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The Influence of Hedge, Arbitrage, and After-Hours Trading on the Holding Returns of TAIEX Futures

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Abstract: This study points out a new explanation of the non-trading effect of financial derivatives from the perspective of hedging demand. We examine the influence of hedging demand on the non-trading effect of TAIEX (Taiwan Stock Exchange Capitalization Weighted Stock Index) Futures. By dividing the sample period into trading period and non-trading period and testing the difference between the risk premiums in these two intervals, we find that there is a non-trading effect in TAIEX Futures, which means that the holding returns of TAIEX Futures in the non-trading period are higher than those in the trading period. By estimating a dummy-regression model, the evidence shows that when the VIX (Taiwan Index Option Volatility Index) indicator is relatively high, the non-trading effect will be more significant, indicating that the non-trading effect may come from investors' hedging needs. In addition, it is found that when the futures index is higher than the spot index, the non-trading effect becomes less obvious. The possible reason is that when there is a positive spread in index futures, investors will expect a bull market, thus reducing the hedging demand of index futures. In the end, we find that the liquidity in the after-hours trading session is poor, resulting in high hedging costs, and forcing investors to hedge during the regular trading period. Therefore, the after-hours trading of TAIEX Futures fails to reduce the non-trading effect.

Keywords: non-trading effect; hedging demand; arbitrage; after-hour trading

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1. Introduction

The so-called non-trading effect generally refers to the considerable difference between the return rate of financial products during the regular trading period and the non-trading period. The relevant research on non-trading effects can be traced back to the 1930s when Ref. [1] first discovered that there were non-trading effects in the stock market, and many scholars began to seek answers and to try to explain the reasons for its occurrence. Some scholars, such as [2–4], showed that the difference in liquidity is the main reason for the difference in holding returns during trading and non-trading periods. In addition, some scholars show that the difference between investors' trading behavior before the weekend and other trading days may be the reason for the non-trading effect. For example, Ref. [5] found that investors' reactions to earnings announcements are related to the timing of the announcement. Investors' reaction to market information on Friday is significantly different from that of normal trading days (see [6,7]), resulting in significantly longer reaction times for the stock prices of companies that make announcements on Friday. On the other hand, Ref. [8] showed that investors are accustomed to shorting stocks on normal trading days and that choosing to close their positions before weekends becomes the main reason for the non-trading effect. In addition, some scholars indicate that the non-trading effect may be caused by the robustness of the measurement method. For example, Refs. [9,10] proved that the size of the sample or the difference of the regression model may affect the significance of the non-trading effect. However, Ref. [11] conducted research on international data and found that non-trading effects exist in many countries in the world and that there is no clear correlation between the causes and the size of the sample or the difference in regression models.

Most of the research on the trading period and non-trading period focuses on the difference of the return rate in these two periods; however, there is also some research on the difference in the volatility. For example, Ref. [12] found that the volatility is significantly greater than that during non-trading periods, the main reason being that the speed of information flow is not the same during trading periods and non-trading periods. Ref. [13] analyzed the influence of non-trading periods on the forecasting ability of volatility and found that volatility significantly declined on the first trading day after holidays and weekends.

The research objects of the above literature all focus the stock market, and we found that only a few studies discuss the non-trading effects of financial derivatives. Related literature, such as [14], took options as the research object and found that the difference in risk during trading and non-trading periods was the main reason for non-trading effects; Ref. [15] examined the influence of informed trades on options trading around holidays.

The trading purpose of stocks is mainly for investment or speculation, while derivatives can not only expand investment benefits, but also have hedging functions. Therefore, the differences in the price behavior of derivatives during trading and non-trading periods may not be the same as of stocks. Most of the previous literature focuses on the stock market, and only a few studies discuss the non-trading effect of financial derivatives. The trading purpose of financial derivatives is quite different from that of the stocks, especially for hedging, which makes it necessary for us to analyze how hedging demand influences the non-trading effect.

The main aim of this study is to get new knowledge about the non-trading effect of financial derivatives from the perspective of hedging demand. In fact, many studies have found that the hedging demand of futures has a significant impact on the futures holding return. For example, Ref. [16] found that hedging pressure has a significant effect on futures returns; Refs. [17,18] introduced hedging demand into the model and re-derived the equilibrium price of futures. In scientific research, the efficient market hypothesis holds that when new information comes into the market, it is immediately reflected in the prices in financial markets. However, the existence of the non-trading effect shows that the financial market is inefficient. The reason for the market inefficiency needs to be discovered, especially for the financial derivatives markets which have been receiving little attention. Since investors may sell futures due to hedging demand before long holidays or weekends, we reasonably suspect that hedging demand may be one of the reasons that causes the non-trading effect of financial derivatives. As far as the author understands, there is no literature to explain the non-trading effects through hedging demand. Therefore, in this study, we take TAIEX Futures as the research object to discuss the relationship between hedging demand and non-trading effects. We hypothesize that when the market risk is high, investors will have a greater incentive to sell futures for hedging before the long holiday, resulting in the low futures price and high holding rate of return in non-trading period and leading to the non-trading effects. In this study, we found that the holding rate of TAIEX Futures in the non-trading range is higher than that in the general trading range, and the gap between the two tends to become larger when the market volatility increases. The evidence suggests that non-trading effects of financial derivatives can be explained by hedging demand. In addition, we also found that when the positive spread widens, the non-trading effect will become less significant. The evidence shows that the non-trading effect is weaker in a bull market. A possible explanation is that when the positive spread widens, investors are optimistic about the future market trend, so the demand for hedging will be low, leading to non-trading effects being less pronounced. Moreover, we found that the after-hours trading of TAIEX Futures did not reduce the non-trading effect. The reason may be that the lack of liquidity in the after-hours trading session increased the cost of hedging, forcing the hedgers to hedge during the regular trading period. As a result, although TAIEX Futures has after-hours trading measures, it has not yet been able to reduce the non-trading effect. Finally, comparing with [14], which showed that option mispricing during periods of market closure causes the option returns to be lower over non-trading periods, we show in this study that, to the contrary, hedging demand has a positive impact on the returns of financial derivatives over non-trading periods. In other words, when the market risk rises, the returns of financial derivatives could be higher over non-trading periods. Our results point out that the non-trading effect in the financial derivatives markets should be analyzed according to the level of market risk.

