

## 4 Empirical Results

To examine the impact of the introduction of TTT, we examine ten liquidity proxies in the two separated periods, from May 2, 2003 to June 27, 2003 for the pre-introduction period, and from July 1, 2003 to August 25, 2003 for the post-introduction period. We begin an analysis of the changes in liquidity measures for the underlying stocks. Five liquidity measures are analyzed in terms of trading activity: trading volume, trade frequency, trade size, standardized volume and standard deviation of daily returns. We then analyze changes in spreads for the underlying stocks and five types of spreads are applied: quoted spread, effective spread, percentage quoted spread, percentage effective spread, and spread in terms of the number of tick size. Finally, we use Lin et al.'s (1995) to decompose the effective spread and analyze changes in spread components for the underlying stocks.

### 4.1 Changes in Liquidity Measures for the Underlying Stocks

Panel A of Table 4.1 reports the mean (median) values for daily trading volume, trade frequency, and trade size both in the pre-TTT and the post-TTT periods. The mean (median) values of Post/Pre ratio for each liquidity measure are reported as well. From panel A of Table 4.1, we observe that trading volume, trade frequency and trade size all significantly increase in the post-TTT period. The mean (median) of trading volume (in 1000 shares) increases by 38% (17%) from 18981.84 (11522.46) to 26216.63 (13425.6). 83% of the Taiwan 50 Index constituents experience an increase in trading volume. The mean (median) value of the Post/Pre ratio for trading volume is 1.3242 (1.2888) and both the  $t$ -test ( $t = 5.4099$ ) and sign test ( $z = 4.2758$ ) are highly significant. Trade frequency also experiences an increase. The mean (median)

trade frequency grows 4% (5%) from 332.50 (344.15) to 347.09 (360.68). This increase is statistically significant since the standard  $t$ -test presents a  $t$ -value of 4.5011 and the sign test shows a  $z$ -value of 3.4286. Most of the underlying stocks, totally 76%, experience an increase in trade frequency.

Similar results are also found in trade size. The mean (median) value of trade size significantly increases from 55.48 (35.63) to 79.45 (38.41) with a  $t$ -value of 4.8277 and a  $z$ -value of 3.5008. The corresponding mean (median) Post/Pre ratio is 1.2947 (1.2851) and 77% of the component stocks have Post/Pre ratios greater than unity. The increase in trade size is quite reasonable. Since the percentage increment in trading volume (38%) is larger than that of trade frequency (4%), this phenomenon leads to the increased trade size.

To ensure that the increase in trading activity is caused by the introduction of TTT, we compute the standardized volume to take the market-wide factor into consideration. Standardized volume is defined as the trading volume in shares for each underlying security divided by the total TSEC volume for the day. From panel A of Table 4.1, we observe that the standardized volume demonstrates an opposite result. The mean (median) of standardized volume decreases from 0.62% (0.39%) to 0.57% (0.27%). The  $t$ -test ( $t = -3.5015$ ) and sign test ( $z = -3.5008$ ) show that the decline is highly significant at 1% level.

As for return volatility, its mean (median) value increases to 2.3583 (2.3748) after the introduction of TTT. The corresponding mean (median) Post/Pre ratios is 1.1966 (1.1942) and 82% of the component stocks have Post/Pre ratios greater than unity. The increase in volatility is highly significant using either the  $t$ -test ( $t = 5.7490$ ) or sign test ( $z = 4.2857$ ). According to Kyle model (1985), the expected profit of the insider increases when the security's variance is larger. Hence, the increased return volatility suggests that the liquidity of the component stocks worsens

because of insiders' superior information.

In the analysis of trading activity, five liquidity proxies demonstrate different patterns. Both trading volume and trade frequency suggest the underlying stocks are more actively traded after the introduction of TTT. However, after we consider the market-wide factor, the standardized volume shows that the component stocks are inactively traded relative to the overall listed stocks in the post-TTT period. We can't rule out the possibility that generally, the Taiwan stock market experiences better performance in the post-TTT period than in the pre-TTT period and active trading commonly exists in every listed security. Specifically, two external shocks including Iraq crisis and the outbreak of Severe Acute Respiratory Syndrome (SARS) epidemic hammered global markets in the pre-TTT period. The United States, together with a few other countries, launched a war against Iraq on March 20, 2003 which had a negative macroeconomic impact on global stock markets. Furthermore, the SARS outbreak in spring 2003 also negatively caused macroeconomic influence on global environment. The Taiwan stock market was affected by these two macroeconomic factors as well and experienced a bear market in the pre-TTT period relative to the post-TTT period. Therefore, after taking the market-wide factors, we suggest that the standardized volume is a more reliable indicator compared with the trading volume when it comes to the analysis of trading activity. Both the standardized volume and the return volatility imply that the liquidity of the Taiwan 50 Index constituents deteriorates after the launch of TTT.

