The Comparison of Trading Costs between Two Markets: KOSPI and KOSDAQ

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ABSTRACT

We apply the pair sample method of Huang and Stoll (1996) to the Korea Exchange (KRX) so as to compare the trading costs of KOSPI and KOSDAQ stocks. The Korea Exchange have two trading places for listed stocks, which are KOSPI vs KOSDAQ, with the same trading mechanisms, i.e., the order-driven trading mechanism. Provided that we follow the pair sample method of Huang and Stoll (1996), we expect similar trading costs between KOSPI and KOSDAQ. One reason for this is that Huang and Stoll (1996) presumes that only trading mechanism under their pair sample does affect the difference in trading costs. Another reason is that KOSPI and KOSDAQ have the same trading mechanism. We found out that percent price impact costs are the same between KOSPI and KOSDAQ. Meanwhile, percent quoted and realized spreads show difference between KOSPI and KOSDAQ. In a further investigation of the intraday 30-minute time-interval trading costs, we found out that the average percent price impact costs were similar between KOSPI and KOSDAQ, while median percent price impact costs were different.

Keywords: Order-driven market, Trading cost, Price impact cost, Pair sample method

I. Introduction

In this study, we will compare the trading costs from KOSPI stocks and their matched KOSDAQ stocks. Both the KOSPI and KOSDAQ stocks are traded on the same mechanism, the order-driven auction mechanism. This particular trading mechanism is different from quote-driven trading mechanism, whose examples are the NYSE specialist trading system and NASDAQ dealer trading system. Meanwhile, Huang and Stoll (1996) examined the difference in trading costs between the NYSE specialist and NASDAQ dealer trading systems. Thus, if we can construct KOSPI samples and their matched KOSDAQ pairs by following the sample construction method of Huang and Stoll (1996), then we will be able to confirm that the difference in trading costs between KOSPI and KOSDAQ holds in the environment of order-driven trading system.

Trading costs have had significant influence on several topics in the finance literature such as securities returns (Amihud and Mendelson (1987)), liquidity (Amihud and Mendelson (1986)), corporate payout policy (Banerjee, Gatchev, and Spindt (2007)), etc.
Some examples of trading costs include quoted spread, realized spread, price impact and so on. These trading costs are measured by the actual quote data. Other examples of trading costs are estimated by economic models (George, Kaul, and Nimalendran (1991); Amihud (2002); Corwin and Schultz (2012), etc.).

Extensive research has been carried out to find out whether trading costs can differ according to trading mechanism since Amihud and Mendelson (1987). Madhavan (1992) analyzed the quote-driven and order-driven mechanisms. In the meantime, several researchers compared trading costs between the two different trading mechanisms in an empirical manner (Affleck-Graves, Hegde, and Miller (1994); Chan, Chung, and Johnson (1995); Huang and Stoll (1996); Bessembinder and Kaufman (1997a); Bessembinder and Kaufman (1997b); Bessembinder (1999); Stoll (2000), etc.).

The concern in comparing trading costs between the two different trading mechanisms is that a stock is usually traded on only one particular trading mechanism. In other words, if a stock is traded on the order-driven mechanism the stock is not usually traded on the other mechanism, which is the quote-driven mechanism. The reason is that a stock is usually listed on only a stock exchange that usually adopts a single trading mechanism. However, an exceptional case is that stock exchanges are to decide daily open and intraday trade prices. Many stock exchanges employ different trading mechanisms to decide an open trade compared to the intraday trade. Therefore, Amihud and Mendelson (1987) used the open and close prices of a stock on the New York Stock Exchange (NYSE), since the open price was decided by the call auction mechanism and the close price was determined by the continuous quote-driven mechanism.

A paired sample method is adopted when two different trading mechanisms are compared in terms of trading costs. For example, Huang and Stoll (1996) selected a paired sample from the NYSE and NASDAQ. This is because the NYSE employed a specialist system and the NASDAQ a dealer system. They exploited four firm-specific factors to select the NYSE sample stocks and matched them with NASDAQ control stocks: the daily close price, book value of equity, long-term debt and total number of shares outstanding. Huang and Stoll (1996) presumed that two stocks paired from the NYSE and NASDAQ would have the same firm-specific features affecting trading costs but different in the trading mechanisms.

For the paired sample method, one can take an advantage of KOSPI- and KOSDAQ-listed firms. The features of the firms that are listed on KOSPI (KOSDAQ) are like those of the NYSE (NASDAQ) respectively. In other words, the KOSPI-listed firms are larger size and longer aged firms than the KOSDAQ-listed firms. Most of the KOSPI-listed firms are manufacturing firms, while the KOSDAQ-listed firms include venture and technology-oriented firms.

Even though the characteristics of firms on KOSPI are different from those on KOSDAQ, stocks are traded on the same trading mechanism, an order-driven auction market that has no market-maker. Provided that the four firm-specific factors in Huang and Stoll (1996) decide the amount of trading costs, only the trading mechanism in the paired sample should affect the costs. Thus, we selected a matched pair from the KOSPI and KOSDAQ by following the sample construction method of Huang and Stoll (1996). We expected no difference in the trading costs of chosen pairs between KOSPI and KOSDAQ. This conjecture was our research question in this study.

We employed the use of two types of data, the intraday and daily data. When we analyzed the intraday data, we found out that quoted and realized spreads from the KOSPI-listed stocks were larger than those from the KOSDAQ-listed stocks. The KOSPI- and KOSDAQ-listed stocks have no difference in the percent price impact costs. This evidence suggests that the four firm-specific factors from Huang and Stoll (1996) compare price impact costs rather than the quoted and realized spreads. We also estimate daily trading costs, such as the Corwin and Schultz (2012) spread, Amihud (2002) illiquidity and George et al. (1991) spread. These estimated trading costs show different amounts between KOSPI and KOSDAQ.

The analysis of the 30 minutes time-interval trading
costs can support the finding of the daily trading costs. The percent price impact costs between KOSPI and KOSDAQ are statistically the same under the sample construction method of Huang and Stoll (1996). In addition, an average of 30 minutes time-interval dollar price impact costs are statistically the same between KOSPI and KOSDAQ.

Our results contribute to the knowledge on how a trading mechanism affects trading costs. We complement the results of Huang and Stoll (1996) in that our pair sample comes from an order-driven trading mechanism. Huang and Stoll (1996) studied the pair sample from a quote-driven trading mechanism in that a specialist trading mechanism (NYSE) and a dealer trading mechanism (NASDAQ) were both considered as quote-driven trading mechanisms.

While our data was collected from the order-driven trading mechanism, few studies have employed the use of intraday data from the order-driven trading mechanism. In this regard, the Korea Exchange (KRX) is a good experimental place that offers two trading places (KOSPI and KOSDAQ) for listed stocks and employs the same trading mechanism. Intraday quote and trade data in the Korea Exchange was available and was, thus, used to examine our hypothesis. Therefore, the Korea Exchange is a good place to complement the findings of market microstructure based on the NYSE and NASDAQ.

II. Literature Review and Methodology

A. The Comparison of Spread Measures between Markets

An important research question to answer in the market microstructure is whether trading costs depend on the trading mechanism, such as order- and quote-driven markets. Amihud and Mendelson (1987) examined how the trading mechanism of the securities affected their price behavior. Huang and Stoll (1996) compared the spreads of matched pairs between the NYSE and NASDAQ. Bessembinder and Kaufman (1997a) compared the average trade execution costs during 1994 for sets of large, medium and small capitalization stocks listed on the NYSE and NASDAQ. Bessembinder (1999), compared the trade execution costs between NASDAQ and NYSE after the adoption of SEC-mandated order-handling rules and reductions in tick sizes. Stoll (2000) examined the NYSE/AMEX and NASDAQ in terms of friction. Venkataraman (2001) compared the trade execution costs of stocks in an automated trading structure, which was Paris Bourse, and a floor-based trading structure, the NYSE. Chung and Chuwonganant (2012) found out that after the implementation of a Regulation National Market System, NASDAQ had had faster and more reliable executions than the NYSE/AMEX. Kim (2017) tested the differences of opinion models of Banerjee and Kremer (2010) and Miller (1977) with the corporate spin-off. Baek, Kim, and Yeom (2018) compared the Korea Exchange gold market and gold futures in the Chicago Mercantile Exchange (CME) in terms of price discovery. This kind of comparison method is an approach to compare two different markets, although it is not the topic of this study.

When various researchers try to answer the question of whether two markets having different trading mechanisms have the same amounts of trading costs, they are usually faced by a fundamental problem, which is how two different markets can be compared. In other words, the question is whether researchers can compare the NYSE and NASDAQ under the condition that the stocks listed on the NYSE are different from those listed on NASDAQ.

To deal with this kind of fundamental question, Huang and Stoll (1996) used a pair sample forming NYSE and NASDAQ stocks. To select pairs, Huang and Stoll (1996) exploited four firm-specific factors, which are the close price, book value of equity, long-term debt and total number of shares outstanding. Bessembinder and Kaufman (1997a) utilized the firms’ capitalizations to compare the NYSE and NASDAQ. Bessembinder (1999) selected the NYSE-listed securities by matching them to the NASDAQ stocks based on the market capitalization of stocks. Another study conducted by Bessembinder and Kaufman (1997b)
employed the cases that the NYSE-listed stocks are traded on the NYSE, NASD dealer market, and the regional stock exchanges. Stoll (2000) used 1,760 stocks listed on the NYSE/AMSE and 2,184 stocks on the NASDAQ.

