.084***	16.640	16.442	16.524	16.431	16.850
	(4.61)	(4.26)	(4.45)	(4.43)	(4.15)	(1.66)	(1.52)	(1.63)	(1.62)	(1.57)
$LogTV\_inst_t$	0.110*	0.080	0.074	0.073	0.101	0.049	0.014	0.026	0.025	0.019
	(1.87)	(1.22)	(1.22)	(1.18)	(1.61)	(0.96)	(0.24)	(0.50)	(0.46)	(0.34)
Ret_t	−0.036***	−0.037***	−0.044***	−0.048***	−0.053***	−0.048***	−0.045***	−0.057***	−0.062***	−0.061***
	(−2.99)	(−2.90)	(−3.48)	(−3.69)	(−3.77)	(−4.14)	(−3.91)	(−4.63)	(−4.73)	(−4.80)
Constant	−4.211*	−3.777	−3.783	−3.733	−3.755	−0.378	−0.327	−0.031	0.011	−0.256
	(−1.74)	(−1.51)	(−1.56)	(−1.54)	(−1.51)	(−0.24)	(−0.20)	(−0.02)	(0.01)	(−0.15)
Year dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	42,555	41,641	42,555	42,555	41,639	42,555	41,641	42,555	42,555	41,639
Adjusted R^2	0.010	0.010	0.010	0.010	0.011	0.001	0.001	0.002	0.002	0.002

Note(s): This table reports the results from regressions of one-week future returns on the institutional option volume ratio quintiles, that is, O/S_inst(Q), P/C_inst(Q), Net C/S_inst(Q) and Net C/S_inst(Q). The dependent variable in Panel A is the next-week raw return. The dependent variable in Panel B is the next-week market-adjusted return. t-statistics are based on standard errors adjusted for firm-clustering effect and are in parentheses. ***, ** and * denote statistical significance at the 1%, 5% and 10% levels, respectively. The sample period is from November 2014 to May 2022

Table 10.
Individual option volume ratios and one-day future returns

	Panel A. Dependent variable: Ret_{t+1}					Panel B. Dependent variable: Mrk-adj Ret_{t+1}				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
$O/S\_indi(Q)_t$	0.021**				0.023**	0.011				0.013
	(2.04)				(2.25)	(1.38)				(1.44)
$P/C\_indi(Q)_t$		0.008			0.008		0.007			0.007
		(0.86)			(0.84)		(0.84)			(0.82)
Net $C/S\_indi(Q)_t$			−0.003		−0.002			−0.005		−0.003
			(−0.30)		(−0.17)			(−0.70)		(−0.41)
Net $P/S\_indi(Q)_t$				−0.003	−0.002				−0.006	−0.006
				(−0.36)	(−0.24)				(−0.72)	(−0.67)
$LogSize_t$	−0.012	−0.005	−0.003	−0.003	−0.016	−0.015	−0.010	−0.010	−0.010	−0.016
	(−0.59)	(−0.20)	(−0.12)	(−0.11)	(−0.76)	(−0.89)	(−0.55)	(−0.54)	(−0.53)	(−0.99)
BM_t	0.050***	0.057***	0.048**	0.048**	0.060***	0.017	0.019	0.016	0.016	0.020
	(2.77)	(2.90)	(2.58)	(2.58)	(3.14)	(1.14)	(1.26)	(1.04)	(1.03)	(1.37)
STD_t	9.294***	9.323**	9.016**	9.021**	9.469**	1.855	2.069	1.689	1.698	2.126
	(2.81)	(2.55)	(2.65)	(2.65)	(2.68)	(0.67)	(0.67)	(0.61)	(0.61)	(0.70)
$LogTV\_indi_t$	0.041**	0.033*	0.030	0.030	0.047***	0.019	0.016	0.013	0.013	0.023
	(2.38)	(1.69)	(1.58)	(1.58)	(2.79)	(1.25)	(0.89)	(0.79)	(0.79)	(1.54)
Ret_t	−0.030***	−0.029***	−0.029***	−0.029***	−0.028***	−0.024***	−0.022***	−0.023***	−0.023***	−0.020***
	(−3.90)	(−3.63)	(−3.63)	(−3.62)	(−3.32)	(−3.64)	(−3.24)	(−3.37)	(−3.30)	(−2.85)
Constant	−0.939**	−0.978**	−0.929**	−0.930**	−1.009**	−0.066	−0.098	−0.053	−0.055	−0.101
	(−2.13)	(−2.29)	(−2.10)	(−2.11)	(−2.32)	(−0.20)	(−0.30)	(−0.16)	(−0.16)	(−0.30)
Year dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	42,697	42,697	40,046	42,697	40,043	42,697	40,046	42,697	42,697	40,043
Adjusted R^2	0.003	0.003	0.003	0.003	0.003	0.001	0.001	0.001	0.001	0.001