Panel B of Table 4.1 summarizes the empirical results of the quoted spread, effective spread, percentage quoted spread, percentage effective, and spread in terms of the number of ticks. In panel B of Table 4.1, the quoted and effective spread increase significantly in the post-TTT period, indicating the liquidity of the underlying stocks deteriorates after the introduction of TTT. For instance, the mean

(median) effective spread increases from 0.1768 (0.1003) to 0.1901 (0.1005). The average effective spread increases by 0.0133. In addition, the mean (median) of the Post/Pre ratio is 1.1012 (1.0015) and 69% of the sample stocks experience an increase in effective spread. Both the  $t$ -test ( $t = 2.6327$ ) and sign test ( $z = 2.2116$ ) prove that the difference is significant. Similar result can be found in the quoted spread, the mean (median) increases from 0.1789 (0.1011) to 0.1920 (0.1014). The corresponding mean (median) of the Post/ Pre ratio is 1.0981 (1.0015) and 63% of the component stocks have Post/Pre ratios greater than 1. The  $t$ -test ( $t = 2.5867$ ) suggests that the increase is significant. This finding is consistent with that of Richie and Madura (2005).

Since spreads may vary in different price level, we take this factor into consideration by examining the percentage quoted spread and the percentage effective spread. From panel B of Table 4.1, we can see a small decline in these two spreads. For example, the percentage quoted spread decreases from 0.4489% (0.4389%) to 0.4298% (0.4071%). This change is significant under the sign test ( $z = 2.2116$ ); however, the  $t$ -test ( $t = -0.8191$ ) does not provide a supportive evidence. Similarly, the percentage effective spread decreases from 0.4446% (0.4352%) to 0.4266% (0.4051%). However, the  $t$ -test ( $t = -0.7162$ ) is insignificant.

We observe that in our sample period, some of the underlying stocks experience the adjustments in tick sizes due to variations in price level. Stock price with smaller minimum increments, or tick sizes, tends to have narrower spreads. To ensure that our investigation of spread for the component stocks are on the same basis, we now turn to the last spread measure, spread in terms of numbers of ticks. As we can see from the last column of panel B of Table 4.1, the  $t$ -test ( $t = -0.5354$ ) is insignificant and the sign test ( $z = -0.4423$ ) is not significant, either. Only 46% of the underlying stocks experience an increase in spread while 54% of the underlying stocks

experience a decrease in spread. It is almost fifty-fifty.

To investigate how spread in terms of the number of ticks changes after the introduction of TTT, we further look into the distribution of the numbers of ticks for the component stocks. Table 4.2 presents the distribution of the number of ticks for the component stocks both in the pre-TTT and post-TTT periods. As we can see from Table 4.2, generally, there is 1 tick size of spread between the ask price and the bid price for the component stocks in the pre-TTT period. More than 95% of the spreads tend to cluster around 1 tick size for each component stock prior to the launch of TTT. As we turn to the distribution of the number of ticks for the post-TTT period, similar results can be found after the introduction of TTT. Still, more than 95% of the spreads congregate around 1 tick size for each component stock in the post-TTT period; specifically, the percentage of the post-TTT period is even higher than that of the pre-TTT period. Hence, spreads in terms of numbers of ticks for component stocks do not experience drastic changes after the launch of TTT. The analysis of the distribution of the numbers of ticks supports our previous findings of the statistic tests for spread in terms of number of ticks.

These five spread measures present different patterns when we take different factors into consideration. Still, we are not able to obtain a consistent result although the change in the quoted and effective spread suggests deterioration in the liquidity of the underlying stocks. Therefore, we can't rule out the possibility that the changes in spreads are not completely caused by the launch of TTT. Moreover, these inconsistent results also lead to the skepticism about the applicability of spreads in Taiwan security market where the ask price and the bid price do not actually exist.

