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The Pricing Behaviors of Stock Index Futures: Some Preliminary Evidence in the Korean Market

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THE PRICING BEHAVIORS OF STOCK INDEX FUTURES :

SOME PRELIMINARY EVIDENCE IN THE KOREAN MARKET

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ABSTRACT

THE PRICING BEHAVIORS OF STOCK INDEX FUTURES : SOME PRELIMINARY EVIDENCE IN THE KOREAN MARKET

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This research examines the pricing behaviors of futures contract in the Korean market in its early inception period. This research is mainly organized into three parts. The first chapter investigates the mispricing of futures contract relative to its theoretical value. Consistent with earlier studies regarding futures markets in other countries, futures have been persistently underpriced in the Korean market. Even after accounting for 10 minute execution lag in the arbitrage trading, arbitrage opportunities have been largely unexploited. Market inertia caused by institutional investors' unfamiliarity is presumed to be largely responsible for underpricing of futures. Unfavorable spot market condition also hinders institutional investors from correcting for mispricing by arbitrage transactions. In the second chapter, lead and lag relationship in returns and volatilities between cash and futures markets is investigated. Based upon the Granger causality test, it is found that futures returns tend to strongly lead spot returns over the whole sample period although there is evidence that spot market also leads futures market from time to time. On the other hand, bi-directional causalities in volatility are observed between cash and futures market with strong ARCH and volume effects. In the final chapter, intraday volatility patterns in the Korean market are examined. In addition, volatilities between cash and futures markets are compared using several methods over the sample period. Generally, futures tend to be more volatile than spot. Combined with results obtained in the second chapter, this fact suggests that futures reflect

new information more rapidly occurring in the marketplace than spot as Ross (1989) proposes. Finally, the expiration day effect on the spot and futures market volatilities is also investigated. On average, spot market does not display any extreme volatility around the expiration date, but futures tend to be more tranquil as they approach maturity. Overall, the pricing behavior of index futures in the Korean market seems to have followed the same path as recorded in the futures markets of other countries.

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CHAPTER I

INTRODUCTION

The stock index futures was introduced as of May 3, 1996 as the first financial derivatives product traded in an organized exchange in Korea. While many empirical studies have been advanced regarding the pricing behaviors of index futures listed in developed countries' exchanges, little work has been done in regards to analysis of the futures contracts in the emerging markets. Among those emerging markets, Asian countries have been economically undergoing the most rapid growth. Their capital markets have been enlarged quantitatively and more technically sophisticated in line with increased national wealth. With about US$182 billion of total market capitalization, Korean stock market has become the third largest among Asian countries, next to Japan and Taiwan, and the 12 th largest in the world. Since Value Line Index futures has been listed for the first time in the Kansas City Board of Trades (KCBT) in 1982, index futures were introduced in Hong Kong and Singapore in 1986 for the first time in Asia, and subsequently in Japan in 1988 and Malaysia in 1995. Korea has become the 5th country in Asia having the index futures market by inaugurating the stock index futures trading in 1996. Compared to other stages along economic development, Korea's derivatives market is relatively new, introduced only 14 years after the U.S. and 8 years later than Japan. Even though Korea is assumed to have acquired some indirect leanings from the examples of the other advanced countries like the U.S. and Japan, it is also reasonable to observe some anomalies occurring in the process of launching an unexperienced financial products in Korea.

Using 10 minutes intraday data obtained from the Korea Stock Exchange (KSE), this research addresses the three main issues regarding the inception of stock index futures. In Chapter II, we investigate the mispricing of Korean stock index futures by observing the ex post deviations from the theoretical cost of carry relationship and present possible explanations about the mispricings of the index futures. In Korea where interest rates are high (about 12% annually) relative to the dividend yields (about 1.5% per annum), futures price should be traded at premium over cash price. However, some mispricing might be found due to the reasons cited in Figlewski (1984). The prices of Korean stock index futures may be better fitted to the cost of carry model based on the forward contract because of restrictions in marking to market (withdrawing of gains are prohibited for the time being). In addition, implied repo rates are compared to the interest rates (Brenner, Subrahmanyam and Uno, 1989, 1990) and the ex ante arbitrage opportunities are also investigated (Chung 1991).

In Chapter III, possible lead and lag relationship in returns and volatilities between futures and stock index in Korea is re-examined using the Granger causality test. It is generally documented in the U.S. that futures price leads cash prices due to a difference in speed of adjustment to the new information, which arises from differences in transaction costs and asynchronous trading in cash prices among others. Lead and lag relationship between futures and cash in Korean market is re-examined using different methodologies such as dynamic simultaneous equations method using 3SLS (Kawaller, Koch and Koch 1987,1990), vector autoregressions method using SUR (Chan and Chung 1993) and cointegration method (Fleming, Ostdiek and Whaley 1996). All of these methodologies are basically similar and based upon the Granger or Sims causality test. Possibility of reverse lead-lag relationship between cash and futures (spot leads futures) in Korean market are examined since price discovery role of futures is likely to be hindered due to the immature futures market, lack of efficiency and arbitrage capital in futures market and restricted participation of foreign capitals. Pre-whitening using ARIMA (Stoll and Whaley 1991) is also conducted before investigation of lead-lag relationship in spot-futures returns and volatility to minimize the spurious results due to infrequent trading of component stocks in the spot index.

In Chapter IV, intraday and interday volatilities for futures contract are compared with those for cash index in Korean market employing the homogeneity test of variances, as well as extreme volatility method based upon historical opening, closing, high, low daily prices. If the futures are correctly priced according to the theoretical cost of carry relationship, return volatility for futures should be equal to that of the spot under the deterministic and frictionless capital market condition. However, return volatility for futures is generally known to be greater than return volatility for cash in the U.S. market due to the severe positive autocorrelation features and the resulting smoothing effects in volatility for cash. Comparisons of inter-temporal volatility between cash and futures are made employing Garman-Klass (1980) volatility measures and Brown-Forsythe's (1974) revised Levene test. Using the above volatility estimation methodologies, comparison is also made between volatilities around the expiration date of futures contracts and those in the non-expiration weeks.

CHAPTER II

MISPRICING OF FUTURES CONTRACT IN THE KOREAN MARKET

2-1. Literature Review

In contrast with what the theoretical cost of carry relationship dictates, futures price tends to persistently deviate from its fair equilibrium prices or even fall below its respective stock index price in the early inception period (e.g., see Cornell and French 1983 ; Modest and Sundaresan 1983 ; Figlewski 1984a,b ; Cornell 1985 ; MacKinlay and Ramaswamy 1988; Billingsley and Chance 1988 ; Brenner, Subrahmanyam and Uno 1989,1990 ; Bailey 1989 ; Yadav and Pope 1990). Many hypotheses have been raised regarding the reasons for underpricing of futures price in the inauguration period. Cornell and French (1983) argue that futures prices may be priced below their theoretical value due to the existence of tax timing option that a stock portfolio has. They insist that a stock portfolio offers certain tax advantage over futures contracts since an investor can save tax by realizing capital loss at short term income rate if the value of his stock portfolio declines or by carrying over the unrealized profit and taking advantage of the low long term capital gain rates if it increases.[1] Modest and Sundaresan (1983) suggest that futures prices may well be at a discount relative to the spot

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[1] In the U.S., futures are marked to market daily and its capital loss or gains are realized at the end of the year in such a way that 60 % of gains are taxed at the long term capital gain tax rate and 40% of gains are taxed at the short term capital gain tax rate no matter how long they are held. Before Tax Reform Act of 1986, the long term capital gain tax rate was 28% and the ordinary income tax rate was 46%. Since 1987, the long term capital gain tax rate increased to 34% while the ordinary income tax rate was reduced to 40%. Therefore, the tax timing option is assumed to have decreased in the U.S. since 1987.

value of the index without giving rise to arbitrage opportunities if it is assumed that an investor seldom obtains full use of the proceeds of his short sales. They maintain, therefore, that futures price should be discounted by an amount equal to the foregone interests on the unavailable proceeds. Chung (1991) also reports that the short sale constraint such as uptick rule in the spot market exposes arbitrageurs to the greater risk of execution lag. Due to this kind of restrictions on short sale in the spot market, they argue that investors may find it more difficult to participate in long hedge than short hedge, which results in underpricing of futures contract. Brennan and Schwartz (1990) and Sofianos (1993) maintain that futures contracts provide an investor with an early closing option so that futures prices may be less than the theoretical cost of carry prices. They insist that previous analyses of futures arbitrage are based upon the assumption that the arbitrage position is held until maturity and investors have no position limit. However, if an arbitrageur faces position limit due to either scarce resources or imposed maximum risk exposure, the early close-out option has value since the costs of closing out an existing position are less than that of initiating a new position. They assert that opening a futures position carries with it an option to close out early thereby making an additional arbitrage profit. If the profits gained by early closing of an established futures position exceeds total transaction costs involved in index arbitrage, futures contracts may be traded at discount relative to the theoretical prices. Imperfect substitutability of index futures for stock portfolio is raised by Figlewski (1984b) and Chen, Cuny and Haugen (1995). Figlewski (1984b) notes that investors may prefer to take a short position in futures rather than in stocks even if futures prices are too low relative to stocks because of the problems of selling short actual shares when the market is likely to drop. When the market is bullish, the same investors prefer buying stocks to futures because they can tailor their own portfolio of stocks, especially something different from the index portfolio even if prices of stocks are too high relative to futures. In addition, Figlewski (1984b) insists that futures contracts can not be a good substitute for stock portfolios that investors are holding since most investors carefully select portfolios of stocks that they believe will outperform the market. Investors would not necessarily want to sell their stocks at market prices they feel are below their true values simply because index futures are also underpriced. On the other hand, investors may be willing to sell index futures at discount to hedge their portfolios because they expect to do better than the market even when it drops. Similarly, Chen, Cuny and Haugen (1995) argue that investors can tailor their own portfolios according to their exogenous hedging purposes or tax consideration, and that based upon private information, they may also distinguish (at least they believe) between stocks of positive or negative value relative to the index. In contrast, futures contract can offer the advantage of better market liquidity. Chen, Cuny and Haugen (1995) call the net advantage of the stock position its customization value (CV) and argue that this value may be positive or negative depending on the relative attractiveness of portfolio tailoring and market liquidity to an investor. Therefore, futures may be traded at discount by the amount of CV relative to its stock price if futures market does not provide sufficient liquidity in the inception period. Regulation constraints upon arbitrage activities can be a reason for early discount of futures contract price. In the Japanese market, Brenner, Subrahmanyam and Uno (1989,1990) find that the frequency and magnitude of mispricing of index futures significantly reduced after the government eased the regulations on arbitrage trading by foreign and domestic institutions. Yadav and Pope (1990) also report in the U.K.

market that the decrease in brokerage commissions and increase in arbitrage trading after Big Bang (market deregulation) resulted in a significant reduction in underpricing of futures price since 1986. Figlewski (1984b) suggests that the discount on index futures is largely a transitory phenomenon caused by unfamiliarity with new markets and institutional inertia in developing systems to take advantage of the opportunities they present. He expects that underpricing of futures contracts becomes smaller as time passes and more index arbitrages by institutional investors are undertaken. By the same token, Chung (1991) reports that the serious persistence of mispricings of the futures contracts in the early periods is mainly due to noise and disappears with time as arbitrage trading tends to correct mispricings. Figlewski (1984a) observes that the basis (futures price- spot price) tends to widen , i.e., futures rise relative to the spot index when the market is rising, and shrinks, even to negative value, when the market drops, which suggests that futures market is overreacting to the forces that moves the cash market. However, he finds that as futures market matures, the overreaction of futures prices to changes in the spot diminishes and that futures prices are determined more by the equilibrium relationship rather than by fluctuations in the stock market movement. Klemkosky and Lee (1991) similarly observe that the S&P 500 futures contracts are more often overpriced than underpriced during their test periods (from March 1983 through December 1987) when the market was bullish, indicating that after initial inception periods, the direction of mispricing of futures contract is largely dependent upon the overall market movement.

MacKinlay and Ramaswamy (1988) note that the series of mispricing is highly autocorrelated so that they tend to persist over or below zero and not fluctuate randomly around zero. They also insist the path dependence of the futures mispricing, implying that if the mispricing has crossed one arbitrage bound, it is less likely to cross the opposite bound due to arbitrageurs' early unwinding of their established positions. Consistent with Figlewski (1984a), they argue that the magnitude of the futures mispricing is positively related to the time left until expiration. Due to the reduced uncertainty surrounding dividend, marking to market flows or tracking the index with a partial basket of stocks, they maintain that mispricing of futures contracts diminishes as the expiration date approaches. Klemkosky and Lee (1991) also confirm that the frequency and degree of mispricing diminishes as expiration of the futures contract approaches.

Chung (1991) insists that a market efficiency test should be carried out as an ex ante test to see the extent to which arbitragers can make positive ex ante arbitrage profits after observing ex post mispricings.[2] In his study, he employs transaction data of the component shares in computing the spot index value since the reported index quotation does not properly reflect the true value of the index due to the asynchronous trading of the component shares of a stock index. He also accounts for the execution lag and the uptick rule for short sales of stocks, and documents that the market efficiency test based upon the ex post mispricing of futures contract significantly overestimates the size and frequency of profitable arbitrages in the index futures market. Moreover, the ex ante profits are substantially smaller and more

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[2] The ex post riskless profit opportunity is not guaranteed since the prices at the next available transaction may not be favorable for the arbitrageur. According to the execution lag between observing an initial mispricing signal and executing an order, Chung (1991) reports that two to five minutes are sufficient time for heavily traded stocks (such as shares in MMI index). He adds that as the execution lag is longer than two minutes, more than 50% of apparent mispricings are eliminated. However, Klemkosky and Lee (1991) suggest that profitable arbitrage is still possible 10 minutes after the initial signal.

volatile than the ex post mispricing signal and likely to be eliminated by higher transaction costs, implying that index arbitrages are not riskless. He reports that the size of the mispricing signal has become a poor predictor of the realized profit from index arbitrage as the index futures market matures. He also adds that short arbitrages involving short sales of shares are much more risky than long arbitrages since the average ex ante arbitrage profit from short arbitrages is significantly smaller and more volatile than that of long arbitrages due to longer execution lag resulting from the uptick rule and much quicker market responses to mispricing signals for underpriced futures (or overpriced spot index). Nonetheless, he observes that the frequency and size of the ex ante (or ex post) arbitrage profits have declined significantly over time.

As for Japanese derivatives market, Brenner, Subrahmanyam and Uno (1989,1990) observe the significant underpricing of index futures in the introduction period (Dec.1986 to Jun.1988) but in the later periods (Dec.1988 to Sep.1989), futures market are traded more often at premium relative to its theoretical price than at discount. Short sale restrictions, regulatory constraints on the participation of foreign financial institution are assumed to be the reasons for the persistent underpricing in the Japanese futures contract in the early periods. Consistent with Figlewski (1984a) and Klemkosky and Lee (1991), their results also suggest that mispricings of the futures contract are largely dependent upon the overall trend of the stock market movements except for brief inception period. As in the case in the U.S., however, deviations from fair futures prices in the Japanese market become more and more bounded by transaction costs and gradually disappear as the futures market matures. Consistent with MacKinlay and Ramaswamy (1988), there exists a strong tendency for mispricings of futures contract to persist for many days in either a positive or negative direction in Japanese futures contracts (mispricing series show high positive autocorrelations at several lags) although daily prices used in their studies do not properly reflect price fluctuations within a day. Unlike other studies conducted in the U.S., however, they do not find any apparent pattern in the size of the mispricing deviations as a function of the time to maturity.

Employing both cost of carry model and continuous time model on the daily data from September 1986 to June 1988, Bailey (1989) also finds that actual Nikkei stock average (Osaka stock average) futures prices on average deviate downward (upward) from the theoretical prices. But futures mispricings are not significantly different from zero if large standard errors are considered. Furthermore, most of pricing errors occur near the inception of trading, during the fall of 1986 for Nikkei market and the middle of 1987 for the Osaka market. He also reports that the pricing errors computed from the continuous time model are not substantially different from those computed by the simpler cost of carry model due to low volatility of Japanese interest rates. Using 5 minute intraday data of the Nikkei Stock Average (NSA) futures market, Lim (1992) documents similar results that arbitrage opportunities are very limited and almost non-existent for institutional investors after transaction costs are accounted for over the period from June 1988 to September 1989.

As for the U.K. futures market, Yadav and Pope (1990) report that before Big Bang (stock market deregulation), actual futures prices on FTSE-100 contract are persistently downward biased relative to the theoretical prices and these violations are too large to be accounted solely by transaction costs. After Big Bang, however, the extent and frequency of systematic mispricing violations decreased considerably and significant mispricing reversals were observed due to an increase in supply of arbitrage services after market deregulation. They suggest that the simple hold to expiration trading rule appears to provide only limited opportunities for arbitrage profits, particularly after market deregulation. In contrast, risky arbitrages such as early unwinding or rolling over an arbitrage position offer valuable profit opportunities and are even attractive for investors with large transaction costs. Consistent with MacKinlay and Ramaswamy (1988), they find that the absolute levels of mispricings increase with time to expiration. However, no apparent relationship is found between the levels of mispricing and time to expiration and therefore does not support Cornell and French's (1983) tax timing option hypothesis. Bühler and Kempf (1995) also note that German DAX index futures contracts are significantly undervalued so that large number of arbitrage signals are observed and most of these indicate long arbitrage opportunities which have not been unexploited even on ex ante basis.

In summary, previous studies find that futures price has been underpriced in the introduction periods in most of countries, but these mispricings gradually disappears as the futures market matures.

2-2. Data Description and Methodology

2-2-1. Trading Features of the Korean Stock Exchange (KSE)

The organizational system and trading mechanism of the Korean futures market follow largely those of the advanced countries such as the U.S. and Japan. However, Korean financial authorities take some special precautionary measures against unfavorable aspect of futures trading such as stock market instability and rapid outflows of national wealth by foreign traders. For example, the Korean futures market maintains daily price limits and a circuit breaker system along with its respective spot market to prevent sudden changes in the spot market condition due to fluctuations in futures market. For this purpose, unlike the U.S., the futures contracts are also listed in the Korean stock exchange (KSE) and the clearing house is not independently organized but rather a part of the KSE. In contrast to futures trading executed under separate exchanges such as CME or CBOT in the U.S., futures contracts are not traded in the independent exchange in Korea. In addition, the participation of foreign capital is temporarily restricted to a certain level in order to prevent a market domination by the experienced foreign capital in the early introduction period. For the purpose of safety in the settlement process, the margin requirement is set at the higher level compared to the futures markets in other countries. Withdrawing the gains occurred by daily marking to market or using them for initiating new position is temporarily prohibited. Moreover, there is minimum margin requirement for market entry to discourage individual investors from market participation.

Korean futures market adopts a computerized auction trading system like Japan, in contrast to the open outcry system in the U.S.[3] The KSE market (both for stocks and futures)

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[3] Pirrong (1996) compares the efficiency and market depth between open outcry system and computerized trading system (CTS) using German treasury bond futures traded both on LIFFE (open outcry system) and DBT Bund market (CTS). He concludes that the computerized DTB Bund market is both more liquid and deeper than the open outcry LIFFE Bund market. He points out that while information asymmetry among traders is less severe in the open outcry system than in CTS, the number of orders that can be processed in a given interval is constrained and error costs and monitoring costs are higher in open outcry system than in CTS.

is a typical order-driven auction market where buy and sell orders compete for the best price. Throughout the trading session, customer orders are continuously matched at a price satisfactory to both parties according to price and time priority. At the time of market opening and closing, however, customer orders are pooled over a certain period of time (before opening of morning session and 10 minutes before closing of afternoon session) and matched at a single price that minimizes any imbalance between the buying and selling parties. This feature replaces the role of specialists in the U.S. market.[4] About 95% of trading volume (including futures contracts) in the KSE is currently handled by the computerized system called the Stock Market Automated Trading System (SMATS) and only a limited number of inactive issues are traded manually. All orders are transmitted directly to the floor or the SMATS of the KSE via the computerized order-routing system. When an order is placed through the system terminal at the office of a member firm, the system first checks if the requirement of the good faith deposit (currently the minimum deposit is 40% of the total transaction value) has been met. For orders received from foreign investors, the system checks whether they are within either the individual or aggregate foreign investment ceiling. Daily trading begins at 9:30 a.m. for both stock and futures markets, and ends at 15:00 p.m. for stock market, and at 15:15 p.m. for futures market. Unlike U.S. market with continuous trading without intermission during daily trading hours, the Korean Stock Exchange (KSE) maintains one and half hours of session break from 11:30 a.m. to 1:00 p.m. During this

[4] In Korea, there is no market maker such as specialist in NYSE. Although floor traders (KSE members) have better access to the information about order flows and may attempt to capitalize on gap between bid and ask price, they do not have any obligation to provide liquidity to the market.

intermission, both stock and futures trading halt and only order receiving is allowed. Table 2-1 illustrates the main organizational characteristics of the Korean futures market.

2-2-2. Data Description

The data set used in this study is comprised of 10 minute intraday price data of the KOSPI 200 index and its nearby futures contract. Although the Korea Composite Stock Price Index (KOSPI, its base index =100 as of Jan.4,1980) is the leading indicator of the Korean stock market, KOSPI 200 index is newly designed to be used as an underlying index for stock index futures trading. Since KOSPI index encompasses all the listed common and preferred stocks, it is deemed not suitable for an underlying index for futures trading because futures trading normally entails passive portfolio strategy such as index tracking or arbitrage transaction between spot and futures markets. The more stocks are included in the underlying index basket, the more difficult it is to track all the securities along with its relationship with futures prices. For this reason, KOSPI 200 index is composed of 200 stocks (out of 721 listed companies in KOSPI as of the end of 1995) that are mainly large and leading companies in their respective industries. Just like KOSPI, the KOSPI 200 index is a market value weighted index and its component stocks are based on the individual stock's liquidity and its position within its industry. It has a base date of January 3,1990 and a base index of 100. The total market capitalization of the component stocks in the KOSPI 200 accounts for over 70 % of that for all listed companies in the Korean Stock Exchange (KSE). Table 2-2 shows the list of the component stocks in the KOSPI 200 index.

In Korean futures market, four contracts with varying maturity can be listed at the same time. Each contract has a life of at most one year and the second nearest contract becomes the new nearby contract when the nearby contract expires at its maturity date. In this study, from May 3rd to June 13th of 1996, the June contract is the nearby contract with the September contract from June 14th to September 12 th and December contract from September 13th to October 16th as the nearby contracts respectively.[5] The sample period covers 135 trading days which include 112 weekdays and 23 Saturdays. Since futures trading begins at the same time as spot market but ends 15 minutes later than the spot markets on each ordinary trading day, this study truncates the last fifteen minute data of futures trading to reconcile the number of observations for both futures and spot. This study also deletes the first 10 minute data (observation at 9:30 a.m.) after opening and the first 10 minute data (13:00 p.m.) in the afternoon session after lunch break since the previous studies suggest the staleness of these prices (e.g. Stoll and Whaley 1990).[6] On the other hand, futures market

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[5] Throughout the entire sample periods (1996.5.3-1996.10.16), rolling-over of the nearby contracts into the next nearby contracts around the expiration date was not actively carried out since the open interest and volume of the second nearby contract were not greater than those of the nearby contract even one day before expiration. For instance, volume and open interest figures for the nearby contract and the second nearby contract from June 10 to June 12 (expiration date of June contract : June 13), from September 9 to September 11 (expiration date of September contract : September 12) as follows.

