Research in International Business and Finance 67 (2024) 102129

Contents lists available at ScienceDirect

Research in International Business and Finance

journal homepage: www.elsevier.com/locate/ribaf

Does market efficiency matter for Shanghai 50 ETF index options?

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A R T I C L E I N F O

JEL Classification:
G10
G13
G14
G15
G17

Keywords:
Options market efficiency
Trading strategy
SSE 50 ETF market efficiency
Put-call parity
Index options

A B S T R A C T

This study aims to measure Shanghai 50 Exchange-Traded Fund (SSE 50 ETF) index options efficiency for trading in different periods of a trading day. We use an econometric model of put-call-parity to test the market efficiency for three moneyness situations: call at-the-money and put at-the-money, call in-the-money and put out-of-the-money, call out-of-the-money, and put in-the-money. The SSE 50 ETF index options market is efficient when both call and put options are at-the-money, leading to accurately-priced call and put options. The SSE 50 ETF index options market is inefficient if the call is in-the-money (out-of-the-money) and the put is out-of-the-money (in-the-money). Furthermore, call and put options are over-priced (under-priced) and under-priced (over-priced), respectively, when the SSE 50 ETF index options market is inefficient. Traders can take a long or short position based on call-put option pricing to reduce hedging costs and increase speculative premiums.

1. Introduction

The Shanghai 50 Exchange-Traded Fund (SSE 50 ETF) index options market started trading on February 9, 2015, providing the first floor-traded options in the Chinese capital market. It represents one of the most important steps to improve the Chinese financial derivatives market (Wang et al., 2018; Xu et al., 2022; Ackert and Tian, 2001). Launching SSE 50 ETF options enables global investors to participate in forecasted market movements without buying or selling many Chinese securities and allows portfolio managers to reduce the downside risk (Liu et al., 2019). Given its prominence and functions, the Chinese derivative market's efficiency is vital to academics, regulators, and domestic and international practitioners. A well-functioning financial market is crucial to a sustainable and robust economy because it facilitates price discovery, risk hedging, and allocating capital most optimally.

Many articles have documented the derivatives market's efficiency, influencing the entire capital market's efficiency. Two popular methods are used to investigate the market's efficiency: model-based and no-arbitrage testing (Brunetti and Torricelli, 2005; (Wright and Swidler, 2023). The former approach is based on the theoretical model for option pricing, for example, Black, Scholes's (1973) options pricing model or the binomial option-pricing model (Cox et al., 1979). However, several weakness concerns are using this method. The first issue relates to the joint hypothesis of the option-pricing model, which requires the model to be valid and market-efficient (Cavallo and Mammola, 2000). The second problem involves the selection of the most accurate estimate of the underlying asset's volatility; thus, detecting efficient pricing by calculating the theoretically efficient price and comparing it with the costs of traded options in financial markets is complicated and challenging. Another approach is based on arbitrage arguments and is

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https://doi.org/10.1016/j.ribaf.2023.102129
Received 14 July 2022; Received in revised form 23 September 2023; Accepted 6 October 2023
Available online 9 October 2023

thus model-free, including put-call parity (PCP), boundary conditions, and the box spread (Ackert and Tian, 2001; Arnold, 2006; Li et al., 2007). Among these methods, the PCP is the most widely used and powerful tool in testing market efficiency. PCP assumes that a no-arbitrage relationship must be held between the prices of a European call and a European put on the same underlying asset with the same maturity date and the exercise price (Brunetti and Torricelli, 2005; Georgievski and Masih, 2004).

Stoll (1969) introduced the PCP condition to study the options market's efficiency; since then, the no-arbitrage relationship has been broadly examined and extended in many directions. Early studies tested PCP, concluding that while PCP holds, it was frequently and significantly violated related to both underpricing and overpricing of calls and puts (Chance, 1987; Gould and Galai, 1974; Evine and Rudd, 1985; Klemkosky and Resnick, 1979, 1980; Ronn and Ronn, 1989; Stoll, 1969). The PCP test in these studies used American options; however, the PCP may not hold for American options due to the possibility of early exercise. Therefore, it is difficult to determine whether PCP violations result from market inefficiency or early exercise. Kamara and Miller (1995) avoided the early exercise problem by investigating the PCP using European options on the Standard and Poor's 500 (S&P 500) stock index. They found that the violations were much less frequent and lower than those using American options. Later research extended PCP, allowing for dividends, transaction costs, the early exercise value of American options, nonsynchronous trades, or margin requirements (Battalio and Schultz, 2006; Brunetti and Torricelli, 2005, 2007; Cavallo and Mammola, 2000; Nisbet, 1992).