Even though multiple methods have been developed to resolve this fundamental concern, there is no perfect resolution that has been devised to compare two different markets. In this paper, the paired sample method used by Huang and Stoll (1996) was employed. The reason we focused on Huang and Stoll (1996) is that if we carefully constructed a paired sample we could easily compare two different samples.

Therefore, we applied the paired sample method to the Korea stock market, which has two different trading places, the KOSPI and KOSDAQ. These two trading platforms are perfect tools to complement Huang and Stoll (1996). The reason is that KOSPI and KOSDAQ employ the same trading mechanism, i.e., an order-driven market. The only difference is the characteristics of the stocks that are traded on the KOSPI and KOSDAQ. KOSPI is more like the NYSE, while KOSDAQ is more like the NASDAQ. What we mean by this is that the KOSPI is composed of large and long-lived firms and KOSDAQ of young and venture-like firms.

B. Institutional Setting of the Korean Stock Exchange

The Korea Exchange is the only institution running the securities market in Korea. The Korea Exchange has four market divisions, which are the KOSPI, KOSDAQ, KONEX and derivatives. The KOSPI is majorly considered the place for publicly traded companies in Korea. The KOSDAQ has about 1,000 small- and medium-sized businesses and start-ups listed on it. The KOSDAQ is considered much riskier than the KOSPI. The KOSDAQ is often compared to the NASDAQ in the US. The KONEX is a trading place for pre-IPO (pre-initial public offering) stocks.

Both the KOSPI and KOSDAQ adopt a continuous order-driven auction trading mechanism. In this trading system, the lowest ask order among asks and the highest bid order among bids are matched through competition during a trading session and the execution price is set according to the price and time priorities. A continuous order-driven auction trading session lasts between 09:00 and 14:50 in the local time. The close call-auction trading mechanism is employed between 08:00 and 09:00 in the local time for the first transaction of the day. This is a pre-trading session and is not considered a regular trading session. The same close call-auction trading session occurs between 14:50 and 15:00 for the last transaction of the day and this last session is included as a regular trading hour. For further information on the trading method, visit the KRX homepage (http://global.krx.co.kr).

C. Spread measures from daily data and intraday data

The market microstructure literature employs various kinds of trading costs. However, we focused on the spread measures. The first consideration is the intraday spreads that can be measured by intraday trade and quote data, e.g., quoted, and realized spreads, and price impact costs. The second consideration is the daily estimated spreads from an economic model (George, et al. 1991; Amihud, 2002; Corwin and Schultz, 2012). These models estimate the daily trading costs with daily close, highest trade and lowest trade prices, etc. These spread measures were developed because researchers sometimes could and still cannot make easy use of the intraday trade and quote data. As a result, researchers try to obtain a proxy on the intraday actual spread.

1. Intraday spread measures

We follow the tradition of Holden and Jacobsen (2014) to compute the intraday spread measures: quoted and realized spreads, and price impact cost. This is done because SAS codes from Holden and Jacobsen (2014) are available on the website http://kelley.iu.edu/cholden/ and we could modify
their codes for our study. As Bessembinder and Kaufman (1997a) discussed, quoted spread, realized spread, and price impact would have measurement errors since we might have classified trades as buy/sell trades incorrectly. Additionally, errors would be introduced due to the use of the quote midpoint as a proxy for the pre-trade economic value. To minimize these errors, we employ and modify the SAS codes of Holden and Jacobsen (2014).

**Dollar Quoted Spread and Percent Quoted Spread**

Although Amihud and Mendelson (1986) used quoted spread as a liquidity measure, the traditional market microstructure theories (e.g., Stoll (1978)) have shown quoted spread as a simple measure for trading cost. The quoted spread in a quote-driven trading mechanism (i.e. dealer market) is composed of adverse selection, inventory and order-processing costs. The quoted spread in an order-driven trading mechanism shall not have the inventory cost since there is no dealer in an order-driven trading mechanism. Therefore, the quoted spread in an order-driven trading mechanism is considered as containing only adverse selection and order processing costs. Even though we do not know the relative proportion of adverse selection, inventory and order processing costs in the quoted spread, the largest proportion of the quoted spread in the order-driven trading mechanism will be the adverse selection costs because the recent development of technology will help reduce the order processing costs of quoted spread.

Dollar quoted spread \((\text{Dollar } QS_t)\) is defined as the difference between the lowest ask quote price \((A_t)\) and the highest bid quote price \((B_t)\) for a given time \(t\).

\[
\text{Dollar } QS_t = (A_t - B_t)
\]  

(1)

Usually, the quoted spread is always positive and the minimum tick size is the smallest quoted spread in the order-driven trading mechanism. The quoted spread represents the cost of executing a round-trip trade. Aggregating over a day, a stock’s daily dollar (percent) quoted spread is the time-weighted average of dollar (percent) quoted spread computed over all time intervals.

\[
\text{Percent } QS_t = \frac{(A_t - B_t)}{(A_t + B_t)/2}
\]  

(2)

Percent quoted spread \((\text{Percent } QS_t)\) is sometimes called the relative quoted spread. McInish and Wood (1992) used relative spread or percentage quoted spread as a preferred measure of liquidity.

**Dollar Realized Spread and Percent Realized Spread:**

Dollar realized spread \((\text{Dollar } RS_t)\) is an estimate of the gain that a market-maker can expect to make from two consecutive transactions (see De Jong and Rindi (2009) for more on spread related measures). In our study, the dollar realized spread on the \(k^{th}\) trade is defined as:

\[
\text{Dollar } RS_k = 2D_k(P_k - M_k+5)
\]  

(3)

, and the percent realized spread on the \(k^{th}\) trade \((\text{Percent } RS_k)\) is defined as;

\[
\text{Percent } RS_k = \frac{2D_k(P_k - M_k+5)}{M_k+5}
\]  

(4)

, where \(D_k\) is an indicator variable that is equal to +1 if the \(k^{th}\) trade is a buy and -1 if the \(k^{th}\) trade is a sell. \(P_k\) is the transaction price at the \(k^{th}\) trade. \(M_k+5\) is the midpoint five minutes after the midpoint \(M_k\). Aggregating over a day, a stock’s daily dollar and percent realized spreads is the dollar-volume-weighted average of dollar and percent realized spread computed over all trades in a day, respectively. The dollar realized spread is the temporary component of the dollar effective spread \((2D_k(P_k - M_k+5))\).

**Dollar price impact and percent price impact**

For any given stock, the dollar price impact \((\text{Dollar } PL_k)\) and percent price impact on the \(k^{th}\) trade \((\text{Percent } PL_k)\) are defined as;
\[
\text{Dollar } PL_h = 2D_h(M_{h+5} - M_h) \\
\text{Percent } PL_h = \frac{2D_h(M_{h+5} - M_h)}{M_h}
\]

where \( D_h \) is an indicator variable that is equal to +1 if the \( k \)th trade is a buy and -1 if the \( k \)th trade is a sell. \( M_{h+5} \) is the midpoint of the quotes reported five minutes after the \( k \)th trade \( M_h \). The dollar price impact is considered as the permanent component of the dollar effective spread \( (2D_h(P_h - M_h)) \). The price impact of a trade detects the effect that the market incorporates to the informational content of a trade by adjusting the quotes after a trade. This is possible because the informed investors continue to trade on the same side of the market and their order flow reveals their existence.

2. Daily estimated spread measures

Bid or ask prices are generated from intraday trading behavior. However, intraday bid and ask price data are not easily to obtain for most researchers and practitioners. Thus, they have developed several methods to estimate transaction costs from the daily data. One of the first study on this was that conducted by Roll (1984), where daily transaction costs could be estimated from the daily closing prices. Then George et al. (1991) extended the study conducted by Roll (1984). More recently, Corwin and Schultz (2012) estimated the daily transaction costs by employing the daily highest, lowest trade and closing prices.

**George, Kaul, and Nimalendran (1991, henceforth GKN)**

GKN showed that the Equation (7) is proved only when the daily price data are available.

\[
GKN_i = 2\sqrt{-\text{Cov}(\eta_{i,t}, \eta_{i,t-1})}
\]

where \( GKN_i \) is an estimated GKN spread for firm \( i \). \( \eta_{i,t} \) and \( \eta_{i,t-1} \) are the residuals from the regression (8).

\[
R_{i,t} = \gamma_{0,i} + \gamma_{1,i}E_{p,t} + \eta_{i,t}
\]

, where \( R_{i,t} \) is the daily return of stock \( i \) at day \( t \). \( E_{p,t} \) is the daily KOSPI return at day \( t \) to which stock \( i \) belongs. The GKN spread is employed by Nam and Park (2001) to estimate the transaction costs in the Korea Exchange.

**Amihud (2002, henceforth AIR)**

Amihud (2002) suggested an illiquidity measure \( (AIR_{i,t}) \) that could be estimated from the daily return and trading volume.

\[
AIR_{i,t} = \frac{|R_{i,t}|}{TV_{i,t}} \times 1,000,000
\]

, where \( AIR_{i,t} \) is Amihud illiquidity measure of stock \( i \) at day \( t \). \( R_{i,t} \) is the daily return of stock \( i \) at day \( t \) and \( TV_{i,t} \) is the trading volume of stock \( i \) at day \( t \).