	Volume		Open Interest	
	Nearby	Second nearby	Nearby	Second nearby
June 10	3,017	304	2,119	561
June 11	3,259	406	1,735	406
June 12	2,726	623	1,482	964
Sept.9	3,237	379	3,068	1,483
Sept.10	3,771	573	2,829	1,736
Sept.11	2,780	796	2,748	2,107

[6]These prices after intermission mainly reflects the previous day's closing price or the closing price of the morning session, not the true value of the market price due to the infrequent trading problem.

ends 10 minutes earlier than spot market at expiration. Since price behaviors of the nearby futures contract mainly reflect the unwinding force at the expiration date, This study also excludes the entire observations on the expiration date. Therefore, in this study of the mispricing of futures contract, total 2916 observations of 10 minute intraday prices are investigated.[7]

2-2-3. Cost of Carry Model of Futures Pricing

Before we investigate the possible mispricing of the futures contract, several assumptions should be introduced. First, our analysis employs the cost of carry relationship based upon pricing of forward contract. Therefore, the daily marking to market effect is not considered.[8] Second, we assume perfect foresight in terms of the interest rates movement and dividend streams[9], which means that the actual daily quotations for 3 month CD rates are

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[7] On May 28th, the futures (spot) market opened at 12:00 p.m. and closed at 4: 45 (4:30) p.m. with 30 minute intermission from 2:00 p.m. to 2:30 p.m. due to the computer system hangup.

[8] Cox, Ingersoll and Ross (1981), Jarrow and Oldfeld (1981) expound that forward prices and futures prices would be equal as long as future interest rates are non stochastic (known in advance) or the correlation between futures price change and changes in interest rates is zero. Under theses condition, marking to market should have no effect on futures price relative to forward prices. Empirically, Cornell and Reinganum (1981), French (1983), Elton, Gruber and Rentzler (1984) report that the effects of marking to market are on average small.

[9] What is meant by the notion that interest rates are deterministic is not saying that interest rates are assumed to be constant, but that market participants can make perfect forecasts of the next day's term structure of interests so that the preclusion of inter-temporal arbitrage opportunities are assured. Levy (1989) and Flesaker (1991) expound this in their papers. In Korean money market where the demand for money is highly volatile and usually outstripping the supply for money, short term interest rates such as one day call loan rates more often than not exceed the long term rates such as 3 month CD rates or 3 year corporate bond yields and thus downward sloping yield curves and

substituted as risk free rates[10] and the actual dividend payments are used as the expected dividend payments.[11] Third, for simplicity, the lending interest rates are assumed to be equal to the borrowing rates. Fourth, the initial arbitrage position is assumed to be closed at expiration date. Thus, early unwinding or rolling over before expiration is not considered. Finally, tax effect on pricing of futures is ignored as in most previous studies.[12]

To create the arbitrage-free transaction band, the following two strategies can be

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negative liquidity premium are often observed. Therefore, it is difficult to interpolate the effective yields to maturity by using one day call loan rates and 3 month CD rates.

[10] Kawaller (1987) , MacKinlay and Ramaswamy (1988) and Sofianos (1993) insist that the actual implementation of arbitrage activities involves the incurrence of various risks (tracking error, execution lag, margin variation, interest rate and dividend uncertainty etc.). Due to these risks, an arbitrageur may not initiate a trade even though the expected return exceeds the risk free return. The three month CD rate is exactly same as the three month repo rate in Korea and is comparable to the U.S. 3 month treasury bill or Japanese Gensaki rate. Use of 3 month CD rates is seen in Figlewski (1984) or MacKinlay and Ramaswamy (1988).

[11] Dividends payments are eventually not considered in this paper because their impact on the futures pricing in Korean market is negligible. Further explanation is followed in details in the later section.

[12] Cornell and French (1983) hypothesize that underpricing of stock index futures relative to the fair price could be attributed to the tax timing option of the spot securities. However, Cornell (1985) empirically find that the effect of tax timing option is not significant. In Korea, tax timing option does not exist since there is no differential taxation between long term capital gain and short term capital gain. With respect to taxation in Korea, for institutional investors (corporations), dividend income from investment on listed companies is not subject to taxation as long as its stake does not exceed 10% of total shares of a listed company. For individual investors, dividend income is subject to comprehensive taxation (levied according to one's total income) after 15% withholding tax. As long as capital gains are concerned, capital gains from investment on listed securities are tax-free for individual investors and subject to comprehensive taxation with other corporate income for institutional investors or corporate investors. For unrealized capital gains and losses, financial authorities such as Securities Supervisory Board (SSB) or Bank Supervisory Board (BSB) currently recommend the institutional investors to book such gains and losses for full amount in their respective fiscal year. Therefore, there would be no difference in tax treatment between futures and stock portfolios.

considered.[13] First, we consider the short hedge (buy spot and sell futures) strategy. The initial up-front costs a customer pays when he or she initiates this hedge process are the sum of brokerage commissions and margin requirement. Hereinafter, we assume that a customer buys spot at ask price and sells futures at bid price and that the effective market interest rate is higher than interest rate assigned to margin requirement by the brokerage house.

Up-front costs

$C_t^{LS} + C_t^{SF} + (M_t^{LS} + M_t^{SF})\, S_t^{A}$ --(2-1)

where S_t^{A} = ask price of spot index at time t (initiation)

C_t^{LS} = brokerage commissions for buying spot

C_t^{SF} = brokerage commissions for selling futures[14]

M_t^{LS} = initial margin requirement (as % of spot index) for buying spot

M_t^{SF} = initial margin requirement (as % of spot index) for selling futures

At expiration date (T= t + N), two positions are closed by reverse transactions and the subsequent cashflows are as follows :

[13] These examples are based on Sofianos (1993)'s paper but modified to consider the special situation in Korean market. Usually, the deposit rates charged against customer's margin are very low (about 3% per annum) compared to the effective market interest rates (around 12-15% per annum). I also add the long hedge strategy in addition to the short hedge strategy demonstrated in Sofianos' paper.

[14] Unlike the case in spot, round-trip brokerage commissions for futures are paid up front at initiation.

Cash flows from futures

$F_t^B - S_{t+N} + (1 + r_{t,t+N}) M_t^{SF} S_t^A$ ---(2-2)

where F_t^B = bid price of futures at time t (contract price at initiation)

S_{t+N} = spot price at expiration

$r_{t,t+N}$ = unannualized interest rate charged against futures initial margin

N= time to expiration (T-t)

Cash flows from spot

$S_{t+N} + d_{t,t+N} S_t^A - (1 + r^e_{t,t+N})(1 - M_t^{LS}) S_t^A - C^{LS}_{t+N}$ ---------------------------(2-3)

where $d_{t,t+N}$ = unannualized dividend yields during contract period

$r^e_{t,t+N}$ = unannualized effective market interest rate charged against borrowing and lending (> $r_{t,t+N}$)

C^{LS}_{t+N} = brokerage commission for reversing long position in spot (selling spot) at expiration

If this customer did not engage in hedge transaction, he could have used the money for up-front costs in other interest bearing investment. Therefore, the foregone profit from other alternative investment will be equal to :

Opportunity cost of capital for up-front costs

$(1 + r^e_{t,t+N})[\, C_t^{LS} + C_t^{SF} + (M_t^{LS} + M_t^{SF}) S_t^A \,]$ --(2-4)

Transaction for arbitrage profit is triggered if the sum of (2-2) and (2-3) exceeds (2-4).

Therefore, futures price should satisfy the below inequality to prevent any arbitrage profit searching transaction. In other words, the upper limit for futures price in arbitrage free band is :

$$F_t^B < S_t^A [1 + (r^e_{t,t+N} - d_{t,t+N})] + (r^e_{t,t+N} - r_{t,t+N}) M^{SF}_t S_t^A + C^{LS}_{t+N} + (1 + r^e_{t,t+N})(C^{LS}_t + C^{SF}_t) \quad \text{(2-5)}$$

since $F_t = F_t^B + SP^{SF}_t$ and $S_t = S^A_t - SP^{LS}_t$

where SP^{SF}_t = a half of bid-ask spread in selling futures and SP^{LS}_t = a half of bid-ask spread in buying spot , the above inequality can be rewritten as follows:

$$F_t < S_t [1 + (r^e_{t,t+N} - d_{t,t+N})] + (SP^{SF}_t + SP^{LS}_t) + (r^e_{t,t+N} - r_{t,t+N}) M^{SF}_t (S_t + SP^{LS}_t) + C^{LS}_{t+N} + (1 + r^e_{t,t+N})(C^{LS}_t + C^{SF}_t) \quad \text{(2-6)}$$[15]

Next, we consider the long hedge (buy futures and sell spot) strategy. The initial up-front costs a customer pays when he or she initiates this hedge process are similar to the short hedge case except that there is restriction to the usage of short sale proceeds (which is similar to the margin requirements when buying spot with leverage). Again a customer is assumed to buy futures at ask price and sell short spot at bid price, and that borrowing interest rate is equal to lending interest rate.

Up-front costs

$$C_t^{SS} + C_t^{LF} + M_t^{LF} S_t^B \quad \text{(2-7)}$$

---

[15] $(SP^{LS}_t)(r^e_{t,t+N} - d_{t,t+N})$ term is negligible in magnitude so it is omitted from the inequality.

where S_t^B = bid price of spot index at time t (initiation)

C_t^{SS} = brokerage commissions for selling short spot

C_t^{LF} = brokerage commissions for buying futures

M_t^{LF} = initial margin requirement (as % of spot index) for buying futures

At expiration date (T= t + N), two positions are closed by reverse transactions and the subsequent cashflows are as follows:

Cash flows from futures

$-F_t^A + S_{t+N} + (1 + r_{t,t+N}) M_t^{LF} S_t^B$ --(2-8)

where F_t^A = ask price of futures at time t (contract price at initiation)

Cash flows from spot

Suppose an arbitrageur faces the restriction to using the proceeds from short-sale of borrowed securities, i.e., there is a margin requirement upon the short-sale proceeds, then the cash flow from spot at expiration will be :

$-S_{t+N} - d_{t,t+N} S_t^B + (1 + r^e_{t,t+N})(1 - M_t^{SS}) S_t^B + (1 + r_{t,t+N}) M_t^{SS} S_t^B - C^{SS}_{t+N}$ ---(2-9)

where M_t^{SS} = margin requirement (as % of spot index) for proceeds from short sale

C^{SS}_{t+N} = brokerage commission for reversing short position in spot (buying spot) at expiration

If this customer did not engage in hedge transaction, he could have used the money for up-front costs in other interest bearing investment. Therefore, the foregone profit from other alternative investment will be equal to :

Opportunity cost of capital for up-front costs

$$(1 + r^{e}_{t,t+N})[C_t^{SS} + C_t^{LF} + M_t^{LF} S_t^{B}] \text{ -------- (2-10)}$$

Transaction for arbitrage profit is triggered if the sum of (2-8) and (2-9) exceeds (2-10). Therefore, futures price should satisfy the below inequality to prevent any arbitrage profit searching transaction. In other words, the lower limit for futures price in arbitrage free band is :

$$F_t^{A} > S_t^{B} [(1 + r^{e}_{t,t+N}) - d_{t,t+N}] - (r^{e}_{t,t+N} - r_{t,t+N}) M^{LF}_t S_t^{B} - (r^{e}_{t,t+N} - r_{t,t+N}) M^{SS}_t S_t^{B} - C^{SS}_{t+N} - (1 + r^{e}_{t,t+N})(C^{SS}_t + C^{LF}_t) \text{ -------- (2-11)}$$

since $F_t = F_t^{A} - SP^{LF}_t$ and $S_t = S^{B}_t + SP^{SS}_t$

where SP^{LF}_t = a half of bid-ask spread in buying futures and SP^{SS}_t = a half of bid-ask spread in short-selling spot , the above inequality can be rewritten as follows :

$$F_t > S_t [(1 + r^{e}_{t,t+N}) - d_{t,t+N}] - (SP^{LF}_t + SP^{SS}_t) - (r^{e}_{t,t+N} - r_{t,t+N}) M^{LF}_t (S_t - SP^{SS}_t) - (r^{e}_{t,t+N} - r_{t,t+N}) M^{SS}_t (S_t - SP^{SS}_t) - C^{SS}_{t+N} - (1 + r^{e}_{t,t+N})(C^{SS}_t + C^{LF}_t) \text{ -----(2-12)}$$[16]

[16] $(-SP^{SS}_t)[r^{e}_{t,t+N} - d_{t,t+N}]$ term is negligible in magnitude so it is omitted from the inequality.

From the above example, the arbitrage free band within which futures price fluctuates without triggering arbitrage transaction can be suggested as such [17] :

$$S_t [(1 + r^e_{t,t+N}) - d_{t,t+N}] - (SP^{LF}_t + SP^{SS}_t) - (r^e_{t,t+N} - r_{t,t+N}) M^{LF}_t (S_t - SP^{SS}_t)$$
$$- (r^e_{t,t+N} - r_{t,t+N}) M^{SS}_t (S_t - SP^{SS}_t) - C^{SS}_{t+N} - (1 + r^e_{t,t+N})(C^{SS}_t + C^{LF}_t) \leq F_t \leq$$
$$S_t [(1 + r^e_{t,t+N}) - d_{t,t+N}] + (SP^{SF}_t + SP^{LS}_t) + (r^e_{t,t+N} - r_{t,t+N}) M^{SF}_t (S_t + SP^{LS}_t) +$$
$$C^{LS}_{t+N} + (1 + r^e_{t,t+N})(C^{LS}_t + C^{SF}_t) \quad \text{(2-13)}$$

In Korea, stock index arbitrage is expected to be mostly undertaken by floor members and other institutional investors[18], and these institutional investors are assumed to be "quasi-arbitrageurs" who already own shares and sufficient funds to carry out arbitrage transactions. They are unlikely subject to either the margin requirements in leveraged buying or shortsale

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[17] Suppose $r^e_{t,t+N}$ is equal to $r_{t,t+N}$, then the arbitrage free band would be simplified such as:

$$S_t [(1 + r^e_{t,t+N}) - d_{t,t+N}] - (SP^{LF}_t + SP^{SS}_t) - C^{SS}_{t+N} - (1 + r^e_{t,t+N})(C^{SS}_t + C^{LF}_t) \leq F_t \leq$$
$$S_t [(1 + r^e_{t,t+N}) - d_{t,t+N}] + (SP^{SF}_t + SP^{LS}_t) + C^{LS}_{t+N} + (1 + r^e_{t,t+N})(C^{LS}_t + C^{SF}_t)$$

[18] There are 48 floor members in Korea stock exchange (KSE), all of which are securities companies licensed by Ministry of Finance (MOF). Among them, 42 securities firms including 33 domestic firms and 9 foreign branches are allowed to participate either in dealing and brokerage of stock index futures while the rest 6 can only do brokerage businesses. Other institutional investors are banks, insurance companies, investment trust companies and merchant banks. KSE sets the minimum initial margin for entry in stock index futures transaction at Won 30 million in cash (about US $ 36,000) to discourage small individual investors' market participation.

restrictions.[19] Therefore, for these institutional investors, $M_t^{LS} = 1$, $M_t^{SF} = .05$ (zero for member), $M_t^{SS} = 0$ and $M_t^{LF} = .05$ (zero for member) and the arbitrage free transaction band becomes simplified as follows:[20]

$$S_t [(1 + r^e_{t,t+N}) - d_{t,t+N}] - (SP^{LF}_t + SP^{SS}_t) - .05(r^e_{t,t+N} - r_{t,t+N})(S_t - SP^{SS}_t) - C^{SS}_{t+N}$$

$$- (1 + r^e_{t,t+N})(C^{SS}_t + C^{LF}_t) \leq F_t \leq S_t [(1 + r^e_{t,t+N}) - d_{t,t+N}] + (SP^{SF}_t + SP^{LS}_t) +$$

$$.05(r^e_{t,t+N} - r_{t,t+N})(S_t + SP^{LS}_t) + C^{LS}_{t+N} + (1 + r^e_{t,t+N})(C^{LS}_t + C^{SF}_t) \text{ ---------------------(2-14)}$$

If we express the brokerage commissions and bid-ask spread as a percent of spot index and turn unannualized market interest rates and dividend yields into continuous compounding, the inequality equation (2-13) can be rewritten as follows :

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[19] For individual investors, the margin requirements in leveraged buying (M_t^{LS}) is 40% and that for net proceeds from short sale (M_t^{SS}) is 100%. Margin loans or securities lending for shortsale to an individual customer are provided by either Korea Securities Finance Corp. (KSFC) or brokers themselves. However, short-selling is less common practice in Korea, accounting for mere .09% of total market turnover on the KSE. Proceeds from short sales of borrowed stocks are normally deposited at broker's house as a collateral. There exist many restrictions regarding short-selling such as maximum amount (Won 50 million per customer and 10% of total shares of a eligible company), eligible share (the 1st section and with paid in capital in excess of Won 1 billion), etc. For institutional investors, from September 1 of 1996, securities lending system is introduced by Korea Securities Depository (KSD) as an intermediary connecting stock lenders and borrowers. Borrowing commission was set at 1.8% per annum.

[20] Since KSE allows its members to use fully marketable securities they hold as substitutes for margin requirements and other institutional investors also can use them up to 10%, only 5% cash requirement for margin will be applied to the arbitrage free condition.

$$S_t\,[\,1 - K_{SS} - K_{LF}\,]\exp^{r((T-t)/365)} - \sum_{j=1}^{T-t} D_{t+j}\exp^{r(T-(t+j)/365)} \le F_t \le$$
$$S_t\,[\,1 + K_{LS} + K_{SF}\,]\exp^{r((T-t)/365)} - \sum_{j=1}^{T-t} D_{t+j}\exp^{r(T-(t+j)/365)} \text{----(2-15)}$$

where S_t = current spot value

F_t = current futures value

K_{SS} = transaction costs (as % of spot index value) of being short in the spot including brokerage commissions, bid-ask spreads and foregone interests on restricted short sale proceeds

K_{LF} = transaction costs (as % of spot index value) of being long in the futures including brokerage commissions, bid-ask spreads and foregone interests on initial margin requirement

K_{LS} = transaction costs (as % of spot index value) of being long in the spot including brokerage commissions and bid-ask spreads

K_{SF} = transaction costs (as % of spot index value) of being short in the futures including brokerage commissions, bid-ask spreads and foregone interests on initial margin requirement

r = effective market interest rate per annum

t = current (initiation)date

T = expiration date

$\sum D_{t+j} \exp^{r(T-(t+j)/365)}$ (j=1,2,....,T-t) = future value of dividends on spot between t and T at expiration (time T)

2-2-4. Measures of Futures Mispricing

In the previous literatures, the deviation of the actual futures price from theoretical price is usually expressed as percentage of spot index value such as below:

$$M_t = (F_t - F^*) / S_t \times 100 \quad \text{-----------------------------(2-16)}$$

where F^* = theoretical futures price based on the cost of carry model

When transaction costs are taken into account, the mispricing of futures can be defined by the deviation from the arbitrage free band :

$$\begin{aligned} M_t &= (F_t - F^+) / F^+ \times 100 && \text{If } F_t > F^+ \\ &= 0 && \text{If } F^+ \geq F_t \geq F^- \\ &= (F_t - F^-) / F^- \times 100 && \text{If } F_t < F^- \quad \text{---------------(2-17)} \end{aligned}$$

where F^+ = upper bound futures price in arbitrage free band

F^- = lower bound futures price in arbitrage free band

Suppose once established arbitrage position is held to the expiration date[21], the annualized expected excess arbitrage return to expiration (AERE) can be calculated.This has an identical

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[21] Brennan and Schwartz (1990) argue that opening a futures position carries with it an option to close out early and thereby make an additional arbitrage profit. Sofianos (1993) suggests that an arbitrageur may initiate arbitrage position even if futures mispricing does not fully cover transaction costs because of this profitable early exercise option. Early closing of position becomes valuable whenever profitable mispricing reversal occurs so that futures contract switches from being overpriced by an amount exceeding transaction costs to being underpriced by an amount exceeding transaction costs. Sofianos insists that the arbitrageur needs smaller mispricing to close a position profitably (early) than to open the position due to lower transaction costs involved. He also documents that more than 70% of futures positions are unwound before the expiration in practice.

implication to the return on investment (ROI) in the capital budgeting decision making.

<u>Annualized expected excess arbitrage return to expiration (AERE)</u>

(i). At short hedge (long in spot and short in futures)

(365/ number of days to expiration)/ [(actual futures price - upper bound)/ arbitrage capital)]

$$(365/N)[(F_t - F^+)/[S_t^A + C_t^{LS} + C_t^{SF} + M_t^{SF} S_t^A] \quad \text{------------------------(2-18)}$$

where F^+ = upper bound futures price in arbitrage free band

N= time to expiration (T-t)

(ii). At long hedge (short in spot and long in futures)

(365/ number of days to expiration)/ [(lower bound - actual futures price)/ arbitrage capital)]

$$(365/N)[(F^-_t - F_t)/[S_t^B + C_t^{SS} + C_t^{LF} + M_t^{LF} S_t^B] \quad \text{------------------------(2-19)}$$

where F^- = lower bound futures price in arbitrage free band

In addition to checking the frequency and magnitude of the mispricing (deviations from arbitrage free band), implied repo rate (IRR) may be compared to the market interest rates to see how often futures price moves outside the arbitrage free band, i.e., profitable arbitrage opportunities are created. This procedure is introduced by Brenner,Subrahmanyam and Uno (1989,1990). Implied repo rates (IRR) is similar to the internal rate of return (IRR) in capital expenditure decision making and equalize the actual futures price with theoretical price when applied to the given current spot price, maturity, and dividend streams.

$$REPO_t = (365/N)[\ln\{F_t/[S_t - PV(Div_t)]\}] \text{------------------------} (2\text{-}20)$$

where $PV(Div_t)$ = present value of dividends paid on spot between t and T

$(=\sum_{j=1}^{T-t} D_{t+j} \exp^{-r(j/365)})$

N= time to expiration (T-t)

When transaction costs are considered, implied repo rate (IRR) can be modified such as :

<u>Implied repo rates (IRR) under transaction cost consideration</u>

(I) $REPO_t = (365/N)[\ln\{F_t/[S_t(1-K_{SS}-K_{LF}) - PV(Div_t)]\}]$ if $F_t < F^-_t$ --------(2-21)

In this condition, $REPO_t < r$ and an arbitrageur can make excess return by short selling spot, lend the proceeds at market rates and buying futures to lock in a lower borrowing rates.

(ii) $REPO_t = r$ if $F^-_t < F_t < F^+_t$ ---(2-22)

In this condition, no arbitrage excess return (out of risk free return) can be made.

(iii) $REPO_t = (365/N)[\ln\{F_t/[S_t(1+K_{SS}+K_{LF}) - PV(Div_t)]\}]$ if $F_t > F^+_t$ ------(2-23)

In this condition, $REPO_t > r$ and it becomes profitable to borrow funds at market interest rates, buy spot, and sell futures to lock in a higher lending rates.