**Table 4.1: Changes in Liquidity Measures for the Underlying Stocks**

This table reports trading activity measures (Panel A) and spread measured (Panel B) for the underlying stocks of the Taiwan 50 Index.

Panel A reports trading activity measured for the underlying stocks of the Taiwan 50 Index over the 40 trading days prior to and after the introduction of the TTT on June 30, 2003. Trade frequency is the number of trades per day. Transaction size is defined as the number of shares purchased/sold in a transaction. Standardized trading volume is defined as the trading volume in shares for each underlying security divided by the total TSEC volume for the day. Volatility is the average standard deviation of daily return. The Post/Pre ratio is defined as the mean value of trading activity in the post-TTT period divided by the corresponding mean value in the pre-TTT period. Portion means the percent of 49 underlying stocks. A standard  $t$ -test is used to test that the mean of the Post/Pre ratio equals to 1. A standard sign test is used to test that the median Post/Pre ratio is unchanged.

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**Panel A: Trading activity measures for the underlying stocks**

	Trading volume (1000 shares)		Trade Frequency	Trade Size	Std. Trading Volume	Volatility (%)
Pre-TTT mean	18981.84	332.50	55.48	0.62%	2.0176	
Pre-TTT median	11522.46	344.15	35.63	0.39%	1.9123	
Pre-TTT S.D.	18706.57	47.88	49.73	0.58%	0.6078	
Post-TTT mean	26216.63	347.09	79.45	0.57%	2.3583	
Post-TTT median	13425.61	360.68	38.41	0.27%	2.3748	
Post-TTT S.D.	32790.56	43.57	100.38	0.75%	0.6632	
Post/Pre ratio						
Mean	1.3242	1.0495	1.2947	0.8369	1.1966	
Median	1.2888	1.0458	1.2851	0.7761	1.1942	
S.D.	0.4064	0.0770	0.4185	0.3193	0.2394	
Ratio >1.0 (%)	83%	76%	77%	23%	82%	
$t$ -test	5.4099***	4.5011***	4.8277***	-3.5015***	5.7490***	
$p$ -value	0.0000***	0.0000***	0.0000***	0.0010***	0.0000***	
Sign test	4.2758***	3.4286***	3.5008***	-3.5008***	4.2857***	
$p$ -value	0.0000***	0.0006***	0.0005***	0.0005***	0.0000***	

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\*\*\*, \*\*, and \* indicate significance at 1%, 5% and 10 % respectively, in a two-tailed test.

Panel B reports spread measures for the underlying stocks of the Taiwan 50 Index over 40 trading days prior to and after the introduction of the TTT on June 30, 2003. Quoted spread is defined as the difference between the ask and bid price. Effective spread is defined as the two times absolute difference between transaction price and the midpoint of the bid-ask prices. Percentage quoted spread is the ratio of the quoted spread to the midpoint of the ask and bid price. Percentage effective spread is the ratio of the effective spread to the midpoint of the ask and bid price. Numbers of tick size is defined as the quoted spread divided by the tick size. The Post/Pre ratio is defined as the mean value of each spread measure in the post-TTT period divided by the corresponding mean value in the pre-TTT period. Portion means the percent of 49 underlying stocks. A standard  $t$ -test is used to test that the mean of the Post/Pre ratio is unchanged and a standard sign test is used to test that the median Post/Pre ratio is equal to 1.

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**Panel B: Spread measures for the underlying stocks**

	Quoted Spread (\$)	Effective Spread (\$)	Percentage Quoted Spread (%)	Percentage Effective Spread (%)	Numbers of tick size
Pre-TTT mean	0.1789	0.1768	0.4489%	0.4446%	1.0188
Pre-TTT median	0.1011	0.1003	0.4389%	0.4352%	1.0096
Pre-TTT S.D.	0.1931	0.1902	0.1502%	0.1515%	0.0259
Post-TTT mean	0.1920	0.1901	0.4298%	0.4266%	1.0180
Post-TTT median	0.1014	0.1005	0.4071%	0.4051%	1.0086
Post-TTT S.D.	0.2022	0.1990	0.1494%	0.1502%	0.0244
Post/Pre ratio					
Mean	1.0981	1.1012	0.9742	0.9771	0.9993
Median	1.0015	1.0015	0.9578	0.9590	0.9998
S.D.	0.2573	0.2606	0.2137	0.2172	0.0083
Ratio >1.0 (%)	63%	69%	33%	33%	46%
$t$ -test	2.5867**	2.6327**	-0.8191	-0.7162	-0.5354
$p$ -value	0.0130**	0.0116**	0.4170	0.4776	0.5950
Sign test	1.3270	2.2116**	-2.8014***	-2.8014***	-0.4423
$p$ -value	0.1845	0.0270**	0.0051***	0.0051***	0.6583