This paper is divided into five sections, in addition to the introduction of this section. The following sections are arranged as follows. Section 2 presents the methodology and data, while Section 3 discusses the empirical results. Section 4 discusses the findings and their implications. The Section 5 is the conclusion of this paper.

2. Methodology and Data

This study applies TAIEX Futures as the research object. The sample is daily data for six futures contracts (including three consecutive months from the current month, plus three consecutive quarterly monthly contracts in March, June, September, and December) per day from 21 July 1998 to 14 January 2019. We refer to the definition of [14] to calculate the risk premium of hedging background index futures. First, we assume that the investor holds a long position in futures and shorts the spot for hedging, and thus the change in the value of the portfolio is

$$(F_t - F_{t-1}) - (S_t - S_{t-1}) \tag{1}$$

where F_t is the price of TAIEX Futures on t day, and S_t is the spot index on t day. In Equation (1), we assume that we can short the spot index. Although we cannot directly short the spot index in practice, theoretically, we can short the spot index by shorting the market portfolio or index ETF. In addition, the same as [14], we assume that the spot short position can generate cash inflow $S_t - S_{t-1}$, which can be reinvested in risk-free assets to earn a risk-free interest rate. Therefore, the return on investment (since shorting stocks in Taiwan does not generate immediate cash inflows, the definition of return in Equation (2) implies that investors hold market portfolios for a long time) can be expressed as

$$\frac{(F_t - F_{t-1}) - (S_t - S_{t-1}) + S_{t-1} r_{t-1} ND_{t-1,t}}{F_{t-1}/L} \tag{2}$$

where r_{t-1} represents the risk-free interest rate from day $t-1$ to day t (the frequency of interest calculation is calculated on a daily basis), $ND_{t-1,t}$ represents the number of days between day $t-1$ and day t. In addition, L represents the leverage multiple. Unlike the holding rate of return of options, which is calculated through the change of the premium, futures trading does not need to pay the premium, but trades through the margin. Investors can adjust the leverage ratio through margin. For example, on 19 August 2019, the closing price of the futures contract due to expire in August is 10,484 points, so its contract value is 10,484 × 200 = $2,096,800. If an investor deposits a margin equal to the contract value ($2,096,800) in the margin account, the investor's trading leverage is 1, which means that the risk of investing in the index futures with a margin equal to the contract value is actually the same as the risk of investing in spot indices. If the investor only deposits half of the contract value in the margin account ($1,048,400), then the trading leverage is 2, which means that the risk of investing in TAIEX Futures is twice that of investing in the spot index. The L in Equation (2) is used to measure the leverage ratio of futures trading. The higher the value of L, the higher the leverage ratio becomes.

Extending Equation (2), we define the risk premium of the hedged position in the index futures as follows:

$$\begin{gathered}\frac{(F_t-F_{t-1})-(S_t-S_{t-1})+S_{t-1}r_{t-1}ND_{t-1,t}}{F_{t-1}/L} - r_{t-1}ND_{t-1,t} \\ = \left[L\frac{F_t-F_{t-1}}{F_{t-1}} - r_{t-1}ND_{t-1,t}\right] - L\frac{S_{t-1}}{F_{t-1}}\left(\frac{S_t-S_{t-1}}{S_{t-1}} - r_{t-1}ND_{t-1,t}\right)\end{gathered} \tag{3}$$