2-3. Empirical Studies Regarding the Mispricing of the Futures Contracts

2-3-1. Corporate Practice of Dividend Payments in Korea

Before we investigate the mispricing of futures contract based upon the theoretical relationship between spot and futures in formula (2-15), the Korean corporate practice regarding dividend payments first has to be considered. Above all, the dividend yield is on average very low when compared to the other countries. According to the KSE, the market weighted average dividend yield in 1995 was mere 1.1%. This figure is comparatively lower than 3- 4 % in the U.S. or 4-5% in the U.K. (see Kim and Yoon 1992). Unlike the cases of the U.S. corporations paying dividends quarterly or Japanese companies with semi annual dividend payments, all Korean companies pay dividends once a year and their ex-dividend dates fall exactly at the end of their fiscal years ,which is the last day of any of March, June, September or December. Since among 200 companies included in KOSPI 200 index, 175 firms (87.5%) predominantly have their ex-dividend dates in December, with only 14 firms in March, 6 firms in June and 4 firms in September.[22] Table 2-2 lists the dividend yields of each component stock based on the dividend record in 1995. Even the largest 200 companies' average dividend yields do not exceed 2%. Moreover, about 20% (41 firms) out of the KOSPI component firms do not pay out at all. Since there are only ten firms (5.0%) whose ex-dividend dates lie within our sample periods and the actual payments of dividends normally take at least three months after ex-dividend dates, the effect of dividends stream is presumed to be minimal and thus the effect of dividend payments on the futures pricing is not considered in our study.[23]

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[22] There is only one firm which have its fiscal year end in January in the KOSPI 200. However, this is very exceptional case in Korea.

[23] The percentage of these ten firms in total market capitalization of KOSPI 200 firms is very low (about 1.2%). Moreover, the percentage these ten firms accounts for in the weighted average dividend yields of the total KOSPI 200 index constituents is only 0.56%. This means that dividends payments affect spot index only by .0163 index point

2-3-2. Estimation of Transaction Costs in Arbitrage Trading

In consideration of transaction costs entailed in the arbitrage between spot and futures market, Table 2-3 provides transaction cost estimates for each market participant according to their position as an investor. KSE members, who are all securities firms, have seats in the trading floor in the KSE and perform as dealers or brokers providing liquidity in the both stock and futures markets. Transaction costs, especially in terms of brokerage commissions, are at minimal level for the KSE members.[24] For other institutional investors such as banks, insurance companies and investment trust companies (similar to the mutual funds in the U.S.), transaction fees normally depend on the arrangement between the investors and the executing members. Although it is reasonable to assume that transaction fees are higher for these types of institutional investors than for KSE members, the difference in transaction costs between members and institutional investors is not expected to be large due to the negotiation power of the institutional investors and fierce competition among member firms. For individual investors, arbitrage transaction is hardly expected since it is almost impossible for an individual to track even a small portion of the component stocks due to the limits in available capital, not to mention relatively high transaction fees involved. In addition, they can hardly

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when we assume spot index being 100 point. According to KSE, the average annual dividend yield of Korean firms in 1995 is mere 1.1% and even that for larger firms (whose paid in capitals are above Won 75 billion and likely to be constituents of KOSPI 200 index) is 1.1%. Although this figure is relatively negligible compared to market interest rates, applying this average annual dividend yield to the calculation of theoretical futures price [$F_t = S_t \exp^{(r-d)(T-t)/365]}$, d= annual dividend yield] would result in underestimation of the fair futures price in our sample.

[24] Sofianos (1993) reports that member firms typically pay no commission fees for proprietary index arbitrage transaction.

participate in long hedge (sell short spot and buy futures) transaction because short sales of borrowed stocks are still not commonly practiced in the Korean stock market. At most, they would participate in outright transaction in futures market in search of speculative profit. In the following study, we rule out the cases of individual investors' arbitrages and consider only the arbitrage opportunities facing the institutional investors including member firms. For KSE members, 1% of KOSPI 200 index value is assumed for transaction costs incurred in the arbitrage trading. For other institutional investors, 2% of spot index value is assigned for transaction fees in the arbitrage transactions. Since the more efficient a market is operating, the less trading costs are incurred, these figures are, on average, set at higher level than those of the comparable markets in other countries such as the U.S. and Japan.

2-3-3. Study on the Mispricing of Futures

In Table 2-4, deviations of actual futures price from the theoretical level are illustrated as percentage of KOSPI 200 index. In most cases during our sample period, actual futures price deviates below the theoretical level. This is consistent with previous studies documenting significant underpricing of futures in early introduction periods.[25] In particular, the absolute mispricing in terms of median increases monotonically with the time passage. For December contract, all deviations take on negative value. Over the sample period, the stock market condition in Korea has been depressed due to deteriorating economic fundamentals

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[25] The magnitude and frequency of mispricing of futures contract in Korean market are comparable to those observed in the Japanese market in its early inception period. Brenner, Subrahmanyam and Uno (1989) document that during 1986.12-1988.6, the percentage of negative mispricing is 73% with mean positive deviation (.51%), mean negative deviation (-1.39%) and mean absolute deviation (1.15%).

such as slower economic growth and ballooning trade deficit. KOSPI index fell by 13.5% and KOSPI 200 index tumbled by 19.3% during the sample period. This indicates that larger firms suffered more under unfavorable market conditions. When we consider that the KOSPI and KOSPI 200 rose back by 10.47% and 10.35% during December contract period (from September 13 to October 16) due to 2% increase in foreign share ownership on October 2nd, the market downturn during the June and September futures contract periods was very serious (KOSPI and KOSPI 200 dropped by 9.42% and 11.80% during June contract period and additionally fell by 8.82% and by 11.59% over September contract period). This result is also consistent with Figlewski (1984a) in that underpricing of futures contract is more severe when the market runs on the downside.

Chart 2-1 shows the trend of mispricing series of futures contracts graphically. Futures price relatively hovers around the theoretical value during the June contract period. During September contract period, the mispricing series fluctuate wildly and the standard deviation (2.0%) is the highest. It is noticeable that futures mispricing is the most severe around the expiration dates. Our sample covers only two expiration dates (June 13 and September 12) and a few days before these two maturity dates, futures price drops sharply below its theoretical level. This indicates either that investors sell heavily futures contract in search of speculative profit or that investors who had originally long positions in futures reverse their positions to reduce capital loss as maturity approaches.

Table 2-5 shows the autocorrelation and partial autocorrelation coefficients of the mispricing series. As the previous empirical studies have documented (e.g., see MacKinlay and Ramaswamy 1988 ; Yadav and Pope 1990 etc.), mispricing series shows severe positive

1st order autocorrelation. Since partial autocorrelation function drops off after lag one, the mispricing series can be approximated by AR(1) process. According to Garbade and Silber (1983), the value of the first order autocorrelation coefficient represents an inverse measure of the elasticity of supply of arbitrage services. Therefore, the smaller the value of the first order autocorrelation coefficient, the more quickly futures price converges back to its respective theoretical price by the arbitrage forces once it deviates from the cost of carry relationship. The value of first order autocorrelation coefficient reveals that the inflow of arbitrage capital is not sufficient in the early inception period. The autocorrelation coefficient of first differenced mispricing series (Yadav and Pope (1990) call it mispricing returns) represents degree of mispricing reversal. If past futures price is underpriced, arbitrage forces push futures price to rise and it normally causes a negative autocorrelation between successive price changes. The autocorrelation of first differenced mispricing also supports the lack of arbitrage activities by market participants in the Korean market. Except for December contract, the 1st order autocorrelation of mispricing returns is positive, not negative as reported in other markets (the S&P 500 index futures in MacKinlay and Ramaswamy 1988 or UK FTSE 100 index futures in Yadav and Pope 1990). In Korean futures market, mispricing seems to persist for at least over 10 minutes in the early period.

In Table 2-6, descriptive statistics of the annualized implied repo rates (IRR) are reported and Chart 2-2 shows the trend of IRR graphically. As is shown in the Chart 2, IRR fluctuates mostly below the 3 month CD rates (used as riskless interest rates) and especially hovers below zero over September contract period . The negative median IRR indicates that over the September contract period, futures price frequently fall even below spot index value.

This fact suggests that although futures underpricing persists in the early introduction period and gives market participants plenty of arbitrage opportunities (by selling short spot and buying futures), the lack of arbitrage capital fails to realign futures price back to its normal level. In its latest reports, Korean Economic Daily (KED) attributes the reason for lack of arbitrage activities by the institutional investors to the unfavorable stock market condition. Before the opening of the index futures market, the stock market was bullish with KOSPI and KOSPI 200 having risen by 12.26% and 14.39% respectively from March 2nd to May 1st. During this time period, institutional investors make errors in forecasting the future direction of stock price and pile a host of stocks in their own account. By sudden change of market condition from bull to bear, institutional investors would have suffered from large capital losses if they had tried to sell short their stocks and take long position in futures as the theoretical long hedge dictates. Because the market participation of foreign capital is restricted, they could not fill the gap. Just like mispricing series in Chart 2-1, annualized IRR drops sharply into negative value before expiration dates, indicating pricing anomaly is serious near the maturity dates.

2-3-4. Analysis of Ex Post Arbitrage Profitability

Table 2-7 reports the results for test of profitability of ex post arbitrage transaction in case that 1% transaction costs (as percentage of KOSPI 200 index) are accounted for. Chart 2-3 also shows graphically the upper bound and lower bound of theoretical arbitrage free band as well as actual futures price. As is seen in the Table 2-7, the frequency of deviation from theoretical arbitrage band increases with time passage. For June contract, only

5.5% of total observations deviate out of the arbitrage free band but for December contract period, 97% of the total observation falls beyond the lower boundary of arbitrage free band. Absolute deviation from theoretical band displays the asymmetry between upward mispricing and downward mispricing. The frequency and magnitude of positive mispricing beyond the upper boundary are only 162 case (5.6%) and .2510 compared to 1387 cases (47.6%) and 2.0117 in the negative mispricing below the lower boundary. By locking in the long hedge (sell short spot and long futures) until maturity, an arbitrageur can gain on average 10.3% extra annual return above the riskless return (annualized excess return to maturity: AERM) while short arbitrageurs (sell futures and long spot) gain only 7.6% extra return in lower chances. Figlewski (1984b) reports that during the early inception period (1982.6-9), the nearby S&P 500 futures contract provides investors with about 6% excess return by taking long arbitrage. Therefore, index futures underpricing in the its early inception period is on average slightly more severe in the Korean market. Chart 2-4 displays graphically the magnitude of mispricing over the sample period after accounting for 1% transaction costs.

In Table 2-8 and Chart 2-5 extend the transaction cost to 2% of the KOSPI 200 index value. The 2% transaction costs eventually eliminate the arbitrage opportunity by short hedge (long spot and short futures) and reduce the frequency of mispricing from 48% to 34% of the total observation. Moreover, investors end up without arbitrage opportunities in the June contract period. However, in September contract period, the percentage of futures underpricing is reduced only by 7% with large unexploited arbitrage opportunities. Over total contract periods, an arbitrageur can still reap 9% above the CD rates annually by taking long arbitrage transaction. Would there be any chances of early exercising to capture extra risk free returns? The answer is Yes for KSE members. When 1% transaction costs are accounted for, futures price falls off below the lower boundary of arbitrage free band from June 14 th through June 26 th, and then rises above the upper boundary of arbitrage free boundary from August 21 to September 3rd. If a member had launched a long futures-short spot arbitrage at the end of June and closed that position by reverse transaction at the end of August or the beginning of September, it would have doubled its arbitrage returns relative to holding its position up to maturity. Chart 2-6 shows graphically the mispricing of futures contract over the sample period when 2% transaction costs are taken into account.

2-3-5. Analysis of Ex Ante Arbitrage Profitability

In addition to the ex post analysis of arbitrage opportunity, the ex ante analysis (similar to the one proposed by Chung 1991) regarding futures mispricing is also investigated. Ex post analysis is based on the assumption that a program trader can establish an arbitrage position at the prices prevailing when the hedge is initially identified as profitable. However, if prices are corrected promptly, it may not be profitable ex ante for a program trader to construct the short or long hedge that are identified as profitable ex post. Then arbitrageurs are exposed to substantial execution risk. On the other hand, execution prices may actually be better than the quoted prices (observed price ex post) if mispricing in the market persists for some reason. In the Korean stock and futures markets where only limit orders are currently allowed, only risk incurred in order execution is that arbitrageurs' orders remain unfilled at the desired bid or ask price that can be different from quoted market price.[26] Therefore, execution risk is minimal in the Korean market when compared to the U.S. where market orders prevail. As a result, the ex ante analysis in the Korean market measures how quickly profitable mispricing opportunities disappear and tests an operational or informational efficiency of the Korean capital market. Since our data covers intraday price data over a 10 minute interval, our ex ante analysis examines the frequency and magnitude of possible arbitrage profits when an arbitrageur observes the futures mispricing at time t and executes an order at time t+1 price, i.e., at price available 10 minutes later in search of ex post arbitrage opportunity. Chung (1991) documents that when 1% transaction costs and 5 minute execution delay are accounted for, almost half of ex post arbitrage opportunities become unprofitable at ex ante basis. Klemkosky and Lee (1991), however, report that the arbitrage position is still profitable even 10 minutes after it is initially identified as profitable. In analysis of ex ante arbitrage profitability, we consider two different cases regarding execution lag in the practice. First, we can assume that an arbitrageur can sell or buy futures as soon as mispricing opportunities are observed, but 10 minute later in spot market. Alternatively, we can also assume that an arbitrageur takes action quickly in spot market as soon as he or she notices mispricing but 10 minute later in futures market. While it is reasonable to assume execution lag in both markets (Chung 1991), spot trading involves simultaneous trading of component stocks in the basket (even though development of program trading substantially reduces execution lag) and thus, the former case can be more close to reality than the latter

[26] Market orders are introduced in the Korean Market on November 25,1996, which is outside of the sample period of this study.

case. Sofianos (1993), however, mentions legging (the cash and futures position in an arbitrage transaction are not established or liquidated simultaneously) in which case an arbitrageur can deliberately submit orders earlier or later in futures market than in cash market in search of bigger arbitrage profit.[27] Therefore, results under two different scenario are presented in our analysis. Table 2-9 and Table 2-10 display results of the ex ante arbitrage profitability in case of 1% and 2% transaction fees incurred respectively when there is 10 minute execution lag in spot trading. Consistent with Klemkosky and Lee's study (1991), only 59 cases (2.0%) out of total ex post mispricing for 1% transaction costs and 24 cases (0.7%) cases for 2% transaction costs become unprofitable ex ante. In terms of median annualized excess return to maturity (AERM), the ex ante profit (10.30% from underpricing and 6.54% from overpricing for 1% transaction costs, and 8.16% from underpricing for 2% transaction costs) turns out to be greater than corresponding ex post profit (9.36% and 6.07% for 1% transaction costs and 7.94% for 2% transaction costs). This indicates that mispricing is not corrected within a 10 minute interval, but tend to persist in the same direction. Although standard deviation of ex ante profitability (AERM) is slightly higher (i.e., the arbitrage is more risky ex ante) than that of ex post profitability in case of 1% transaction costs, the opposite is true when 2% transaction costs are accounted for. Table 2-11 and Table 2-12 show results of the ex ante arbitrage profitability in case of 1% and 2%

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[27] Sofianos takes an example of legging as such : "suppose the futures price drops ahead of the cash price, so that the cash market is overvalued. The arbitrageur should buy the futures and sell the cash. The arbitrageur, however, expects the futures price to continue falling before the cash starts falling and sell the cash immediately but delays buying the futures until they are cheaper. If the arbitrageur's expectations are confirmed, delaying the futures side of the transaction locks in a bigger mispricing " (see Sofianos (1993), p.p.16).

transaction fees incurred respectively when there is 10 minute execution lag in futures trading. Again, only 54 cases (1.9%) of 1% transaction costs and 32 cases (1.1%) of 2% transaction costs become unprofitable at ex ante basis. Since underpricing of futures contract tends to be persistent over the sample period, it is not unreasonable to observe that mispricing is not eliminated as quickly as the efficient market dictates. This also supports MacKinlay and Ramaswamy's (1988) path dependence hypothesis of futures mispricing, which states that once futures price crosses either upper or lower bound, it takes a while for such mispricing to touch the other side of the boundary.

2-3-6. Relationship of Futures Mispricing with Time to Expiration

Our study also examines the Cornell and French's (1983) tax timing option hypothesis or Brennan and Schwartz's (1990) early closing option hypothesis regarding the futures pricing. Although these two hypotheses suggest different explanations for futures underpricing below the theoretical level, they both expect futures' underpricing to decrease as the expiration date approaches. In panel 1 of Table 2-13, all mispricings have significant negative relationships with the time left to maturity, which is consistent with either tax timing option hypothesis or early exercise option hypothesis. We also investigate MacKinlay and Ramaswamy's (1988) argument that the absolute mispricing is positively related to the time left until maturity in panel 2 of Table 2-11. Indeed, this regression suggests that the magnitude of mispricing continues to shrink as the maturity approaches. In the panel 3 of Table 2-11, we regress the futures mispricing on the return on stock market to see if the market condition can account for, at least partially, the severity of futures underpricing over the sample period. Consistent with Figlewski (1984a), the more the stock market falls, the more severe the underpricing of the futures contract is, especially over September and December contract periods.[28]

2-3-7. Basis and Arbitrage Trading

Table 2-14 provides the descriptive statistics and autocorrelation coefficient of the basis and Chart 2-7 displays the trend of basis graphically. As shown in the previous analysis, the futures price frequently falls below the corresponding spot price, resulting in negative basis over September contract period. Negative autocorrelation in the basis changes are said to result from active arbitrage forces in the market. Miller, Muthuswamy and Whaley (1994), however, insist that the negative autocorrelation in basis changes may result from statistical illusion, i.e., the positive first order autocorrelation in spot index changes due to infrequent trading. Even without any significant arbitrage forces involved, asynchronous trading effect, i.e., positive autocorrelation in spot index may spuriously induce basis change to have negative serial correlation. In our sample, except for December contract, the basis changes take on positive first order autocorrelation, not a negative one as in other studies. This is mainly due to the fact that unlike studies regarding futures market in the U.S., the changes of futures price have the significant positive first order autocorrelation rather than negative first order autocorrelation if any. This fact also may confirm the persistence of futures underpricing and lack of arbitrage forces. Dwyer Jr., Locke and Yu (1996) report that in

[28] Over June contract period where futures price moves closely with theoretical value, stock market movement does not explain changes in mispricing.

response to positive or negative shocks to the cash index, the basis returns to values inside the transaction cost bounds only after more than 20 minutes. They also document that the basis converges faster to the normal when arbitrage is profitable than when arbitrage is unprofitable. Harris, Sofianos and Shapiro (1994) similarly document that it takes an average of 10 minutes after a program trade for the basis to revert to a theoretically correct value. They also find that the basis returns to the normal level more quickly for buy rather than sell (spot) index arbitrage trades. Our result is generally consistent with their findings in that the basis tends to be corrected only after more than 10 minutes, and in that persistence in basis (mispricing of futures price) results mainly from inactive arbitrage trades that are in turn caused by unfavorable spot market condition.

Finally Table 2-13 summarizes the actual trading activities during our sample periods. Consistent with our previous analysis, the arbitrage transactions have shrunken substantially in both number and amount since June contract, leaving persistent arbitrage opportunities unexploited. While the level of trading volume and open interest relatively remain stable during the whole sample periods, the percentage of arbitrage trading to the total trading decreases continuously from 1.4% in June to 0.6% in July, 0.4% in August, 0.2% in September and 0.3% in December. This fact confirms inactive arbitrage transactions in the Korean futures market in the early introduction period.

2-4. Conclusion

In this chapter, we analyze the mispricing of futures contract in the early inception period. Our analysis takes into account transaction costs incurred in index arbitrages that are executed mainly by institutional investors and KSE members. Consistent with previous empirical studies concerning the pricing of index futures in other countries, futures contract in the Korean market have been undervalued relative to the theoretical price based upon the cost of carry relationship. When 2% transaction fees (relative to spot index value) are considered, however, futures price of June contract moved within the boundary of arbitrage free band. Futures contract began to deviate substantially from its fair value and sometimes even below its corresponding cash value since June and left plenty of long arbitrage opportunities (sell short spot and long futures). However, most of these arbitrage opportunities have not been exploited by the investors so that the trend of futures underpricing persists. Bearish stock market condition seems to have resulted in substantial capital losses on the existing stock portfolio of institutional investors and this may have made them unable to capture these profit opportunities by taking long hedge. Even after accounting for 10 minute execution lag, most of arbitrage profit opportunities are still left unexploited and long futures-short spot arbitrage would have resulted in substantial extra returns above the riskless rates even on the ex ante basis.

Several reasons for futures mispricing can be raised. First, lack of arbitrage capital due to market regulations (for example, withdrawing of gains from marking to market is prohibited) or limited participation of experienced foreign capital could have caused the underpricing. Second, as Figlewski (1984b) notes, the market inertia caused by the practitioner's unfamiliarity would be a reason for underpricing.

Table 2-1. Main Features of Korean Stock Index Futures Contract

1. Underlying asset	KOSPI 200 Market value weighted index of the 200 representative Stocks (its base index point is 100 as of Jan3,1990)
2. Contract size	KOSPI 200 multiplied by Won 500,000 (about US $600)
3. Contract Months	March, June, September and December (Four contract months open at a time so that longest maturity period is one year)
4.Last day of trading preceding	The second Thursday of the delivery month or the day the second Thursday in case the second Thursday is a holiday
5.Settlement date	The second business day after the last trading day
6.Trading hours[a]	Ordinary day Weekday : 9:30 - 11:30 a.m. (morning session) 1:00 - 3:15 p.m. (afternoon session) Saturday : 9:30 - 11:45 a.m. (morning session only) Last trading day Weekday : 9:30 - 11:30 a.m. (morning session) 1:00 - 2:50 p.m. (afternoon session) Saturday : 9:30 - 11:20 a.m. (morning session only)
7. Method of trading	Computer assisted auction
8. Tick size	0.05 index point that is equivalent of Won 25,000 (0.05 × Won 500,000)
9. Settlement procedure	Cash settlement
10.Price limits[b]	±5% of the previous settlement (closing) price
11.Margin[c]	KSE Members (Securities firms) 10 % of transaction value Customers I) Initial margin 15% of transaction value (at least 5% cash)

	ii)Maintenance margin 10% of transaction value (at least 5% cash)
	iii)Minimum deposit for market entry Won 30 million (US$36,000)
12.Trading halts[d]	I) program trading order in the cash market will be delayed for 5 minutes as futures price of the contract with the largest volume in the previous day changes more than by 3% of the previous closing price (trading halt will be lifted when price changes are recovered within 2%) ii) futures trading will be suspended for 5 minutes as price of the contract with largest volume in the previous day changes up to the daily limit and lasts for 1 minute
13. Exchange tax	None
14. Commission[e]	Determined solely by each member up to the maximum of 0.09% of transaction value
15. Ceiling on foreign capital[f]	By total 30% of average daily open interest for all the contract months in the previous three trading months By Individual 5% of average daily open interest for all the contract in the previous three trading months
16. Special clause on marking to market[g]	Withdrawal of gains occurred by marking to market is prohibited until closing of contract and profit realization

[a] Trading hours of the morning session are the same as those of the stock market. Trading hours on Saturday and afternoon sessions on weekdays are extended by 15 minutes. Futures market will be closed 10 minutes before the stock market closes on the last trading day.

[b] The daily price change limit for spot market was ±6% of the previous day's closing price until November 1st of 1996. From then on, the new daily limit has been up by 2% to ± 8%.