Note(s): This table reports the results from regressions of one-day future returns on the individual option volume ratio quintiles, that is, O/S_indi(Q), P/C_indi(Q), Net C/S_indi(Q) and Net C/S_indi(Q). The dependent variable in Panel A is the next-day raw return. The dependent variable in Panel B is the next-day market-adjusted return. t-statistics are based on standard errors adjusted for firm-clustering effect and are in parentheses. ***, ** and * denote statistical significance at the 1%, 5% and 10% levels, respectively. The sample period is from November 2014 to May 2022

The results in Table 10 show that only the individual investors' O/S ratio has a significant association with the next-day return. Paralleling Table 6, which uses total option ratios, the coefficients of the individual investors' O/S ratio quintiles are positive. However, other option ratios have no significant association with future returns. When we use the market-adjusted return as the dependent variable, no option ratios are significantly related to future returns. These findings are consistent with expectations because individual traders are regarded as noise traders, so their trading volume may not convey information.

We also examine the relationship between the next-week future return and individual investors' option ratio, as we did using institutional investors' data. To save space, we do not report the findings in detail, but we find that no individual option ratios have significant associations with the next-week raw or market-adjusted returns.

Overall, we conclude that we need to classify option volume ratios by the type of investor to test the informativeness of the option ratio, especially in markets in which a high number of noise traders participate.

4.4 Foreign investors

Ryu and Yang (2018), argue that foreign investors typically have superior information about the options market and find that foreign institutional investors outperform domestic institutional and individual traders, especially in emerging options markets (Ahn *et al.*, 2008; Chang *et al.*, 2009; Lin *et al.*, 2017; Yang *et al.*, 2017). Using the KOSPI 200 index options in Korea, Ryu and Yang (2018) also find that foreign investment firms' options trading volume predicts next-day spot returns. Therefore, we use individual stock options to determine whether foreign investors' option ratios have a significant chance of predicting future returns. Unfortunately, foreign investors rarely traded in the Korean options market before October 2021, so the sample period for the analyses of the foreign option ratios begins in October 2021 and ends in May 2022. This period is too short, but we test and report the findings to compare with other investors' results and those of prior studies.

We replicate the previous regressions using foreign investors' option ratio quintiles, the O/S_forg quintile (O/S_forg(Q)), the P/C_forg quintile (P/C_forg(Q)), Net C/S_forg quintile (Net C/S_forg(Q)), and Net P/S_forg quintile (Net P/S_forg(Q)) as explanatory variables. For these variables, we rank foreign investors' option ratios into quintiles and use the quantile number as the variable's value. As foreign investors' O/S ratios are scaled by their stock volume, we use their stock volume (LogTV_forg) as the measure for the trading volume. We calculate the stock volume, LogTV_forg_t, as the log of 1 plus foreign investors' trading volume of the stock on date t. The results are reported in Table 11.