**Corwin and Schultz (2012, henceforth CS)**

Corwin and Schultz (2012) employed the use of daily highest and lowest trade prices to estimate the daily transaction cost of stock \( i \).

\[
CS = \frac{2(e^\alpha - 1)}{1 + e^\alpha}
\]

, where CS spread is computed by the Equation (10). \( \alpha \) in the Equation (10) is computed by the Equation (11).

\[
\alpha = \sqrt{2\beta - \sqrt{\beta}} \sqrt{\frac{\lambda}{3 - 2\sqrt{2}}} - \sqrt{\frac{\lambda}{3 - 2\sqrt{2}}}
\]

, where

\[
\beta = E\left\{ \sum_{j=0}^{1} \ln \left( \frac{H_{t+j}^\alpha}{L_{t+j}^\alpha} \right) \right\}^2
\]

\[
\lambda = \left[ \ln \left( \frac{H_{t+1}^\alpha}{L_{t+1}^\alpha} \right) \right]^2
\]

In Equations (12) and (13), \( H_{t}^\alpha \) and \( L_{t}^\alpha \) are the highest and lowest trade prices at day \( t \), respectively. CS showed that their spread is working well in the
nyse. CS provides their SAS codes on the website “http://www3.nd.edu/~scorwin/” and we modified their codes for our study.

3. Huang and Stoll (1996) matching process

The matching method of Huang and Stoll (1996) has represented one of the traditional matching methods in the market microstructure area. Bacidore and Sofianos (2002), Boehmer (2005) and Battalio, Ellul, and Jennings (2007) and other researchers have made use of a similar method. The main difference between Huang and Stoll (1996) and others is the variable that is employed for the match process. Bacidore and Sofianos (2002) used market capitalization, share price and volatility; Boehmer (2005) did market capitalization, share price, adjusted daily dollar volume, and daily relative price range; Battalio et al. (2007) did market capitalization, share price, trade volume and volatility.

Huang and Stoll (1996) employed long-term debt of the NASDAQ and NYSE stocks ($LD_{i}^{NASDAQ}$, $LD_{j}^{NYSE}$), closing price of NASDAQ and NYSE stocks ($P_{i}^{NASDAQ}$, $P_{j}^{NYSE}$), shares outstanding of NASDAQ and NYSE stocks ($SO_{i}^{NASDAQ}$, $SO_{j}^{NYSE}$), and book value of the asset of NASDAQ and NYSE stocks ($BV_{i}^{NASDAQ}$, $BV_{j}^{NYSE}$) as four firm-specific factors. A pair score was computed on Equation (14).

\[
\text{pair score} = \left[ \left( \frac{P_{i}^{NASDAQ} - P_{j}^{NYSE}}{P_{i}^{NASDAQ} + P_{j}^{NYSE}} \right)^{2} + \left( \frac{LD_{i}^{NASDAQ} - LD_{j}^{NYSE}}{LD_{i}^{NASDAQ} + LD_{j}^{NYSE}} \right)^{2} + \left( \frac{BV_{i}^{NASDAQ} - BV_{j}^{NYSE}}{BV_{i}^{NASDAQ} + BV_{j}^{NYSE}} \right)^{2} + \left( \frac{SO_{i}^{NASDAQ} - SO_{j}^{NYSE}}{SO_{i}^{NASDAQ} + SO_{j}^{NYSE}} \right)^{2} \right] / 2
\] (14)

where subscripts $i$ and $j$ represents stock $i$ from the NASDAQ and stock $j$ from the NYSE, respectively. After they computed a matched pair score, they picked a NYSE stock that had the smallest score for each NASDAQ stock. They also deleted pairs that had duplicate NYSE stocks.

III. Empirical Analysis

A. Selection of Sample KOSPI-listed stocks and their matched KOSDAQ-listed stocks

We employed the use of the matching method by Huang and Stoll (1996). $P_{i}^{KOSPI}$ is the closing price of a KOSPI-listed stock $i$, and $P_{j}^{KOSDAQ}$ is the closing price of a KOSDAQ-listed stock $j$. $LD_{i}^{KOSPI}$, $BV_{i}^{KOSPI}$, and $SO_{i}^{KOSPI}$ are the long-term debt, book value, and total number of shares outstanding of KOSPI-listed firm $i$, respectively. $LD_{j}^{KOSDAQ}$, $BV_{j}^{KOSDAQ}$, and $SO_{j}^{KOSDAQ}$ follow the same definition as $LD_{i}^{KOSPI}$, $BV_{i}^{KOSPI}$, and $SO_{i}^{KOSPI}$ while the only difference is that $LD_{j}^{KOSDAQ}$, $BV_{j}^{KOSDAQ}$, and $SO_{j}^{KOSDAQ}$ are constructed on a KOSDAQ- listed firm $j$. Then we computed a pair score based on Equation (15).

\[
\text{pair score} = \left[ \left( \frac{P_{i}^{KOSPI} - P_{j}^{KOSDAQ}}{P_{i}^{KOSPI} + P_{j}^{KOSDAQ}} \right)^{2} + \left( \frac{LD_{i}^{KOSPI} - LD_{j}^{KOSDAQ}}{LD_{i}^{KOSPI} + LD_{j}^{KOSDAQ}} \right)^{2} + \left( \frac{BV_{i}^{KOSPI} - BV_{j}^{KOSDAQ}}{BV_{i}^{KOSPI} + BV_{j}^{KOSDAQ}} \right)^{2} + \left( \frac{SO_{i}^{KOSPI} - SO_{j}^{KOSDAQ}}{SO_{i}^{KOSPI} + SO_{j}^{KOSDAQ}} \right)^{2} \right] / 2
\] (15)

For the pair score, we downloaded the data about long-term debts, closing prices, shares outstanding and book value of KOSPI and KOSDAQ stocks for financial year 2013 from www.Fnguide.com. The book value of equity and long-term debt were the end value of 2013 financial statements. Moreover, we collected daily closing prices of stocks and daily total numbers of shares outstanding that covered one year from January 1st to December 31st 2013. We
changed these daily data to a year value by averaging the collected daily values. Our sample selection period and samples were similar to that of Ji (2017), where it covered the KOSPI and KOSDAQ listed companies from 2011 to 2014. We compute the pair score based on Equation (15).

After we computed the pair score, we chose a pair that had less than a pair score of one. In addition, we selected a pair that was in the same Korean standard industry classification. We excluded the finance industry, such as commercial banks, investment banks and insurance companies, since these industries have different formats of financial statements from those from the manufacturing companies.

After we found matching pairs that had less than one pair score and within the same industry, we limited the number of pairs in the same industry. In other words, we selected less than three pairs of stocks in each industry. If we had not restricted the number of pairs in the same industry, the numbers of selected pairs would have been too many in a specific industry. For example, 25 pairs are found for the Manufacture of Electronic Components, Computer, Radio, Television and Communication. Thus, if we did not control the number of pairs in an industry our sample would be biased by a few industries. Finally, the total number of our final sample is 62 pairs of the KOSPI- and KOSDAQ-listed stocks. The selected pairs are shown in Appendix 1.

(Table 1) shows the sample statistics of KOSPI- and KOSDAQ-listed stocks. The average price of KOSPI- and KOSDAQ-listed stocks were 5,802 and 5,629 won, respectively. The average values of the book value of equity, shares outstanding, and long-term debt look comparable. This suggests that our sampling was conducted in a proper manner.

**B. Empirical Comparison of KOSPI-listed stocks and their matched KOSDAQ-listed stocks**

1. **The comparison of daily spread**

With the selected pairs, we collected the daily close prices, daily trading volumes, intraday quote prices and intraday trade prices, etc., during the year 2014. Thus, our sample period for trading costs covers the year 2014 as a whole year. During the process of data collection, we employed the use of filters to delete trades and quotes that were highly likely to be errors. The case example is that the bid quote is higher than the ask quote at the same trading time. We winsorized all the spread variables (quoted spread, realized spread, and price impact cost) to provide a moderate distribution of spread variables.