Another research direction focused on testing the cross-market efficiency of options and futures markets for the United States (US), European, and Asian markets. Both PCP condition (Stoll, 1969) and put-call-futures parity (PCFP)—which was generalized by Tucker (1991)—were used to capture the cross-market efficiency of options and futures markets. The violations were more frequent and common for PCP (Vipul, 2008). Most literature on testing market efficiency of index options and joint efficiency of options and futures markets focused on the US market (Evine and Rudd, 1985; Finucane, 1991; Fung and Chan, 1994; Kamara and Miller, 1995; Ofek et al., 2004), finding PCP violations. Similar violations were also reported for European markets, including Chesney et al. (1995) for the Swiss market, Capelle-Blancard and Chaudhury (2001) for the French market, and Cassese and Guidolin (2004) for the Italian market. Asian markets also experienced PCP violations, such as Brown and Easton (1992) for the Australian market and Vipul (2008, 2009) for the Indian market. In contrast, no significant put-call-index parity violations were found in several studies on the US market (Ackert and Tian, 2001; Blomeyer and Boyd, 1995; Klemkosky and Resnick, 1979) or in research by Mitnnik and Rieken (2000) for the German market and Fung et al. (1997) for Hong Kong. Most evidence was reported for PCP violations, mainly due to the restriction on the short sales in the cash market, and the puts tend to overprice (Vipul, 2008). In contrast, the violations were smaller in frequency and size for PCFP. Some studies confirmed these negligible violations, such as Bharadwaj and Wiggins (2001) for the US market and Wang et al. (2018) for the Chinese market; however, significant violations were not proven for markets in the US, Hong Kong, and the (United Kingdom) UK. Notably, no significant violations were found for the US market (Fung and Chan, 1994; Garay et al., 2003; Lee and Nayar, 1993), the Hong Kong market (Fung et al., 1997; Fung and Mok, 2001; Lai and Marshall, 2002), the UK market (Draper and Fung, 2002), or the Italian market (Brunetti and Torricelli, 2005, 2007).

Most studies on the market efficiency of derivatives have been implemented for developed markets, such as Australia, Canada, Germany, Hong Kong, Switzerland, the UK, and the US. Although research interest in emerging markets has increased (Atilgan et al., 2016), the number of studies on these markets remains small. For example, Aggarwal and Gupta (2009), Bhat and Arekar (2015), Mohanti and Priyan (2015), Shankar and Gupta (2016), and Vipul (2008, 2009) examined the market efficiency and cross-market efficiency of the Indian options and futures market using PCP, PCFP, box spread. Similarly, Ahn et al. (2001) employed the PCP method and box spread arbitrage to investigate the efficiency of the South Korean options market (KOSPI 200), determining that arbitrage occurred more frequently at the opening-closing time and near the end of contract periods. Guo et al. (2013) applied parametric and nonparametric models and reported significant arbitrage opportunities in the KOSPI 200 options market. Jongadsayakul (2016) tested the market efficiency of SET50 index options using the box spread method on daily data and found that using bid-ask price instead of closing price led to decreased arbitrage opportunities. Furthermore, Jongadsayakul (2018) examined the SET50 index options and the futures market's cross-market efficiency using PCFP. The findings indicated that PCFP violations' magnitude depends on the SET index options market's liquidity estimated by the options' moneyness and open interest.

Using the PCFP method, Wang et al. (2018) tested the equilibrium relationship between the Shanghai 50 stock index futures and the SSE 50 ETF options markets using one-minute transaction data from May 2015 and May 2017. They found that cost spread, option volatility, option maturity, options moneyness, trading strategy, and policy factors have a crucial effect on arbitrage opportunities. They did not recognize the cross-market efficiency between the Shanghai 50 stock index futures and the Shanghai 50 ETF options market; however, the efficiency in each market has steadily improved. Using the boundary condition violations method and high-frequency data, Liu et al. (2019) examined the price disagreement between China's ETF 50 index and options markets and considered the signal of market inefficiency. The empirical results revealed that upper boundary condition violations were less informative than lower option boundary condition violations. Zhang and Watada (2019) explored the market efficiency of SSE 50 ETF options contracts using PCP, box spread arbitrage, and boundary condition arbitrage based on the daily data from February 2015 to April 2017. They considered bid-ask spreads, margins, and different scenarios in the efficiency tests. The findings showed that the size of profitable arbitrage opportunities was small for the box spread and boundary condition approach. In contrast, for PCP, the arbitrage opportunities occurred during significant fluctuations in the Chinese stock market—both the moneyness and expiration time of options impacted arbitrage opportunities.