[c] Margin requirement is stricter in Korean market relative to the U.S. In the U.S., the margin requirement differs according to the type of transaction and varies from time to time. For example, CME requires US$16,800 per contract as initial margin and US$ 15,000 per contract as maintenance margin for speculative trading as of 1997. In contrast, both initial and maintenance margin for member's proprietary arbitrage trading are US$8,000 per contract and those for intramarket spread trading are only $169 and $150 per contract respectively. Therefore, the initial and maintenance margin for customers set by member's discretion are no greater than 5% even for speculative trading in case of S&P 500 futures. On the other hand, in Japanese TOPIX futures (as of 1997), the initial margin is set at 15% of the contract value or ¥ 6 million, whichever is greater, and the maintenance margin is set at 12% of the contract value. At least 3% of the margin should be deposited in cash. When margin requirements in the Korean market is compared to those set by other markets in the early introduction period, however, the current margin level in the Korean futures market is relatively set high to prevent default on performance and discourage small individual investors' market participation. In 1983, the initial and maintenance margins for speculative trading were US$ 6,000 and US$2,500 per contract (about 9% and 4% of the contract value) respectively in the S&P 500 futures contract. As for TOPIX futures contract, the initial and maintenance margins were 9% and 6% of the total contract value in 1988. Members should deposit at KSE the required margins amounting to 10% of total contract values including their proprietary as well as their customers' positions. For KSE members, the entire amount of margin may be deposited by marketable securities unlike customers. Also, KSE members' margin will be computed based on the first futures price of a contract and this base price will not be changed until the futures price changes by more than 30%. The leverage effect of futures over spot trading in the Korean market is relatively low compared to the case in the U.S. market. In the U.S., Federal Reserve Board (FRB) requires at least 50% of margin in spot trading while 40% of margin is required in Korean spot market. Therefore, the leverage effect of futures is about 2.7 times greater than that of spot trading in Korea while in the U.S., futures' leverage effect is about 10 times greater than that of spot trading.

[d] In case of I), there will be no trading halt 30 minutes before closing of daily trading.

In case of ii), if there has been a trading halt in a day, there will be no more trading halts in the same day. Also, there will be no trading halt after 2:20 p.m. (10:50 a.m. in the absence of afternoon session).

[e] Official commission rates set by some members as follows :

Daewoo Securities Co. :	Transaction value	< Won 500 mil.	: 0.05%
	"	< Won 1 bil.	: 0.045% + Won25,000
	"	< Won 5 bil.	: 0.040% + Won75,000
	"	> Won 5bil	: 0.035% + Won325,000
Dongsuh Securities Co. :	Transaction value	> Won 5bil	: 0.020%
	The other ranges are same as Daewoo Securities Co.		
Dongwon Securities Co. :	Transaction value	< Won 1 bil.	: 0.03%
	"	< Won 2.5 bil.	: 0.02% + Won50,000
		> Won 2.5 bil	: .020% + Won175,000

However, large customers like institutional investors tend to negotiate commission rates with members and pay less than the above rates. (Source : Korea Economic Daily)

[f] From November 1 of 1996, MOF increased the ceiling on the foreign capital in index futures from 15 % to 30% in total and from 3.0% to 5.0% per individual.

[g] Applying gains from daily marking to market toward the margin for other trading is also prohibited. However, loss from daily marking to market is reflected in calculation of margin requirement for another transactions. These asymmetric treatments for gains and losses from marking to market process over-emphasize the riskiness of futures trading and eventually reduces attractiveness of futures trading and efficiency of the futures market.

Table 2-2. Component Stocks in KOSPI 200 **(Won Bil.)**

Company	FY[a]	Mkt Cap.[b]	Div.[c]	Div.Yield[d]
(Manufacturing : 139 stocks)				
Dong Won Ind.	12	1,301.30	44.61	3.43%
Dong Bang Corp.	12	686.30	1.99	0.29%
Nong Shim	6	720.00	22.50	3.13%
Cheil Foods & Chemical	12	4,893.38	10.27	0.21%
Hai Tai Confectionary	6	813.25	26.73	3.29%
Tong Yang Confectionary	12	851.76	21.29	2.50%
Miwon	12	1,587.38	9.47	0.60%
Tai Han Sugar	12	684.64	14.83	2.17%
Woo Sung Feed Mill	12	685.98	15.45	2.25%
Sewon Co.	12	1,077.11	9.65	0.90%
Samyang Genex	6	1,168.92	11.07	0.95%
Jinro	9	1,630.87	58.68	3.60%
Oriental Brewery	12	892.17	0.00	0.00%
Chosun Brewery	12	2,362.08	0.00	0.00%
Lotte Chilsung Beverage	12	1,245.19	5.42	0.44%
Ssang Bang Wool	12	1,102.75	16.50	1.50%
Tae Chang	1	1,040.40	8.70	0.84%
Choong Nam Spinning	12	1,175.80	0.00	0.00%
Dai Nong Corp.	12	923.94	12.06	1.31%
Cheil Ind.	12	2,921.40	86.40	2.96%
Tong Yang Nylon	12	2,160.39	44.33	2.05%
Kohap	12	2,193.92	35.05	1.60%
Hanil Synthetic Fiber	12	1,128.11	0.00	0.00%
Kolon Ind.	12	2,215.37	12.61	0.57%
Sun Kyung Ind.	12	2,398.58	58.39	2.43%
Cheil Synthetic Textiles	12	1,657.60	47.46	2.86%
Sam Yang	6	2,520.24	8.70	0.35%
Pang Rim	9	1,549.45	9.00	0.58%
Nasan Ind.	12	600.60	11.55	1.92%
Shin Won Corp.	12	1,553.59	30.30	1.95%
Kukje Corp.	12	1,340.23	0.00	0.00%
Sung Chang Enterprise	9	1,968.00	15.00	0.76%
Hankuk Paper Mfg.	12	1,095.00	26.00	2.37%
Hansol Paper Co.	12	4,342.10	112.59	2.59%
Shin Poong Paper	12	676.49	12.11	1.79%
On Yang Pulp	6	538.84	3.90	0.72%
Sepoong Corp.	12	1,029.37	0.00	0.00%
Dong Hae Pulp	12	1,574.00	0.00	0.00%
Ssang Yong Paper	12	764.07	17.48	2.29%

(Table 2-2 continued)

Hanwha Chemical	12	5,594.39	47.73	0.85%
Oriental Chemical	12	2,140.07	14.65	0.68%
Korea Kumho Petro.	12	2,169.25	124.18	5.72%
Isu Chemical	12	840.45	0.00	0.00%
Dongbu Chemical	12	836.13	0.00	0.00%
Posco Chemical	12	808.47	16.56	2.05%
Han Nong Corp.	12	657.40	12.97	1.97%
LG Chemical	12	12,368.46	443.68	3.59%
Miwon Petro Chemical	12	898.96	3.57	0.40%
Dong Sung Chemical	12	592.80	12.48	2.11%
Kuk Do Chemical	12	1,145.33	30.06	2.62%
Honam Petro. Chemical	12	4,651.56	238.95	5.14%
Korea Chemical	12	3,120.00	40.00	1.28%
Yuhan Corp.	12	1,422.72	16.23	1.14%
Dong-A Pharm.	12	1,692.82	16.12	0.95%
Il Yang Pharm.	12	864.16	15.77	1.82%
Dong Wha Pharm	3	727.89	2.90	0.40%
Choong Wae Pharm.	12	1,469.87	25.81	1.76%
Chong Kun Dang	12	935.55	14.17	1.51%
Korea Green Cross	12	1,779.04	13.44	0.76%
Dong Shin Pharm.	12	873.15	0.81	0.09%
Pacific Corp.	12	1,683.32	40.80	2.42%
Hanwha Corp.	12	3,071.44	0.00	0.00%
Hankook Titanium	12	768.28	26.72	3.48%
Saehan Media	12	1,210.85	24.46	2.02%
Yukong	12	16,687.89	362.26	2.17%
Ssang Yong Oil Refining	12	12,494.63	852.66	6.82%
Hanwha Energy	12	1,779.74	0.00	0.00%
Han Kook Tire	12	2,116.21	32.20	1.52%
Kumho	12	1,730.99	0.00	0.00%
Dong-A Tire	12	1,198.88	0.00	0.00%
STC Corp	12	1,205.75	33.94	2.81%
Han Kook Glass	12	2,926.88	75.75	2.59%
Hankuk Safety Glass	12	745.00	9.40	1.26%
Hanil Cement	12	1,836.00	26.52	1.44%
Asia Cement	12	1,336.00	26.00	1.95%
Ssang Yong Cement	12	7,455.87	212.23	2.85%
Hyundai Cement	12	1,188.00	21.60	1.82%
Tong Yang Cement	12	2,703.96	82.47	3.05%
Sung Shin Cement	12	1,183.49	27.72	2.34%
Keum Kang	12	3,474.00	60.00	1.73%
Kang Won Ind.	6	1,309.56	5.30	0.40%

(Table 2-2 continued)

Dong Kuk Steel Mill	12	4,305.60	140.40	3.26%
Pohang Iron & Steel	12	47,608.21	892.06	1.87%
Hanbo Steel	12	1,243.06	0.00	0.00%
Korea Iron & Steel	12	1,548.00	48.00	3.10%
Kia Steel	12	1,312.07	0.00	0.00%
Dong Bu Steel	12	1,951.22	42.54	2.18%
Sammi Steel	12	2,849.46	0.00	0.00%
Inchon Iron & Steel	12	3,234.00	66.00	2.04%
Hyundai Pipe	12	1,010.00	25.00	2.48%
Se Ah Steel	12	1,422.91	11.20	0.79%
LG Metals Corp.	12	1,560.00	48.00	3.08%
Korea Zinc Co.	12	3,268.00	86.00	2.63%
Poong San	12	2,974.38	86.35	2.90%
Choil Aluminum	12	653.40	16.50	2.53%
Dae Han Jung Suok	12	2,202.65	7.98	0.36%
Daewoo Heavy Ind.	12	30,858.26	918.87	2.98%
Ssang Yong Heavy Ind.	12	932.31	0.00	0.00%
Hanwha Machinery	12	954.32	0.00	0.00%
Kyungwon Century	3	1,596.00	45.00	2.82%
Korea Computer	12	747.90	23.37	3.12%
Taeil Media	12	1,675.88	35.83	2.14%
Trigem Computer	12	1,666.04	34.56	2.07%
Chung Ho Computer	12	2,238.97	22.02	0.98%
Nae Wae Semiconductor	12	707.93	4.81	0.68%
LG Electronics	12	26,803.50	311.52	1.16%
Samsung Electronics	12	109,933.63	805.75	0.73%
Inkel Corp.	12	569.37	15.91	2.79%
Daewoo Electronics	12	6,730.67	274.07	4.07%
Daeryung Ind.	12	789.83	12.41	1.57%
Sungmi Telecom Electro.	12	1,689.89	24.43	1.45%
Han Chang	12	1,338.52	0.00	0.00%
Anam Ind.	12	2,814.96	43.65	1.55%
Samsung Display Dev.	12	15,659.12	49.64	0.32%
Samsung Electro-Mech.	12	8,202.05	54.46	0.66%
Korea Electronics	9	1,020.21	20.00	1.96%
Orion Electric	12	2,393.89	15.24	0.64%
Daewoo Telecom	12	3,295.27	0.00	0.00%
Dae Duk Ind.	12	419.71	1.22	0.29%
Daewoo Elec. components	12	638.70	7.38	1.16%
Taihan Electric Wire	12	3,528.00	100.80	2.86%
LG Cable	12	2,254.50	58.18	2.58%
LG Ind. System	12	5,087.69	101.75	2.00%

(Table 2-2 continued)

Rocket Electric	12	167.17	9.05	5.41%
Kia Motors	12	13,785.19	55.88	0.41%
Hyundai Motors	12	17,481.84	353.98	2.02%
Ssang Yong Motors	12	3,155.01	0.00	0.00%
Asia Motors	12	3,475.56	0.00	0.00%
Hyundai Precision	12	3,530.53	115.47	3.27%
Tongil Heavy Ind.	12	2,709.24	0.00	0.00%
Mando Machinery	12	2,315.16	50.37	2.18%
Yoosung Enterprise	12	735.00	14.70	2.00%
Daewoo Precision	12	1,188.16	10.15	0.85%
Jindo corp.	12	1,209.50	13.84	1.14%
Hyundai Mipo Dock Yard	12	1,352.00	40.00	2.96%
Samsung Heavy Ind.	12	13,078.16	321.57	2.46%
Samsung Aerospace	12	4,088.00	69.40	1.70%
Hyundai Wood Ind.	12	741.00	0.00	0.00%
Young Chang Akki	12	900.00	11.25	1.25%
(Utilities & Gas : 3 stocks)				
Korea Electric Power	12	189,941.94	3,083.47	1.62%
Samchully	12	1,301.04	11.70	0.90%
Kyungnam Energy	12	814.30	12.75	1.57%
(Building & Construction : 16 stocks)				
Samwhan Enterprise	12	1,746.56	39.26	2.25%
Dong Ah Construction	12	7,565.73	167.50	2.21%
Doosan Engin. & Const.	12	1,997.25	10.84	0.54%
Daelim Ind.	12	4,396.19	31.58	0.72%
Sambu Construction	12	1,901.59	0.00	0.00%
Hanshin Construction	12	868.03	0.00	0.00%
Kuk Dong Engin. & Const.	12	1,546.00	0.00	0.00%
Hanjin Engin. & Const.	12	2,631.34	0.00	0.00%
LG Construction	12	2,461.30	65.20	2.65%
Hyundai Construction	12	17,757.77	0.00	0.00%
Kumho Const. & Engin.	12	2,975.32	34.51	1.16%
Kun Young	12	1,490.58	0.00	0.00%
Dong Shin Construction	12	945.00	14.00	1.48%
Tai Young	12	3,082.65	33.47	1.09%
Kisan	12	1,506.00	22.67	1.51%
Chongu H & C	12	2,216.31	46.51	2.10%
(Trades & Transport : 12 stocks)				
Hyundai Motor Service	12	4,646.06	90.13	1.94%
Daewoo Corp.	12	10,178.69	452.38	4.44%
Samsung Corp.	12	5,556.68	141.77	2.55%
LG Int'l Corp.	12	3,073.17	89.31	2.91%

(Table 2-2 continued)

Sun Kyung	12	3,649.62	18.23	0.50%
Shinsegae Dept. Store	12	6,240.00	8.84	0.14%
Hwasung Ind.	12	1,656.80	37.33	2.25%
Keumkang Dev.	12	1,904.65	44.78	2.35%
Hotel Shilla	12	1,873.05	47.48	2.53%
Korea Express	12	3,258.71	72.00	2.21%
Hanjin Shipping	12	2,730.01	0.00	0.00%
Korea Air	12	13,854.85	257.85	1.86%
(Telecommunications : 2 stocks)				
Korea Mobile Telecom	12	33,323.97	71.65	0.22%
Dacom	12	17,627.71	69.72	0.40%
(Finances : 28 stocks)				
Korea LT Credit Bank	12	9,610.10	219.40	2.28%
Commercial Bank	12	13,175.00	255.00	1.94%
Choheung Bank	12	14,809.20	328.00	2.21%
Korea First Bank	12	11,316.00	0.00	0.00%
Hanil Bank	12	13,744.80	332.00	2.42%
Seoul Bank	12	11,037.20	0.00	0.00%
Koram Bank	12	3,416.58	68.40	2.00%
Shin Han Bank	12	18,626.40	616.00	3.31%
Hana Bank	12	3,418.79	43.55	1.27%
Boram Bank	12	2,855.12	128.88	4.51%
Korea Exchange Bank	12	14,206.50	330.00	2.32%
Citizens National Bank	12	11,081.89	97.21	0.88%
Kyungki Bank	12	3,042.28	46.03	1.51%
Daegu Bank	12	4,752.00	195.00	4.10%
Pusan Bank	12	3,231.90	85.50	2.65%
Kwangju Bank	12	2,646.34	88.79	3.36%
Daishin Securities	3	5,155.20	0.00	0.00%
Daewoo Securities	3	11,537.21	0.00	0.00%
LG Securities	3	7,232.66	0.00	0.00%
Hyundai Securities	3	3,168.72	0.00	0.00%
Dongsuh Securities	3	5,647.07	0.00	0.00%
Coryo Securities	3	3,262.01	0.00	0.00%
Ssang Yong Inv. & Sec.	3	5,070.41	0.00	0.00%
Dongwon Securities	3	4,476.11	53.84	1.20%
Shin Young Securities	3	2,293.87	41.10	1.79%
Tong Yang Securities	3	2,351.47	0.00	0.00%
Samsung Securities	3	3,132.00	12.00	0.38%
Hyundai M & F Insurance	3	4,058.76	44.70	1.10%
Total (Average)		1,109,441.84	17307.09	1.56%

[a] FY indicates the month to which the ex dividend date of each company belongs

(Table 2-2 continued)
[b] Market capitalization (Won Bil.) for each company is calculated by multiplying the closing price on Dec. 31,1995 by the number of listed shares on KSE.
[c] Dividends (Won Bil.) include only cash outlays to shareholders, not stock dividends.
[d] Dividend yields are computed from dividing total dividends by value of market capitalization.

Table 2-3. Transaction Costs for Stock Index Arbitrage in the Korean Financial Markets, May 3rd 1996 - October 16th 1996 (As % of Spot Index Price on Basis of 90 Days Hedge Period)[a]

	KSE Members (Securities Firms)	Other Institutional Investors	Individual Investors
Spot Market(A)			
1.Brokerage Commissions[b]	-	0.40%	0.80%
2.Transaction Tax	0.30%	0.30%	0.30%
3.Market Impact[c]	0.40%	0.40%	0.40%
4.Cost of Borrowing Stock for Short Sales[d]	-	-	2.20%
Futures Market(B)			
1.Brokerage Commissions	-	0.04%	0.10%
2.Cost of Margin Requirement[e]	-	0.15%	0.15%
3.Market Impact	0.30%	0.30%	0.30%
Total (A+B)	**1.00%**	**1.59%**	**4.25%**

[a] Chung (1991) argues that an arbitrageur, having capital constraints and knowing the risks of ex ante trading, may require a mispricing signal of more than the amount needed to cover transaction costs before entering into a trade. Therefore, application of transaction costs in Table 2-3 may overestimate the actual frequency of execution and the size of arbitrage transactions. With regard to total transaction costs involved in arbitrages , Stoll and Whaley (1986) report 0.6125% of spot index value and Sofianos (1993) suggests 0.2% for members and 0.5% for institutional investors in the U.S. market. As for Japanese market, Brenner, Subrahmanyam and Uno (1990) report 0.5% ~ 0.8% for members and 1.0% ~ 1.5% for institutional investors. As the market matures with enhanced market depth and efficiency,

transaction costs involved in index arbitrages should decrease. Therefore, it is natural to expect higher transaction costs in the emerging stock market such as Korea than in the advanced capital markets. However, Sofianos (1993) points out that transaction costs estimated in the previous studies overstate the actual transaction costs incurred in the real practice.

[b]According to KSE, the number of shares held by institutional investors at the end of 1995 was 32% relative to 36% for individuals. In addition, the trading proportion of institutional investors to the total trading was 27% relative to 66% for individuals in 1995. When members are trading stocks or futures on their account (7.2% to total stock trading value in 1995 and 9.4% in 1994), their actual costs for brokerage commission are almost nil in practice.

[c]Stoll and Whaley (1986), Fleming, Ostdiek and Whaley (1996) insist that bid-ask spread is a part of market impact costs incurred in selling and buying futures and stocks. Except for bid-ask spread as a compensation for market makers for providing immediate order execution, there can be a additional market impact cost in forms of a price concession for large trade. But in our study, we only take into account the round trip bid-ask spreads as market impact costs. As for bid and ask spread in the Korean stock market, two estimates are used in this study since no data or study about bid -ask spreads is available. First, the tick size or the minimum price change of a stock varies according to its price and is stratified as follows.

Stock price	Tick Size	Tick Size / Price (%)
Price < Won 10,000	Won 10	< 0.1%
Price < Won 100,000	Won 100	<0.1%
Price < Won 500,000	Won 500	<0.1%
Price > Won 500,000	Won 1,000	>0.5%

(Source: KSE)

The average stock price of KSE listed shares as of the end of 1995 is Won 25,021, and when we assume that the normal trading without excessive price fluctuation is made consecutively and continuously with bid-ask bounce by tick size, the estimated bid-ask spread is about 0.4%

(Won 100/ Won 25,021).

The second method is to estimate the bid-ask spread from actual transaction data of the representative stocks among constituent stocks in the KOSPI 200 index. Roll (1984) argues that under an informationally efficient market, the bid-ask spread can be approximated by 2 × (- first order serial covariance of price change)$^{0.5}$. However, his estimation method has two major caveats. First, the autocovariance of successive price change of a stock can be positive so that the value of estimated spread can bear imaginary number. Second, his spread estimates tend to be dependent upon the sample frequency or time interval. Therefore, in our study, we employ the modified Roll's estimation method by Hsia, Fuller and Kao (1994). Their method removes the effect of overall market movement from observed security returns and thereby effectively eliminates the above mentioned problems in Roll's estimation. Details of this modified method is as follows.

Suppose the return behavior of a security can be written as

$r_t = \alpha + \beta\, r_{mt} + \epsilon_t$ and ϵ_t takes on the first order moving average(MA) process such that $\epsilon_t = a_t - \theta\, a_{t-1}$ and a_t is white noise with $E(a_t) = 0$ and $Cov(a_t, a_{t-1}) = 0$ if $k \neq 0$ or σ^2 if $k=0$.

Since $Cov(r_t, r_{t-1}) = \beta^2 Cov(r_{mt}, r_{mt-1}) - \theta\sigma^2$ and $Cov(r_{mt}, r_{mt-1})$ approaches to zero as the number of stocks in the market increases, $Cov(r_t, r_{t-1}) \approx -\theta\sigma^2$.

Since Roll (1984) shows that

$$
\begin{aligned}
Cov(r_t, r_{t-1}) &= -(1/4)\, spread^2 \quad \text{if } k=1 \\
&= -(1/2)\, spread^2 \quad \text{if } k=0 \\
&= 0 \quad \text{, otherwise}
\end{aligned}
$$

and from the above relations,

$$
\begin{aligned}
Cov(\epsilon_t, \epsilon_{t-1}) &= -(1/4)\, spread^2 = -\theta\sigma^2 \quad \text{if } k=1 \\
&= -(1/2)\, spread^2 = (1+\theta^2)\,\sigma^2 \quad \text{if } k=0 \\
&= 0 \text{, otherwise}
\end{aligned}
$$

If we solve the above expressions simultaneously, we get $\theta = 1$ and spread $= 2\sigma$. Therefore, holding the moving average parameter θ equal to 1, the effective bid-ask spread is equal to twice the standard deviation of white noise of the first order moving average process of the residual term ϵ_t. Then we normalize these bid-ask spread estimates by dividing with square root of sample frequency to eliminate the sample frequency dependence effect. In applying this estimation method in calculation of bid-ask spread in the Korean market, we select

Korean Electric Power Co. (KEPCO) and Commercial Bank of Korea (CBOK) as proxy stocks since KEPCO is the largest company in the Korea in terms of the market capitalization (13.6% of total market capitalization in the KSE) and CBOK has the highest average turnover among the KOSPI 200 constituent stocks (1995 average daily volume :142,118 shares a day). In our calculation, we get 0.336% of spread estimates for KEPCO and 0.346% for CBOK. Therefore, we assume that the bid-ask spread in the Korean stock market is approximately around 0.35% to 0.4%. As for future market, we obtain 0.356% by Roll's (1984)method and 0.179% by the modified method. Since it is reported that the bid-ask spread is normally smaller for future market than for cash market, we assume 0.30% for the bid-ask spread estimate in the Korean index future market. Harris, Sofianos and Shapiro (1994) report that the typical stock price in the S&P 500 has a quoted spread of about 0.5% so that the spread for the index is therefore also about 0.5%. However, Sofianos (1993) also insist that arbitragers often carry out arbitrage transactions using surrogate stock baskets containing only most liquid stocks so that the spread could be as low as 0.3%.