**Table 1. Basic statistics of KOSPI-listed firms and their matched KOSDAQ-listed firms**

Price is daily close price of a KOSPI-listed firm or KOSDAQ-listed firms, book value of equity is the book value of a KOSPI-listed firm or KOSDAQ-listed firm, shares outstanding is the total number of shares outstanding of KOSPI-listed firm or KOSDAQ-listed firm, long-term debt is the long-term debt of a KOSPI-listed firm or KOSDAQ-listed firm, respectively. These data cover financial year 2013 to select KOSPI-listed firms and their matched KOSDAQ-listed firms. These pairs should belong to the same industry in terms of Korea standard industry classification. Price and shares outstanding are collected daily, but book value of equity and long-term debt are yearly values.

|        | Average | Std. Dev. | 25%Quartile | Median | 75%Quartile |
|--------|---------|-----------|-------------|--------|-------------|
| **KOSPI** |         |           |             |        |             |
| Price   | 5,802   | 5,174     | 2,543       | 3,819  | 8,000       |
| Book value of equity | 13,767,853 | 10,127,998 | 6,459,375 | 10,375,877 | 17,362,848 |
| Shares outstanding | 25,215,242 | 26,036,244 | 11,657,215 | 17,480,464 | 31,336,971 |
| Long-term debt    | 28,061,811 | 43,238,005 | 5,566,213 | 13,349,710 | 29,429,534 |
| **KOSDAQ** |         |           |             |        |             |
| Price   | 5,629   | 4,224     | 2,534       | 4,613  | 7,979       |
| Book value of equity | 13,108,533 | 10,094,138 | 6,543,802 | 9,910,642 | 16,757,465 |
| Shares outstanding | 23,620,113 | 19,870,455 | 11,543,750 | 17,529,406 | 25,596,679 |
| Long-term debt    | 26,725,970 | 44,202,641 | 6,446,541 | 12,994,484 | 27,071,526 |
In (Table 2), CS represents the Corwin and Schultz (2012) daily spread, which is computed by Equation (13). AIR is computed by Equation (9). GKN is the measure estimated by Equation (7). The dollar quoted, percent quoted, dollar realized and percent realized spreads together with the dollar price impact, and percent price impact are all measured from the intraday trade and quote data. To compute the daily spread measures from the intraday quote and price data, we adjusted Holden and Jacobsen (2014) SAS codes to the Korean stock market. The reason is that NYSE and NASDAQ employ a quote-driven trading system, while the Korean stock market adopts order-driven trading system. ‘i’ and ‘q’ represent KOSPI- and KOSDAQ-listed stocks, respectively.

(Table 2) shows the basic statistics of daily spreads that were estimated from the daily prices and of intraday spreads that are measured from the intraday quotes. Daily spreads are the CS spread, AIR measure and GKN measure. Intraday spreads are dollar/percent quoted spreads, dollar/percent realized spreads, and dollar/percent price impact costs. Column ‘Pair-T’ shows the paired-t test results that all the spread measures except for the percent price impact, which are statistically different between the KOSPI- and KOSDAQ-listed stocks. These results contradict our expectation in that the pairs from the KOSPI- and KOSDAQ-listed stocks should have had the same amounts of trading costs under the pair sample method of Huang and Stoll (1996).

**Table 2. Sample statistics and paired t test results**

|           | mean  | Pair-T       | Standard Deviation | skewness | kurtosis |
|-----------|-------|--------------|--------------------|----------|----------|
| CS_i      | 0.0049| 2.5987***    | 0.0168             | -0.6237  | 2.9586   |
| CS_q      | 0.0044| 2.5987***    | 0.0168             | -0.6237  | 2.9586   |
| Air_i     | 0.1324| 6.1111***    | 0.2596             | 2.7604   | 9.6005   |
| Air_q     | 0.1172| 2.7654       | 0.2596             | 2.7604   | 9.6005   |
| Gkn_i     | 0.0133| 6.1111***    | 0.0072             | 0.5895   | 2.5127   |
| Gkn_q     | 0.0130| 2.7654       | 0.2596             | 2.7604   | 9.6005   |
| Dollar QS_i | 32.3777| 30.2290*** | 27.6748            | 1.0968   | 3.1671   |
| Dollar QS_q | 25.9539| 23.3338     | 1.3907             | 3.9401   |
| Percent QS_i | 0.0059| 21.4026***  | 0.0041             | 1.6832   | 5.0865   |
| Percent QS_q | 0.0051| 21.4026***  | 0.0041             | 1.6832   | 5.0865   |
| Dollar RS_i | 14.8681| 24.7384***  | 18.0749            | 1.3979   | 4.1960   |
| Dollar RS_q | 10.7149| 14.6931     | 1.3979             | 4.1960   |
| Percent RS_i | 0.0029| 12.5399***  | 0.0031             | 1.3101   | 4.2047   |
| Percent RS_q | 0.0025| 12.5399***  | 0.0031             | 1.3101   | 4.2047   |
| Dollar PI_i | 15.7484| 7.5369***   | 17.1380            | 1.4881   | 4.2842   |
| Dollar PI_q | 14.5787| 15.7308     | 1.4881             | 4.2842   |
| Percent PI_i | 0.0025| 0.1218      | 0.0019             | 1.0509   | 3.6345   |
| Percent PI_q | 0.0025| 0.1218      | 0.0019             | 1.0509   | 3.6345   |

Subscript ‘i’ represents KOSPI and subscript ‘q’ represents KOSDAQ. CS represents Corwin and Schultz (2012) spread. AIR represents Amihud illiquidity spread based on Amihud (2002). Gkn represents George, Kaul, and Nimalrendran (1994) spread. Dollar quoted spread (Dollar QS) is the difference between ask and bid prices, while percent quoted spread (Percent QS) is the ratio amount that dollar quoted spread is divided by the middle price of ask and bid prices. Dollar realized spread (Dollar RS) is the difference between trade price and the middle price, while percent realized spread (Percent RS) is the ratio amount that dollar realized spread is divided by the middle price. Dollar price impact (Dollar PI) is the difference between the midpoint five minutes after the midpoint and the midpoint price, while percent price impact (Percent PI) is the ratio amount that dollar price impact is divided by the midpoint price.

Pair-T is the Paired T test statistics. * represents p < 0.05, ** p < 0.01, *** p < 0.001.
We obtained the anticipated result from our sampling method in the case of percent price impact costs. The KOSPI-listed stocks do have statistically the same percent price impact as stocks listed in KOSDAQ. Price impact was considered as an actual trading cost when the informed traders transact. It has been found out that price impact has a significant relationship with the trading of institutional investors (Chiyachantana, Jain, Jiang, and Wood (2004)). Thus, the paired t-test results indicate that institutional investors may have the same price impact costs when stocks are traded on the same trading mechanism.

The paired-t test results in (Table 2) may provide the insight that the matching sample method of Huang and Stoll (1996) may control the percent price impact between NYSE and NASDAQ, if all other things are equal between the NYSE, NASDAQ and Korea Exchange. However, this conjecture needs to be confirmed with data from various other countries.

The spread measures from intraday data, such as the dollar quoted spread, percent quoted spread, dollar realized spread, percent realized spread and dollar price impact show greater spread in the case of KOSPI-than those of KOSDAQ-listed stocks. In addition, GKN spreads have the same tendency as intraday spread measures like the dollar quoted spread. In contrast, the CS spread and Air spread are larger in KOSDAQ-listed stocks than in the KOSPI-listed stocks.

The skewness of the columns in the (Table 2)
depicts how symmetrical the data is. All the spread measures have positive skewness, except for the CS spread. This implies that the spread measures have a long tail to the right (higher value). A CS spread having a negative skewness suggests that the CS spread has a long tail to the left. These results may be reasonable in that all spread measures should have been positive values. Column ‘Kurtosis’ in (Table 2) tests whether the shape of data distribution matches a Gaussian distribution. All kurtosis statistics have much higher positive values, meaning that the spread measure distributions are more peaked than a Gaussian distribution. Even though all spread variables are winsorized, not all spread variables are exactly normally distributed.

We used the paired-t tests to compare the KOSPI- and KOSDAQ-listed stocks spreads since our sample is a matched pair based on the four firm-specific factors. However, the spread variables do not follow the Gaussian distribution. Therefore, we do the Wilcoxon signed rank sum test that is the non-parametric version of a paired samples t-test. The results are provided in the (Table 3).

The overall Wilcoxon signed rank sum tests were similar to the paired t-test results except for the CS spread. The dollar quoted, percent quoted, dollar realized and percent realized spreads, and dollar price impacts present significant statistical differences between KOSPI- and KOSDAQ-listed stocks. Air and GKN spreads too show a significant statistical difference. However, CS spread and percent price impact are statistically the same between the KOSPI- and KOSDAQ-listed stocks. (Table 3), similar to (Table 2), shows that the four firm-specific factors used in the matched pair score (15) successfully control only the percent price impact.

The only difference between the paired-t test in (Table 2) and the Wilcoxon sign rank sum test in (Table 3) appear in the case of the CS spread in that CS_i and CS_q are significantly different in the paired-t test, but not in the Wilcoxon signed rank test.

The median AIR, median dollar quoted, median percent quoted, median dollar realized, and median percent realized spreads had greater spread in KOSPI-listed stocks than KOSDAQ-listed stocks. Contrary results appear in the cases of median GKN spread and median dollar price impact in that there is a higher median spread in the KOSPI-listed stocks than the KOSDAQ-listed stocks.

The overall results from the tables 2 and 3 indicate that percent price impact was the same between the KOSPI- and KOSDAQ-listed stocks, whilst most other spread measures showed a difference.

2. Intraday Comparison between KOSPI and KOSDAQ

The paired-t and Wilcoxon signed rank sum tests show that all daily trading costs, except for the percent price impact, were different between the KOSPI and KOSDAQ. These results produce another question, namely whether similar results will appear in the intraday trading costs. Thus, we compared the intraday trading costs between the KOSPI and KOSDAQ. For this purpose, we measured the 30 minute interval trading costs, such as quoted and realized spreads, and price impact. The method to measure intraday trading costs is similar to the one employed by Holden and Jacobsen (2014). Detailed statistics, such as mean and median trading costs, are shown in Appendix 2. Subsequently, we subtracted the KOSDAQ intraday trading costs from the KOSPI intraday trading costs in order to compute the difference between these two costs. If the difference is positive, then the KOSPI trading costs are higher than the KOSDAQ trading costs during the same 30 minute time interval.