Like Zhang and Watada (2019), our paper aims to examine the market efficiency of the SSE 50 ETF index options market traded on the Shanghai Stock Exchange; however, we use a different methodology. Traditional methodology to explore the PCP holds for options market efficiency applied in Zhang and Watada's (2019) paper involved several weaknesses. First, the PCP violations were reported without setting up the minimum arbitrage profit margin. If the PCP violation fails to attract the arbitrageur with its generated profit, then the PCP should not be said to contribute to the options market's efficiency (Hoque, 2010). Second, the findings showed that the transaction costs led to the infrequency of arbitrage opportunities; however, the transaction costs of the options vary widely among different brokers—it is not easy to standardize the data to apply the study results. To address the traditional method's weakness, we employ an econometric approach to test the market efficiency by accommodating the transaction costs issue; thus, our paper traces the market inefficiency in both directions of mispricing of puts and calls. Distinct from other research on market efficiency for the Chinese option market, our study shows overpricing and underpricing for put and call contracts.

Our econometric model used the 5-minute high-frequency data from August 26, 2016 to June 30, 2021 to investigate the market efficiency in the Chinese SSE 50 ETF index options market. Arbitrage profits increase dramatically during a financial crisis (Fung et al., 1997; Zhang and Watada, 2019); therefore, the high-frequency data covers all massive fluctuations introduced in 2015 and provides a comprehensive picture of the SSE 50 EFT Index options market.

The existence of arbitrage opportunities mostly depends on different characteristics, such as the trading time during the day, time to expiration, moneyness, and underlying asset volatility (Vipul, 2008; Zhang and Watada, 2019). Hence, we classify all options into three more refined categories: at-the-money (ATM), in-the-money (ITM), out-of-the-money (OTM), and three maturity groups (one-month, two-month, and three-month). Two trading mechanisms are applied for the trades on SSE 50 ETF index options on the Shanghai Stock Exchange. The opening and closing mechanism require all market and relevant limit orders to be executed at a single opening or closing price, respectively. The remaining trading day is the daily concurrent transaction time (continuous auction), where orders are executed in the sequence that they arrive. The trading mechanism differences affect the equilibrium prices of options (Amihud and Mendelson, 1987; Stoll and Whaley, 1990). Our study scrutinizes arbitrage opportunities of SSE 50 ETF index options during the opening auction, concurrent continuous trading time, and closing auction. This approach allows us to test whether a noticeable difference exists in market efficiency during specific times of the day.

This paper provides three significant findings for the options traders. First, the SSE 50 ETF index options market is efficient when both call and put options are accurately priced; thus, ATM-call and ATM-put SSE 50 EFT Index options are appropriate for hedging. Second, the costs of holding SSE 50 ETF index options will be less through buying ITM-call or receiving a higher premium by selling OTM-put when the option's expiration time is two months or less. Third, writing OTM-call or holding ITM-put options with a maturity of either one or three months will provide higher profits.

The remainder of the paper is structured as follows. Section 2 discusses the methodology and data used in this study, and Section 3 describes the econometric analysis using high-frequency intraday data. The economic significance for options traders is presented in Section 4, while Section 5 summarizes the significant findings and concludes the paper.

2. Methodology and Data

This section presents the general design for the market efficiency tests. The PCP condition states a deterministic relationship between put and call prices if both options are written on the same index and have the same strike prices and expiration dates. The PCP econometric model is developed based on the PCP regression analysis conducted by Mittnik and Rieken (2000). Table 1 presents the notations and descriptions of the variables used in the PCP model.