Equation (3) divides the risk premium of the hedged position in the index futures into two parts; the part in brackets is the risk premium of the unhedged position in the index futures, and the minus sign is the hedged position the impact caused. In addition, in Formula (3), $(S_t - S_{t-1})/S_{t-1}$ should be regarded as the actual rate of return of the spot index rather than the percentage change of the price. The spot index will deduct the value of the spot index to reflect the impact of the ex-dividend. Simply calculating the percentage of change will underestimate the risk aversion effect and overestimate the risk premium of the index futures hedging position. Therefore, in this study, we will regard $(S_t - S_{t-1})/S_{t-1}$ as the actual rate of return of the spot index from day $t-1$ to day t. Finally, the futures pricing theory proves that the futures price will be affected by the spot price and the risk-free interest rate, so Equation (3) can also be regarded as the TAIEX Futures rate of return after excluding the influence of the spot index and the risk-free interest rate (in this article, we use the one-year deposit rate as the risk-free rate). The descriptive statistics of the risk premium of the hedged position in the index futures are presented in Table 1. In order to compare the impact of the spot index on the index futures rate of return, Table 1 also presents the risk premium of the non-hedged positions. In addition, to understand whether the leverage ratio has an impact on our research results, four kinds of leverage ratios are considered in Table 1 and subsequent analyses: L = 1, 5, 10, and 20. The data in Table 1 show that the risk premiums of both the hedged and non-hedged positions of TAIEX Futures are positive. Since the spot index has a long-term positive return, the risk premium of the non-hedged position will be slightly higher than that of the hedged position, and the gap between the two will increase with the increase of the leverage ratio. For example, when the leverage ratio is 1, the position that has not been hedged is only 0.0051% higher than the position that has been hedged. As the leverage ratio increases, the gap between the hedged position and the non-hedged position also increases. When the leverage increases to 20, the gap between the two comes to 0.1033%.

Table 1. Descriptive statistics.

		Mean%	Std.%	Skewness	Kurtosis
$L = 1$	Non-hedged	0.0171	1.5400	−0.0729	4.1220
	Hedged	0.0120	0.5861	0.1684	15.3029
$L = 5$	Non-hedged	0.1186	7.6984	−0.0672	4.1224
	Hedged	0.0928	2.9296	0.1852	15.2911
$L = 10$	Non-hedged	0.2455	15.3965	−0.0665	4.1224
	Hedged	0.1938	5.8591	0.1873	15.2892
$L = 20$	Non-hedged	0.4992	30.7926	−0.0662	4.1225
	Hedged	0.3959	11.7182	0.1883	15.2882

Sample size: 25,515. Sample period: 21 July 1998~14 January 2019.

Next, we observe that adopting a hedging strategy will significantly reduce the risk of the TAIEX Futures. The data in Table 1 show that through hedging, the standard deviation falls by about 62%. These data are close to those of [14] for stock call options. The results of [14] show that through delta hedging, the standard deviation of call options risk premium decreases by about 63%. Then we observe that the skewness coefficients of the hedged positions are higher than those of the non-hedged positions. This result is also consistent with [14]. In addition, we also observe that the skewness of the non-hedged positions is all negative, while the skewness of the hedged positions is all positive, which is slightly different from [14]. Ref. [14] found that the skewness of both the hedged and non-hedged positions of options are positive, which shows that futures have a higher probability of falling sharply than options. Finally, in the part of the kurtosis, we observe that the risk premium of the index futures has a thick tail, and the thick tail of the hedged position is more obvious. Ref. [14] also have similar findings, but our data show that the kurtosis of the hedged position of the TAIEX Futures is about 15.3, while Ref. [14] show that the kurtosis of call options is as high as 51.3. The main reason is that since the options uses delta hedging, ignoring the convexity of the option price, the hedging effect is less effective when the stock price rises and falls sharply, and so it is prone to the thick tail phenomenon.

These observations illustrate that futures and options are still quite different in nature, which underscores the need for this study.

3. Empirical Results

In this section, we will analyze the difference between the holding rate of index futures during the trading period and the non-trading period after excluding the impact of the spot index and the risk-free interest rate. The non-trading period referred to in this study is the same as the definition in [14], which means the interval between two consecutive closing prices is more than one day. The most important non-trading period is weekends, and a small part of the data for non-trading periods comes from national holidays.

3.1. Non-Trading Effects

First, we divide the sample period into trading period and non-trading period and test the difference between the risk premiums in these two intervals. The results are presented in Table 2. First, we observe that the average risk premium of the spot index during the trading period is 0.0268%, which is significantly positive at the 90% confidence level, and −0.074% during the non-trading period, which is significantly negative at the 90% confidence level. Similar to [14], we define the difference between the two as the non-trading effect. The data in Table 2 show that the non-trading effect of the spot index is −0.101%, which is significantly negative at the 95% confidence level. Following on, we observe that when the leverage ratio is 1, the average risk premium of the non-hedged position of the TAIEX Futures during the trading period is 0.0355%, which is significantly positive at the 99% confidence level, and −0.049% during the non-trading period, which is significantly negative at the 95% confidence level, and the non-trading effect is −0.084%, which is significantly negative at the 99% confidence level. In addition, we found that the non-hedged position of the TAIEX Futures and the spot index have the same positive and negative values in the data during the trading period and the non-trading period, whether it is the risk premium or the non-trading effect. However, the risk premium and non-trading effect of the non-hedged positions of the TAIEX Futures are more significant than those of the spot index. Furthermore, when the leverage multiples are 5, 10, and 20, the same phenomenon is also observed. Next, we consider the hedged position, when the leverage ratio is 1 and the average risk premium is 0.0078% and 0.0268% during the trading period and non-trading period, respectively. The results of the *t*-test show that these two values are significantly greater than 0. Since the risk premium in the non-trading period is higher than that in the trading period, the non-trading effect is positive and significant by the *t*-test. The non-trading effects of the three portfolios with leverage ratios of 5, 10, and 20 are also significantly positive, and the higher the leverage ratio is, the higher the significance becomes.

Table 2. The difference between the risk premium in trading periods and non-trading periods.