As shown in the following figures (Figures 1 and 2), we divided a day’s trading hours (09:00 ~ 14:50 for the Korea Exchange) into 30 minute time-intervals. The time-interval 1 represents trading time-interval between 09:00 and 09:30. Time-interval 2 represents the trading time interval between 09:30 and 10:00. Time-intervals continue in this way, until time-interval 12, which represents between 14:30 and 14:50. The last 10 minute-interval in the Korea Exchange, i.e., between 14:50 and 15:00, is a closing call auction period. The buy/sell orders can be submitted to the exchange. However, the last and actual trading could happen with the closing of the Korean stock exchange.
This means that quoted and realized spreads, and price impact do not exist during the call auction period. This last 10 minutes time-interval was excluded in the analysis.

(Figure 1) is about dollar trading costs, while (Figure 2) illustrates percent trading costs; (subfigure A) in each figure shows mean difference and (subfigure B) does median difference. Thus, (subfigure 1.A) shows the cases of average difference in dollar trading costs, while (subfigure 1.B) does the cases of median difference in dollar trading costs between KOSPI and KOSDAQ. (Subfigure 2.A) shows the mean difference in percent trading costs and (subfigure 2.B) shows the median difference in percent trading costs.

In (subfigure 1.A), the average differences in the dollar quoted spread in each 30-minutes time-interval seem to be statistically significant. This implies that the dollar quote spread of the KOSPI is greater than that of the NASDAQ. The dollar realized spread too shows a statistically significant difference between the KOSPI and KOSDAQ in each 30-minute time-interval. However, close-to-zero average differences in dollar price impact appear in ten out of twelve 30-minutes time-intervals, implying that there is no average

![Figure 1. Difference in dollar trading costs between KOSPI and KOSDAQ](image_url)

Y-axis represents dollar amounts which is Korean won. X-axis represents 30 minutes time-intervals during the trading session in the Korea Exchange. For example, time-interval one covers 30 minutes between 09:00 ~ 09:30. Meanwhile time-interval 12 covers only 20 minutes between 14:30~14:50. The reason we exclude 10 minutes between 14:50 ~ 15:00 is that close call auction is processing during this time interval, implying that no bid-ask spread exists. Bold dot represents statistically significance with less than 10% level of significance.
difference in the dollar price impact between KOSPI and KOSDAQ.

Overall findings in (subfigure 1.B) propose similar findings of (subfigure 1.A), in that the dollar quoted and realized spreads of each time-interval were statistically different between the KOSPI and KOSDAQ. However, the median dollar price impact of the KOSPI shows no difference to median dollar price impact of the KOSDAQ.

(Figure 2) displays slightly different results from (Figure 1) in that the average percent trading costs are more likely to show no difference between the KOSPI and KOSDAQ, but median percent trading costs are more likely to display a difference between the KOSPI and KOSDAQ. In (subfigure 2.A), eight time-intervals out of twelve show no significant differences in average percent quoted spread. In the case of the percent realized spread, nine time-intervals have no average difference. The dotted line of percent price impact indicates that eleven time-intervals show no average difference between the KOSPI and KOSDAQ.

The overall suggestion of (subfigure 2.B) is opposite to that of (subfigure 2.A), in that all median differences from percent quoted and realized spreads, and percent

![Subfigure 2.A Mean difference percent trading costs between KOSPI and KOSDAQ](image)

![Subfigure 2.B Median difference percent trading costs between KOSPI and KOSDAQ](image)

Y-axis represents ratios. X-axis represents 30 minutes time-intervals during the trading session in the Korea Exchange. For example, time-interval one covers 30 minutes between 09:00 ~ 09:30. Meanwhile time-interval 12 covers only 20 minutes between 14:30~14:50. The reason we exclude 10 minutes between 14:50 ~ 15:00 is that close call auction is processing during this time interval, implying that no bid-ask spread exists.

Bold dot represents statistically significance with less than 10% level of significance.

Figure 2. Difference in percent trading costs between KOSPI and KOSDAQ
Price impact have a marginally significant difference. Median differences between the KOSPI and KOSDAQ were very marginal. However, Wilcoxon signed rank sum test statistics indicate that all the percent intraday trading costs were different between the KOSPI and KOSDAQ.

IV. Conclusion and Discussion

Huang and Stoll (1996) assumed that no other firm-specific factors should affect the trading costs of selected pairs except for the four factors. Then the only difference between the NYSE- and NASDAQ-listed stocks in Huang and Stoll (1996) was the trading mechanism (specialist vs dealer trading mechanisms). In the comparison between the NYSE- and NASDAQ-listed stocks turned out that the NASDAQ-listed stocks had higher trading costs than matched the NYSE-listed stocks. The result suggested that the dealer trading mechanism had higher trading costs than the specialist trading mechanism under the pair sample method.

On the other hand, if the pair sample method of Huang and Stoll (1996) picked a proper pair to compare the two trading mechanisms, the pair selected from the KOSPI and KOSDAQ should have same trading costs, since the KOSPI and KOSDAQ adopt the same trading mechanism, which is the continuous order-driven trading mechanism. This proposition was the research question for this study.

When we apply the pair sample method of Huang and Stoll (1996) to the KOSPI and KOSDAQ, we found out that the KOSPI-listed stocks had the same size of percent price impact cost as the KOSDAQ-listed stocks did. The average percent price impact costs between the KOSPI and KOSDAQ were still alike during the intraday 30 minute time-interval. Our results suggested that the pair sample method of Huang and Stoll (1996) does have some control on the trading costs (e.g. percent price impact cost).

Our study contributes to the knowledge about trading costs. Our findings could be analogous to the findings of Huang and Stoll (1996), where the NYSE stock spreads (quoted spread, realized spread, and effective spread) were smaller than their matched NASDAQ stock spreads. However, when the pair sample method of Huang and Stoll (1996) was employed for the KOSPI and KOSDAQ, the percent price impacts of the KOSPI stocks were statistically the same as those of KOSDAQ stocks. Percent quoted and realized spreads of the KOSPI is greater than those of the KOSDAQ. The NYSE and NASDAQ have different trading mechanisms, which are the specialist and dealer trading mechanisms, respectively. On the other hand, the KOSPI and KOSDAQ adopt the same trading mechanism (an order-driven trading mechanism).

Our result on the price impact cost contradicts the practitioner’s general belief that KOSDAQ has a higher information asymmetry between individuals and institutions. Our result implies that informed trading costs measured by price impact cost are similar between the KOSPI- and KOSDAQ-listed stocks under such conditions as the match process of Huang and Stoll (1996). This is because price impact cost is a measure of loss that uninformed investors trade with informed investors on a stock. While most individual investors are generally considered as uninformed traders, institutional traders are generally informed traders. Therefore, similar price impact cost between the KOSPI- and KOSDAQ-listed stocks implies that informed trading costs too are similar between two trading places. Since our result does provide other evidence on the general belief about information asymmetry on the KOSPI and KOSDAQ, we need further research results on this topic in the future.

Another contradictory finding to the practitioner’s general belief is that the trading costs of the KOSPI-listed stocks are greater than those of the KOSDAQ-listed stocks in terms of the quoted and realized spreads. Korea stock market participants generally believe that the KOSPI has relatively lower trading costs than the KOSDAQ. This is because the KOSPI is a bigger market and is more liquid than the KOSDAQ. Thus, depending on the comparison method between the KOSPI and KOSDAQ, the general belief about the
amount of quoted and realized spreads could be changed. Once again, we need more research results on the quoted and realized spreads on the KOSPI and KOSDAQ.

The contradictions based on our results to the general belief in trading costs on the KOSPI and KOSDAQ should be carefully considered because the matching process to make a pair could generate sample bias. The paired sample method is a strong tool to compare a pair (one from a sample and the other from its matched control) and to show a clear difference between a sample and matched control sample. However, if the pairs from a sample and another are not carefully chosen, then the results from the paired method can mislead researchers to an incorrect conclusion. In other words, when researchers employ a paired sample method, the fundamental problem that researchers confront is whether the paired sample is carefully selected with the proper criteria. This means that the choice criteria for a pair should be restrained of all other factors except for those that researchers want to investigate. However, there is no guarantee that a pair (two stocks) from two different stock exchanges has the same factors generating trading costs. This kind of concern is inevitable when researchers employ a paired sample method. This concern does not limit Huang and Stoll (1996), but all papers that adopt a paired sample method.