The PCP relationship is based on the arbitrage principles, as stated in Eq. (1):

$$C_{t,i,j} + X_{t,i,j}e^{-R_{t,i,j}T} = P_{t,i,j} + S_{t,i,j} \tag{1}$$

Where $\forall_i = opening \quad auction; midday \quad closing; midday \quad opening; closing \quad auction$

$$\forall_j = one - month; two - month; three - month$$

Now we rearrange Eq. (1) and consider that $C_{t,i,j} - P_{t,i,j} = Y_{t,i,j}; S_{t,i,j} – X_{t,i,j}e^{-R_{t,i,j}T} = X_{t,i,j}$ to develop the regression Eq. (2) as Mittnik and Rieken (2000) with no dividend payments:

$$Y_{t,i,j} = \lambda_o + \lambda_1 X_{t,i,j} + \varepsilon_{t,i,j} \tag{2}$$

Eq. (2) provides the econometric analysis for the PCP condition. If the PCP relationship is violated, an arbitrage opportunity arises, indicating the options mispricing. Under the null hypothesis that PCP is valid, coefficients λ_o and λ_1 in Eq. (2) should be 0 and 1, respectively, thus concluding that the Shanghai 50 ETF index options market is efficient.

In the regression analysis, the Durbin–Watson (DW) test detects the positive serial correlation (i.e., DW < 2). In its presence, the estimated standard error is smaller than the actual standard error, thus rejecting the null hypothesis of intercept and slope while it

Table 1
Notations and descriptions of variables.

Variables	Notations	Descriptions
Call price	C_t	European Call options price at time t
Put price	P_t	European put options price at time t
Spot price	S_o	China SSE 50 ETF price at time t
Strike price	X_t	Strike price at time t
Risk-free rate	R_t	Chinese Yuan deposit interest rate at time t
Option life	T	Time to maturity of the options

Source:

should not be rejected. Therefore, we employ the autoregressive moving average (ARMA) model to accommodate the serial correlation (i.e., DW close to 2) and obtain unbiased intercept and slope coefficients. The higher adjusted R-squared (Adj-R^2) suggests that the PCP econometric model fits all regression analysis observations. The slope equals one, revealing that the SSE 50 ETF index options market is efficient, and both call and put options are accurately priced (AP); however, a slope other than one indicates that the options market is inefficient. Furthermore, a slope less than one suggests that the call is under-priced (UP) and the put is over-priced (OP); however, we find the opposite consequence (the call and put options are OP and UP, respectively) when the slope is more than one.

This study used the 5-minute quote for SSE 50 ETF index options from the Thomson Reuters database. The SSE ETF 50 index options market was established on February 9, 2015. The SSE 50 ETF options are European, with each contract written on 10,000 shares of the SSE 50 Exchange-Traded Open-End Index Securities Investment Fund (50 ETF). The SSE 50 ETF options have four different expiration times: the current month, the next month, and the following two consecutive quarters. The Thomson Reuters database provides high-frequency data for options trading volume, bid price, ask price, trading time, underlying asset price, and interest rate. Due to the unavailability of high-frequency data of SSE 50 ETF options on Thomson Reuters before August 26, 2016, our sample period began on August 26, 2016 and ended on June 30, 2020. The options were traded on Monday to Friday (excluding public holidays) from 09:15–15:00 and expired on the fourth Wednesday of each maturity month. We classify the options according to three moneyness and three time-to-expiration categories. We determine ITM, OTM, and ATM options using the ratio of the strike price to stock price, as Xing et al. (2010) suggested. The time to maturity of an option was assumed to be the number of calendar days remaining until the option matured. The sample options expired in one-month (2–30 days), two-month (31–60 days), and three-month (61–90 days) periods. We investigated the market efficiency for the opening auction (09:15–09:25), midday closing period (11:00–11:30), midday opening period (13:00–13:30), and closing auction (14:57–15:00) of a trading day. We used the one-month, two-month, and three-month Chinese yuan (CNY) deposit interest rate as the risk-free interest rate proxy.

3. Econometric Findings

We conducted the PCP test using the econometric model as in Eq. (2) for three options for moneyness situations: (1) ATM-call and ATM-put, (2) ITM-call and OTM-put, (3) OTM-call and put-ITM; the results are presented in Tables 2, 3, and 4, respectively. Each moneyness situation is divided into the opening auction period (09:15–09:25), midday closing period (11:00–11:30), midday opening

Table 2
PCP test for ATM-call and ATM-put (moneyness situation 1).