		Trading Period %	Non-Trading Period %	Non-Trading Effect %
Spot index		0.0268 (1.300 *)	−0.074 (−1.588 *)	−0.101 (−1.978 **)
$L = 1$	Non-hedged	0.0355 (3.399 ***)	−0.049 (−2.083 **)	−0.084 (−3.289 ***)
	Hedged	0.0078 (1.883 **)	0.0268 (3.394 ***)	0.0190 (2.130 **)
$L = 5$	Non-hedged	0.2007 (3.838 ***)	−0.175 (−1.494 *)	−0.375 (−2.931 ***)
	Hedged	0.062 (2.992 ***)	0.2029 (5.147 ***)	0.1409 (3.164 ***)
$L = 10$	Non-hedged	0.4071 (3.894 ***)	−0.332 (−1.421 *)	−0.739 (−2.886 ***)
	Hedged	0.1297 (3.131 ***)	0.423 (5.367 ***)	0.2933 (3.294 ***)
$L = 20$	Non-hedged	0.8199 (3.921 ***)	−0.647 (-1.384 *)	−1.467 (−2.864 ***)
	Hedged	0.2652 (3.200 ***)	0.8632 (5.476 ***)	0.598 (3.358 ***)

Sample size of trading period: 19,939. Sample size of non-trading period: 5579. Sample period: 21 July 1998~14 January 2019. * 90% confidence level, ** 95% confidence level, *** 99% confidence level.

From Table 2, we observe that the non-trading effect of non-hedged positions is negative, due to the influence of the spot index. After excluding the influence of the spot index, we find that the hedged positions have a positive non-trading effect. In the following sections, we will focus on the hedged positions. The main reason is that the hedged positions have eliminated the influence of the spot; therefore, the reason for its non-trading effect comes from other factors than the spot index. We are curious about what causes such a significant non-trading effect after excluding the impact of the spot index. Furthermore, Ref. [14] found that the non-trading effect of stock options in the hedged position was negative, while we found in Table 2 that the non-trading effect of the hedged position in TAIEX Futures was positive. These differences also make it necessary for us to analyze the hedged positions.

3.2. Hedging and Non-Trading Effects

When the market risk is high, investors' demand for hedging also increases, so they hedge by selling futures. Especially before weekends or long holidays, investors will have stronger demand for hedging, causing futures to be oversold before weekends or long holidays, resulting in low futures prices and a high holding rate of return in the non-trading period and leading to the non-trading effects. Base on the above inference, we have the following hypothesis:

Hypothesis 1. *The higher the hedging demand, the higher the non-trading effect.*

Ref. [19] took the S&P500 index as the research object and found that when the implied volatility of the index is higher, investors will have higher hedging needs. To test the hypothesis, we use the Taiwan Index VIX to measure the market's hedging demand. The Taiwan Index VIX is the implied volatility derived from the market price of the Taiwan Index option to reflect market investors' expectations of the volatility of the stock market in the short term in the future. If the VIX of the Taiwan index decreases, it means that investors believe that the volatility of the Taiwan stock market will slow down in the future, so the demand for hedging will also decrease. On the contrary, if the VIX of the Taiwan index rises, it means that the investors believe that the volatility of the Taiwan stock market will increase significantly in the future, so the demand for hedging will also increase.

The Taiwan Futures Exchange has been compiling the Taiwan Index VIX since 2006. The largest sample collected in this study was 3000 daily data from 1 December 2006 to 14 January 2019. During our sample period, the average VIX was 19.74, the highest was 60.41, the lowest was 7.82, and the median was 17.08, slightly lower than the average; the skewness of 1.38 shows that the distribution of VIX is slightly skewed to the right. Please refer to Table 3 for relevant data.

Table 3. Descriptive statistics of VIX.

Mean	Median	Std.	Kurtosis	Skewness	Min.	Max.
19.74	17.08	8.55	1.85	1.38	7.82	60.41

Sample size: 3000. Sample period: 1 December 2006~14 January 2019.

We divide the sample into the following two sub-samples with Med (the median of the VIX) as the critical value:

$$\text{Sub-sample I: \{Risk premium of hedged positions in TAIEX Futures} \mid \text{VIX} > \text{Med\}} \quad (4)$$

$$\text{Sub-sample II: \{Risk premium of hedged positions in TAIEX Futures} \mid \text{VIX} < \text{Med\}} \quad (5)$$

Sub-sample I collects the data when the value of VIX is higher than the median, so the market has a high demand for hedging during the period covered by this sample. The relative sub-sample II is the sample that represents the market with low hedging demand. During the sample period from 1 December 2006 to 14 January 2019, we collected a total of 14,968 pieces of data, with 7484 pieces of data in each of the two sub-samples.