In Table 11, when we use the next-day raw return as the dependent variable, foreign investors' O/S ratio quintiles are positively related to future returns, as was the case with the results from total and other investors' O/S ratios. A difference is that the foreign investors' P/C ratio quintiles are significantly negatively associated with future returns. We obtain parallel results when we use market-adjusted returns as the dependent variable. These findings are consistent with studies like those of Pan and Poteshman (2006) and Blau *et al.* (2014), who find the negative return predictability of the P/C ratios in the USA. We do not identify the nationality of foreign investors in Korean markets, but their P/C's informativeness is similar to that of investors in other options markets and different from Korean institutions. Our finding is consistent with that of Ryu and Yang (2018), who show the negative predictability of the P/C ratio for the index option in Korea. However, foreign investors' net option volume ratios, unlike those of domestic institutional investors, are not significantly associated with future returns.

To determine whether foreign investors' option ratios can predict returns over a longer period, we perform equivalent regressions using the next-week raw return and next-week market-adjusted return as dependent variables. The results are presented in Table 12. When

Table 11.
Foreign option volume ratios and one-day future returns

	Panel A. Dependent variable: Ret_{t+1}					Panel B. Dependent variable: Mrk-adj Ret_{t+1}				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
$O/S\_forg(Q)_t$	0.039**				0.032*	0.026				0.031**
	(2.11)				(1.88)	(1.66)				(2.04)
$P/C\_forg(Q)_t$		−0.045*			−0.046*		−0.042**			−0.043**
		(−1.94)			(−1.99)		(−2.29)			(−2.35)
Net $C/S\_forg(Q)_t$			0.014		0.005			0.009		0.004
			(0.62)		(0.25)			(0.48)		(0.20)
Net $P/S\_forg(Q)_t$				0.018	0.013				0.012	0.008
				(0.74)	(0.50)				(0.50)	(0.35)
$LogSize_t$	−0.151***	−0.152***	−0.154***	−0.155***	−0.152***	−0.055*	−0.047	−0.058*	−0.058*	−0.046
	(−4.79)	(−4.39)	(−4.84)	(−4.86)	(−4.34)	(−1.76)	(−1.39)	(−1.85)	(−1.86)	(−1.32)
BM_t	0.062***	0.044**	0.054***	0.054***	0.051**	0.039**	0.027	0.034*	0.034*	0.033*
	(3.58)	(2.27)	(2.91)	(2.92)	(2.69)	(2.21)	(1.41)	(1.82)	(1.82)	(1.79)
STD_t	−13.409***	−12.525***	−14.945***	−14.932***	−11.351***	−10.256***	−9.027**	−11.275***	−11.265***	−7.860**
	(−3.73)	(−2.79)	(−3.76)	(−3.75)	(−2.79)	(−3.03)	(−2.21)	(−3.03)	(−3.00)	(−2.18)
$LogTV\_forg_t$	0.137***	0.121***	0.116***	0.117***	0.140***	0.036	0.019	0.022	0.023	0.037
	(5.37)	(5.09)	(4.70)	(4.75)	(5.40)	(1.54)	(0.72)	(0.89)	(0.91)	(1.42)
Ret_t	−0.012	−0.019	−0.011	−0.010	−0.017	−0.029*	−0.032*	−0.027	−0.027	−0.030
	(−0.83)	(−1.19)	(−0.69)	(−0.59)	(−0.97)	(−1.76)	(−1.85)	(−1.67)	(−1.54)	(−1.65)
Constant	1.368**	2.013**	2.082***	2.061***	1.413*	0.950	1.233	1.424**	1.411**	0.669
	(2.11)	(2.43)	(2.87)	(2.88)	(1.90)	(1.56)	(1.62)	(2.09)	(2.09)	(0.98)
Year dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	5,401	5,203	5,401	5,401	5,201	5,401	5,203	5,401	5,401	5,201
Adjusted R^2	0.002	0.003	0.002	0.002	0.003	0.002	0.002	0.002	0.002	0.002