Scenarios	Intercept $H_o : \lambda_o = 0$ (t-statistics)	Slope $H_o : \lambda_1 = 0$ (t-statistics)	Accommodating serial correlation		Adj-R^2	Slope equal to 1 Wald test	
			DW	ARMA		t-statistics	Slope (call/put)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A: Opening auction period (09:15–09:25)							
one-month	− 0.0025 (−1.4611)	0.9921 * (163.14)	2.0211	(4, 0)	0.9707	− 1.2896	1.00 (AP/AP)
two-month	− 0.0104 (−1.8776)	0.9953 * (125.03)	2.0002	(4, 4)	0.9642	− 0.5827	1.00 (AP/AP)
three-month	− 0.0155 * (−1.9652)	1.0143 * (63.054)	2.0262	(2, 2)	0.9455	0.8928	1.00 (AP/AP)
Panel B: Midday closing period (11:00–11:30)							
one-month	− 0.0018 (−1.1803)	0.9977 * (275.56)	2.0012	(4, 1)	0.9884	− 0.6153	1.00 (AP/AP)
two-month	− 0.0094 (−1.4799)	0.9956 (189.55)	2.0009	(4, 1)	0.9857	− 0.8262	1.00 (AP/AP)
three-month	− 0.0126 (−1.4696)	0.9950 * (62.397)	2.0053	(3, 0)	0.9684	− 0.3097	1.00 (AP/AP)
Panel C: Midday opening period (13:00–13:30)							
one-month	− 0.0031 (−1.8668)	0.9992 * (195.47)	2.0003	(5, 0)	0.9879	− 0.1374	1.00 (AP/AP)
two-month	− 0.0104 * (−2.1482)	1.0052 * (219.40)	2.0084	(5, 0)	0.9850	1.1498	1.00 (AP/AP)
three-month	− 0.0130 (−1.7903)	1.0009 * (82.098)	2.0135	(4, 1)	0.9742	0.0788	1.00 (AP/AP)
Panel D: Closing auction period (14:57–15:00)							
one-month	− 0.0062 (−1.7871)	1.0080 * (138.73)	2.0028	(3, 3)	0.9053	1.1080	1.00 (AP/AP)
two-month	− 0.0125 (−1.7112)	1.0060 * (105.22)	2.0021	(2, 1)	0.9211	0.6343	1.00 (AP/AP)
three-month	− 0.0143 (−1.4590)	0.9889 * (66.25)	2.0030	(4, 1)	0.9664	− 0.7416	1.00 (AP/AP)

Notes: PCP = put-call parity; ATM = at-the-money; AP = accurately priced. * denotes that the null hypothesis was rejected at a 99% significance level.

period (13:00–13:30), and closing auction period (14:57–15:00) as panels A, B, C, and D, respectively. Furthermore, each period considers one-month, two-month, and three-month maturity options to examine market efficiency. We performed an SSE 50 EFT Index regression analysis using the twelve scenarios for each option's moneyness situation.

Table 2 provides the results of PCP analysis when both call and put options are ATM (i.e., moneyness situation 1). In column 2, the null hypothesis, H_0: $\lambda_o = 0$, cannot be rejected at any significance level for all scenarios except for the three-month maturity opening auction (panel A) and the two-month maturity midday opening (panel C) period. This result indicates that the intercepts are statistically zero. Conversely, the null hypothesis of slope H_0: $\lambda_1 = 0$ in column 3 can be rejected at any significance level, suggesting that the slopes are statistically different from zero. For the precise value of slope coefficients, the t-statistics of the Wald test in column 7 confirm that slopes are statistically one in column 8; therefore, call and put options are AP, as suggested in the parenthesis below the slope coefficients.

Table 3 presents the PCP test results for the ITM-call and OTM-put options (i.e., moneyness situation 2). The null hypothesis for the intercepts, H_0: $\lambda_o = 0$, cannot be rejected at any level of significance for all scenarios (except three-month maturity, opening auction (panel A), midday closing (panel B), and midday opening (panel C) period) in column 2; however, the slopes are statistically different from zero since the t-statistics can reject the null hypothesis of slope H_0: $\lambda_1 = 0$ in column 3 at any level of significance. Furthermore, under the Wald test, t-statistics in column 7 ensure that slopes are statistically other than one in the last column. Call and put options are OP or UP, presented in the parenthesis beneath the slope coefficients. ITM-call and OTM-put options are UP and OP, respectively, for 8 out of 12 scenarios.