We test the differences between the two sub-samples during the trading period and the non-trading period, respectively, and the results are presented in Table 4. The result shows that when the leverage ratio is 1, the risk premium of sub-sample I is 0.0125% and 0.0547% during the trading period and non-trading period, respectively, and in sub-sample II it is 0.0164% and 0.0353%, respectively. These four values are significantly positive at the 99% confidence level. We observe significant non-trading effects for both sub-samples. When the VIX is higher than the median, the non-trading effect is 0.0422%, and when the VIX is lower than the median, the non-trading effect drops to 0.0189%. Since we define the difference between these two data as the effect gap, the effect gap is 0.0233% when the leverage is 1. A positive effect gap indicates that the VIX has a positive correlation with the non-trading effect, which means that the higher the VIX, the more obvious the non-trading effect. To test whether the effect gap is significant we consider the following regression model:

$$ER_t = \beta_1 D_{1,t} + \beta_2 D_{2,t} + \beta_3 D_{3,t} + \beta_4 D_{4,t} + \varepsilon_t \quad (6)$$

where ER_t is the risk premium of the hedged position in the TAIEX Futures on day t, and $D_{i,t}$ is the dummy variable defined as follows:

$$D_{1,t} = \begin{cases} 1, & t \in \text{ trading period and } \mathrm{VIX}_t > \text{Med} \\ 0, & \text{others} \end{cases} \quad (7)$$

$$D_{2,t} = \begin{cases} 1, & t \in \text{ trading period and } \mathrm{VIX}_t < \text{Med} \\ 0, & \text{others} \end{cases} \quad (8)$$

$$D_{3,t} = \begin{cases} 1, & t \in \text{ nontrading period and } \mathrm{VIX}_t > \text{Med} \\ 0, & \text{others} \end{cases} \quad (9)$$

$$D_{4,t} = \begin{cases} 1, & t \in \text{ nontrading period and } \mathrm{VIX}_t < \text{Med} \\ 0, & \text{others} \end{cases} \quad (10)$$

Table 4. The influence of volatility on non-trading effect.

		Trading Period %	Non-Trading Period %	Non-Trading Effect %	Effect Gap %
$L = 1$	VIX > Med	0.0125 (2.516 ***)	0.0547 (5.824 ***)	0.0422 (3.970 ***)	0.0233 (1.549 *)
	VIX < Med	0.0164 (3.294 ***)	0.0353 (3.756 ***)	0.0189 (1.779 **)	
$L = 5$	VIX > Med	0.0789 (3.146 ***)	0.3252 (6.867 ***)	0.2463 (4.597 ***)	0.1204 (1.590 *)
	VIX < Med	0.0958 (6.354 ***)	0.2217 (4.679 ***)	0.1259 (2.348 ***)	
$L = 10$	VIX > Med	0.1618 (3.220 ***)	0.6634 (6.987 ***)	0.5015 (4.669 ***)	0.2420 (1.593 *)
	VIX < Med	0.1951 (3.883 ***)	0.4547 (4.787 ***)	0.2595 (2.416 ***)	
$L = 20$	VIX > Med	0.3278 (3.257 ***)	1.3397 (7.046 ***)	1.012 (4.704 ***)	0.4851 (1.594 *)
	VIX < Med	0.3937 (3.912 ***)	0.9207 (4.841 ***)	0.5269 (2.449 ***)	

Sample size of trading period: 11,694. Sample size of non-trading period: 3275. Sample period: 1 December 2006~14 January 2019. * 90% confidence level, ** 95% confidence level, *** 99% confidence level.

Let $\hat{\beta}_i$ be the estimator of the regression coefficient, then $\hat{\beta}_3 - \hat{\beta}_1$ represents the non-trading effect when the VIX is higher than the median, which is 0.0422% from Table 4, and $\hat{\beta}_4 - \hat{\beta}_2$ represents the non-trading effect when the VIX is lower than the median, which is 0.0189%. The effect gap is $(\hat{\beta}_3 - \hat{\beta}_1) - (\hat{\beta}_4 - \hat{\beta}_2)$ = 0.0233%. To confirm our hypothesis, we do the following hypothesis tests:

$$H_0 : (\beta_3 - \beta_1) - (\beta_4 - \beta_2) = 0$$

$$H_1 : (\beta_3 - \beta_1) - (\beta_4 - \beta_2) > 0$$

The t-statistic of the test results is 1.549, rejecting H_0 at the 90% confidence level. The results show that the non-trading effect when the VIX is higher than the median is significantly higher than the non-trading effect when the VIX is below the median. This phenomenon can also be seen when the leverage ratio is 5, 10, and 20, and when the leverage ratio is higher, the effect gap is larger.

From Table 4, we observe that the higher the market volatility, the more obvious the non-trading effect. The result supports our hypothesis, because when the market is more volatile, investors' demand for hedging also increases (refer to [19] for related literature), and hence the incentives for investors to sell futures for hedging are relatively high. Especially before weekends or long holidays, investors will have stronger hedging needs, causing the oversold phenomenon of TAIEX Futures before weekends or long holidays, resulting in TAIEX Futures having a higher holding return during non-trading periods and thereby bringing about more serious non-trading effects.

3.3. Arbitrage and Non-Trading Effects

In addition to hedging, the purpose of futures trading may also be arbitrage. In this section, we will analyze the impact of arbitrage on non-trading effects. First, we define the price spread between futures and spot as the settlement price of the futures minus the closing price of the spot. When the futures price is higher than the spot price, the spread is positive, which is the so-called positive spread. At this time, investors can make arbitrage by buying the spot and selling the futures. On the contrary, when the futures price is lower than the spot price, the spread is negative, which is the so-called backward spread. At this time, investors can make arbitrage by selling the spot and buying futures. In this section, we will only test whether the arbitrage behavior of investors by selling futures and buying spot is related to non-trading effects when the TAIEX Futures are in contango. The main reason is that the ex-dividend peak season for Taiwan stocks is in July, August, and September. At this time, the index will "evaporate" due to ex-dividend, resulting in a serious backwardation. Using the backwardation to measure the market's arbitrage demand may be distorted. On the other hand, since the closing time of the Taiwan index is 13:30 and the closing time of the futures index is 13:45, there is a 15-min time difference between the futures settlement price and the spot closing price. As a result, the spread we define is not the spread that investors can arbitrage but is only an indicator used to measure the demand for arbitrage.

