3 Data, Liquidity Measures, and Methodology

3.1 Sample Selection and Data Description

The data used in this paper are taken from the Taiwan Economic Journal database. The sample period starts from May 2, 2003 to August 25, 2003. Originally, there are 50 underlying stocks of the TTT. However, we observe that one of the initial component stocks, Macronix International, was replaced shortly after the launch of TTT.[7] Since it did not fully exist in our sample period, we exclude it from our analysis sample. The final sample contains 49 stocks in total. Appendix shows a constituent list of the component stocks analyzed in this study.

In order to ensure the integrity of the dataset, a number of filters are applied to the intraday data. We examine only trades executed on the TSEC from 9:05 a.m. to 1:25 a.m. Any transaction occurred in the span of the first 5 minutes after the TSEC opening is excluded in order to minimize the opening effects due to overnight news arrival. The last transaction is discarded as well because the market closes with another call auction preceded by a 5-minute pre-closing period.

In addition, transactions with no unexecuted limit buy orders or no unexecuted limit sell orders are eliminated since we are unable to compute bid-ask spreads in either cases.[8] The data on TTT index component securities in the sample period contains 1,331,996 trades in total. The number of trade observations per security ranges from a high of 31,058 for Taiwan Semiconductor Manufacturing Co., Ltd. to a low of 13,215 for President Chain Store Corporation.

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[7] On July 10, 2003, TSEC Taiwan 50 Index Committee announced that Macronix International Co., Ltd. would be replaced by Ritek Corporation. This change to the TSEC Taiwan 50 Index became effective after the close of business on Friday, 18 July 2003 (i.e. on Monday, 21 July 2003).

[8] Definitions of spreads are presented in Section 3.2.

Figure 3.1: Rolling Correlation Coefficients of Daily Trading Volume between the TTT and the Equally Weighed Portfolio of the Underlying Stocks upon the Introduction of TTT