Finally, Table 4 shows the results of the PCP test for OTM-call and ITM-put options (i.e., moneyness situation 3). For intercepts in column 2, the null hypothesis H_0: $\lambda_o = 0$, cannot be rejected at any significance level for any scenarios except two-month maturity, opening auction (panel A), and midday closing (panel B) period. Interestingly, the null hypothesis of slope H_0: $\lambda_1 = 0$ in column 3 can be rejected at any significance level, suggesting that the slopes are statistically different from zero. The t-statistics of the Wald test in column 7 substantiate that slopes are statistically other than 1 in column 8. Furthermore, call and put options, whether OP or UP, are presented in the parenthesis below the slope coefficient. OTM-call and ITM-put options are OP and UP, respectively, for 9 out of 12 scenarios.

Table 3
PCP test for ITM-call and OTM-put (moneyness situation 2).

Scenarios	Intercept $H_o : \lambda_o = 0$ (t-statistics)	Slope $H_o : \lambda_1 = 0$ (t-statistics)	Accommodating Serial correlation		Adj-R^2	Slope equal to 1 Wald test	
			DW	ARMA		t-statistics	Slope (call/put)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A: Opening auction period (09:15–09:25)							
one-month	− 0.0014 (−0.9765)	0.9912 * (327.12)	2.0784	(2, 0)	0.9937	0.4221	0.99 (UP/OP)
two-month	− 0.0049 (−1.4589)	0.9816 * (279.22)	2.0348	(3, 0)	0.9816	0.4817	0.98 (UP/OP)
three-month	− 0.0225 * (−2.8447)	1.0298 * (155.26)	2.0311	(3, 0)	0.9835	1.4867	1.02 (OP/UP)
Panel B: Midday closing period (11:00–11:30)							
one-month	− 0.0005 (−0.3508)	0.9897 * (406.61)	2.0106	(2, 0)	0.9969	− 0.0989	0.99 (UP/OP)
two-month	− 0.0060 (−1.4230)	0.9871 * (318.86)	2.0051	(3, 0)	0.9953	− 0.9355	0.99 (UP/OP)
three-month	− 0.0160 * (−2.0965)	1.0104 * (204.99)	2.0517	(2, 0)	0.9921	− 1.9391	1.02 (OP/UP)
Panel C: Midday opening period (13:00–13:30)							
one-month	− 0.0009 (−0.6351)	0.9910 * (499.29)	2.0005	(2, 0)	0.9975	0.5488	0.99 (UP/OP)
two-month	− 0.0088 (−1.6398)	0.9935 * (113.86)	2.0171	(5, 0)	0.9801	1.5526	0.98 (UP/OP)
three-month	− 0.0177 * (−2.2098)	1.0153 * (240.47)	2.0086	(5, 0)	0.9931	− 1.0940	1.02 (OP/UP)
Panel D: Closing auction period (14:57–15:00)							
one-month	− 0.0037 (−1.8659)	0.9946 * (306.57)	2.0662	(3, 2)	0.9956	1.4476	0.99 (UP/OP)
two-month	− 0.0076 (−1.5620)	0.9855 * (259.91)	2.0237	(3, 0)	0.9937	1.4694	0.98 (UP/OP)
three-month	− 0.0140 (−1.7552)	1.0007 * (221.03)	2.0037	(2, 0)	0.9908	0.1709	1.02 (OP/UP)

Notes: PCP = put-call parity; ITM = in-the-money; OTM = out-of-the-money; UP = underpriced; OP = over-priced. * denotes that the null hypothesis was rejected at a 99% significance level.

Table 4
PCP test for OTM-call and ITM-put options (moneyness situation 3).