During our sample period, there are 6926 transactions in the market with positive spreads, of which 5430 transactions belong to the trading period, accounting for 78%, and 1496 transactions belong to the non-trading period, accounting for 22%. The descriptive statistics for the positive spread are shown in Table 5. The data show that the average positive spread is 75.20, while the median is only 34.31, which was about half the average. The maximum value of 1015.39 occurred on 14 April 2000, when the settlement price of the TAIEX Futures expiring in December was 10,390 and the spot closing price was 9374.61. Since we exclude the data of negative spreads, the distribution of spreads tends to be skewed to the right, and the skewness coefficient of 2.79 shows a right-skewed characteristic. Finally, the kurtosis coefficient of 11.04 shows that the spread is prone to large changes.

Table 5. Descriptive statistics of positive spreads.

Mean	Median	Std.	Kurtosis	Skewness	Min.	Max.
75.20	34.31	102.08	11.04	2.79	0.01	1015.39

Sample size: 6926. Sample period: 21 July 1998~14 January 2019.

We divide the data when the market is in a contango into two sub-samples during the trading period and the non-trading period and test the difference between the two sub-samples of the TAIEX Futures risk premium. The results are presented in Table 6. When the index is in a contango, investors have incentives to sell futures and buy spot for arbitrage trading. Therefore, when the positive spread widens, theoretically, futures may be oversold due to arbitrage demand, resulting in low futures prices and high holding returns. Through the data in Table 6, we observe that when the market is in a contango, the risk premium of the hedged position in the TAIEX Futures is relatively high. For example, when the leverage ratio is 1, the average risk premium during the trading period is 0.1532%, which is only 0.0078% compared to the average risk premium of the hedged positions in Table 2. On the other hand, when the market is in a positive spread, the risk premium during the non-trading period is 0.1502%, which is also higher than the average risk premium of 0.0268% in the non-trading period for the hedged positions in Table 2. Next, we observe that there is no significant difference in the risk premium between trading and non-trading periods when the market is in a contango. For example, when the leverage ratio is 1, the risk premiums during the trading period and the non-trading period are 0.1532% and 0.1502%, respectively, and the non-trading effect is −0.003%. The difference between the two is found to be insignificant by the *t*-test. When the leverage multiples are 5, 10, and 20, although the non-trading effect turns positive, it is still insignificant. This result shows that the non-trading effect becomes less obvious when the TAIEX Futures is in a contango.

Table 6. The difference between the risk premium in trading periods and non-trading periods when the market is in a contango.

	Trading Period %	**Non-Trading Period %**	**Non-Trading Effect %**
$L = 1$	0.1532 (19.535 ***)	0.1502 (10.056 ***)	–0.003 (–0.134)
$L = 5$	0.8016 (20.248 ***)	0.8530 (11.308 ***)	0.0514 (0.470)
$L = 10$	1.6122 (20.305 ***)	1.7315 (11.445 ***)	0.1193 (0.546)
$L = 20$	3.2334 (20.331 ***)	3.4884 (11.512 ***)	0.2551 (0.584)

Sample size of trading period: 5430. Sample size of non-trading period: 1496. Sample period: 21 July 1998~14 January 2019. *** 99% confidence level.

To analyze whether the magnitude of the spread is related to the non-trading effect, we adopt the analysis method similar to Table 4 and use the median of the positive spread as the cut-off point to divide the data into the following two sub-samples:

$$\text{Sub-sample III: \{Risk Premium of Hedged Positions} \mid \text{Positive spread} > \text{Med\}} \quad (11)$$

$$\text{Sub-sample IV: \{Risk Premium of Hedged Positions} \mid \text{Positive spread} < \text{Med\}} \quad (12)$$

Both sub-sample III and sub-sample IV collect the risk premium of the hedged positions when the TAIEX Futures are in a contango. Among them, the positive spread of sub-sample III is higher than the median, so the arbitrage demand covered by this sample is relatively high. Sub-sample IV, on the other hand, has a positive spread lower than the median, so the need for arbitrage is relatively low. We test the differences between the two sub-samples during the trading period and the non-trading period, respectively, and the results are presented in Table 7. First of all, when the leverage is 1, the average risk premium of sub-sample III is 0.2041% and 0.1868% during the trading period and non-trading period, respectively, while the average risk premium of sub-sample IV is 0.1020% and 0.1144% during the trading period and non-trading period, respectively. These four values are all significantly positive at the 99% confidence level. Then we observe that the non-trading effects of sub-sample III and sub-sample IV are −0.0170% and 0.0124%, respectively. The *t*-test shows that the non-trading effects of these two sub-samples are not significant. These results are consistent with Table 6, showing that when the index is in a positive spread, the non-trading effect will become less obvious. The effect gap is negative, which means that the larger the positive spread, the lower the non-trading effect. Using the method in Table 4 for testing, it is found that the effect gap is not significant. Roughly, the data in Table 7 shows that the expansion of the positive spread will reduce the non-trading effect; however, the test results show that the effect is not significant. The same phenomenon can also be observed at leverages of 5, 10, and 20.