[d]Institutional investors including KSE members (all securities firms) are assumed to be quasi arbitrageurs so that they are presumed not to subject to any costs involved in borrowing stocks for short sales or such costs would be minimal if any. For individual investors, costs incurred by selling short borrowed stocks are excessively high since in Korea they should apply their own stocks equivalent of at least 40% of the total trading value in order to borrow additional 60% of stocks from brokers. Still more, they have to deposit all proceeds from selling borrowed stocks to a broker's house or to KSFC as a collateral. Brokers usually pay much lower interest rates (3% per annum) on the customers'margins than the effective market rates (about 12% per annum). The cost of borrowing shown in this table indicates foregone interests on proceeds from short sales of borrowed stocks assuming 90 days of hedge period ($(12\%-3\%) \times 90/365 \approx 2.2\%$).

[e]Opportunity cost of margin requirement in future trading is calculated by multiplying the minimum cash requirement rate (5%) by the effective market rates (about 12% per annum) for 90 days. Since there is no cash margin requirement for KSE members, such costs would

be negligible for members. Because it is reported that most of futures traders in Korea are afraid of locking in a large capital losses so that they tend to trade like short term speculators (day traders or scalpers) during this beginning periods, this figure may overestimate the true costs involved in short selling futures and is conservative in that sense.

Table 2-4. Mispricing of Futures Contract as % of KOSPI 200 Index

June Contract (1996.5.3 - 1996.6.12, N=720)

	Positive Mispricng	Negative Mispricing	Absolute Value Mispricing
Mean	.1887	-.5259	.4711
Median	.1489	-.5007	.4278
Max	.6358	-7.92E-04	1.4399
Min	6.66E-05	-1.4399	6.66E-05
STD	.1546	.3056	.3123

Number (percentage) of Negative Mispricing : 603 (83.8%)

September Contract (1996.6.14 - 1996.9.11, N=1644)

	Positive Mispricng	Negative Mispricing	Absolute Value Mispricing
Mean	.9273	-2.6724	2.3200
Median	.9963	-2.5403	1.4207
Max	1.8014	-8.10E-04	8.1572
Min	.0048	-8.1572	8.10E-04
STD	.4577	2.0874	2.0025

Number (percentage) of Negative Mispricing : 1312 (79.8%)

December Contract (1996.9.13 - 1996.10.16, N=552)

	Positive Mispricng	Negative Mispricing	Absolute Value Mispricing
Mean	-	-2.2843	2.2843
Median	-	-2.1497	2.1497
Max	-	-.5870	4.0623
Min	-	-4.0623	.5870
STD	-	.8414	.8414

Number (percentage) of Negative Mispricing : 552 (100.0%)

Mispricing of futures is calculated by dividing futures price's deviation from theoretical value with corresponding cash index.

For each contract, futures prices for expiration date are excluded.

Table 2-5. Autocorrelation of Futures Mispricing [(F_t - F^*_t) / C_t]

1) June contract (N=720)

	Level		1st difference	
Lag	**AC**	**PAC**	**AC**	**PAC**
1	.917*	.917*	.063	.063
2	.824*	-.106*	-.090*	-.094*
3	.746*	.049	-.174*	-.164*
4	.697*	.128*	-.175*	-.170*
5	.677*	.140*	-.130*	-.156*
6	.678*	.132*	.012	-.048
7	.676*	.032	.015	-.082*
8	.672*	.063	.047	-.041
9	.660*	.026	.030	-.038
10	.643*	.024	.004	-.039

2) September contract (N= 1644)

	Level		1st difference	
Lag	**AC**	**PAC**	**AC**	**PAC**
1	.996*	.996*	.012	.012
2	.992*	-.016	-.073*	-.074*
3	.989*	.070*	-.101	-.100
4	.986*	.093*	-.085*	-.090*
5	.984*	.088*	-.038	-.054*
6	.983*	.047	.021	-.003
7	.981*	-.001	.022	-.003
8	.979*	.004	.015	-.001
9	.977*	-.004	.005	.001
10	.975*	.003	-.004	-.001

3) December contract (N=552)

	Level		1st difference	
Lag	**AC**	**PAC**	**AC**	**PAC**
1	.967*	.967*	-.011	-.011
2	.935*	-.001	-.026	-.026
3	.905*	.010	-.042	-.043
4	.878*	.031	-.129	-.131
5	.858*	.099*	-.074	-.081
6	.843*	.071	-.057	-.072
7	.832*	.070	-.066	-.089*
8	.825*	.081	-.037	-.075
9	.821*	.067	-.009	-.050
10	.817*	.025	.025	-.017

* indicates 5% significance level.

Table 2-6. Annualized Implied Repo Rate (AIRR)

June Contract (N= 720)

	Negative Mispricing(N=603)	Positive Mispricing(N=117)
Mean	-4.307%	15.028%
Median	1.856%	14.190%
Max	11.959%	27.397%
Min	-131.043%	10.471%
STD	20.843%	3.491%

September Contract (N= 1644)

	Negative Mispricing(N=1312)	Positive Mispricing(N=332)
Mean	-5.062%	36.444%
Median	-4.801%	37.419%
Max	14.657%	66.835%
Min	-113.774%	13.721%
STD	13.444%	12.501%

December Contract (N= 552)

	Negative Mispricing(N=552)	Positive Mispricing(N=0)
Mean	3.154%	-
Median	2.985%	-
Max	10.625%	-
Min	-2.766%	-
STD	3.066%	-

Total Contract (N= 2916)

	Negative Mispricing(N=2467)	Positive Mispricing(N=449)
Mean	-3.039%	30.863%
Median	.768%	30.243%
Max	14.657%	66.835%
Min	-131.043%	10.471%
STD	14.677%	14.394%

Implied repo rates (IRR) are the interest rate (similar to internal rate of return) that equalizes the actual futures price with theoretical futures price. Implied repo rate is calculated by the following formula: $REPO_t = (365/N)[\ln\{F_t/[S_t - PV(Div_t)]\}]$ where N is the days to expiration.

Table 2-7. Profitability of the Ex Post Arbitrage Transaction in case that Transaction Costs of 1% of Cash Index Value are considered

1. Futures price deviates below the lower theoretical boundary

(1)June contract (N=720)

No. (Percentage) of Mispricing : 40 (5.56%)

	Absolute Deviation	% of Deviation[a]	AIRR(%)[b]	AERM (%)[c]
Mean	.15896	.148	8.633	1.606
Median	.13092	.121	9.061	1.233
Max	.46564	.431	10.733	4.469
Min	.01004	.010	5.218	.114
STD	.12402	.115	1.446	1.283

(2)September contract (N=1644)

No. (Percentage) of Mispricing : 814 (49.51%)

	Absolute Deviation	% of Deviation	AIRR(%)	AERM (%)
Mean	2.7120	2.929	-2.464	13.739
Median	2.6884	2.951	-3.266	14.375
Max	6.3295	7.007	15.025	30.329
Min	.0205	.003	-21.195	.019
STD	1.3962	1.501	7.093	6.245

(3)December contract (N=552)

No. (Percentage) of Mispricing : 533 (96.56%)

	Absolute Deviation	% of Deviation	AIRR(%)	AERM (%)
Mean	1.0814	1.282	7.961	5.601
Median	.9778	1.159	8.251	5.361
Max	2.5006	2.958	14.142	11.504
Min	.0012	.001	1.451	.007
STD	.6505	.783	3.158	2.971

(4)Total contracts (N=2916)

No. (Percentage) of Mispricing : 1387 (47.56%)

	Absolute Deviation	% of Deviation	AIRR(%)	AERM (%)
Mean	2.0117	2.216	1.862	10.262
Median	1.8169	2.050	3.339	9.366
Max	6.3295	7.007	15.025	30.329
Min	.0012	.001	-21.195	.007
STD	1.4234	1.522	7.747	6.628

Table 2-7. Continued

2. Futures price deviates above the upper theoretical boundary

(1)June contract (N=720)
No. (Percentage) of Mispricing : 0 (0.00%)

(2) September contract (N=1644)
No. (Percentage) of Mispricing : 162 (9.85%)

	Absolute Deviation	% of Deviation	AIRR(%)	AERM (%)
Mean	.2510	.298	22.265	7.669
Median	.2044	.243	20.665	6.074
Max	.6608	.784	36.925	24.585
Min	.0050	.006	15.084	.164
STD	.1761	.115	5.165	5.809

(3) December contract (N=552)
No. (Percentage) of Mispricing : 0 (0.00%)

(4) Total contracts (N=2916)
No. (Percentage) of Mispricing : 162(5.56%)

[a] The percentage of mispricing is computed by dividing absolute deviation of futures price from its theoretical lower (or upper) boundary after accounting for 1% transaction cost with the lower (or upper)boundary value.

[b] Annualized implied repo rate (AIRP) is calculated by the following formulas.

$REPO_t = (365/N)[\ln\{F_t/[S_t(1-K_{SS}-K_{LF}) - PV(Div_t)]\}]$ if $F_t < F^-_t$

$REPO_t = (365/N)[\ln\{F_t/[S_t(1+K_{SS}+K_{LF}) - PV(Div_t)]\}]$ if $F_t > F^+_t$

where $PV(Div_t)$ = present value of dividends paid on spot between t and T

$(=\sum_{j=1}^{T-t} D_{t+j}\exp^{-r(j/365)})$

N= time to expiration (T-t)

[c] Annualized expected excess return to maturity (AERM) is calculated by the following formulas.

if $F_t > F^+_t$, (365/ N)/ [(actual futures price - upper bound)/ arbitrage capital)]

if $F_t < F^-_t$, (365/ N)/ [(lower bound - actual futures price)/ arbitrage capital)]

Table 2-8. Profitability of the Ex Post Arbitrage Transaction in case that Transaction Costs of 2% of Cash Index Value are considered

1. Futures price deviates below the lower theoretical boundary

(1)June contract (N=720)
No. (Percentage) of Mispricing : 0 (0.00%)

(2)September contract (N=1664)
No. (Percentage) of Mispricing : 702 (42.19%)

	Absolute Deviation	% of Deviation[a]	AIRR(%)[b]	AERM (%)[c]
Mean	2.1335	2.325	.907	11.414
Median	2.1521	2.373	.853	11.395
Max	5.4171	6.058	12.692	28.112
Min	.0201	.022	-16.445	.155
STD	1.1470	1.251	5.833	5.627

(3)December contract (N=552)
No. (Percentage) of Mispricing : 295 (53.44%)

	Absolute Deviation	% of Deviation	AIRR(%)	AERM (%)
Mean	.7029	.849	10.427	3.719
Median	.6032	.737	10.908	3.340
Max	1.6465	1.967	14.368	8.188
Min	.0004	.000	5.709	.002
STD	.4794	.577	2.408	2.373

(4)Total contracts (N=2916)
No. (Percentage) of Mispricing : 997 (34.19%)

	Absolute Deviation	% of Deviation	AIRR(%)	AERM (%)
Mean	1.7102	1.888	3.724	9.138
Median	1.4754	1.673	4.736	7.947
Max	5.4171	6.058	14.368	28.112
Min	.0004	.000	-16.445	.002
STD	1.192	.577	6.675	6.055

2. Futures price deviates above the upper theoretical boundary
There is no case for the entire period in which futures price rises beyond the upper boundary of theoretical pricing band when 2% hedge costs are accounted for.

Table 2-9. Profitability of the Ex Ante Arbitrage Transaction in case that Transaction Costs of 1 % of Cash Index Value are considered[a] (10 Minute Execution Lag in Spot Trading)

1. Futures price deviates below the lower theoretical boundary

(1)June contract (N=720)

No. (Percentage) of Mispricing : 18 (2.50%)

	Absolute Deviation	% of Mispricing	AERM (%)
Mean	.1725	.160	1.798
Median	.1111	.103	1.165
Max	.5556	.515	5.805
Min	.0089	.008	.096
STD	.1519	.141	1.592

(2) September contract (N=1644)

No. (Percentage) of Mispricing : 801 (48.72%)

	Absolute Deviation	% of Mispricing	AERM (%)
Mean	2.7442	2.964	15.130
Median	2.6979	2.948	15.813
Max	6.1970	6.871	32.389
Min	.0024	.003	.020
STD	1.3597	1.462	6.594

(3) December contract (N=552)

No. (Percentage) of Mispricing : 533 (96.56%)

	Absolute Deviation	% of Mispricing	AERM (%)
Mean	1.0721	1.272	6.048
Median	.9497	1.102	5.823
Max	2.5051	2.984	12.687
Min	.0012	.001	.008
STD	.6442	.776	3.184

(4) Total contracts (N=2916)

No. (Percentage) of Mispricing : 1352 (46.36%)

	Absolute Deviation	% of Mispricing	AERM (%)
Mean	2.0507	2.260	11.372
Median	1.8778	2.100	10.305
Max	6.1971	6.871	32.389
Min	.0012	.001	.008
STD	1.4029	1.497	7.110

Table 2-9. continued

1. Futures price deviates above the upper theoretical boundary

(1)June contract (N=720)
No. (Percentage) of Mispricing : 0 (0.00%)

(2) September contract (N=1644)
No. (Percentage) of Mispricing : 138 (8.39%)

	Absolute Deviation	% of Mispricing	AERM (%)
Mean	.2788	.331	7.493
Median	.2534	.301	6.541
Max	.6309	.738	18.729
Min	.0023	.003	.068
STD	.1504	.178	4.293

(3) December contract (N=552)
No. (Percentage) of Mispricing : 0 (0.00%)
(4) Total contracts (N=2916)
No. (Percentage) of Mispricing :138 (4.73%)

[a] The ex ante test of arbitrage profitability is conducted by investigating whether the ex post deviation from the arbitrage free band would be still profitable after considering 10 minute delay in executing the arbitrage transaction. 1% transaction costs are assumed to be incurred in this arbitrage.

Table 2-10. Profitability of the Ex Ante Arbitrage Transaction in case that Transaction Costs of 2 % of Cash Index Value are considered[a] (10 Minute Execution Lag in Spot Trading)

1. Futures price deviates below the lower theoretical boundary

(1)June contract (N=720)
No. (Percentage) of Mispricing : 0 (0.00%)

(2)September contract (N=1664)
No. (Percentage) of Mispricing : 700 (42.07%)

	Absolute Deviation	% of Mispricing	AERM (%)
Mean	2.1262	2.318	11.373
Median	2.1847	2.423	11.452
Max	5.2862	5.920	27.473
Min	.0095	.011	.073
STD	1.1399	1.243	5.650

(3) December contract (N=552)
No. (Percentage) of Mispricing : 273 (49.46%)

	Absolute Deviation	% of Mispricing	AERM (%)
Mean	.7394	.894	3.896
Median	.7027	.857	3.800
Max	1.6571	1.994	8.344
Min	.0026	.003	.017
STD	.4612	.554	2.275

(4) Total contracts (N=2916)
No. (Percentage) of Mispricing : 973 (33.47%)

	Absolute Deviation	% of Mispricing	AERM (%)
Mean	1.7371	1.918	9.275
Median	1.4702	1.680	8.162
Max	5.2860	5.920	27.473
Min	.0026	.003	.017
STD	1.1758	1.268	5.975

2. Futures price deviates above the upper theoretical boundary
There is no case for the entire period in which futures price rises beyond the upper boundary of theoretical pricing band when 2% hedge costs are accounted for.

[a] The ex ante test of arbitrage profitability is conducted by investigating whether the ex post deviation from the arbitrage free band would be still profitable after considering 10 minute delay in executing the arbitrage transaction. 2% transaction costs are assumed to be incurred in this arbitrage.

Table 2-11. Profitability of the Ex Ante Arbitrage Transaction in case that Transaction Costs of 1% of Cash Index Value are considered[a] (10 Minute Execution Lag in Futures Trading)

1. Futures price deviates below the lower theoretical boundary

(1)June contract (N=720)

No. (Percentage) of Mispricing : 32 (4.44%)

	Absolute Deviation	% of Mispricing	AERM (%)
Mean	.3219	.301	3.356
Median	.2846	.265	3.041
Max	.6554	.606	10.734
Min	.0398	.038	.416
STD	.1707	.159	2.154

(2) September contract (N=1644)

No. (Percentage) of Mispricing : 807 (49.09%)

	Absolute Deviation	% of Mispricing	AERM (%)
Mean	2.7401	2.959	13.884
Median	2.7374	3.004	14.554
Max	6.4295	7.118	30.808
Min	.0032	.004	.025
STD	1.3944	1.498	6.203

(3) December contract (N=552)

No. (Percentage) of Mispricing : 516 (93.48%)

	Absolute Deviation	% of Mispricing	AERM (%)
Mean	1.1162	1.323	5.776
Median	.9956	1.190	5.382
Max	2.7361	3.227	12.458
Min	.0216	.025	.143
STD	.6628	.797	3.043

(4) Total contracts (N=2916)

No. (Percentage) of Mispricing : 1355 (46.47%)

	Absolute Deviation	% of Mispricing	AERM (%)
Mean	2.0646	2.273	10.548
Median	1.8393	2.082	9.542
Max	6.4295	7.118	30.808
Min	.0032	.004	.025
STD	1.4183	1.515	6.563

Table 2-11. Continued

1. Futures price deviates above the upper theoretical boundary

(1)June contract (N=720)
No. (Percentage) of Mispricing : 0 (0.00%)

(2) September contract (N=1644)
No. (Percentage) of Mispricing : 140 (8.52%)

	Absolute Deviation	% of Mispricing	AERM (%)
Mean	.3057	.364	8.496
Median	.2704	.319	6.876
Max	.8108	.982	27.152
Min	.0003	.000	.005
STD	.2177	.261	6.632

(3) December contract (N=552)
No. (Percentage) of Mispricing : 0 (0.00%)
(4) Total contracts (N=2916)
No. (Percentage) of Mispricing :140 (4.80%)

[a] The ex ante test of arbitrage profitability is conducted by investigating whether the ex post deviation from the arbitrage free band would be still profitable after considering 10 minute delay in executing the arbitrage transaction. 1% transaction costs are assumed to be incurred in this arbitrage.

Table 2-12. Profitability of the Ex Ante Arbitrage Transaction in case that Transaction Costs of 2% of Cash Index are considered[a] (10 Minute Execution Lag in Futures Trading)

1. Futures price deviates below the lower theoretical boundary

(1)June contract (N=720)
No. (Percentage) of Mispricing : 0 (0.00%)
(2)September contract (N=1664)
No. (Percentage) of Mispricing : 692 (41.59%)

	Absolute Deviation	% of Mispricing	AERM (%)
Mean	2.1693	2.364	11.596
Median	2.2164	2.458	11.695
Max	5.5171	6.170	28.631
Min	.0095	.011	.073
STD	1.1450	1.248	5.655

(3) December contract (N=552)
No. (Percentage) of Mispricing : 273 (49.46%)

	Absolute Deviation	% of Mispricing	AERM (%)
Mean	.7707	.929	4.085
Median	.7095	.867	3.942
Max	1.879	2.240	9.268
Min	.0038	.005	.021
STD	.487	.587	2.410

(4) Total contracts (N=2916)
No. (Percentage) of Mispricing : 965 (33.09%)

	Absolute Deviation	% of Mispricing	AERM (%)
Mean	1.7737	1.958	9.471
Median	1.5491	1.754	8.419
Max	5.5171	6.170	28.631
Min	.0038	.005	.021
STD	1.1848	1.277	6.002

2. Futures price deviates above the upper theoretical boundary
There is no case for the entire period in which futures price rises beyond the upper boundary of theoretical pricing band when 2% hedge costs are accounted for.

[a] The ex ante test of arbitrage profitability is conducted by investigating whether the ex post deviation from the arbitrage free band would be still profitable after considering 10 minute delay in executing the arbitrage transaction. 2% transaction costs are assumed to be incurred in this arbitrage.

Table 2-13. Relationship of the Magnitude of Mispricing with the Time to Expiration and Stock Market Condition[a]

1. Regression of mispricing on the time to expiration
$[F_t - F^*_t = \alpha + \beta (T - t) + \epsilon_t]$

	β coefficient	standard error	t value	P value	R^2
June	-7.25E-05	1.19E-05	-6.090	.000	.05
September	-7.92E-05	1.08E-06	-73.469	.000	.76
December	-5.58E-05	2.49E-06	-22.420	.000	.48

2. Regression of absolute mispricing on the time to expiration
$[| F_t - F^*_t | = \alpha + \beta (T - t) + \epsilon_t]$

	β coefficient	standard error	t value	P value	R^2
June	7.00E-05	9.44E-06	7.420	.000	.07
September	6.32E-05	1.06E-06	59.494	.000	.68
December	5.58E-05	2.49E-06	22.420	.000	.48

3. Regression of mispricing on the return on cash index
$[F_t - F^*_t = \alpha + \beta \ln(C_t / C_{t-1}) + \epsilon_t]$

	β coefficient	standard error	t value	P value	R^2
June	-.0899	.0729	-1.234	.217	.00
September	.6579	.3425	1.920	.055	.00
December	.6091	.1703	3.577	.000	.02

[a] F_t : actual futures price at time t
F^*_t : Theoretical futures price based on cost of carry relationship at time t
C_t : Spot price (KOSPI 200 index) at time t
T : expiration date

Table 2-14. Summary of Basic Statistics of Basis [Futures(F_t) - Cash(C_t)]

1) June contract (N=720)

Descriptive Statistics		lag	Basis	Δ Basis	Δ Cash	Δ Futures
			Autocorrelation			
Mean	.2651	1	.937*	.075*	.296*	.139*
Median	.2150	2	.867*	-.083*	-.005	-.055
Max	1.6700	3	.807*	-.172*	-.098*	-.047
Min	-.7500	4	.768*	-.187*	-.149*	-.054
STD	.4730	5	.750*	-.137*	-.108*	-.015
Skewness	.3114	6	.746*	.003	.027	.080*
Kurtosis	2.5176	7	.741*	.009	.053	.043
J.B test	18.62	8	.735*	.045	.024	-.016
(p value)	(.000)	9	.723*	.035	-.011	-.008

2) September contract (N= 1644)

Descriptive Statistics		lag	Basis	Δ Basis	Δ Cash	Δ Futures
			Autocorrelation			
Mean	-.2699	1	.993*	.013	.384*	.136
Median	.0100	2	.985*	-.070*	.165*	.028
Max	2.2700	3	.979*	-.104*	-.011	-.040
Min	-4.7800	4	.974*	-.086*	-.073*	-.054*
STD	1.4888	5	.970*	-.037	-.072*	-.014
Skewness	-.5504	6	.967*	.020	-.023	.042
Kurtosis	2.3748	7	.963*	.019	.026	.046
J.B test	109.76	8	.960*	.013	.052*	.051*
(p value)	(.000)	9	.956*	.001	.076 *	.044

3) December contract (N=552)

Descriptive Statistics		lag	Basis	Δ Basis	Δ Cash	Δ Futures
			Autocorrelation			
Mean	.5143	1	.939*	-.006	.407*	.084
Median	.4950	2	.880*	-.019	.211*	.065
Max	1.9400	3	.823*	-.038	.031	.014
Min	-.5400	4	.771*	-.132*	-.049	-.043
STD	.5227	5	.733*	-.084	-.085	.004
Skewness	.1988	6	.704*	-.063	-.126*	-.010
Kurtosis	2.6191	7	.683*	-.079	-.058	.015
J.B test	6.97	8	.671*	-.029	-.041	-.016
(p value)	(.031)	9	.661*	-.012	.028	.025

* indicates 5% significance level.