Note(s): This table reports the results from regressions of one-day future returns on the foreign option volume ratio quintiles, that is, O/S_forg(Q), P/C_forg(Q), Net C/S_forg(Q) and Net C/S_forg(Q). The dependent variable in Panel A is the next-day raw return. The dependent variable in Panel B is the next-day market-adjusted return. t-statistics are based on standard errors adjusted for firm-clustering effect and are in parentheses. ***, ** and * denote statistical significance at the 1%, 5% and 10% levels, respectively. The sample period is from November 2014 to May 2022

Table 12. Foreign option volume ratios and one-week future returns

	Panel A. Dependent variable: $Ret_{t+1,\ t+5}$					Panel B. Dependent variable: Mrk-adj $Ret_{t+1,\ t+5}$				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
$O/S\_forg(Q)_t$	0.116*				0.131*	0.070				0.105
	(1.76)				(1.85)	(1.04)				(1.45)
$P/C\_forg(Q)_t$		−0.076			−0.080		−0.079			−0.082*
		(−1.49)			(−1.56)		(−1.64)			(−1.71)
Net $C/S\_forg(Q)_t$			−0.025		−0.031			−0.011		−0.018
			(−0.38)		(−0.57)			(−0.17)		(−0.34)
Net $P/S\_forg(Q)_t$				−0.006	0.003				0.011	0.021
				(−0.07)	(0.03)				(0.15)	(0.32)
$LogSize_t$	−0.609***	−0.563***	−0.619***	−0.620***	−0.547***	−0.205	−0.127	−0.211	−0.212	−0.114
	(−4.35)	(−3.80)	(−4.22)	(−4.21)	(−3.90)	(−1.40)	(−0.86)	(−1.40)	(−1.40)	(−0.80)
BM_t	0.226**	0.201**	0.206**	0.206**	0.227**	0.138	0.123	0.126	0.125	0.144
	(2.62)	(2.04)	(2.31)	(2.28)	(2.38)	(1.60)	(1.27)	(1.43)	(1.42)	(1.50)
STD_t	−65.614***	−57.641**	−69.378***	−69.638***	−52.368**	−49.694***	−40.465**	−52.030***	−52.235***	−36.501**
	(−3.55)	(−2.72)	(−3.50)	(−3.50)	(−2.66)	(−2.79)	(−2.09)	(−2.78)	(−2.77)	(−2.05)
$LogTV\_forg_t$	0.478***	0.372***	0.420***	0.419***	0.443***	0.055	−0.058	0.019	0.019	−0.002
	(4.00)	(3.54)	(3.86)	(3.83)	(3.77)	(0.45)	(−0.55)	(0.17)	(0.17)	(−0.02)
Ret_t	−0.117***	−0.122***	−0.119***	−0.117***	−0.126***	−0.052*	−0.041	−0.053*	−0.050	−0.041
	(−5.68)	(−4.41)	(−4.96)	(−4.71)	(−3.82)	(−1.99)	(−1.50)	(−1.79)	(−1.65)	(−1.26)
Constant	7.779**	9.388**	9.925***	9.930***	6.829*	5.870*	6.259*	7.169**	7.154**	4.187
	(2.45)	(2.37)	(2.76)	(2.74)	(1.85)	(1.90)	(1.71)	(2.08)	(2.07)	(1.24)
Year dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	5,260	5,062	5,260	5,260	5,061	5,260	5,062	5,260	5,260	5,061
Adjusted R^2	0.015	0.016	0.014	0.014	0.016	0.008	0.007	0.007	0.007	0.007

Note(s): This table reports the results from regressions of one-week future returns on the foreign option volume ratio quintiles, that is, O/S_forg(Q), P/C_forg(Q), Net C/S_forg(Q) and Net C/S_forg(Q). The dependent variable in Panel A is the next-day raw return. The dependent variable in Panel B is the next-day market-adjusted return. t-statistics are based on standard errors adjusted for firm-clustering effect and are in parentheses. ***, ** and * denote statistical significance at the 1%, 5% and 10% levels, respectively. The sample period is from November 2014 to May 2022

the dependent variable is the raw return, the coefficients of the foreign investors' O/S ratios are still significant, but the significance of their P/C ratios decreases. When we regress market-adjusted returns, the coefficients of their O/S ratios are insignificant, but the P/C ratios have a marginally significant association to future returns.