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### Appendix 1. KOSPI-listed companies and their matched KOSDAQ-listed companies

Ind. code is the Korea Standard industry code. Dist is the pair score which is computed by the equation

\[
pair\ score = \frac{(p_{\text{KOSPI}} - p_{\text{KOSDAQ}})^2}{(p_{\text{KOSPI}} + p_{\text{KOSDAQ}})/2} + \frac{(LD_{\text{KOSPI}} - LD_{\text{KOSDAQ}})^2}{(LD_{\text{KOSPI}} + LD_{\text{KOSDAQ}})/2} + \frac{(BV_{\text{KOSPI}} - BV_{\text{KOSDAQ}})^2}{(BV_{\text{KOSPI}} + BV_{\text{KOSDAQ}})/2} + \frac{(SO_{\text{KOSPI}} - SO_{\text{KOSDAQ}})^2}{(SO_{\text{KOSPI}} + SO_{\text{KOSDAQ}})/2}
\]

Price is the daily close price and shares outstanding is the daily share outstanding of during the year 2013. Book value of equity and long-term debt is from the financial year 2013.

| No. | Ind code | dist | Company name | Price | Book value of equity (million won) | Shares outstanding (Thousand shares) | Long-term debt (million won) | Company Name | Price | Book value of equity | Shares outstanding | Long term debt |
|-----|----------|------|--------------|-------|-------------------------------------|-------------------------------------|-------------------------------|---------------|-------|---------------------|------------------|-----------------|
| 1   | 10       | 0.3390 | Dongwoo      | 3.670 | 11,430                              | 22,860                              | 12,833                        | WoosungFeed   | 3.281 | 15,450              | 30,900           | 8,698           |
| 2   | 10       | 0.4072 | EasyBio, Inc.| 4.501 | 23,865                              | 46,980                              | 235,786                       | SAJODONGAONE  | 3.218 | 32,590              | 65,066           | 172,257         |
| 3   | 10       | 0.5372 | Hanil Feed   | 1.269 | 15,965                              | 31,931                              | 14,768                        | KoreaIndustrial | 1.194 | 24,939              | 17,601           | 15,978          |
| 4   | 11       | 0.3491 | PUNGGUK ETHANOL INDUSTRIAL | 5.484 | 4,200                                | 8,400                               | 6,444                         | MHETHANOL     | 3.345 | 4,408               | 7,000            | 8,552           |
| 5   | 13       | 0.7030 | SI Resources | 1.054 | 30,024                              | 60,050                              | 13,405                        | SG CHOONGBANG | 1.486 | 20,874              | 41,747           | 24,177           |
| 6   | 13       | 0.7919 | Kahee        | 9.074 | 6,000                               | 1,200                               | 16,249                        | TaianTextile | 20.098 | 5,300               | 1,060            | 25,305          |
| 7   | 13       | 0.9141 | AztechWB     | 2.176 | 7,785                               | 15,957                              | 5,563                         | DSR           | 4.411 | 8,000               | 16,000           | 2,765           |
| 8   | 14       | 0.7411 | STO          | 2.550 | 2,852                               | 5,704                               | 9,687                         | hyungi-elite  | 2.665 | 5,155               | 10,554           | 7,697           |
| 9   | 14       | 0.7504 | Codes Combine | 1.161 | 25,367                              | 50,576                              | 7,193                         | In the F      | 921   | 29,466              | 58,933           | 16,933          |
| 10  | 17       | 0.7423 | DAEYANG PAPER MFG. | 12.198 | 13,425                              | 27,775                              | 18,300                        | KoreaExportPackaging | 23,416 | 20,000              | 4,000            | 33,583          |
| 11  | 17       | 0.8666 | Kuk-il Paper Mfg | 476  | 10,000                              | 2,000                               | 26,097                        | KGP           | 554   | 6,713               | 4,475            | 36,139          |
| 12  | 20       | 0.0060 | Korea Alcohol Industrial | 3.828 | 10,802                              | 21,606                              | 19,968                        | Kyungnong     | 3.551 | 10,846              | 21,692           | 20,355          |
| 13  | 20       | 0.0262 | KCL          | 4.750 | 5,500                               | 11,000                              | 3,324                         | TAEKYUNGCHEMICAL | 5.004  | 5,800               | 11,600           | 3,800           |
| 14  | 20       | 0.1167 | KSCB         | 6.834 | 7,035                               | 11,929                              | 7,949                         | DongbangAgro  | 6.393 | 6,809               | 13,618           | 10,822          |
| 15  | 21       | 0.0319 | HWAIL PHARMACEUTICAL | 8.865 | 7,205                               | 14,376                              | 11,323                        | DuewanPharmaceutical | 10.202 | 7,794               | 15,363           | 11,795          |
| 16  | 21       | 0.1019 | BIONEER      | 15.635 | 6,502                             | 12,644                              | 6,080                         | REYON PHARMACEUTICAL | 19.321 | 6,450               | 12,900           | 4,783           |
| 17  | 21       | 0.1822 | BIO LAND     | 14.064 | 7,500                               | 15,000                              | 6,454                         | WhaninPharm   | 11.575 | 9,700               | 18,600           | 5,378           |
| 18  | 22       | 0.0831 | Dong-A Hwa Sung | 5.108 | 8,000                               | 15,800                              | 3,431                         | WISCOM        | 4.889 | 7,513               | 15,026           | 2,606           |
| 19  | 22       | 0.1327 | MNtech       | 9.373 | 11,644                              | 23,290                              | 49,116                        | YoulchonChemical | 11.218 | 14,776              | 24,800           | 60,098          |
| 20  | 22       | 0.2421 | DAEJINDMP    | 4.549 | 5,850                               | 11,700                              | 7,340                         | Duksung       | 3.875 | 7,840               | 15,680           | 5,898           |
| No. | Ind code | dist | Company name | Price | Book value of equity (Thousand won) | Shares outstanding (Thousand shares) | Long-term debt (Thousand won) |
|---|---|---|---|---|---|---|---|
| 21 | 23 | 0.2154 | DONGKUK REFRACTORIES & STEEL | 1,490 | 18,400 | 18,400 | 41,085 |
| 22 | 23 | 0.3412 | Tokai Carbon Korea | 9,080 | 5,837 | 11,675 | 2,337 |
| 23 | 23 | 0.8996 | Home Center | 3,202 | 9,821 | 19,643 | 13,156 |
| 24 | 24 | 0.0227 | PJ METAL | 1,925 | 10,861 | 21,723 | 6,579 |
| 25 | 24 | 0.0362 | Hankuk Steel Wire | 2,179 | 12,261 | 24,235 | 14,132 |
| 26 | 24 | 0.0804 | Jielsteel MFG | 3,570 | 5,062 | 10,064 | 27,330 |
| 27 | 25 | 0.3813 | DAERYUK CAN | 4,888 | 7,951 | 15,903 | 19,677 |
| 28 | 25 | 0.5173 | BOOSTER | 4,603 | 4,080 | 8,160 | 371 |
| 29 | 25 | 0.6542 | DONGKUK STRUCTURES & CONSTRUCTION | 3,834 | 28,571 | 57,143 | 30,885 |
| 30 | 26 | 0.0167 | HYUNWOOINDUSTRIAL | 3,143 | 5,000 | 10,000 | 17,687 |
| 31 | 26 | 0.0394 | KMW | 19,683 | 8,050 | 16,100 | 29,217 |
| 32 | 26 | 0.0456 | PSMC | 628 | 18,914 | 36,518 | 5,273 |
| 33 | 27 | 0.4855 | PS Tec. | 4,687 | 7,286 | 14,269 | 8,444 |
| 34 | 27 | 0.5067 | ED | 3,953 | 11,935 | 22,064 | 2,839 |
| 35 | 27 | 0.6956 | Optroniec | 13,646 | 10,084 | 20,155 | 26,296 |
| 36 | 28 | 0.3124 | Bosung Power Technology | 1,891 | 15,371 | 30,742 | 5,170 |
| 37 | 28 | 0.3584 | VITZRO TECH | 4,149 | 6,740 | 13,481 | 9,547 |
| 38 | 28 | 0.3587 | Woori Technology | 613 | 33,102 | 62,354 | 29,710 |
| 39 | 29 | 0.0447 | Advanced Process Systems | 10,670 | 11,605 | 22,354 | 23,522 |
| 40 | 29 | 0.0451 | Jinsung T.E.C. | 6,775 | 10,000 | 20,000 | 65,309 |
| 41 | 29 | 0.0570 | SNU Precision | 8,360 | 10,216 | 20,433 | 16,706 |
| 42 | 30 | 0.0430 | Degenx | 1,709 | 9,605 | 18,500 | 19,745 |
| No. | Ind code | dist | Company name | Price | Book value of equity (million won) | Shares outstanding (Thousand shares) | Long-term debt (million won) | Company name | Price | Book value of equity | Shares outstanding | Long term debt |
|-----|----------|------|--------------|-------|-----------------------------------|-------------------------------------|-----------------------------|--------------|-------|---------------------|----------------|--------------|
| 43  | 30       | 0.0545 | KB Autosys | 4,624 | 5,750                             | 11,500                              | 17,012                      | INFAC        | 5,145 | 5,000               | 10,000         | 18,147        |
| 44  | 30       | 0.1087 | SUNGCHANG AUTOTECH | 6,727 | 3,650                             | 7,300                                | 14,181                      | SamsungClimateControl | 7,645 | 4,063               | 8,126           | 10,879        |
| 45  | 41       | 0.6002 | KCC Engineering & Construction | 13,777 | 29,000                            | 5,800                                | 172,868                     | KyeryongConstructionIndustrial | 8,755 | 44,655              | 8,931           | 211,326       |
| 46  | 41       | 0.7789 | SEOHAN Const. & Eng. | 1,215 | 50,447                            | 100,895                              | 33,231                      | ChinhungInternational | 1,894 | 46,749              | 190,240        | 52,705        |
| 47  | 42       | 0.3510 | SUNDGO ENGINEERING & CONSTRUCTION | 6,232 | 7,500                             | 15,000                              | 9,080                       | Dong-Ah Geological Engineering | 9,941 | 5,750               | 11,500          | 9,378         |
| 48  | 42       | 0.6985 | nt-pia       | 1,233 | 18,265                            | 35,342                              | 10,109                      | Samho Development   | 2,417 | 12,500              | 25,000          | 8,776         |
| 49  | 46       | 0.0419 | Daou Data    | 4,635 | 17,850                            | 35,700                              | 189,349                     | TONGYANG NETWORKS | 4,401 | 20,805              | 40,285          | 196,327       |
| 50  | 46       | 0.1333 | Korea Information Engineering Services | 3,693 | 4,099                             | 8,018                               | 3,404                       | JINDO        | 3,995 | 5,012               | 10,024          | 2,877         |
| 51  | 46       | 0.2209 | SDN          | 1,532 | 12,648                            | 23,671                              | 11,547                      | HANSOL PNS     | 1,415 | 13,795              | 26,752          | 7,395         |
| 52  | 47       | 0.8654 | Inteopark Holdings | 8,657 | 30,421                            | 60,842                              | 125,680                     | SAVEZONE I&C | 3,762 | 41,041              | 41,041          | 117,452       |
| 53  | 58       | 0.1813 | Gabia        | 5,028 | 6,667                             | 13,336                              | 7,631                       | SAMSUNG PUBLISHING | 4,889 | 5,000               | 10,000          | 6,695         |
| 54  | 58       | 0.1930 | AfreecaTV    | 9,704 | 4,948                             | 9,495                               | 4,455                       | TELCOWARE     | 10,061 | 5,026               | 9,703           | 2,857         |
| 55  | 58       | 0.5084 | THINKWARE    | 12,123 | 3,997                            | 7,996                               | 42,472                      | VISANG EDUCATION | 14,167 | 6,498               | 12,988          | 35,623        |
| 56  | 62       | 0.2387 | Insung Information | 4,038 | 8,480                             | 16,954                              | 3,000                       | Daouincube | 2,953 | 7,916               | 15,833          | 4,337         |
| 57  | 63       | 0.2760 | NICE Information Service | 2,821 | 30,357                            | 49,898                              | 3,273                       | KTcs         | 2,844 | 23,843              | 45,685          | 2,052         |
| 58  | 63       | 0.2834 | SK Communications | 6,667 | 21,713                            | 43,427                              | 1,886                       | Ktics         | 4,376 | 17,401              | 34,802          | 2,124         |
| 59  | 71       | 0.3781 | Neowiz Holdings | 12,050 | 4,653                            | 9,157                               | 47,197                      | SINGSONGHOLDINGS | 8,312 | 5,914               | 11,829          | 33,184        |
| 60  | 71       | 0.9397 | Harim Holdings | 2,528 | 44,578                            | 86,743                              | 43,763                      | Chinyang Holdings | 1,833 | 27,948              | 55,895          | 87,259        |
| 61  | 73       | 0.8800 | JYP Ent.     | 4,975 | 17,021                            | 26,051                              | 7,245                       | IHQ          | 2,377 | 20,488              | 40,975          | 10,696        |
| 62  | 75       | 0.4579 | SEJOONG      | 5,453 | 9,052                             | 18,105                              | 3,835                       | LOTTE TOUR DEVELOPMENT | 9,807 | 12,307              | 16,998          | 4,632         |
### Appendix 2. Intraday trading costs between KOSPI and KOSDAQ