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\*\*\*, \*\*, and \* indicate significance at 1%, 5% and 10 % respectively, in a two-tailed test.

**Table 4.2: Distribution of the Number of Ticks**

Constituent Name	Sample Period	Number of Ticks			
		1	2	3	≥4
AU Optronics	Post	99.82%	0.17%	0.01%	0.01%
	Pre	99.93%	0.07%	0.00%	0.00%
Acer	Post	97.77%	1.95%	0.20%	0.08%
	Pre	96.93%	2.88%	0.18%	0.01%
Advanced Semiconductor	Post	99.18%	0.82%	0.01%	0.00%
	Pre	99.44%	0.56%	0.00%	0.00%
Asustek Computer Inc	Post	99.20%	0.75%	0.06%	0.00%
	Pre	99.69%	0.31%	0.00%	0.00%
Benq	Post	99.07%	0.90%	0.03%	0.01%
	Pre	99.09%	0.90%	0.01%	0.01%
Cathay Financial Holding	Post	97.59%	2.14%	0.23%	0.05%
	Pre	95.81%	3.93%	0.22%	0.04%
Chang Hwa Bank	Post	99.52%	0.48%	0.00%	0.00%
	Pre	97.58%	2.40%	0.02%	0.00%
Cheng Shin Rubber Industry	Post	93.59%	5.79%	0.53%	0.09%
	Pre	92.01%	7.07%	0.78%	0.15%
Chi Mei Optoelectronics	Post	99.26%	0.69%	0.03%	0.01%
	Pre	97.01%	2.90%	0.09%	0.00%
China Airlines	Post	88.73%	10.43%	0.76%	0.08%
	Pre	88.85%	10.25%	0.71%	0.20%
China Development Financial Holdings	Post	98.83%	1.17%	0.00%	0.00%
	Pre	98.98%	1.02%	0.00%	0.00%
China Motor	Post	99.83%	0.17%	0.00%	0.00%
	Pre	99.77%	0.23%	0.00%	0.00%
China Steel	Post	99.94%	0.06%	0.00%	0.00%
	Pre	99.93%	0.07%	0.00%	0.00%
Chinatrust Financial Holding	Post	99.74%	0.26%	0.00%	0.00%
	Pre	99.70%	0.30%	0.00%	0.00%
Chunghwa Telecom	Post	98.23%	1.47%	0.27%	0.03%
	Pre	99.78%	0.22%	0.00%	0.00%
Chungwha Picture Tubes	Post	99.89%	0.11%	0.00%	0.00%
	Pre	99.45%	0.54%	0.01%	0.00%
Cmc Magnetics Corporation	Post	99.60%	0.39%	0.01%	0.00%
	Pre	99.61%	0.39%	0.00%	0.00%



Table 4.2 (continued)