Table 2-15. Monthly Trading Profile of Futures Contract over the Sample Periods (May 3,1996 ~ Oct.31, 1996)

Month	Volume (Contracts)	Value (Won Bil.)	Open Interest (Contracts)	Arbitrage Trade Contract	Arbitrage Trade Value (Won Bil.)
May	83,330	4,367	38,192	-	-
June	68,169	3,182	60,480	965	44.3
July	72,669	3,233	126,206	444	19.6
August	79,492	3,306	144,348	344	15.1
September	87,200	3,626	104,788	251	10.5
October[a]	118,935	5,079	142,481	396	17.1
Year Total	509,795	22,793	616,495	2,400	106.6
Daily Average	3,444	154	4,166	16.2	0.72

Source : Korea Stock Exchange

[a] The above table offers the total tally of the entire October month for comparison purpose even though our sample covers only up to 16th of October.

Chart 2-1. Trend of Futures Mispricing (As of cash Index)

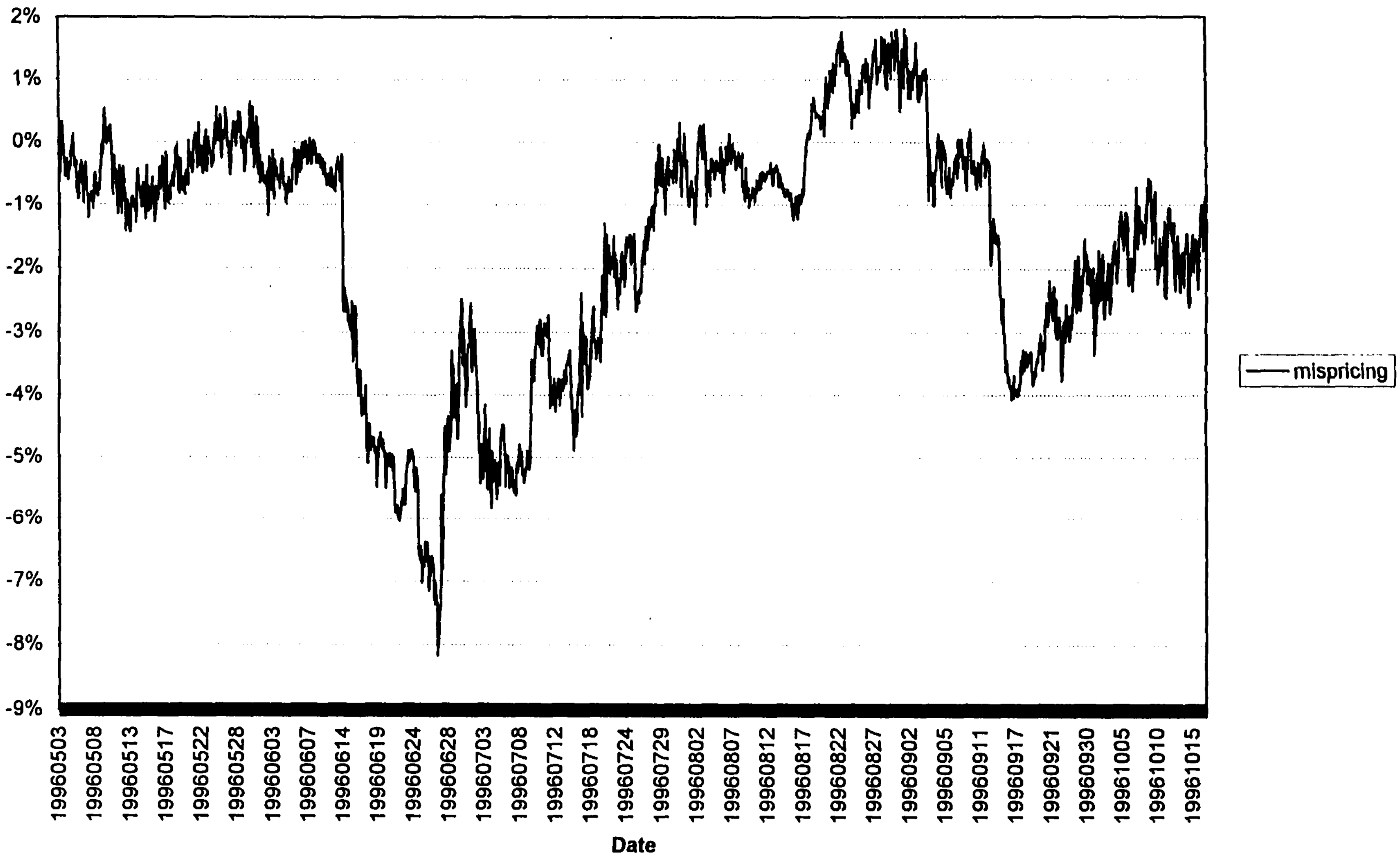


Chart 2-2. Annualized Implied Repo Rates (IRR)

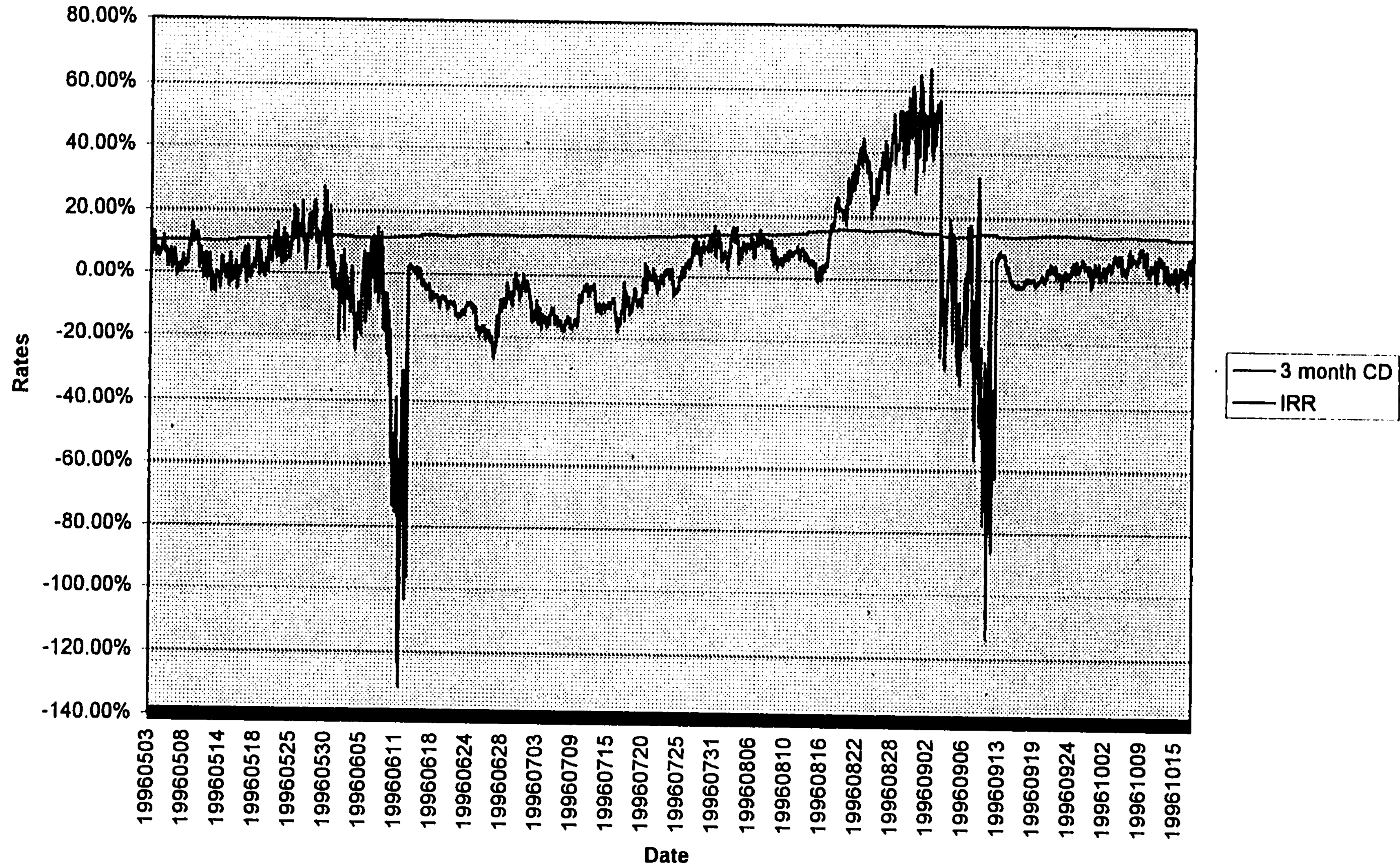


Chart 2-3. Price Movement of Futures Contract (1% Transaction Cost)

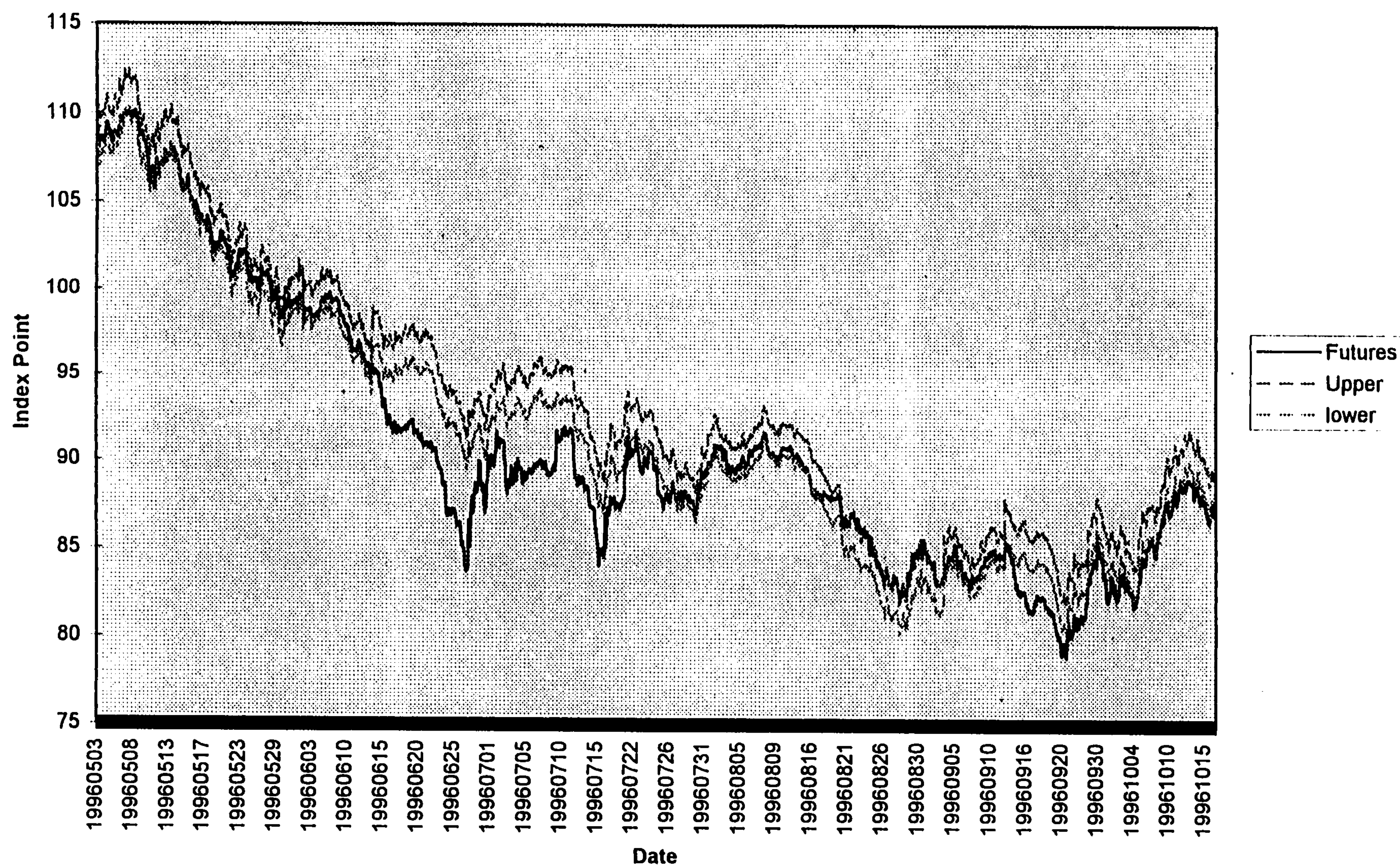


Chart 2-4. Trend of Mispricing (1% Transaction Costs)

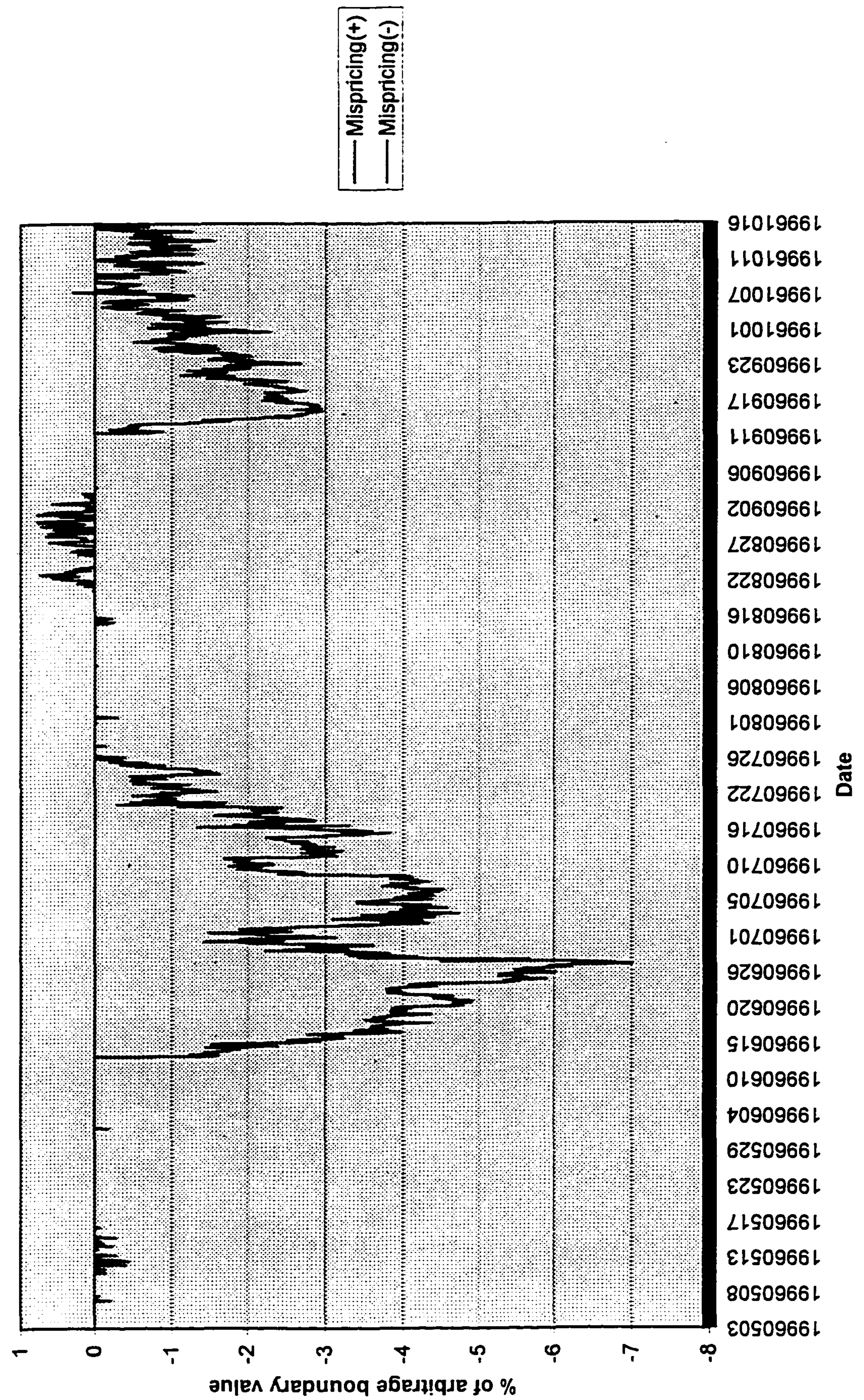


Chart 2-5. Price Movement of Futures Contract (2% Transaction Cost)

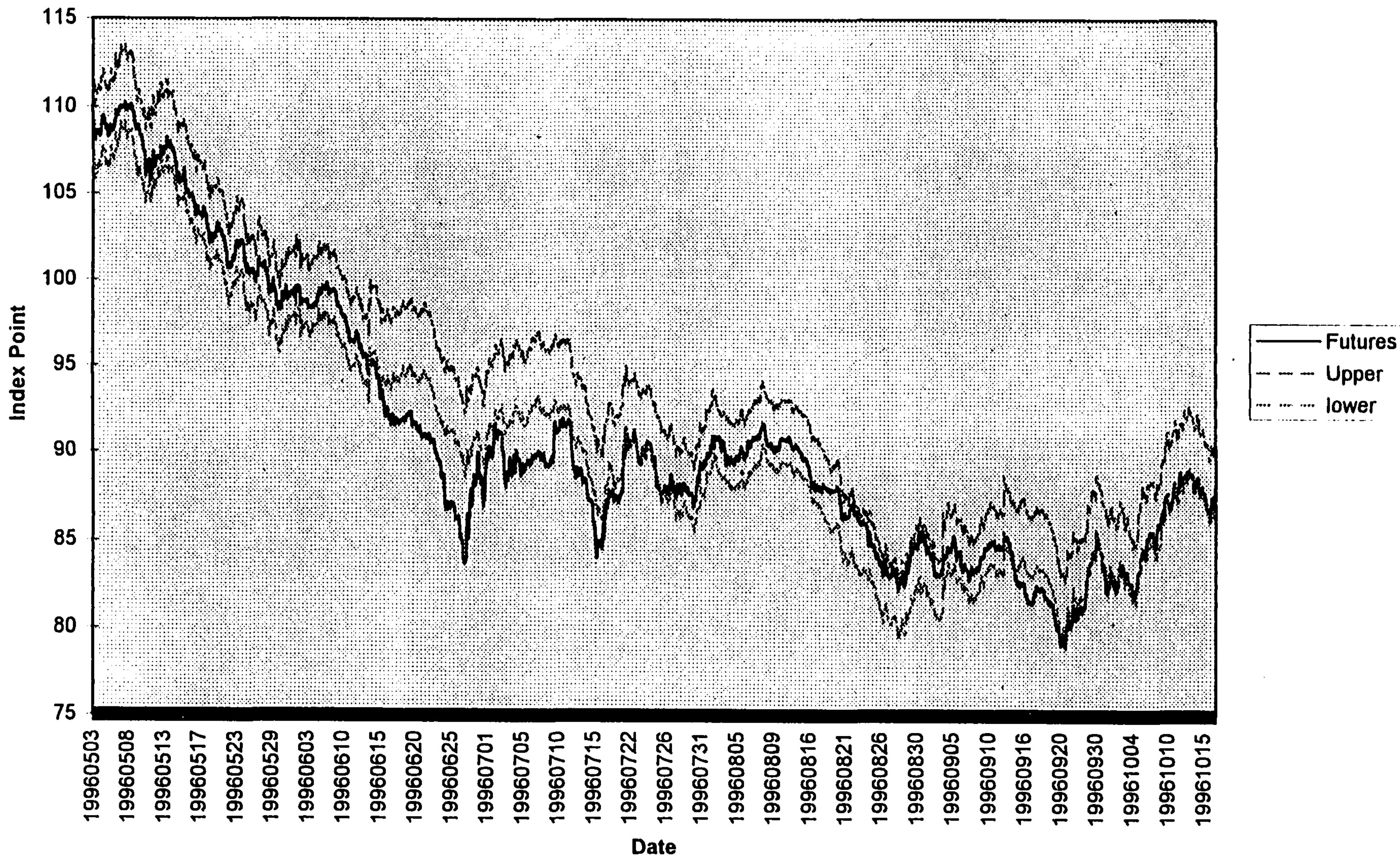


Chart 2-6. Trend of Mispricing (2% Transaction Costs)