Overall, foreign investors' P/C ratios can predict returns, while their net option ratios cannot, a result that differs from that of domestic institutional traders. There may be some reasons for the difference in results between them although all of them are usually regarded as informed traders. First, the sample periods for each investor are different and the sample period for the foreign option ratios is far shorter. Second, foreign investors do not need to work as liquidity providers, while institutional option volume includes the volume from providing liquidity. Meanwhile, like those of other investors in Korea, foreign investors' O/S ratios predict positive future returns.

4.5 Robustness test

As robustness tests, we regress future returns on buying and selling option volume ratios, instead of net volume ratios, for institutional and individual traders. The buying option (calls or puts) volume ratio for investor j (BC/S_j or BP/S_j) is defined as investor j's buying option (calls or puts) volume, scaled by the investor's share volume. Selling O/S volume ratios for investor j, (SC/S_j and SP/S_j) are defined as investor j's selling option (calls or puts) volume, scaled by investor j's share volume. We add control variables LogSize, BM, STD, LogTV, and Ret. Our regressions adjust standard errors for the firm-clustering effect and include year dummies. Table 13 presents the results. In regressions 1, 2, 3, and 4, the dependent variables are the next-day raw return, the next-day market-adjusted return, the next-week raw return, and the next-week market-adjusted return, respectively.

In Table 13, only institutional investors' buying and selling put-to-stock ratios have a significant association with all four types of future returns. The coefficients of institutional investors' buying P/S ratios are negatively associated with future raw and market-adjusted returns, and the coefficients of the selling P/S ratios are positively associated with future returns. This result indicates that institutional investors' put trading contains information about future returns, but individual option ratios never have a significant relationship with future returns. Institutional investors' buying C/S ratios are also not significantly related to future returns. Although institutional investors' selling C/S ratio has a significantly positive relationship with future returns, these trades do not predict future returns satisfactorily because selling call volume would expect higher returns.

Our results show that institutional investors' put-to-share volume ratios predict future returns when we analyze them using various option ratios. However, individual option volume ratios do not predict future returns because they do not contain private information.

5. Conclusion

We examine the determinants of the O/S volume ratio and the P/C volume ratio of individual stocks in the Korean market. Our regressions show that O/S and P/C ratios are higher when market-adjusted returns are higher. We also show that firms whose stocks have higher O/S ratios are likely to have larger size and to have lower BM ratios, trading volumes, and short-selling volumes. Firms whose stocks have higher P/C ratios are likely to have larger size.

We also use regression analysis to investigate the relationship between O/S and P/C ratios and future returns and find a positive relationship between O/S ratios and future returns but no significant relationship between P/C ratios and returns when the future return is the next-day raw return, the next-day market-adjusted return, the next-week raw return, or the next-week market-adjusted return. Because institutional traders tend to be informed and