Table 7. The influence of contango on non-trading effect.

		Trading Period %	Non-Trading Period %	Non-Trading Effect %	Effect Gap %
$L = 1$	Contango > Med Contango < Med	0.2041 (18.440 ***) 0.1020 (9.197 ***)	0.1868 (8.8066 ***) 0.1144 (5.444 ***)	−0.0170 (−0.490) 0.0124 (0.479)	−0.0290 (−0.880)
$L = 5$	Contango > Med Contango < Med	1.0674 (19.102 ***) 0.5346 (9.545 ***)	1.0652 (9.948 ***) 0.6448 (6.078 ***)	−0.0020 (−0.0125) 0.1100 (0.855)	−0.1120 (−0.6604)
$L = 10$	Contango > Med Contango < Med	2.1465 (19.154 ***) 1.0752 (9.574 ***)	2.163 (10.073 ***) 1.3078 (6.147 ***)	0.0167 (0.0473) 0.2326 (0.903)	−0.2159 (−0.632)
$L = 20$	Contango > Med Contango < Med	4.3048 (19.178 ***) 2.1566 (9.587 ***)	4.3592 (10.134 ***) 2.6338 (6.181 ***)	0.0545 (0.0772) 0.4772 (0.926)	0.4227 (0.618)

Sample size of trading period: 5430. Sample size of non-trading period: 1496. Sample period: 21 July 1998~14 January 2019. *** 99% confidence level.

In the previous section, we found that the non-trading effect may come from investors' hedging demand. Specifically, the higher (lower) investors' hedging demand, the more serious (moderate) the non-trading effect. On the other hand, Ref. [20] found that when the hedgers are extremely optimistic, they tend to simply hold spot positions instead of hedging. Combining the result of the previous section with the results of [20], we have the following inferences: When the index is in a contango, investors are optimistic about the future trend of the market and expect larger gains, resulting in relatively low demand for hedging. Since the need for hedging decreases, the non-trading effect will be moderated at this time based on the results of the previous section. The results in Table 7 (the widening of the positive spread has the effect of reducing the non-trading effect) support our inferences made above.

3.4. After-Hours Trading and Non-Trading Effects

In recent years, there have been frequent black swan events and frequent fluctuations in financial markets around the world. In order to provide market participants with better trading and hedging channels, the Futures Exchange, on considering the practices of major international markets, plans for the domestic futures market to conduct after-hours trading after the general trading hours. Starting from 15 May 2017, the trading hours of TAIEX Futures have been extended from the original 5 h to 19 h, and the after-hours trading hours will start from 15:00 to 5:00 am the next day. After-hours trading allows investors to hedge after hours. Therefore, the sell orders of TAIEX Futures generated by the demand for hedging before weekends or long holidays may be dispersed to after-hours, thus slowing down the non-trading effect. In this section, we will analyze the impact of after-hours trading measures on TAIEX Futures on non-trading effects.

We divide the data into two sub-samples with after-hours trading and no after-hours trading and test the differences in risk premiums between the two sub-samples during trading and non-trading periods. The results are presented in Table 8. It has been shown that the non-trading effect is greater when there is after-hours trading than when there is no after-hours trading, although the difference between the two is not significant. For example, when the leverage is 1, when there is after-hours trading, the risk premium during the regular trading period is 0.0146%, during the non-trading period is 0.0509%, and the non-trading effect is 0.0363%. On the other hand, when there is no after-hours trading, the risk premium is 0.0072% during the trading period, increases to 0.0245% during the non-trading period, and the non-trading effect is 0.0173%. The non-trading effect with after-hours trading is 0.0190% higher than that without after-hours trading, but the test results show that the difference is not significant.

Table 8. The influence of after-hours trading on non-trading effect.

	After-Hours Trading	Trading Period %	Non-Trading Period %	Non-Trading Effect %	Effect Gap %
$L = 1$	With	0.0146 (1.041)	0.0509 (1.933 *)	0.0363 (2.759 ***)	0.0190
	Without	0.0072 (1.657 *)	0.0245 (2.993 ***)	0.0173 (1.787 **)	(0.0001)
$L = 5$	With	0.0847 (1.191)	0.2904 (2.180 **)	0.2057 (3.134 ***)	0.0711
	Without	0.0598 (2.742 ***)	0.1945 (4.709 ***)	0.1346 (2.783 ***)	(0.0001)
$L = 10$	With	0.1722 (1.208)	0.5896 (2.207 **)	0.4174 (3.166 ***)	0.1362
	Without	0.1257 (2.872 ***)	0.407 (4.914 ***)	0.2813 (2.907 ***)	(0.0001)
$L = 20$	With	0.3472 (1.216)	1.1881 (2.220 **)	0.8409 (3.188 ***)	0.2663
	Without	0.2574 (2.936 ***)	0.832 (5.015 ***)	0.5746 (2.970 ***)	(0.0001)

Sample size with after-hours trading: 2207. Sample size without after-hours trading: 23,308. Sample period: 21 July 1998~14 January 2019. * 90% confidence level, ** 95% confidence level, *** 99% confidence level.