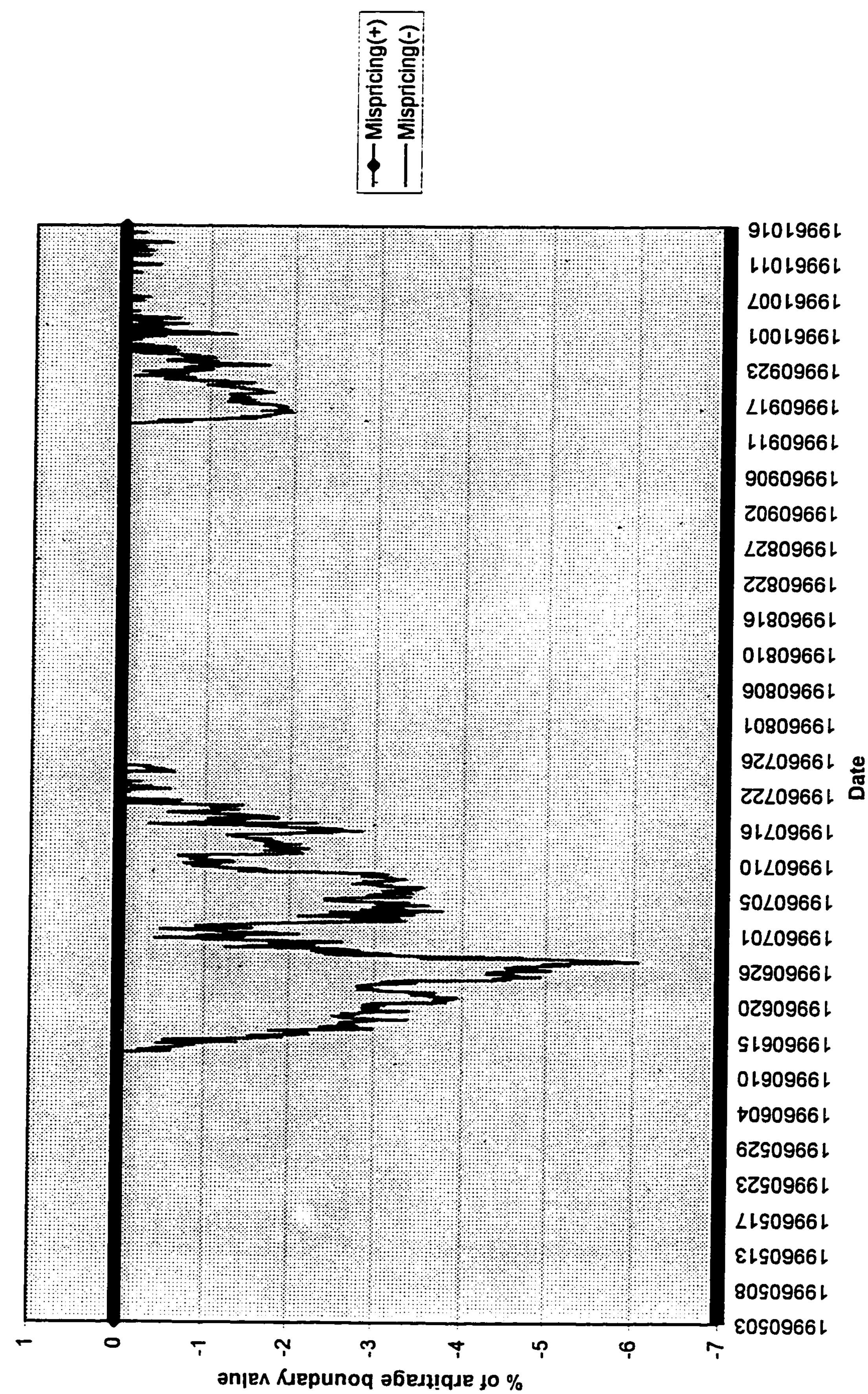
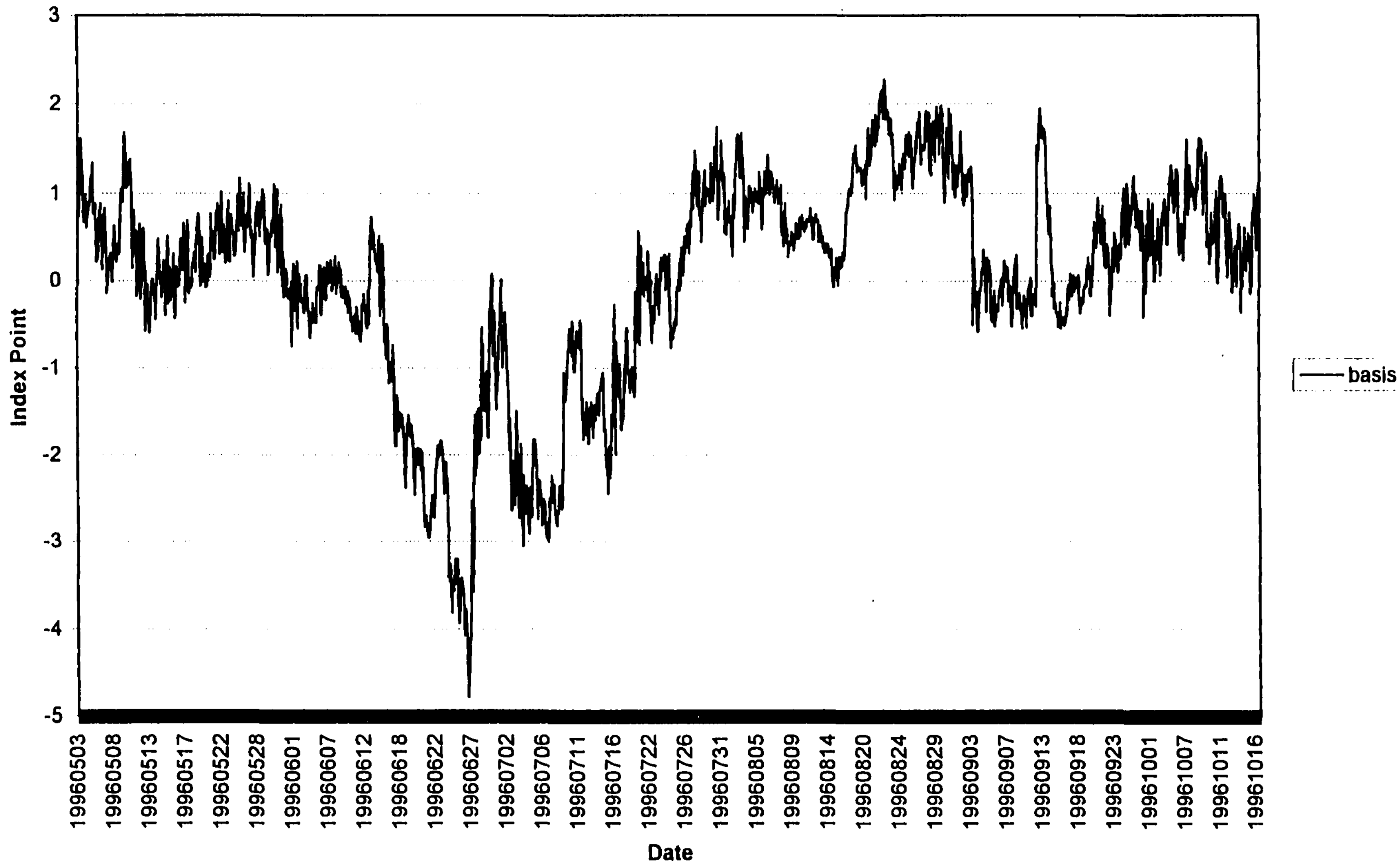


Chart 2-7. **Trend of Basis (Futures - Cash)**



CHAPTER III

LEAD AND LAG RELATIONSHIP IN PRICE CHANGES BETWEEN CASH AND FUTURES MARKETS

3-1. Literature Review

Black (1976) argues that the greatest benefit earned from the existence of futures market is neither risk hedging nor allocation of risk, but rather its side effect : a discovery of price by which market participants can make a corporate decision. Grossman (1989) also emphasizes the role of price discovery by the futures market that transmits information from informed traders to the uninformed. He argues that the futures market tends to develop if and only if informed traders will profit from their information and some of that information is not transmitted to the uninformed traders by equilibrium spot prices. In contrast, in an efficient capital market where all available information is fully and instantaneously utilized to determine the market price of capital asset, futures price should move concurrently with its corresponding spot price without any lead and lag in price movements from one market to the other.

Due to the market frictions such as transaction costs or the capital market microstructure effects, however, significant lead and lag relationship between two markets is frequently observed. In the U.S. market, it is generally documented that futures price leads cash prices due to differences in speed of adjustment to the new information, which result from differences in transaction costs, asynchronous trading in cash prices and etc. Herbst, McCormick and West (1987) find that index futures prices tend to lead those of their cash indices for both Value Line and S&P 500, but the spot index adjusts so quickly (on average less than one minute) that knowledge of the lead and lag relationship can not be used for profitable trading opportunity. Finnerty and Park (1987) explain the chain of causality from futures to cash in program trading in the following way : Initially, when investors expect the stock price to rise, they first buy futures because there is no initial investment and low transaction costs. Imbalance between futures and underlying cash index prices occurs subsequently due to a rise in futures price. Then, the gap between futures and stock prices is reduced due to the simultaneous sale of futures and purchase of the underlying index in the program trading. They maintain that internal factors such as changes in investor expectation or external factors such as interest rate changes will cause the change in spread between futures and spot, which in turn, affect the lead-lag relationship. In the early introduction period of index futures for both MMI and MMMI (especially before 1986), however, they find little correlation between change in the futures price and subsequent change in the index. As the futures market matures, futures price changes strongly lead spot index changes in their study. Garbade and Silber (1983) and Ng (1987) insist that inter-relationship between spot prices and future prices depends on the supply of arbitrage services between the two markets. Garbade and Silber (1983) argue that if the supply of arbitrage services is perfectly elastic, futures contract will be a perfect substitute for a cash market position and each will follow a common random walk. Ng (1987) suggests that when arbitrage transactions are costly (the supply of arbitrage service is not perfectly elastic), then one market may lead or lag the other in reflecting new information and that the lower costs of transacting in the futures market make the futures markets more informationally efficient than their corresponding spot markets.[29] Using daily data, she finds that lead-lag relationship does not persist for more than one day due to possible arbitrage between two markets and even though futures prices lead spot prices for the stock indexes and some currency futures, the small magnitudes of cross correlation between lagged futures price and spot prices make it difficult for the uninformed traders to earn excess profits using this relationship. She also asserts that the harder the instantaneous arbitrage strategies are implemented, i.e., the more stocks a spot index is comprised with, the more salient a lead and lag relationship is present between two markets.[30] Kawaller, Koch and Koch (1987) document that S&P 500 futures price and the index are simultaneously related throughout the trading day[31]. But they also find that the lead from futures to cash prices persists for over twenty minutes while the reverse relationship does not last for more than one minute. They attribute this stronger "futures leading spot"relationship to the infrequent trading in the stock market. Herbst, et al. (1987) call it " wait to be traded" feature of a spot index. If the market makes a significant move, some of the stock in the index will not yet have traded and the index based in part on pre-move prices of less actively traded stocks will under represent the true index value. In this regard, Fleming, Ostdiek and Whaley

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[29] She argues that transaction costs are more binding in hindering arbitrage activities especially in case of short sale due to margin requirement and uptick rule.

[30] She observes a stronger causal relationship for the Value Line index than for the S&P 500 index. Herbst etc. (1987) also document that S&P 500 stock index reacts faster (in 8 minutes) to changes in futures price than Value Line index does (in 16 minutes). They argue that the more volume of trading is and the less number of securities in basket are, the faster spot index adjusts to the changes in futures contract price.

[31] They observe that the magnitudes of the contemporaneous coefficients overwhelm all lag coefficients in both directions, indicating that futures and spot prices move largely in tandem.

(1996) observe that the S&P 100 index more strongly leads the S&P 500 stock index. With the greater trading frequency of S&P 100 stocks relative to S&P 500 stocks, S&P 100 have less serious asynchronous trading problems than S&P 500. However, infrequent trading in spot index alone does not seem to explain the observed strong lead from futures price to spot index value. Stoll and Whaley (1990a) report that index futures lead their spot prices by about five to ten minutes even after purging microstructure effects such as infrequent trading and bid-ask bounces. But they also find some evidence that spot returns lead futures returns in the early inception period of futures trading. Consistent with Kawaller, et al.(1987), they report that returns in the futures and spot markets mostly move contemporaneously. Chan (1992) also suggests that information adjustment is faster for futures than for cash index due to the staleness of component stock prices by asynchronous trading and less costly transaction costs in futures market.[32] After controlling non-synchronous trading, he also find an asymmetric lead and lag relationship between the two markets with strong evidence that futures leads the cash index and only weak evidence that the cash index leads the futures. In addition, he adds that cash index prices lag futures not only under bad news but also under good news[33] and,

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[32] He suggests three factors as the possible determinants of the lead and lag relations between futures and spot market. First, restrictions on short sale in spot market slow the adjustment of prices to private information, especially with respect to private bad news. Hence, futures prices without short sale constraints should lead the cash index to a greater degree under bad news. Second, the lead-lag relationship may be affected by the intensity of trading activity in the two markets while price discovery and trading activity are related. Third, the futures market should reflect market-wide information more quickly than cash market does.

[33] He hypothesizes that due to the short sale restrictions such as uptick rule and the resulting greater execution risk, spot respond more slowly to futures price change under bad news than under good news. However, he does not find any stronger tendency for the

more importantly that when there are more stocks moving together, the feedback from the futures market to the cash market is stronger. Moreover, he documents that futures return leads not only cash index return, but also individual stock return such as IBM. Since IBM is a more frequently traded stock than index futures and has no serious infrequent trading problem, his result suggests that microstructure effects alone can not account for strong lead from futures to cash. He concludes that the futures market becomes the main source of market-wide information while the cash market is the main source of firm-specific information. Similarly, Subrahmanyam (1991) insists that stock index futures provide a preferred trading medium for uninformed liquidity traders who wish to trade portfolios because adverse selection costs (incurred in trading against informed traders) are lower in the stock index futures market than in markets for individual securities. He argues that the independent orders submitted by informed traders in the basket tend to offset each other when the number of securities comprising the basket is large. He adds that this diversification benefit reduces the transaction costs of the liquidity traders and improves their terms of trade against informed traders when they trade in the basket. Therefore, uninformed liquidity traders and traders with only market wide information migrate to invest in the stock index futures market while informed traders prefer to invest in individual securities. This will cause stock index futures market to reflect more rapidly market wide information.

In terms of volatility interaction between cash and futures market, Kawaller, Koch and Koch (1990) do not observe any systematic pattern of lead and lag relationship in volatilities

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futures to lead the cash index under bad news than under good news.

between two markets[34], in contrast to the lead and lag relationship in price changes between two markets. In line with Kawaller, et al. (1990), Chan and Chan, Karolyi (1991) report that price innovations in either the cash or futures market influence the volatility in the other market, suggesting that while the lead and lag relationship in returns is almost unidirectional or asymmetric (futures leading cash), that of volatility is bi-directional or symmetric. They also note that although the lead and lag relations between the price changes of the cash and futures markets appears to diminish over the sample period[35], the inter-market dependence of volatility grows stronger and comparably in both directions. As Ross (1989) argues that price volatility is directly related to the rate of information arrival, their evidence is consistent with the hypothesis that new market information disseminates in both the futures and stock markets, and that both markets serve important price discovery roles. They suggest that new information that hits either markets can, in general, predict the arrival rate of information in the other market. Chan and Chung (1993) also document similar bi-directional volatility movements that over 1984-85, MMI index futures price volatility is preceded by volatility in the underlying spot index and current spot volatility is strongly correlated with past futures price volatility. However, they report that there is asymmetry in the economic magnitude of the respective lead and lag relationship and that the lead from futures volatility to cash

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[34] They find that the volatility relationships are not robust across different contract periods with index volatilities leading futures volatility in some sample periods (1985) and the reverse movements in the other period (1986). They also argue that even though future prices lead spot prices, lagged volatilities in spot prices could influence the futures price volatilities.

[35] Over the two subsample periods (1985-1986, 1988-1989), they do not find significant lead from cash to futures but observe that the impact of cash market return shocks and past cash market volatility on the futures market volatility is even stronger than usual.

volatility is stronger than the opposite direction. Lee and Linn (1994) also report that causality in volatility runs in both directions for S&P 500 futures and index despite evidence of stronger lead from futures return to spot return. Similarly, Cheung and Ng (1990,1996) document strong feedback (simultaneous interaction) in volatilities between S&P 500 futures and spot index although there is evidence of the direction of causality running from futures price volatility to cash price volatility during the first 15 minute trading.

As for empirical studies conducted in other countries, these report different empirical results regarding the lead and lag relations of returns and volatilities between futures and stock markets. Abhyankar (1995) tests the lead and lag relationship in returns and volatility between the FT-SE 100 stock index futures and the underlying cash index using hourly intraday data. He finds a strong contemporaneous relationship between the FT-SE futures and cash market along with some significant evidence of futures leading cash market, especially during times of high volatility. It is noted, however, that the sizeable reduction in transaction costs in the London equity market after Big Bang made the size and the significance of the lead of the futures returns over the index returns decrease. However, he does not find any clear pattern of one market leading the other in terms of volatility. He observes strong contemporaneous volatility interaction between futures and cash markets, but lead and lag relationship in volatility are changed according to the sample period. This result is consistent with earlier evidence in the U.S. market such as Kawaller, et al. (1990) and Chan, et al. (1991). Alternatively, Shyy, Vijayraghavan and Scott-Quinn (1996) find the reverse causality from cash (CAC cash index) to futures (CAC futures contract) in the French market when asynchronous trading problem is resolved by using the midquote points of bid-ask prices, even though they find the lead-lag relationship from futures to cash when the minute by minute transaction data is used. They conclude that previous results showing futures leading cash may be primarily due to market asynchronous trading and stale price problems, as well as differences in trading mechanisms used in cash or futures markets. Lim (1992) observes that the futures price movements on Nikkei Stock Average (NSA) futures contract are highly positive correlated with contemporaneous spot price movements within five minute intervals. However, beyond contemporaneous comovements, no apparent lead and lag relationship is found between returns for futures contract on SIMEX and returns for cash index on the Tokyo market. Iihara, Kato and Tokunaga (1996) report that Nikkei Stock Average (NSA) futures return strongly leads cash returns, but that no bidirectional volatility feedbacks in volatility between futures returns and cash returns are not observed in Japan, contrary to the results reported by Chan, Chan and Karolyi (1991). Instead, they observe that futures market shocks are transmitted significantly to the volatility of the cash market, not in the opposite way. Martikainen, Perttunen and Puttonen (1995) investigate the lead and lag relationship between futures contract and individual stocks or between cash index and individual stocks in the Finnish market. They insist that futures market returns predict the returns of most stocks, traded both infrequently and frequently, better than the cash index returns do. Since the most frequently traded stocks are led by futures market returns at least as clearly as the portfolio of infrequently traded stocks, they conclude that the asynchronous trading of component stock prices does not seem to be a dominant factor, making it appear that futures prices lead cash index prices. In the Australian market, Gannon (1994) finds uni-directional volatility movement from futures to cash.

In summary, different samples (contracts) have different results about lead and lag relationship, but most of the previous studies suggest that the lead and lag relationship between futures and spot returns is asymmetric or uni-directional. On the other hand, volatility transmissions between two markets are bi-directional. Knowledge of this relationship between two markets, however, can not be exploited for making excess returns since the arbitrage activities will soon eliminate such profitable opportunities, bringing the cost of carry relation back into alignment.[36]

3-2. Data and Methodology

3-2-1. Data Description

Due to the computerization of arbitrage transactions and the program trading, the data needs to be sampled on an intradaily rather than daily basis in order to detect an economically meaningful causal relationship. In our study, we are using 10 minute intraday data from May 3rd through October 16th, covering 2715 ten minute intraday returns, 112 session break returns (sampled over 1 hour and 40 minutes) and 132 overnight returns for KOSPI 200 index, KOSPI index and the nearby futures contract.[37] In addition to the lead and lag

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[36] Stoll and Whaley (1990a) and Fleming, Ostdiek and Whaley (1996) suggest that growth in stock market volume, increasing efficiency of index arbitrage and programing trading execution make a contemporaneous relationship between futures and cash markets stronger with less lead and lag relationship as time passes. This indicates a continued integration of the index futures and stock market.

[37] Most previous studies omit the overnight returns, because they are sampled over different time interval. However, unlike the U.S., Korean stock market has intermission between morning and afternoon session, and this causes another complexity for conducting time series using intraday data. Since our data covers 10 minute intraday data, lack of sample size inevitably made us to rely on the other method (see Kawaller, Koch

relationship in returns and volatility between KOSPI 200 index and futures, those between KOSPI index and futures or between two stock indexes are also examined to differentiate the effects of price movement of the large cap stocks on the lead-lag relationship from those of the small cap stocks. This investigation can also test Chan's (1992) market wide information hypothesis. Each of the return series is constructed as continuous compounding percentage returns by taking natural logarithm on the ratio of current price to the lagged price and multiplying this by 100. Following Kawaller, Koch and Koch (1990),Cheung and Ng (1990) and Chan,Chan and Karolyi (1991), we control overnight returns and session break returns from 10 minute intraday returns by dummy variables. It is well documented that new information arrives and accumulates even during the non-trading hours, which affects the returns during trading hours. Since there is a disparity in futures price before and after each of the expiration dates of the nearby contract, we divide the total sample into three periods according to the life of the nearby futures contract.

Table 3-1 displays the descriptive statistics for each of stock index return and its nearby futures contract. For 10 minute intraday returns, their means and medians are not positive except for futures return in December throughout the entire sample period. This mainly results from the unfavorable stock market condition during our sample period. To reflect the inertia in trading for the early inception period, the median return of futures contract is zero for the whole contract period. Over the entire period, futures volatility (standard deviation) is greater than those for spot market indexes and between two stock indexes, volatility of KOSPI 200 is greater than that for KOSPI. Infrequent trading of

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and Koch 1990 ; Cheung and Ng 1990).

component stocks (especially small sized stocks) seems to dampen return volatility. while the volatility is relatively higher during June contract period than over September or December contract periods for both stock indexes, futures returns are more volatile over September or December contract periods than over June contract period. Chan and Chung (1993) and Chen,Cuny and Haugen (1995) report that large mispricing in futures price results in an increase in supply of arbitrage services and an increase in volatility in both futures and cash markets.This increase in volatility subsequently reduces mispricing of futures contract. However, they suggest that when stocks are moving downward and futures contracts are underpriced, this relationship becomes attenuated. Therefore, it is observable that lack of arbitrage capital reduces stock market volatility over the September and December contract periods whereas more volatile stock market condition (due to active arbitrage activities) makes future price move relatively well in line with cost of carry relationship over June contract period. For all return series, Jarque-Bera normality test rejects the null hypothesis of normal distribution.

Table 3-2 summarizes the same descriptive statistics for session break returns. Except for futures contract, the session break returns are on average positive for stock indexes. It is noticeable that the standard deviation of the session break return is not so much higher or over some periods lower than the 10 minute intraday returns for all return series.[38] Unlike 10

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[38] If stock or futures price follows random walk process, the variance of the return (differenced log price) increases proportionately with sample interval. Therefore, in theory, the standard deviation of session break return or overnight return should be greater than 10 minute intraday return by multiples of $\sqrt{10}$ and $\sqrt{111}$. However, previous studies (French and Roll 1986 etc.) document that overnight return's volatility is not so much high as the theory dictates.

minute intraday returns, the normality is satisfied for all of session break returns except for KOSPI 200 index over September contract period. As shown in the Table 3-3, overnight returns are larger in magnitude than 10 minute returns or session break returns and take on positive value on average for stock indexes. On the contrary, for futures contract, overnight returns are more negative and larger in magnitude than the session break return or intraday returns. The volatility (standard deviation) for overnight returns are approximately three times greater than the 10 minute intraday returns or session break returns for all of stock index and futures return series.

3-2-2. Methodologies in Lead and Lag Relationship Study

In terms of methodological breakdown for previous studies, Herbst, McCormick and West (1987), Ng(1987), Kawaller, Koch and Koch (1987),Chan,Chan and Karolyi (1991) and Cheung and Ng (1996) employ the sample cross-correlations between future returns and cash returns to check the lead and lag relationship. Kawaller, Koch and Koch (1987, 1990), Finnerty and Park (1987), Stoll and whaley (1990a), Chan (1992), Chan and Chung (1993, 1995), Koch (1993), Lee and Lin (1994), Gannon (1994), Martikainen, Perttunen and Puttonen (1995) and Fleming, Ostdiek and Whaley (1996) use the Granger causality test[39] to

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[39] Granger causality (X_t causes Y_t in Granger sense) implies that the past information of X_t contributes to the lower variance of prediction of Y_t than without that information. That is, consider two stationary and egordic time series, X_t and Y_t and let be I_t and J_t be two information sets defined by $I_t = \{ X_{t-j} ; j \geq 0 \}$ and $J_t = \{ X_{t-j}, Y_{t-j} ; j \geq 0 \}$. Y_t is said to cause X_{t+1} in variance if $E\{ (X_{t+1} - \mu_{x,,t+1})^2 | I_t \} \neq E\{ (X_{t+1} - \mu_{x,,t+1})^2 | J_t \}$, where $\mu_{x,,t+1}$ is the mean of X_{t+1} conditioned on I_t . Feedback in variance occurs if X_t causes Y_t and Y_t causes X_t. There is instantaneous causality in variance if $E\{ (X_{t+1} - \mu_{x,,t+1})^2 | J_t \} \neq E\{ (X_{t+1} - \mu_{x,,t+1})^2 | J_t + Y_{t+1} \}$, see more details in Ng (1987) and Cheung and Ng (1996).

identify the uni or bi-directional movements in returns and volatilities between futures and cashes.[40] In addition, Chan, Chan and Karolyi (1991) use the bivariate GARCH model to explore the volatility spillover effects between futures and cashes. In line with the previous studies, we apply various regression techniques based upon the Granger causality concept in our analysis of lead and lag relationship in returns and volatility between stock indexes and futures contract.