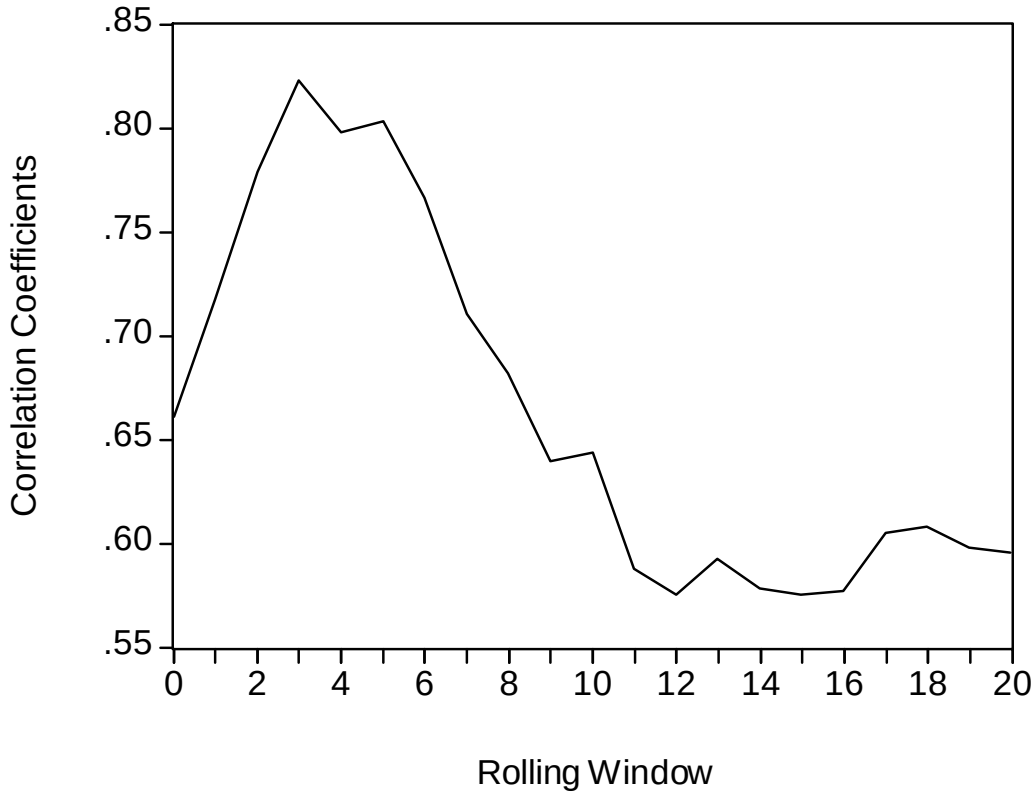
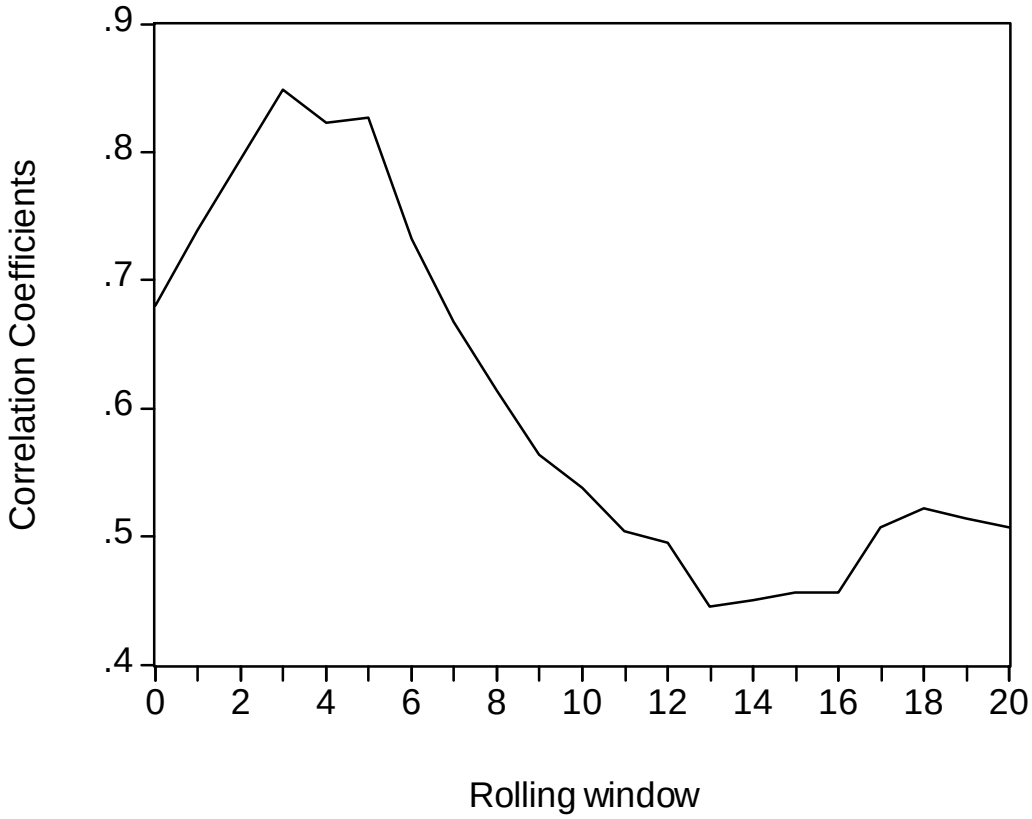


Figure 3.2: Rolling Correlation Coefficients of Daily Trading Volume between the TTT and the FTSE-Weighed Portfolio of the Underlying Stocks upon the Introduction of TTT



We adopt event study in this research; therefore, the sample is divided into two groups to examine the changes of liquidity and transaction cost components. We select a forty-day trading window for the pre- and post-introduction periods. The pre-event window is formed from May 2, 2003 to June 27, 2003 and the post-event window starts from July 1, 2003 to August 25, 2003. We choose the window period based the following reasons. Fist, the index-tracking security was actively traded upon its introduction. In the first 40 days from the trading of the TTT, average daily trading volume of TTT was 8,196,000 shares and average daily dollar volume was $333,177,000. These data implies that the liquidity effects could be realized within the first 40-day trading period. Second, the data of daily trading volume of the TTT and its underlying stocks are highly correlated in the fist 40 days after TTT trading. To examine the correlation between the TTT and its constituents, we use the daily trading volume of the TTT and of its component securities respectively to form a rolling window of 30 transaction days.[9] Figure 3.1 shows that the rolling correlation coefficients between the TTT and the equally weighed portfolio of the underlying stocks upon the introduction of the TTT. The correlation coefficient has increased after the listing of TTT and peaks at 0.85 followed by a declining trend until the end of the 12th rolling window. Similarly, we can observe the consist pattern in Figure 3.2 which presents the rolling correlation coefficients between the TTT and the FTSE-weighted portfolio of the underlying stocks upon the introduction of the TTT.[10]

[9] To form a rolling window, we select 30 transaction days as the window period from the listing day of TTT. This window then moves forward to form another rolling window with the same window period of 30 trading days.