Panel A: The comparison of dollar trading costs between KOSPI and KOSDAQ

QS stands for quoted spread; RS realized spread; PI price impact cost. *** represents 1% level of significance; ** 5% level of significance; * 10% level of significance.

#### Quoted spread

| Time interval  | Mean dollar QS of KOSPI  | Mean dollar QS of KOSDAQ | Mean difference dollar QS | Paired-t test | Mean dollar QS of KOSPI  | Mean dollar QS of KOSDAQ | Median difference dollar QS | Wilcoxon Signed rank sum test |
|----------------|--------------------------|--------------------------|--------------------------|---------------|--------------------------|--------------------------|---------------------------|-----------------------------|
| 09:00~09:30    | 51.2989                  | 37.481                   | 13.8179                  | 14.5801 ***   | 29.2118                  | 20.4536                 | 4.1028                    | 32.514 ***                  |
| 09:30~10:00    | 34.4254                  | 26.554                   | 7.8713                   | 14.5753 ***   | 18.7705                  | 14.5387                 | 2.078                     | 26.657 ***                  |
| 10:00~10:30    | 30.9794                  | 25.1669                  | 5.8126                   | 5.3966 ***    | 16.1775                  | 13.4549                 | 1.6352                    | 23.892 ***                  |
| 10:30~11:00    | 29.672                   | 24.2197                  | 5.4522                   | 5.034 ***     | 15.2331                  | 12.9464                 | 1.3892                    | 22.887 ***                  |
| 11:00~11:30    | 28.5509                  | 23.6973                  | 4.8535                   | 4.4841 ***    | 14.7755                  | 12.5205                 | 1.2469                    | 22.227 ***                  |
| 11:30~12:00    | 27.6468                  | 22.9019                  | 4.7449                   | 4.3251 ***    | 13.9027                  | 11.9423                 | 1.1554                    | 22.192 ***                  |
| 12:00~12:30    | 26.7064                  | 22.5397                  | 4.1667                   | 3.7322 ***    | 13.5007                  | 11.6311                 | 1.003                     | 21.174 ***                  |
| 12:30~13:00    | 27.184                   | 22.4916                  | 4.6923                   | 4.159 ***     | 13.7275                  | 11.7282                 | 1.1446                    | 22.091 ***                  |
| 13:00~13:30    | 27.9213                  | 22.8258                  | 5.0955                   | 4.3276 ***    | 13.9145                  | 11.9476                 | 1.1929                    | 21.789 ***                  |
| 13:30~14:00    | 28.7871                  | 23.4501                  | 5.337                    | 3.4606 ***    | 14.0219                  | 12.1543                 | 1.0562                    | 21.163 ***                  |
| 14:00~14:30    | 28.8019                  | 23.7883                  | 5.0136                   | 3.2808 ***    | 14.1813                  | 12.3231                 | 1.2049                    | 21.539 ***                  |

#### Realized spread

| Time interval  | Mean dollar RS of KOSPI  | Mean dollar RS of KOSDAQ  | Mean difference dollar RS | Paired-t test | Mean dollar RS of KOSPI  | Mean dollar RS of KOSDAQ  | Median difference dollar RS | Wilcoxon Signed rank sum test |
|----------------|--------------------------|---------------------------|--------------------------|---------------|--------------------------|---------------------------|---------------------------|-----------------------------|
| 09:00~09:30    | 28.4748                  | 21.1556                   | 7.3114                   | 10.0317 ***   | 12.7589                  | 9.5279                    | 2.929                     | 16.295 ***                  |
| 09:30~10:00    | 17.3337                  | 11.1818                   | 6.1524                   | 9.5673 ***    | 7.5872                   | 5.1531                    | 2.0482                    | 15.207 ***                  |
| 10:00~10:30    | 16.0797                  | 11.9436                   | 4.1365                   | 3.7632 ***    | 7.1163                   | 5.0972                    | 1.7244                    | 14.441 ***                  |
| 10:30~11:00    | 16.2328                  | 11.7889                   | 4.4439                   | 4.0362 ***    | 7.3293                   | 5.2442                    | 1.8279                    | 15.606 ***                  |
| 11:00~11:30    | 15.8065                  | 12.3217                   | 3.4849                   | 3.1597 ***    | 7.4129                   | 5.2733                    | 1.7491                    | 14.87 ***                   |
| 11:30~12:00    | 16.1386                  | 12.5664                   | 3.5722                   | 3.1642 ***    | 7.6111                   | 5.6138                    | 1.6725                    | 16.605 ***                  |
| 12:00~12:30    | 16.0085                  | 12.7433                   | 3.2652                   | 2.901 ***     | 7.8157                   | 5.6029                    | 1.5874                    | 15.582 ***                  |
| 12:30~13:00    | 16.5089                  | 12.8644                   | 3.6447                   | 3.209 ***     | 7.7968                   | 5.673                     | 1.8085                    | 16.883 ***                  |
| 13:00~13:30    | 15.9254                  | 11.7902                   | 4.1352                   | 3.4191 ***    | 7.2218                   | 5.2776                    | 1.6659                    | 15.32 ***                   |
| 13:30~14:00    | 16.753                   | 12.6873                   | 4.065                    | 2.6383 ***    | 7.3945                   | 5.6067                    | 1.511                     | 14.68 ***                   |
| 14:00~14:30    | 17.4022                  | 13.2906                   | 4.1116                   | 2.6666 ***    | 7.7354                   | 5.8731                    | 1.6586                    | 14.876 ***                  |
| 14:30~14:50    | 20.6089                  | 14.6554                   | 5.9536                   | 3.7606 ***    | 9.2258                   | 6.84                      | 1.7228                    | 15.74 ***                   |