Scenarios	Intercept $H_o : \lambda_o = 0$ (t-statistics)	Slope $H_o : \lambda_1 = 0$ (t-statistics)	Accommodating Serial correlation		Adj-R^2	Slope equal to 1 Wald test	
			DW	ARMA		t-statistics	Slope (call/put)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A: Opening auction period (9:15–9:25)							
one-month	0.0006	1.0227 *	2.0348	(2, 0)	0.9881	0.6986	1.02
	(0.4371)	(258.84)					(OP/UP)
two-month	− 0.0118 *	0.9939 *	2.0012	(2, 2)	0.9804	− 1.0155	1.01
	(−2.0430)	(125.05)					(OP/UP)
three-month	− 0.0145	1.0004 *	2.0648	(2, 0)	0.9861	− 1.0529	1.02
	(−1.6565)	(105.12)					(OP/UP)
Panel B: Midday closing period (11:00–11:30)							
one-month	− 0.0017	1.0061 *	2.0035	(3, 0)	0.9925	− 1.2729	1.01
	(−1.0179)	(330.03)					(OP/UP)
two-month	− 0.0114 *	0.9847 *	2.0138	(2, 0)	0.9871	− 1.1840	0.99
	(−2.8317)	(222.23)					(UP/OP)
three-month	− 0.0108	1.0067 *	2.0790	(1, 0)	0.9901	− 1.3620	1.02
	(−1.2609)	(103.36)					(OP/UP)
Panel C: Midday opening period (13:00–13:30)							
one-month	− 0.0024	1.0043 *	1.9989	(4, 4)	0.9946	− 1.0185	1.01
	(−0.8977)	(357.78)					(OP/UP)
two-month	− 0.0098	0.9978 *	2.0053	(6, 1)	0.9880	1.9053	0.99
	(−1.9096)	(241.24)					(UP/OP)
three-month	− 0.0094	1.0195 *	2.0072	(5, 1)	0.9892	− 0.0371	1.02
	(−1.1991)	(89.764)					(OP/UP)
Panel D: Closing auction period (14:57–15:00)							
one-month	− 0.0040	1.0066 *	2.0171	(2, 0)	0.9873	− 1.0751	1.01
	(−1.6593)	(323.68)					(OP/UP)
two-month	− 0.0120	0.9911 *	2.0027	(4, 0)	0.9863	0.2719	0.99
	(−1.9061)	(229.07)					(UP/OP)
three-month	− 0.0109	1.0226 *	2.0057	(2, 0)	0.9914	0.3888	1.02
	(−1.1808)	(147.51)					(OP/UP)

4. Discussion and Economic Significance

The allocation and performance of portfolios are vital topics in modern finance. This study's findings contribute to the theoretical implications of the associated empirical research and have a practical impact on developing and implementing investment strategies. Bauer et al. (2009) indicated that most investors incurred substantial losses on their option investment, much larger than the losses

Table 5
Economic significance analysis.

Scenarios	OTM-put (Moneyness situation 2)		OTM-call (Moneyness situation 3)		Scenarios appropriate for options trading strategies		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	options mispricing	trading position	options mispricing	trading position	Protective put	covered call	short strangle
Panel A: Opening auction period (9:15–9:25)							
one-month	OP	STO	OP	STO	No	Yes	Yes
two-month	OP	STO	OP	STO	No	Yes	Yes
three-month	UP	BTO	OP	STO	Yes	Yes	No
Panel B: Midday closing period (11:00–11:30)							
one-month	OP	STO	OP	STO	No	Yes	Yes
two-month	OP	STO	UP	BTO	No	No	No
three-month	UP	BTO	OP	STO	Yes	Yes	No
Panel C: Midday opening period (13:00–13:30)							
one-month	OP	STO	OP	STO	No	Yes	Yes
two-month	OP	STO	UP	BTO	No	No	No
three-month	UP	BTO	OP	STO	Yes	Yes	No
Panel D: Closing auction period (14:57–15:00)							
one-month	OP	STO	OP	STO	No	Yes	Yes
two-month	OP	STO	UP	BTO	No	No	No
three-month	UP	BTO	OP	STO	Yes	Yes	No

Notes: OTM = out-of-the-money; UP = under-priced; OP = over-priced; BTO = buy-to-open; STO = sell-to-open; PP = protective put; CC = covered call; SSGL = short strangle.

from equity trading. Therefore, significant pricing for the SSE 50 EFT Index options can guide investors to select relevant strategies when trading on the Shanghai options market. For the moneyness situation 1, the SSH 50 EFT Index options market is efficient, and both call and put options are AP; however, SSH 50 EFT Index options are mispriced for moneyness situations 2 and 3. We developed Table 5 by including 12 scenarios by reproducing UP and OP options in columns 2 and 4 from column 8 of Tables 3 and 4, respectively.