[10] We use the underlying stocks to form an equally weighted portfolio as well as a FTSE-weighted portfolio. For the FTSE-weighted portfolio, the individual weight of each stock in the Taiwan 50 Index is calculated by FTSE. We assign the weight to each stock to form the matching portfolio. The historical daily constitute lists are not easily accessible; thus, we adjust the weight of each stock according the significant events announced by the TSEC committee during our sample period. We

What we observe from these two figures implies that the TTT and its underlying stocks are highly correlated in the fist 40 trading days after TTT trading. Finally, a shorter window period minimizes the possibility that other events confound our analysis.

Table 3.1 contains descriptive statistics for our sample of 49 stocks. This table reports market capitalization, price per share, and turnover of our sample. The market capitalization shows that generally, the component stocks have high market values in both periods. The market capitalization has increases after the listing of the TTT. Market capitalization averages $139,070 million for all firms in the post-introduction. The smallest firm in our sample has a market value of $32,315 million after the introduction of the TTT while the largest has a value of $1,089,439 million. As for share price, in the pre-introduction period, it ranges from a minimum of $9.87 to a maximum of $186.10, with a mean (median) value of $32.74 ($24.90). Further, stock prices of our sample have increased following the creation of the TTT. In the post-introduction period, the mean (median) value of share price is $38.98 ($31.94), with a minimum of $11.29 and a maximum of $238.01. Similar results can be observed in turnover. The mean (median) value increases from 0.7369% (0.5131%) to 1.0596% (0.7515%), the minimum value increases slightly from 0.0623% to 0.0763% and the maximum value increases from 2.3277% to 4.8593%. These sample stocks are more actively traded after the introduction of TTT.

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made a request to FTSE for 3 free constitute lists. Weights of each stock from the 3 constituent lists are presented in Appendix.

Table 3.1: Summary Statistics for Taiwan 50 Stocks

Time period is the 40 trading days before and after the introduction of the TTT on June 30, 2003. Market capitalization is the market value of equity on the first day of the pre-TTT period and on the first day of the post-TTT period. Price is the average daily closing stock price in the pre-TTT and post-TTT period. Turnover is defined as the average ratio of the shares traded on a day to outstanding shares at the end of the day in the pre-TTT and post-TTT period.

	Sample Period	Mean	Median	Standard Deviation	Maximum	Minimum
Market Capitalization (in millions)	Post	139070	82770	169769	1089439	32315
	Pre	117954	61675	146485	899485	25018
Price	Post	38.98	31.94	34.99	238.01	11.29
	Pre	32.74	24.90	27.48	186.10	9.87
Turnover Rate (%)	Post	1.0596	0.7515	1.0296	4.8593	0.0763
	Pre	0.7369	0.5131	0.5790	2.3277	0.0623

3.2 Definitions of Liquidity Measures

Previous studies use numerous indicators to measure the liquidity of a market, which may display similar or different patterns. Throughout this paper, we use the trading volume, trade frequency, trade size, standardized trading volume, volatility, and bid-ask spreads as different proxies for liquidity in this paper. These measures are used by Hedge and McDermott (2004) to study the liquidity effects of basket securities. Kumar, Sarin, and Shastri (1998) use similar measures to examine the impact of options trading on market quality.

1. Trading volume, trade frequency, trade size and standardized trading volume

Liquidity is positively related to the trading volume or trade frequency. In this paper, we analyze trading volume, trade frequency, trade size and standardized

trading volume to study the liquidity effects of TTT trading on its underlying stocks. Trading volume and trade frequency are defined as the average of each trading day. Trade size is measured as the average number of shares purchased or 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.

2. Volatility

Volatility reflects liquidity because thin, speculative markets are more volatile than deep ones (Cohen et al., 1976). According to Kyle (1985), the expected profit of the insider increases when the security's variance is larger. Gorton and Pennacchi (1993) indicate that the larger is the security's variance, the greater is the value of the insider's superior information. Currently, some scholars have associated volatility with liquidity in their empirical studies on liquidity effects of basket trading (Jegadeesh and Subrahmanyam, 1993; Hedge and McDermott, 2004). Thus, we examine the changes in volatility of underlying stocks. Volatility is measured as the standard deviation of daily close-to-close returns of each underlying stocks.