Compal Electron	Post	99.26%	0.70%	0.00%	0.04%
	Pre	98.76%	1.19%	0.02%	0.03%
Delta Electronic Industrial	Post	91.44%	7.69%	0.72%	0.15%
	Pre	91.44%	7.29%	0.98%	0.29%
Evergreen Marine	Post	97.62%	2.33%	0.04%	0.01%
	Pre	97.42%	2.42%	0.16%	0.00%
Far Eastern Textile	Post	95.45%	4.46%	0.07%	0.02%
	Pre	97.65%	2.13%	0.18%	0.04%
First Financial Holding	Post	99.77%	0.23%	0.01%	0.00%
	Pre	99.08%	0.91%	0.01%	0.00%
Formosa Chemicals & Fibre	Post	98.02%	1.80%	0.16%	0.02%
	Pre	98.12%	1.82%	0.05%	0.01%
Formosa Plastics Corp	Post	97.35%	2.37%	0.27%	0.01%
	Pre	96.96%	2.86%	0.15%	0.02%
Fubon Financial Holdings	Post	98.45%	1.52%	0.04%	0.00%
	Pre	98.17%	1.81%	0.02%	0.00%
Hon Hai Precision Co.	Post	99.35%	0.65%	0.00%	0.00%
	Pre	99.01%	0.99%	0.00%	0.00%
Hua Nan Financial Holdings	Post	99.32%	0.66%	0.01%	0.01%
	Pre	99.37%	0.63%	0.00%	0.00%
Inventec Co.	Post	98.11%	1.88%	0.01%	0.00%
	Pre	98.32%	1.68%	0.01%	0.00%
Lite-On Technology	Post	98.84%	1.12%	0.04%	0.00%
	Pre	99.00%	0.96%	0.04%	0.00%
MediaTek	Post	97.44%	2.52%	0.01%	0.02%
	Pre	98.25%	1.70%	0.05%	0.00%
Mega Financial Holding	Post	99.86%	0.14%	0.00%	0.00%
	Pre	99.92%	0.08%	0.00%	0.00%
Micro-Star International	Post	99.63%	0.37%	0.00%	0.00%
	Pre	99.60%	0.40%	0.00%	0.00%
Nan Ya Plastic	Post	96.55%	3.10%	0.28%	0.07%
	Pre	97.90%	2.08%	0.01%	0.01%
Nanya Technology	Post	99.22%	0.73%	0.03%	0.02%
	Pre	99.38%	0.61%	0.01%	0.01%
Pou Chen	Post	98.76%	1.20%	0.04%	0.00%
	Pre	98.92%	1.06%	0.02%	0.00%
President Chain Store	Post	89.47%	9.16%	0.93%	0.44%

Table 4.2 (continued)

	Pre	76.93%	15.08%	4.61%	3.39%
Quanta Computer	Post	99.75%	0.25%	0.00%	0.00%
	Pre	99.56%	0.44%	0.00%	0.00%
Realtek Semiconductor	Post	99.77%	0.23%	0.00%	0.00%
	Pre	99.52%	0.48%	0.00%	0.00%
Siliconware Precision Industries	Post	98.22%	1.67%	0.08%	0.02%
	Pre	99.33%	0.67%	0.00%	0.00%
Sinopac Holdings	Post	98.32%	1.64%	0.04%	0.00%
	Pre	98.02%	1.94%	0.02%	0.02%
Sunplus Technology	Post	95.82%	3.86%	0.28%	0.04%
	Pre	92.92%	6.41%	0.57%	0.10%
Taishin Financial Holdings	Post	99.15%	0.85%	0.00%	0.00%
	Pre	99.41%	0.59%	0.00%	0.00%
Taiwan Cellular	Post	99.18%	0.81%	0.01%	0.00%
	Pre	99.16%	0.84%	0.00%	0.00%
Taiwan Semiconductor	Post	99.98%	0.02%	0.00%	0.00%
	Pre	99.93%	0.07%	0.00%	0.00%
Uni-president Enterprises	Post	96.63%	3.31%	0.06%	0.00%
	Pre	95.84%	4.04%	0.11%	0.01%
United Microelectronics	Post	99.97%	0.03%	0.00%	0.00%
	Pre	99.97%	0.03%	0.00%	0.00%
Via Technologies	Post	99.73%	0.27%	0.01%	0.00%
	Pre	97.11%	2.73%	0.13%	0.03%
Winbond Electronics	Post	99.79%	0.20%	0.01%	0.00%
	Pre	99.35%	0.65%	0.01%	0.00%
Yulon Motor Co.	Post	97.98%	1.97%	0.04%	0.01%
	Pre	98.53%	1.44%	0.02%	0.01%

## 4.2 Changes in Spread Components for the Underlying Stocks

Table 4.3 contains the spread components obtained from Lin, Sanger and Booth's model (1995). The three spread components are estimated as fractions of the effective spread. From Table 4.3, we observe that the asymmetric information cost of transacting increases upon the introduction of the TTT. For instance, the mean

(median) adverse selection cost increases by 12% (2%) from 0.3352 (0.3180) to 0.3752 (0.3244) in the post-TTT period. The mean (median) of the Post/Pre ratio is 1.1598 (1.0844) and 63% of the component stocks have Post/Pre ratios greater than 1. The increase is significant using either  $t$ -test ( $t = 2.4661$ ) or sign test ( $z = 1.7143$ ). This result is consistent with Subrahmanyam's (1991) hypothesis that creation of basket securities tends to increase informational asymmetry in the stock market and leads to worse market liquidity of underlying stocks. In addition, our finding is similar to that of Jegadeesh and Subrahmanyam (1993).