	Ret_{t+1} (1)	Mrk-adj Ret_{t+1} (2)	$Ret_{t+1, t+5}$ (3)	Mrk-adj $Ret_{t+1, t+5}$ (4)
$BC/S\_inst(Q)_t$	−0.005	−0.016	−0.005	−0.042
	(−0.24)	(−0.88)	(−0.11)	(−1.07)
$SC/S\_inst(Q)_t$	0.031	0.038**	0.053	0.089**
	(1.57)	(2.26)	(1.14)	(2.51)
$BP/S\_inst(Q)_t$	−0.053***	−0.045***	−0.120**	−0.104**
	(−3.28)	(−3.22)	(−2.55)	(−2.53)
$SP/S\_inst(Q)_t$	0.046**	0.041**	0.117***	0.107***
	(2.24)	(2.70)	(3.24)	(3.42)
$BC/S\_indi(Q)_t$	−0.005	−0.010	−0.008	−0.030
	(−0.32)	(−0.80)	(−0.21)	(−1.14)
$SC/S\_indi(Q)_t$	−0.003	−0.000	−0.027	−0.031
	(−0.19)	(−0.00)	(−0.75)	(−1.01)
$BP/S\_indi(Q)_t$	−0.009	−0.011	−0.007	−0.005
	(−0.63)	(−0.88)	(−0.21)	(−0.17)
$SP/S\_indi(Q)_t$	0.015	0.011	0.049	0.026
	(1.15)	(0.85)	(1.31)	(0.74)
$LogSize_t$	−0.017	−0.009	0.015	−0.014
	(−0.66)	(−0.42)	(0.14)	(−0.18)
BM_t	0.051***	0.018	0.187***	0.063
	(2.91)	(1.16)	(2.75)	(1.07)
STD_t	9.660***	2.058	56.765***	14.388
	(3.09)	(0.79)	(3.71)	(1.24)
$LogTV_t$	0.045*	0.014	0.123	0.040
	(1.92)	(0.72)	(1.51)	(0.64)
Ret_t	−0.034***	−0.027***	−0.046***	−0.059***
	(−4.14)	(−3.98)	(−3.76)	(−4.68)
Constant	−0.925**	−0.151	−5.079**	−0.669
	(−2.09)	(−0.43)	(−2.53)	(−0.44)
Year dummy	Yes	Yes	Yes	Yes
Observations	42,696	42,696	42,555	42,555
Adjusted R^2	0.003	0.001	0.010	0.002

Note(s): This table reports the results from regressions of future returns on the institutional and individual option buying and selling volume ratio quintiles, that is, BC/S_inst(Q), SC/S_inst(Q), BP/S_inst(Q), SP/S_inst(Q), BC/S_indi(Q), SC/S_indi(Q), BP/S_indi(Q) and SP/S_indi(Q). The dependent variables in regressions 1, 2, 3 and 4, the dependent variables are the next-day raw return, the next-day market-adjusted return, the next-week raw return and the next-week market-adjusted return, respectively. t-statistics are based on standard errors adjusted for firm-clustering effect and are in parentheses. ***, ** and * denote statistical significance at the 1%, 5% and 10% levels, respectively. The sample period is from November 2014 to May 2022

Table 13. Institutional and individual option buying and selling ratios and future returns

individual investors tend to be uninformed, we also calculate individual, institutional, and foreign investors' option ratios to determine which ratios have a significant association with future returns. Using investors' O/S ratios and net buying O/S ratios, we find that, for all investors, high O/S ratios predict higher future returns, but we also find that institutional and individual investors' P/C ratios have no significant association with returns; however, foreign investors' P/C ratio predicts negative next-day raw and market-adjusted returns. When we use investors' net buying O/S ratios as the explanatory variables in our regressions, institutional investors' net buying P/S ratios consistently predict negative future returns, but other investors' net buying P/S ratios do not. In our additional tests, institutional investors' buying and selling put volume ratios predict future returns. We conclude that institutional investors' put-to-share volume ratios predict future returns when our analyses use various option ratios, while individual investors' option volume ratios do not.

Notes

1. Ryu and Yang (2018) and Woo and Kim (2021) examine the return predictability of two option volume ratios using the Korean index and individual stock options, respectively.
2. Ge *et al.* (2016) also show that the role of options in providing embedded leverage is the most important reason for option trading's predicting stock returns.
3. From 2015 through 2021, individual and institutional trading accounted for 53.3 percent and 19.9 percent of total trading volume, respectively, in the composite index of Korean stock markets (KOSPI).