3. Quoted spread

$$QS_{i,t} = LS_{i,t} - HB_{i,t}, \quad i = 1,2,3,...,49, \quad t = 1,2,3,...,n. \tag{3.1}$$

In an order-driven market, such as the Stock Exchange of Hong Kong or the Tokyo Stock Exchange, all liquidity is provided to a market by public limit orders submitted by buyers and sellers. Limit orders establish the bid-ask spread which is regarded as a part of the transaction costs when traders desired to make

their orders executed immediately and actively. Glosten (1994) concludes that the existence of adverse selection costs generates positive bid-ask spreads in an order-driven market. Therefore, the bid-ask spread compensates for the costs of supplying immediacy.

Different bid-ask spreads are widely applied and show multidimensional market facets. The most commonly used spread is quoted spread. Following Brockman and Chung (1999), we compute the quoted spread as the difference between the lowest price of the sell limit orders among the five best unexecuted orders and the highest price of the buy limit orders among the five best unexecuted orders. Suppose investors trade security i for n times within each trading day, $HB_{i,t}$ and $LS_{i,t}$ are the prices of the highest buying and lowest selling order of a security as transaction t is executed. $QS_{i,t}$, the difference between $LS_{i,t}$ and $HB_{i,t}$ is computed as the quoted spread.

4. Effective spread

$$ES_{i,t} = 2\left|P_{i,t} - M_{i,t}\right|, \tag{3.2}$$

$$\text{where } M_{i,t} = \frac{LS_{i,t} + HB_{i,t}}{2}, \quad i = 1,2,3,...,49, \quad t = 1,2,3,...,n. \tag{3.3}$$

$P_{i,t}$ is the trade price of security i in transaction at time t and $M_{i,t}$ is the midpoint of prevailing LS and HB.

5. Percentage quoted spread

$$\%QS_{i,t} = \frac{LS_{i,t} - HB_{i,t}}{M_{i,t}} \times 100\%, \qquad i = 1,2,3,...,49, \quad t = 1,2,3,...,n. \qquad (3.4)$$

6. Percentage effective spread

$$\%ES_{i,t} = \frac{2\left|P_{i,t} - M_{i,t}\right|}{M_{i,t}} \times 100\%, \quad i = 1,2,3,...,49, \quad t = 1,2,3,...,n. \qquad (3.5)$$

7. Spread in terms of the number of ticks

Prices of all stocks move in minimum increments, or tick sizes. Tick sizes vary in different price level. Therefore, the tick size may vary from stock to stock and may change over time for the same stock. Zivot (2005) suggests that price change can be measured by the change in terms of the number of ticks. We use this proxy as well to measure the spread between the lowest price of the sell limit orders among the five best unexecuted orders (LS) and the highest price of the buy limit orders among the five best unexecuted orders (HB). This measure ensures that our analysis of spread for the underlying stocks is on the same basis.

3.3 Methodology

3.3.1 Bid-Ask Spread Decomposition Model

Suggested in the finance literature, the bid-ask spread is mainly made up of three trading-related costs: adverse selection cost, order processing cost, and inventory holding cost due to risk aversion. An adverse selection cost is due to asymmetric information and informed traders. The market maker includes an adverse selection cost in the spread to compensate for his expected losses resulting from trading with

informed traders. As for order processing cost, it is composed of exchange and clearing fees, bookkeeping and back office costs, the market maker's time and effort, and other costs of doing business. It is a fixed cost. Finally, the inventory holding cost results from the order-flow imbalances. The market maker is obliged to hold inventories to equilibrate the imbalanced order-flows. Thus, he bears a risk that his inventory position may deviate from the optimal level.

Theories about bid-ask spread decomposition models have been well developed. Generally, spread decomposition models can be grouped into two categories: the three-way decomposition models and the two-way decomposition models. Three-way decomposition models identify order-processing cost, inventory holding cost, and adverse selection cost as spread components (Stoll, 1989; Huang and Stoll, 1997). On the other hand, two-way decomposition models, the bid-ask spread is decomposed into order processing cost and adverse selection cost (Glosten and Harris, 1988; George, Nimalendran, and Kaul, 1991; Lin, Sanger, and Booth, 1995; Madhavan, Richardson, and Roomans, 1995; Huang and Stoll, 1997). Inventory holding cost is combined with the order processing cost in Glosten and Harris's model (1988) and Madhavan, Richardson, and Roomans (1995) while it is combined with the adverse selection cost in Huang and Stoll's model (1997). Furthermore, the inventory cost is not taken into consideration in George, Nimalendran, and Kaul (1991), Lin, Sanger, and Booth (1995), as well as Madhavan, Richardson, and Roomans (1995).