Furthermore, UP options make trading position buy-to-open (BTO) advantageous by paying less than the actual premium; however, OP options make trading position sell-to-open (STO) profitable by receiving more than the actual premium. Columns 3 and 5 provide the trading potions BTO/STO based on the options mispricing (UP or OP) in columns 2 and 4, respectively. Columns 2 and 4 also show that OTM-put and OTM-call options are OP in most scenarios. Trading strategies, such as covered calls, protective puts, strangle, or straddle, comprise over 50% of all strategy trades (Fahlenbrach and Sandås, 2010). Therefore, economics significance analysis considers three prevalent trading strategies for options: protective put (PP), covered call (CC), and strangle (SGL); here, OTM-call and OTM-put options are a critical part of the strategic plan. The PP and CC trade single put and call options, respectively; however, put and call options are traded simultaneously for the SGL strategy.

We construct a PP strategy by buying the SSE 50 EFT Index and OTM-put options on the SSE 50 EFT Index. If the OTM-put options are UP (column 2), holding the BTO position (column 3) pays less than the actual premium, and PP is considered an appropriate strategy. This situation is depicted as "Yes" in column 6. Again, options traders may consider a CC position by buying the SSE 50 EFT Index and writing OTM-call options on the SSE 50 EFT Index. If the OTM-call options are OP (column 4), holding the STO position (column 5) receives more than the actual premium, and CC is reported as a profitable (i.e., Yes) strategy in column 7.

For the long-strangle (LSGL) strategy, we buy OTM-call and OTM-put on the SSE 50 EFT Index with the same expiration date by considering that the SSH 50 EFT will experience significant volatility, and call or put options will be expired ITM. Since the LSGL represents debit spreads, we can only minimize the cost of LSGL through BTO if both OTM-call and BTO the OTM-put options are UP simultaneously in columns 2 and 4, respectively; however, none of these 12 scenarios considers LSGL an appropriate strategy in our economic significance analysis. Furthermore, for the short-strangle (SSGL) strategy, traders sell OTM-call and OTM-put on the SSE 50 EFT Index for the same expiration date. They believe the SSH 50 EFT Index will experience little volatility, and both call and put will expire without exercise. Since the SSGL is credit spreads, traders can receive more than the actual premium through STO the OTM-put and STO the OTM-call when both options are OP concurrently in columns 2 and 4, respectively. This situation leads to SSGL being profitable (i.e., Yes) in column 8.

5. Conclusion

The SSE 50 ETF index options market started trading in early 2015, and we believe it is still in the settling curve; therefore, we analyze the SSE 50 ETF index options market efficiency for three different options moneyness situations to examine whether the market efficiency is a concern for trading options. The options moneyness situation 1 (ATM-call and ATM-put) confirms that the SSE 50 ETF index options market is efficient, and both call and put options are AP. This finding implies that ATM-call and ATM-put SSE 50 ETF index options are appropriate for hedging, avoiding additional costs due to options mispricing. The options moneyness situation 2 (ITM-call and OTM-put) suggests that one-month and two-month maturity ITM-call and OTM-put options are UP and OP, respectively. These findings imply that the costs of holding the SSE 50 ETF index will be less through buying ITM-call or receiving a higher premium by selling OTM-put when the option's maturity is not more than two months. The options moneyness situation 3 (OTM-call and ITM-put) reveals that one-month and three-month maturity OTM-call and ITM-put options are OP and UP, respectively. These findings imply that the proceeds of selling the SSE 50 ETF index will be higher through writing OTM-call, or the cost of holding ITM-put will be less when the option's maturity is one or three months.

We find that the ITM and OTM options are OP and UP. Furthermore, OTM options are OP in most scenarios. We conducted the economic significance analysis for the three most popular options trading strategies, PP, CC, and short strangle (SSGL); here, OTM-call and OTM-put options are vital factors for the strategic plan. The PP and CC strategy exercise through trading single put and call options, respectively; however, the SGL strategy involves simultaneously trading put and call options. The analysis uncovers three significant findings of economic significance. If three-month maturity OTM-put options are UP, the PP strategy is appropriate for the SSE 50 ETF index. The CC strategy is suitable when one-month or three-month maturity SSE 50 ETF index OTM-call options are OP. The SSGL method is applicable for one-month maturity SSH 50 ETF index OTM-put and OTM-call when both options are OP and simultaneously traded with the same maturity.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data Availability

Data will be made available on request.

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