References

Ahn, H.-J., Kang, J. and Ryu, D. (2008), "Informed trading in the index option market: the case of KOSPI 200 options", *Journal of Futures Markets*, Vol. 28 No. 12, pp. 1118-1146, doi: 10.1002/fut.20369.

An, B. J., Ang, A., Bali, T. G. and Cakici, N. (2014), "The joint cross section of stocks and options", *Journal of Finance*, Vol. 69 No. 5, pp. 2279-2337, doi: 10.1111/jofi.12181.

Battalio, R.H. and Schultz, P.H. (2006), "Options and the bubble", *Journal of Finance*, Vol. 61 No. 5, pp. 2071-2102, doi: 10.1111/j.1540-6261.2006.01051.x.

Black, F. (1975), "Fact and fantasy in the use of options", *Financial Analysts Journal*, Vol. 31 No. 4, pp. 36-72, doi: 10.2469/faj.v31.n4.36.

Blau, B. M., Nguyen, N. and Whitby, R. J. (2014), "The information content of option ratios", *Journal of Banking & Finance*, Vol. 43, pp. 179-187, doi: 10.1016/j.jbankfin.2014.03.023.

Cao, M. and Wei, J. (2010), "Options market liquidity: commonality and other characteristics", *Journal of Financial Markets*, Vol. 13 No. 1, pp. 20-48, doi: 10.1016/j.finmar.2009.09.004.

Cao, C.Q., Chen, Z. and Griffin, J.M. (2005), "The information content of option volume prior to takeovers", *Journal of Business*, Vol. 78 No. 3, pp. 1073-1109, doi: 10.1086/429654.

Chakravarty, S., Gulen, H. and Mayhew, S. (2004), "Informed trading in stock and option markets", *Journal of Finance*, Vol. 59 No. 3, pp. 1235-1258, doi: 10.1111/j.1540-6261.2004.00661.x.

Chan, K., Chung, Y.P. and Fong, W.M. (2002), "The informational role of stock and option volume", *Review of Financial Studies*, Vol. 15 No. 4, pp. 1049-1075, doi: 10.1093/rfs/15.4.1049.

Chang, C. C., Hsieh, P. F. and Lai, H. N. (2009), "Do informed option investors predict stock returns? Evidence from the Taiwan stock exchange", *Journal of Banking & Finance*, Vol. 33 No. 4, pp. 757-764, doi: 10.1016/j.jbankfin.2008.11.001.

Chen, C.R., Lung, P.P. and Tay, N.S. (2005), "Information flow between the stock and option markets: where do informed traders trade?", *Review of Financial Economics*, Vol. 14 No. 1, pp. 1-23, doi: 10.1016/j.rfe.2004.03.001.

Chung, C. Y., Ryu, D., Wang, K. and Zykaj, B. B. (2018), "Optionable stocks and mutual fund performance", *Journal of Futures Markets*, Vol. 38 No. 3, pp. 390-412, doi: 10.1002/fut.21844.

Cremers, M. and Weinbaum, D. (2010), "Deviations from put-call parity and stock returns", *Journal of Financial and Quantitative Analysis*, Vol. 45 No. 2, pp. 335-367, doi: 10.1017/s002210901000013x.

Danielsen, B.R. and Sorescu, S.M. (2001), "Why do option introductions depress stock prices? A study of diminishing short sale constraints", *Journal of Financial and Quantitative Analysis*, Vol. 36 No. 4, pp. 451-484, doi: 10.2307/2676220.

DeTemple, J. and Jorion, P. (1990), "Option listing and stock returns: an empirical analysis", *Journal of Banking & Finance*, Vol. 14 No. 4, pp. 781-801, doi: 10.1016/0378-4266(90)90076-e.

Diamond, D.W. and Verrecchia, R.E. (1987), "Constraints on short selling and asset price adjustment to private information", *Journal of Financial Economics*, Vol. 18 No. 2, pp. 277-312, doi: 10.1016/0304-405x(87)90042-0.