Majois and Winne (2003) suggest that in order-driven markets, the inventory holding cost may not account for the bid-ask spread; instead, the adverse selection cost and order processing cost are the major spread components because there is no liquidity suppliers obliged to equilibrate the imbalanced order-flows. Hence, two-way decomposition model may provide better estimation of spread components for order-driven trading markets. In this paper, we use Lin, Sanger and Booth's model

(1995) to study the spread components of the underlying stocks of TTT since those underlying stocks of TTT are traded in the order-driven Taiwan Stock market.

In this paper, we adopt Lin et al. (1995) where three parameters are estimated: the order processing cost(γ), the adverse selection cost(λ), and the order persistence(θ). These parameters can be estimated by using the following regression models:

$$M_{t+1} - M_t = \lambda z_t + e_{t+1}, \tag{3.6}$$

$$z_{t+1} = \theta z_t + \eta_{t+1}, \tag{3.7}$$

$$P_{t+1} - P_t = -\gamma z_t + u_{t+1}, \tag{3.8}$$

where M_t is the bid-ask spread midpoint (in logarithms) at time t (i.e. $M_t = \frac{A_t + B_t}{2}$), P_t is the transaction price (in logarithms) at time t, z_t is the difference between P_t and M_t (i.e. $z_t = P_t - M_t$), and z_t is one half the signed effective spread with $z_t > 0$ for a buy order and $z_t < 0$ for a sell order. In equations (3.6) and (3.7), the disturbance terms e_{t+1} and η_{t+1} are assumed to be uncorrelated.

First of all, we estimate the order persistent component, θ, which can be obtained from equation (3.7). Order persistent reflects order arrivals. It measures the probability that a buy order following a buy order, or that a sell order following a sell order. From equation (3.7), we can observe that z_t, the independent variable of equation (3.6), displays first order autocorrelation. The basic assumptions of Ordinary Linear Squares (OLS) are violated. Therefore, we use instrumental variables regression to estimate the parameter λ, the adverse selection component, by

choosing the one-period lagged independent variable, z_{t-1} as the instrument variable. Finally, γ, the order processing component can be obtained from equation (3.8). Given equation (3.6) and (3.7), equation (3.8) holds where $u_{t+1} = e_{t+1} + \eta_{t+1}$ and where $\gamma = 1 - \lambda - \theta$. Equation (3.8) indicates the market maker's gross profit, the cost of order processing, as a fraction of the effective spread.

3.3.2 Mean Test and Median Test

To investigate the impact of TTT listing on its underlying stocks, we examine changes of liquidity measures and spread components in both the pre-and post-introduction periods. Means (median) of alternative liquidity variables are calculated for each stock i in both the pre and post-TTT periods. r_i is the ratio of the mean (median) value of the liquidity variable under consideration in the post-introduction period divided by the corresponding mean (median) values in the pre-introduction period. A Post/Pre ratio is computed as follows:

$$r_i = \frac{\overline{L}_{i,post}}{\overline{L}_{i,pre}}, \qquad i = 1,2,3,...,49. \tag{3.9}$$

where $\overline{L}_{i,post}$ is the mean (median) of a liquidity variable in the post-TTT periods and $\overline{L}_{i,pre}$ is the mean (median) of a liquidity variable in the pre-TTT period.

If the ratio is greater than 1, then it implies that there is an increase in the liquidity variable over time. To examine whether there is difference in liquidity measures for the Taiwan 50 Index underlying stocks after the creation of TTT, we use the standard t-test to test, for each variable, the null hypothesis that the mean of the Post/Pre ratio (r) is equal to 1. In addition, a sign test is used to test that the median of the Post/Pre ratio (r) is unchanged.

The Hypotheses of the mean test are demonstrated as follows:

$$H_0 : mean(r) = 1 \tag{3.10}$$

$$H_1 : mean(r) \neq 1 \tag{3.11}$$

where $r \equiv \{r_i\}, \qquad i = 1,2,3,...,49.$

The Hypotheses of the median test are demonstrated as follows:

$$H_0 : median(r) = 1 \tag{3.12}$$

$$H_1 : median(r) \neq 1 \tag{3.13}$$

where $r \equiv \{r_i\}, \qquad i = 1,2,3,...,49.$