#### Price impact cost

| Time interval  | Mean dollar PI of KOSPI  | Mean dollar PI of KOSDAQ  | Mean difference dollar PI | Paired-t test | Mean dollar PI of KOSPI  | Mean dollar PI of KOSDAQ  | Wilcoxon Signed rank sum test |
|----------------|--------------------------|---------------------------|--------------------------|---------------|--------------------------|---------------------------|-----------------------------|
| 09:00~09:30    | 19.2457                  | 14.9594                   | 4.2886                   | 2.7442 ***    | 6.1584                   | 5.6884                    | 0.5907                     | 6.384 ***                   |
| 09:30~10:00    | 17.1227                  | 15.9927                   | 1.13                     | 0.9933        | 6.1291                   | 6.4504                    | 0.1523                     | 2.242 ***                   |
| 10:00~10:30    | 16.087                   | 17.2442                   | -1.156                   | -0.3926       | 5.2871                   | 5.672                     | 0.0396                     | 2.092 **                    |
| 10:30~11:00    | 16.6142                  | 12.5478                   | 4.0663                   | 2.1996 **     | 4.7848                   | 5.1772                    | 0                          | 0.421                       |
| 11:00~11:30    | 16.9256                  | 12.0177                   | 4.9078                   | 1.4838        | 4.3287                   | 4.872                     | 0                          | -0.158                      |
### Panel 2.A The Comparison of Dollar Price Impact Costs Between KOSPI and KOSDAQ

| Time interval | Mean dollar PI of KOSPI | Mean dollar PI of KOSDAQ | Mean difference dollar PI | Paired-t test | Median dollar PI of KOSPI | Median dollar PI of KOSDAQ | Median difference dollar PI | Wilcoxon Signed rank sum test |
|---------------|-------------------------|--------------------------|---------------------------|--------------|----------------------------|----------------------------|-----------------------------|-------------------------------|
| 11:30~12:00   | 11.4872                 | 11.4865                  | 0.0007                    | 0.0008       | 3.6326                     | 4.3308                     | -0.1481                     | -2.424**                      |
| 12:00~12:30   | 10.5445                 | 10.0559                  | 0.4886                    | 1.0542       | 3.3758                     | 3.898                      | -0.0128                     | -1.388                        |
| 12:30~13:30   | 12.4925                 | 10.703                   | 1.7888                    | 0.8729       | 3.4456                     | 4.0079                     | 0                           | -1.556                        |
| 13:00~14:00   | 13.7124                 | 12.5091                  | 1.2027                    | 0.9068       | 4.0309                     | 4.5012                     | -0.0341                     | -0.926                        |
| 14:00~14:30   | 16.199                  | 13.3036                  | 2.8955                    | 1.3801       | 4.1775                     | 4.6406                     | 0                           | -0.382                        |
| 14:30~14:50   | 15.0802                 | 14.6301                  | 0.45                      | 0.2004       | 3.75                       | 3.9717                     | 0                           | 0.335                         |

### Panel 2.B The Comparison of Percent Trading Costs Between KOSPI and KOSDAQ

| Time Interval | Mean percent QS of KOSPI | Mean percent QS of KOSDAQ | Mean difference percent QS | Paired-t test | Median percent QS of KOSPI | Median percent QS of KOSDAQ | Median difference percent QS | Wilcoxon Signed rank sum test |
|---------------|--------------------------|---------------------------|---------------------------|--------------|----------------------------|----------------------------|-----------------------------|-------------------------------|
| 09:00~09:30   | 0.0087                   | 0.0073                    | **0.0014**                | 7.7703       | 0.0058                     | 0.0049                     | 0.0006                      | 17.336***                     |
| 09:30~10:00   | 0.0059                   | 0.0051                    | **0.0008**                | 4.8078       | 0.0042                     | 0.0037                     | 0.0003                      | 13.865***                     |
| 10:00~10:30   | 0.0053                   | 0.0048                    | **0.0005**                | 2.3406**     | 0.0039                     | 0.0035                     | 0.0002                      | 11.423***                     |
| 10:30~11:00   | 0.005                    | 0.0046                    | 0.0003                    | 1.384        | 0.0037                     | 0.0033                     | 0.0002                      | 10.58***                      |
| 11:00~11:30   | 0.0049                   | 0.0046                    | 0.0004                    | 1.252        | 0.0036                     | 0.0032                     | 0.0001                      | 9.379***                      |
| 11:30~12:00   | 0.0047                   | 0.0043                    | 0.0004                    | 1.3938       | 0.0035                     | 0.0031                     | 0.0001                      | 9.523***                      |
| 12:00~12:30   | 0.0045                   | 0.0043                    | 0.0002                    | 0.765        | 0.0034                     | 0.0031                     | 0.0001                      | 9.048***                      |
| 12:30~13:00   | 0.0048                   | 0.0045                    | 0.0003                    | 0.8692       | 0.0035                     | 0.0031                     | 0.0001                      | 10.245***                     |
| 13:00~13:30   | 0.005                    | 0.0045                    | 0.0005                    | 1.2461       | 0.0035                     | 0.0031                     | 0.0001                      | 10.032***                     |
| 13:30~14:00   | 0.0053                   | 0.0046                    | 0.0007                    | 1.5387       | 0.0035                     | 0.0032                     | 0.0001                      | 7.888***                      |
| 14:00~14:30   | 0.0054                   | 0.0048                    | 0.0006                    | 1.2629       | 0.0035                     | 0.0032                     | 0.0001                      | 8.633***                      |
| 14:30~14:50   | 0.0059                   | 0.0049                    | **0.001**                 | 1.8266*      | 0.0036                     | 0.0033                     | 0.0001                      | 9.795***                      |

### Quoted spread

- QS stands for quoted spread; RS realized spread; PI price impact cost. *** represents 1% level of significance; ** 5% level of significance; * 10% level of significance.

### Realized spread

- QS stands for quoted spread; RS realized spread; PI price impact cost. *** represents 1% level of significance; ** 5% level of significance; * 10% level of significance.
| Time Interval | Mean percent RS of KOSPI | Mean percent RS of KOSDAQ | Mean difference percent RS | Paired-t test | Median percent RS of KOSPI | Median percent RS of KOSDAQ | Median difference percent RS | Wilcoxon Signed rank sum test |
|---------------|--------------------------|---------------------------|---------------------------|--------------|---------------------------|---------------------------|---------------------------|-----------------------------|
| 14:00~14:30   | 0.0033                   | 0.003                     | 0.0003                    | 0.746        | 0.002                     | 0.0017                    | 0.0003                    | 7.229 ***                    |
| 14:30~14:50   | 0.0041                   | 0.0032                    | 0.0009                    | 1.7963       | 0.0023                    | 0.0019                    | 0.0003                    | 7.253 ***                    |

Price impact cost

| Time Interval | Mean percent PI of KOSPI | Mean percent PI of KOSDAQ | Mean difference percent PI | Paired-t test | Median percent PI of KOSPI | Median percent PI of KOSDAQ | Median difference percent PI | Wilcoxon Signed rank sum test |
|---------------|--------------------------|---------------------------|---------------------------|--------------|---------------------------|---------------------------|---------------------------|-----------------------------|
| 09:00~09:30   | 0.0028                   | 0.0026                    | **0.0003**                | 1.8167*      | 0.0017                    | 0.0016                    | **0.0001**                | 2.922 ***                    |
| 09:30~10:00   | 0.0028                   | 0.0027                    | 0.0001                    | 0.5732       | 0.0016                    | 0.0018                    | 0                         | -1.926 ***                   |
| 10:00~10:30   | 0.0026                   | 0.0026                    | -0.0001                   | -0.3397      | 0.0014                    | 0.0015                    | **-0.0001**               | -1.967 ***                   |
| 10:30~11:00   | 0.0025                   | 0.0022                    | 0.0002                    | 1.0798       | 0.0013                    | 0.0014                    | **-0.0001**               | -2.551 ***                   |
| 11:00~11:30   | 0.0024                   | 0.0021                    | 0.0003                    | 1.3391       | 0.0012                    | 0.0013                    | **-0.0001**               | -2.748 ***                   |
| 11:30~12:00   | 0.0019                   | 0.002                     | -0.0001                   | -0.6286      | 0.001                     | 0.0011                    | **-0.0001**               | -4.94 ***                    |
| 12:00~12:30   | 0.002                    | 0.0019                    | 0.0001                    | 0.3717       | 0.0009                    | 0.001                     | **-0.0001**               | -3.579 ***                   |
| 12:30~13:00   | 0.002                    | 0.0019                    | 0.0001                    | 0.6276       | 0.0009                    | 0.0011                    | **-0.0001**               | -4.012 ***                   |
| 13:00~13:30   | 0.0023                   | 0.0021                    | 0.0002                    | 0.9075       | 0.001                     | 0.0011                    | **-0.0001**               | -3.418 ***                   |
| 13:30~14:00   | 0.0022                   | 0.0023                    | -0.0001                   | -0.3437      | 0.0011                    | 0.0012                    | **-0.0001**               | -3.789 ***                   |
| 14:00~14:30   | 0.0027                   | 0.0024                    | 0.0003                    | 1.0186       | 0.0011                    | 0.0012                    | **-0.0001**               | -3.646 ***                   |
| 14:30~14:50   | 0.0026                   | 0.0027                    | -0.0001                   | -0.4095      | 0.001                     | 0.0011                    | 0                         | -2.284 ***                   |