Easley, D., O'Hara, M. and Srinivas, P.S. (1998), "Option volume and stock prices: evidence on where informed traders trade", *Journal of Finance*, Vol. 53 No. 2, pp. 431-465, doi: 10.1111/0022-1082.194060.

Figlewski, S. and Webb, G.P. (1993), "Options, short sales, and market completeness", *Journal of Finance*, Vol. 48 No. 2, pp. 761-777, doi: 10.1111/j.1540-6261.1993.tb04738.x.

Ge, L., Lin, T.C. and Pearson, N.D. (2016), "Why does the option to stock volume ratio predict stock returns?", *Journal of Financial Economics*, Vol. 120 No. 3, pp. 601-622, doi: 10.1016/j.jfineco.2015.08.019.

Hao, X., Lee, E. and Piqueira, N. (2013), "Short sales and put options: where is the bad news first traded?", *Journal of Financial Markets*, Vol. 16 No. 2, pp. 308-330, doi: 10.1016/j.finmar.2012.09.005.

Hu, J. (2014), "Does option trading convey stock price information", *Journal of Financial Economics*, Vol. 111 No. 3, pp. 625-645, doi: 10.1016/j.jfineco.2013.12.004.

Johnson, T. L. and So, E. C. (2012), "The option to stock volume ratio and future returns", *Journal of Financial Economics*, Vol. 106 No. 2, pp. 262-286, doi: 10.1016/j.jfineco.2012.05.008.

Kacperczyk, M. and Pagnotta, E.S. (2019), "Chasing private information", *Review of Financial Studies*, Vol. 32 No. 12, pp. 4997-5047, doi: 10.1093/rfs/hhz029.

Kim, S. (2007), "Information contents of call-put options trading value ratio", *Journal of Derivatives and Quantitative Studies*, Vol. 15 No. 2, pp. 31-53, doi: 10.1108/jdqs-02-2007-b0002.

Kumar, R., Sarin, A. and Shastri, K. (1998), "The impact of options trading on the market quality of the underlying security: an empirical analysis", *Journal of Finance*, Vol. 53 No. 2, pp. 717-732, doi: 10.1111/0022-1082.285595.

Lin, W. T., Tsai, S. C., Zheng, Z. and Qiao, S. (2017), "Does options trading convey information on futures prices?", *North American Journal of Economics and Finance*, Vol. 39, pp. 182-196, doi: 10.1016/j.najef.2016.10.005.

Pan, J. and Poteshman, A. M. (2006), "The information in option volume for future stock prices", *Review of Financial Studies*, Vol. 19 No. 3, pp. 871-908, doi: 10.1093/rfs/hhj024.

Roll, R., Schwartz, E. and Subrahmanyam, A. (2009), "Options trading activity and firm valuation", *Journal of Financial Economics*, Vol. 94 No. 3, pp. 345-360, doi: 10.1016/j.jfineco.2009.02.002.

Roll, R., Schwartz, E. and Subrahmanyam, A. (2010), "O/S: the relative trading activity in options and stock", *Journal of Financial Economics*, Vol. 96 No. 1, pp. 1-17, doi: 10.1016/j.jfineco.2009.11.004.

Ryu, D. and Yang, H. (2018), "The directional information content of options volumes", *Journal of Futures Markets*, Vol. 38 No. 12, pp. 1533-1548, doi: 10.1002/fut.21960.

Woo, M. and Kim, M. A. (2021), "Option volume and stock returns: evidence from single stock options on the Korea Exchange", *Journal of Derivatives and Quantitative Studies*, Vol. 29 No. 4, pp. 280-300, doi: 10.1108/jdqs-06-2021-0012.

Yang, H., Choi, H.-S. and Ryu, D. (2017), "Option market characteristics and price monotonicity violations", *Journal of Futures Markets*, Vol. 37 No. 5, pp. 473-498, doi: 10.1002/fut.21826.

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