After the opening of after-hours trading, some of the hedging demand for TAIEX Futures before the weekend or long holiday should be scattered after the market. Intuitively, the oversold phenomenon of TAIEX Futures should be slowed down before weekends or long holidays, thus reducing the non-trading effect. However, our empirical results found that the non-trading effect did not decrease, but increased slightly, although the increase was not significant. We believe that such a phenomenon may be related to hedging costs. During our sample period, the after-hours trading volume of TAIEX Futures only accounted for 17.61% of the trading volume during normal trading hours. In addition, the after-hours trading time is as long as 14 h, while the general trading time is only 5 h. Calculated per unit hour, the hourly after-hours trading volume only accounts for 6.29% of the hourly trading volume during the regular trading period. The liquidity of post-trading is obviously not as good as during normal trading. Insufficient liquidity will increase the cost of hedging (for related literature refer to [21]), thus reducing the hedging demand of the hedgers (Ref. [22] show that insufficient liquidity will lead to an increase in the cost of hedging and thus reduce the hedging demand of investors) forcing the hedgers to conduct hedging transactions during the regular trading period. As a result, although there are after-hours trading measures in the TAIEX Futures, the measures have not been able to effectively reduce the non-trading effect.

4. Discussion

In this study we analyze the difference between the holding returns of index futures during the trading period and the non-trading period. First, excluding the influence of the spot index, we find that the futures index has a significant non-trading effect. In comparison to [14], who found that the non-trading effect of stock options was negative, we found a positive non-trading effect in TAIEX Futures.

Second, we hypothesize that the higher hedging demand leads to a higher non-trading effect. By testing a dummy-regression model, the evidence shows that the higher the value of the VIX indicator, the more significant the non-trading effect will be. The evidence indicates that the non-trading effect may come from investors' hedging needs and hence supports our hypothesis. On the other hand, Ref. [23] show that when the VIX is high, investors tend to reduce the volatility of their portfolios. In order to do so, investors sell high-risk stocks in favor of low-risk stocks, and as a result the return of low-risk stocks is increased. In this study, we have similar results: when the VIX is high, investors tend to sell futures before weekends or long holidays to reduce the market risk, which leads to the return of hedged positions being relatively high during the non-trading periods.

Third, using the price spread between futures and spot to measure the demand for arbitrage, we found that the larger the positive spread, the lower the non-trading effect. The possible reason is that when the index is in a contango, the market is usually in a bullish pattern. Therefore, the investors' hedging needs before weekends or long holidays will drop significantly, and thus, the non-trading effect is reduced. The result can also be interpreted from the perspective of [20], who shows that when the hedgers are extremely optimistic, they tend to simply hold spot positions instead of hedging.

Finally, dividing the data into two sub-samples with after-hours trading and no after-hours trading and testing the differences in risk premiums between the two sub-samples, we found that the non-trading effect with after-hours trading is higher than that without after-hours trading, although the evidence is not significant. Since the liquidity in after-hours session is worse, forcing the hedgers to hedge during the regular trading period, as a result the non-trading effects have no significant difference between the sub-samples with and without after-hours trading.

5. Conclusions

The main aim of this study is to get new knowledge about the non-trading effect of financial derivatives from the perspective of hedging demand. We hypothesize that when the market fluctuates more, investors' demand for hedging also increases, so they hedge by selling futures. Especially before weekends or long holidays, investors will have a stronger demand for hedging, causing futures to be oversold before weekends or long holidays, resulting in higher holding returns of futures during non-trading periods, leading to a positive non-trading effect. Our empirical results show that when the market volatility is higher, the non-trading effect is more obvious, which shows that the non-trading effect may come from investors' hedging demand and supports our hypothesis. The evidence also points out a new explanation of the non-trading effect of financial derivatives from the perspective of hedging demand and indicates that the non-trading effect in the financial derivatives markets should be analyzed according to the level of market risk.

Moreover, we found that the after-hours trading measures of the TAIEX Futures have not been able to reduce the non-trading effect. The possible reason is that the liquidity of the after-hours trading of the TAIEX Futures is not as good as that of the regular trading period, resulting in high after-hours hedging costs, forcing hedgers to hedge during normal trading periods, thus failing to effectively reduce non-trading effects. The result indicates the lack of liquidity of TAIEX Futures during the after-hours trading period. To increase the liquidity, we suggest the Futures Exchange should increase the incentive by, for example, decreasing the transaction cost for after-hours trading.

Theoretically, the persistently higher holding returns of the TAIEX Futures in the non-trading period appear to be evidence of market inefficiency. Practically, one simple trading strategy based on this information would be for an individual to long the index futures and short sell the spot index before weekends or long holidays when the VIX is relatively high, and then close out the strategy on the following trading day. In the future research, it is tempting to create trading strategies base on our findings and analyze the profitability of the strategies.

Finally, in this research we collect a large sample which covers a period over two decades. Even though the tested result is reliable base on the large sample size, reform of the trading system or an evolution of market structure may change the research results. These limitations are also suggested for future research. On the other hand, the result of the study is only confined to the index futures, and further research is needed to extend the scope of the study to other derivatives such as warrants and options.

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