On the contrary, the other component of transaction costs, the order processing cost, shows a small decrease, roughly 6%. The mean order processing cost decreases from 0.4252 (0.4297) to 0.4009 (0.4323) after the launch of TTT. The mean (median) value of the Post/Pre ratio is 0.9670 (0.9437). The  $t$ -test ( $t = -1.7050$ ) shows that the decrease in the order processing cost weakly significant at 10% level while the sign test ( $z = -0.8752$ ) does not show a significant evidence. Only 57% of the underlying constituents experience a decrease in the order processing cost. It is well established that an increase in trade size is expected to contribute to a decrease in order processing cost because the fixed-cost component is spread over more shares for large trades. Thus, our result that a decline in the order processing cost is logical since we find significant evidence that the trade size increases following the TTT introduction (see Table 4.1). This finding is consistent with previous study in which the order processing cost was found to decline as trade size increases (Lin, Sanger, and Booth 1995)). Finally, the change in order persistent component for the underlying stocks is slight, approximately a decrease of 4%. However,  $t$ -test ( $t = -1.4916$ ) indicates that the decrease in the order persistent is insignificant while the sign test ( $z = -1.8764$ ) suggests a weak evidence.

In the analysis of changes in spread components, we find that there is an increase

in the adverse selection cost while there is a decrease in the order processing cost. Since the percentage increment of the adverse selection cost (12%) is greater than that of the order processing cost (6%), the overall transaction cost becomes higher following the introduction of TTT. This result suggests that the widening effective spread of the underlying stocks is mainly caused by the increase in the adverse selection cost. Hence, the liquidity for the underlying stocks deteriorates after the introduction of TTT due to more severe adverse selection problem. Furthermore, the order processing cost is the major component of the effective spread although it slightly decreases in the post-TTT period. It is clearly demonstrated that the average order processing cost (0.4009) outweighs the average adverse selection cost (0.3752) and the average order persistent (0.2406).

**Table 4.3: Changes in Spread Components for the Underlying Stock**

The sample period is the 40 trading days before and after the introduction of the TTT on June 30, 2003. Components of the effective spread are estimated by using the Lin et al.'s (1995) model.  $\lambda$  measures the adverse selection component of the effective spread,  $\gamma$  reflects the order processing component and  $\theta$  denotes the order persistent component. The Post/Pre ratio is defined as spread component under consideration in the post-TTT period divided by the corresponding value in the pre-TTT period. Portion means the percent of 49 underlying stocks. A standard  $t$ -test is used to test that the mean of the Post/Pre ratio is unchanged and a standard sign test is used to test that the median Post/Pre ratio is equal to 1.

	Adverse Selection ( $\lambda$ )	Order Processing ( $\gamma$ )	Order Persist ( $\theta$ )
Pre-TTT mean	0.3352	0.4252	0.2503
Pre-TTT median	0.3180	0.4297	0.2403
Pre-TTT S.D.	0.1321	0.0925	0.0456
Post-TTT mean	0.3752	0.4009	0.2406
Post-TTT median	0.3244	0.4323	0.2380
Post-TTT S.D.	0.1916	0.1365	0.0508
Post/Pre ratio			
Mean	1.1598	0.9220	0.9670
Median	1.0844	0.9622	0.9437
S.D.	0.4537	0.3135	0.1533
Ratio >1.0 (%)	63%	43%	35%
$t$ -test	2.4661**	-1.7050*	-1.4916
$p$ -value	0.0173**	0.0949*	0.1425
Sign test	1.7143*	-0.8752	-1.8764*
$p$ -value	0.0865*	0.3815	0.0606*

\*\*\*, \*\*, and \* indicate significance at 1%, 5% and 10 % respectively, in a two-tailed test.