3-2-3. Dynamic Simultaneous Equations Model (SEM) and Vector Autoregression Model (VAR)

To test the temporal price relationship between the index and its nearby futures contract, the Granger or Sims causality test is frequently employed in the previous literature. Suppose two time series, $\{Y_t\}$ and $\{X_t\}$. The series X_t fails to Granger cause Y_t if in a regression of Y_t on lagged Y's and lagged X's, the coefficients of the latter are zero. That is,

$$Y_t = \sum_{i=1}^{k} \alpha_i Y_{t-i} + \sum_{i=1}^{k} \beta_i X_{t-i} + \varepsilon_t \text{------------------} (3-1)$$

Then if $\beta_i = 0$ (I = 1,2, ..., k), X_t fails to cause Y_t. The lag length k is , to some extent arbitrary. Alternatively, Sims (1972) includes the current and future terms of X_t as well as

[40] While their approaches are fundamentally similar in checking the possible causal relationships, Kawaller, Koch and Koch (1987,1990), Koch (1993) insist on using the dynamic simultaneous equations model (SEM) that includes the contemporaneous returns (or volatilities) in the right-hand side as well as the left hand side of the equation system. Chan and Chung (1993, 1995), on the other hand, argue that including such contemporaneous terms in the equations may be misleading in interpretation of the causality and that the vector autoregression (VAR) is preferable.

lagged X_t in a regression of Y_t. Sims says that Y_t fails to cause X_t in the Granger sense if in a regression of Y_t on lagged, current, and future X_t, the latter coefficients are zero. Consider the regression,

$$Y_t = \sum_{j=0}^{k} \alpha_j X_{t-j} + \sum_{j=1}^{k} \beta_j X_{t+j} + \upsilon_t \text{---------}(3\text{-}2)$$

and test $\beta_j = 0$ (j=1,2,.....,k). This says that the prediction of Y from current and past X's would not be improved if futures values are included. Although there are some econometric differences between two tests, they basically test the same hypothesis (e.g., see Geweke, Meese and Dent 1983 and Maddala 1992). To investigate the inter-dependence between two time series (in our case, stock index and its corresponding futures price) based upon the above mentioned two causality notions, we employ several estimation techniques used in financial literatures. In our study, dynamic simultaneous equations model (SEM, see Kawaller, Koch and Koch 1987) using three stage least squares (3SLS) estimation method is first applied on our data set to see if futures and cash prices may affect each other contemporaneously. If two series are concurrently correlated, OLS estimation would result in inconsistent and inefficient estimation. Three stage least squares (3SLS)extends two stage least squares technique by taking into account cross equation correlation and yields more efficient parameter estimates than 2SLS. Dynamic simultaneous equations model in our study can be written as follows.

$$I_t = c_1 + \sum_{k=1}^{p} \alpha_{1k} I_{t-k} + \sum_{k=0}^{q} \beta_{1k} F_{t-k} + \epsilon_{1t}$$
$$F_t = c_2 + \sum_{k=0}^{p} \alpha_{2k} I_{t-k} + \sum_{k=1}^{q} \beta_{2k} F_{t-k} + \epsilon_{2t} \qquad \text{------------(3-3)}$$

where ϵ_{1t} and ϵ_{2t} are contemporaneously correlated.

The order of lag p and q is somewhat arbitrary and determined in our study by cross correlation function and Akaike information criterion (AIC) value. We test whether sum of coefficients of α's and β's in each equation is equal to zero to interpret the lead and lag relationship between futures and spot market movements. The Wald test is applied for joint coefficient restriction and its test value is calculated by the following way.

$$\chi_k = \frac{(SSE_R - SSE_F)}{SSE_F \;/\; (T-k-1)} \qquad \text{--------------(3-4)}$$

Where SSE_R, SSE_F = residual sum of squares of the reduced and full models, respectively

T = total number of observations,

k = number of lagged series I_t, F_t

The Wald test statistic follows χ-distribution with degree of freedom k.

Vector autoregression (VAR) was developed by Sims (1980) and originally contrived to avoid any structural restrictions on the parameter estimation by treating all variables as endogenous. It requires minimal theoretical demand on the structure of the model. This original VAR model can be estimated by OLS since there are no unlagged endogenous variables on the right-hand side, and since the right-hand side variables are the same in each equation, OLS is a consistent and efficient estimator. However, the efficiency of the original VAR model might be improved by using Zellner's seemingly unrelated regression method (SUR), because SUR takes explicit account of cross equation correlation by transforming the equations to minimize the correlation across residuals. Chan and Chung (1993), however, argue that the reduced model (VAR) and the simultaneous equation model (SEM) are just simple transformations of each other and so one does not contain information that the other does not. Since we analyze the lead and lag relationship between cash and futures markets using common data set for SEM and VAR estimations, VAR and SEM should basically deliver consistent message regarding price movements between cash and futures markets.

3-2-4. Cointegration Test

Two economic variables are said to be cointegrated when a linear combination of the two variables is stationary even though each variable is non stationary. In other words, y_t is integrated of order 1; y_t=I (1), that is, the first differencing makes y_t stationary and another time series variable x_t is I (1) then if there is a nonzero coefficient β such that $y_t - \beta x_t$ is I (0), y_t and x_t are said to be cointegrated. If y_t and x_t are not cointegrated, i.e., z_t, a combination of two time series, y_t and x_t is also I (1), then two variables y_t and x_t can drift apart from each other more and more as time goes on so that there would be no long run equilibrium relationship between them. Alternatively, if the system between two economic variables is moving toward equilibrium, economic theory suggests that the long run relationship between x_t and y_t should be $y_t = \beta x_t$ and the equilibrium error $z_t = y_t - \beta x_t$. In order to test whether the series x_t and y_t are cointegrated, it is necessary to establish that each series is I (1), i.e., each has a unit root in its autoregressive representation. Test for the presence of a unit root is performed by conducting the augmented Dickey-Fuller (ADF) test (1979).

$$\Delta X_t = \alpha_0 + \rho X_{t-1} + \sum_{j=1}^{p} \delta_j \Delta X_{t-j} + \epsilon_t \quad \text{-----------------(3-5)}$$

The augmented Dickey-Fuller (ADF) test is modified version of Dickey-Fuller (DF) test by adding sufficient terms in Δx_{t-j} to account for autocorrelations in residual ϵ_t. We run the above regression and test whether the coefficient ρ is zero (x_t is non-stationary). If the ADF test on series can not reject the null hypothesis of existence of a unit root, we subsequently conduct the ADF test on first differenced time series to identify the second unit roots and so on. The t statistics on coefficient ρ do not follow the normal t distribution and can be expressed as integrals of Brownian motions. (see Engle and Yoo 1987). This distribution is skewed to the left and has most of its mass below zero reflecting the fact that values of ρ greater than zero could have generated a particular data set only with very low probability. Once it is found that each series contains a single unit root, i.e., I(1), it will be checked to see whether the two series are cointegrated. In the first step, residuals (z_t) are obtained by running OLS regression on two time series x_t and y_t : $x_t = \alpha_0 + \beta y_t + z_t$. In the next step, the augmented Dickey-Fuller(ADF) test is conducted on these residual series z_t to determine that residuals follow stationary movements. If the two series x_t and y are cointegrated, the z_t will be I(0).

$$\Delta Z_t = \rho Z_{t-1} + \sum_{j=1}^{p} \delta_j \Delta Z_{t-j} + \mu_t \quad \text{-------------------------(3-6)}$$

The t ratio from this test, however, no longer has the Dickey-Fuller distribution since the cointegrating coefficient β has been estimated and therefore makes the residual series appear slightly more stationary than if it were computed at true β.[41] Engle and Granger (1987) show that if two series are cointegrated, they are necessarily represented by an error correction model (ECM) such as equations 3-7.

$$\Delta X_t = \rho_1 Z_{t-1} + lagged(\ \Delta X_t,\ \Delta Y_t\ ) + \epsilon_{1t} \qquad \text{----------(3-7)}$$

$$\Delta Y_t = \rho_2 Z_{t-1} + lagged(\ \Delta X_t,\ \Delta Y_t\ ) + \epsilon_{2t}$$

where ϵ_{it} , ϵ_{2t} are white noise and at least one of ρ_1 , ρ_2 is non zero.

If x_t and y_t are cointegrated, then each component of each equation is I (0), and so the equations are balanced. Error correction model (ECM) includes both short run and long run information in modeling the time series. It relates the change in x_t (Δx_t) to the change in y_t (Δy_t) and the past period's disequilibrium (z_{t-1}). In equation 3-7, z_t is a measure of the extent to which the system is out of long run equilibrium , and thus called the equilibrium error. The next change in x_t and y_t will be influenced by the size and sign of the current equilibrium error. It can be noted that if there is a period with no shocks, so that ϵ_{it} , ϵ_{2t} are zero, the system will

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[41] The distribution of this test is called the Engle-Granger distribution and MacKinnon (1991) provides more precise critical values based on 25,000 simulation experiments. According to his tables, the estimated critical value for any number of observation T can be calculated using the following equation.

$$C(p,T) = \beta_\infty + \beta_1 T^{-1} + \beta_2 T^{-2}$$

where p and T stand for significance level and sample size, and all beta values are asymptotic critical values in his tables. See more details in MacKinnon (1991).

converge so that Δx_t ,Δy_t both go to zero, so that the points (x_t , y_t) converge so that they lie on the line $x_t = \beta y_t$. The error correction equations may be thought of as the disequilibrium mechanism that guides the economy to the equilibrium (see Engle and Granger 1991). The test for causality between two series x_t and y_t is based on an Wald statistic that is calculated by estimating the above ECMs in both unrestricted (full model) and restricted (reduced model) forms.

3-2-5. Treatments Regarding Infrequent Trading Effect, Overnight and Session Break Returns

In the first stage of specifying the structure of return dynamics for each asset, we first take into account the microstructure effects such as asynchronous trading and bid-ask bounce on the lead and lag relationship between futures and cash market since these microstructure effects may lead to the spurious results regarding interpretation of the possible lead and lag relationship. Stoll and Whaley (1990a) employ ARMA(2,3) filtering to account for microstructure effects. Chan (1992), Miller, Muthuswamy and Whaley (1994) argue that asynchronous trading problem in the stock index can be reasonably approximated by the first order autoregressive model (AR(1)). They insist that bid and ask bounces are not significant for stock index because they are canceled out in the middle of combining the constituent stocks into a single stock index. In contrast, futures price shows relatively low and insignificant autocorrelation and hence is usually used in its raw returns for analysis or the first order moving average model (MA(1)) is applied to control the bid -ask bounces. On the other hand, Jokivuolle (1995) demonstrates that the observed stock index can be represented by a standard infinite order MA process, which can be readily represented as an ARMA(p,q) according to the Wold decomposition. He insists that Beveridge-Nelson permanent component[42] of the observed index process equals the true index level and that the true stock index value may be assessed by eliminating infrequent trading effects by filtering the observed index value with the first order moving average (MA(1)) model.[43] Similarly, the first order moving average (MA(1)) model is employed to capture the effect of non-synchronous trading by French, Schwert and Stambaugh (1987) and Hamao, Mauslis and Ng (1990). In consideration of the spurious results the infrequent trading of component stocks in the stock index may cause to the lead and lag relations between cash and futures market, our study investigates Granger causal relationship using both unfiltered raw return series and pre-whitened return series. Since our sample covers overnight returns and session break returns as well as 10 minute intraday returns, pre-whitening procedure using ARMA specification should be applied to the 10 minute raw returns while simultaneously controlling for these returns based on longer time span. Chan, Chan and Karolyi (1991) and Kawaller, Koch and Koch (1990) note that new information continues to accumulate during non-trading hours and is likely to influence the time series process of intraday returns over trading hours. Therefore, in addition to treatments for non-synchronous trading effects in stock indexes, our sample controls for overnight and session break returns using dummy variables and applying transfer

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[42] For more details about Wold decomposition (1938) and Beveridge and Nelson (1981), see *Time Series Analysis* (1994) by Hamilton, J.D., p.p.108 -109 and p.p.504-505.

[43] For example, suppose that the log difference of the observed index , $R_t^o = X_t^o - X_{t-1}^o$ can be estimated by the MA(1) process such as $R_t^o = \mu + \theta_1 \epsilon_{t-1}^o + \epsilon_t^o$, the Beveridge-Nelson permanent component or the log of the true index level equals $X_t^o + \theta_1 \epsilon_t^o$.

function (or ARMAX) on the raw returns as follows:

$$R_t = c_0 + c_1 d_{SB} + c_2 d_o + \phi^{-1}(L)\theta(L)\epsilon_t \qquad \text{-------------------------(3-8)}$$

where

$\phi^{-1}(L) = 1/(1 - \phi_1 L - \ldots\ldots\ldots - \phi_p L^p)$ for autoregressive representation (AR) of order p

$\theta(L) = \quad (1 - \theta_1 L - \ldots\ldots\ldots - \theta_p L^q)$ for moving average representation (MA) of order q

L = lag operator

d_{SB} = dummy variable taking on value of one for overnight return and, zero otherwise

d_o = dummy variable taking on value of one for session break return, and zero otherwise

In this transfer function specification (3-8), a regression model using dummy variables is first constructed to control for overnight returns and session break returns and then an ARMA model is developed to remove infrequent trading effect or bid-ask bounce effect from the residual series in the regression equation. All parameters in both regression equation and ARMA equations are simultaneously estimated. In our study, alternative ARMA models should be tested on the each stock index return or futures return to select the most parsimonious return specification. Akaike Information Criteria (AIC) are used in selection of the order of ARMA terms and Ljung-Box Q test is conducted to insure white noise of residual return series.

3-2-6. Volatility Structure

Following Schwert (1989,1990), we use the absolute value of return innovation (or residuals) employed in the Granger causality test of the conditional returns as a proxy for return volatility to investigate volatility structure between futures and cash markets. Each absolute residual is multiplied by $(\pi/2)^{1/2}$ and this figure estimates the standard deviation of either futures return or stock index return.[44] Again, VAR model is applied to the relationship between contemporary volatility and its lagged own and other market's volatility as follows:[45]

$$|U_{I,t}| = c_1 + \sum_{k=1}^{p} \alpha_{1k} |U_{I,t-k}| + \sum_{k=1}^{q} \beta_{1k} |U_{F,t-k}| + \upsilon_{1t}$$

$$|U_{F,t}| = c_2 + \sum_{k=1}^{p} \alpha_{2k} |U_{I,t-k}| + \sum_{k=1}^{q} \beta_{2k} |U_{F,t-k}| + \upsilon_{2t}$$

$$\text{where } |U_t| = \sqrt{(\pi/2)} \times |\epsilon_t| \qquad \text{-------------(3-9)}$$

ϵ_t = return innovation obtained after ARMA filtering and controlling for session break and overnight return in equation (3-8)

Davidian and Carroll (1987) insist that estimates of standard deviation based on absolute value transformation of residuals are more robust to departures from normality than are squared residuals. In line with the return dynamics analysis, trading volumes and dummy variables for overnight and session break volatility are included as exogenous variables in the

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[44] If residuals (unexpected return) follows normal distribution, ie, $\sim N(0, \sigma^2)$, then mean absolute residual $E(|\epsilon_t|) = (2/\pi)^{1/2}\sigma$

[45] VAR model is employed in many studies to estimate the multivariate volatility structure. For example, Schwert (1989), Battacharya and Sundaran (1986), Chatrath, Ramchander and Song (1995) and Huang, Mauslis and Stoll (1996).

VAR system.

3-3. Empirical Results regarding Lead and Lag Relationship between Cash andFutures

3-3-1. Analyses of Sample Correlations

Table 3-4 shows autocorrelation coefficients for the stock indexes and futures returns over the three futures contract periods. As the Ljung-Box Q statistics at lag 10 suggest, all of the return series do not follow white noise process except for futures returns over the December contract period. For both KOSPI and KOSPI 200 index returns, the first order autocorrelation is positive and strong as the theory predicts. Except for December contract period, the first and second order autocorrelation coefficients are slightly higher for KOSPI than for KOSPI 200. This is consistent with infrequent trading effect theory because KOSPI encompasses smaller stocks than KOSPI 200 so that spurious positive autocorrelation the non-synchronous trading causes is more salient in KOSPI. The first order autocorrelation for stock indexes becomes larger in magnitude over the sample period. It indicates that non-synchronous trading problem in the cash market becomes more serious. It is also observable that futures contract also has a positive first order autocorrelation in the Korean market. In most of previous studies (MacKinlay and Ramaswamy 1988 ; Miller, Muthuswamy and Whaley 1994) in the U.S. market, they find that futures contract has a close to zero autocorrelation or if any, negative autocorrelation as the bid -ask bounce at order flows predicts. However, for those studies about futures markets in other countries, significantly positive first order autocorrelation is commonly observed (For example, see Iihara, Kato and Tokunaga 1996 for Japan market ; and Abhyankar 1995 for the U.K. market). As seen in

Tables 3-1, 3-2 and 3-3, futures contract shows negative return throughout the whole trading or non trading hours. The inertia in the futures market due to lack of arbitrage capital or weak stock market condition may contribute to the positive linear dependency in futures returns. Therefore, futures returns also need to be filtered by the appropriate ARMA specification before examining the lead and lag relationship between cash and futures.

Table 3-5 displays the cross correlation coefficients between stock index and futures returns, or between two stock index returns. While the contemporaneous correlation seems to be the strongest for each pair of returns, it is apparent that futures returns tend to lead the stock index returns over the whole periods since the lagged futures return is more frequently and strongly correlated with the current stock index returns than the opposite way. Although it is less clear in lead and lag relationship in terms of cross correlation function between KOSPI 200 and KOSPI, the magnitude (or significance) is stronger when the lagged KOSPI 200 returns are matched with the current KOSPI returns than the case where the lagged KOSPI returns are correlated with the current KOSPI 200 returns. Therefore, it can be said that KOSPI 200 leads KOSPI weakly.

3-3-2. Results of Prewhitening

Table 3-6 shows how much different overnight returns and session break returns are from the mean of 10 minute intraday returns over the sample periods. Except for futures returns which show little difference in overnight or session break returns from the intraday 10 minute returns, the overnight and session break returns of the stock market indexes turn out to be significantly higher than the comparable average 10 minute returns. This result is consistent with Wood, McInish and Ord (1985) and Ekman's (1992) studies. It confirms the needs to control for overnight and session break returns in our sample. In Table 3-7, appropriate ARMA specifications are presented for removing any spurious autocorrelation in each of return series of the stock index and futures contract. Using ARMAX (transfer function), the dummy variables for overnight and session break returns are simultaneously controlled. To insure that return innovations (residuals) are white noise procedure, Ljung-Box Q test is conducted at lag 20. The result shows that whitening of residuals is successfully achieved.

3-3-3. Results of Simultaneous Equation Model (SEM) and Vector Autoregression (VAR)

Table 3-8 presents the results of parameter estimation by simultaneous equations model (SEM) using 3SLS. In each pair of series, regressions are run both on raw returns without whitening and on the residuals after whitening. Besides the return series, variables proxying for trading volume are included in the system. Following Chan and Chung (1993), the logarithmic transformed volume within 10 minute interval is used as proxy for trading volume. The number of lags in the regression system is determined by the Akaike Information Criteria (AIC). For Granger causal relationship between KOSPI 200 and futures contract, the Wald statistic indicates that a bilateral lead and lag relationship between futures and KOSPI 200 was observed during June and September contract periods. However, the strength of the Granger causality is stronger when futures leads KOSPI 200 than when KOSPI 200 leads futures. Over December periods, KOSPI 200 no longer leads the futures while futures still strongly lead KOSPI 200. One striking feature is that unlike cross correlation, the current futures returns do not move together with the KOSPI 200 returns. Rather, lagged futures returns have stronger explanatory power in variation in the movement of KOSPI returns. For lead and lag relationship between futures and the wider stock market index, KOSPI does not Granger cause the futures except over the June contract period where a bilateral lead and lag relationship is present. Again, the lagged returns of futures are more strongly related to the current KOSPI movement. Between two stock indexes, KOSPI 200 always leads KOSPI strongly over the whole sample periods whereas the KOSPI never Granger cause KOSPI 200 at all. Bessembinder, Chan and Seguin (1996) argue that trading of large capitalization stocks is more closely associated with market-wide news than is that of small capitalization stocks. However, unlike relationship with futures, the concurrent movement is present between movements of two stock index returns. Overall, these results also support Chan's (1992) argument that futures price reflects the market wide information more rapidly than the stock index and are consistent with Bessembinder, Chan and Seguin's (1996) finding in that larger stocks (mostly constituents of KOSPI 200) reflect this information faster than the small stocks (represented by KOSPI).

In Table 3-9, results of vector autoregression (VAR) estimation are presented. In this estimation, the concurrent terms are omitted from the regression system. Generally, the estimation results of VAR model are similar to those of the SEM estimation. Futures strongly lead both KOSPI 200 and KOSPI over the entire sample periods. However, a bilateral lead and lag relationship between either of stock indexes and futures is also present except for December contract periods, although lead from stock indexes to futures is relatively weak compared to the lead from future to the stock indexes. Again, KOSPI 200 strongly leads KOSPI while the opposite way does not hold. Over the whole sample period, the volume has negative impact on the returns of futures contract, indicating that heavy transactions tend to push futures price downward.

3-3-4. Results of Cointegration

Table 3-10 presents the results of unit root tests for stock indexes and futures price. Unit root tests are conducted on the logarithmic transformed price series. ADF tests indicate that all of price series are the first order non-stationary, i.e., the first differencing makes them stationary. In Table 3-11, cointegration tests are run on each pair of stock index and futures return series to see if there is any long run equilibrium relationship between them. Theoretically, there should be a long run relationship among them since cost of carry relationship dictates futures price to move in tandem with stock price and KOSPI 200 is a subset of KOSPI. Strikingly, over the whole sample periods, the null hypothesis of no cointegration can not be rejected between KOSPI and KOSPI 200 at any conventional significance level. Some answer can be found for this disparity between two stock indexes by examining the trend of returns of large cap stocks and small cap stocks over the sample period. In Table 3-12, the monthly returns of large cap stocks , medium cap stocks and small cap stocks are presented. As is clearly seen from the table, large cap stocks suffer more from the capital loss than the medium cap stock or small cap stocks. Since the KOSPI 200 is composed of mainly large cap stocks, the market downturn would have effected differential impact on the KOSPI and KOSPI 200, leaving the equilibrium relationship between two indexes temporarily broken over the sample period. Except for September contract period where deviation of futures price from the cost of carry relationship is severe, futures and each of stock indexes interact with each other along their long run price relationship.

Table 3-13 displays the results of error correction model (ECM) raised by Engle and Granger (1987). They are similar to the VAR model except that ECM includes error correction terms (Z_{t-1}) in its equation system. Their results are basically the same as those obtained from VAR or SEM in that futures strongly lead stock indexes although in some periods, a bilateral lead and lag relationship between cash and futures markets is observed. Consistent with cointegration results from ADF tests, error correction term (Z_{t-1}) is statistically significant and negative for each pair of KOSPI 200 and futures or KOSPI and futures except for September contract. This indicates that deviation from the long run equilibrium relationship would affect the returns of stock index or futures and make them revert to the equilibrium relationship.

3-3-5. The Extent of Stock Market Co-Movement by Market-Wide Information

Chan (1992) develops a few proxy variables to measure the extent of market-wide movement. One of these variables is measured by $| N_u - N_d | / (N_u + N_d + N_z)$, where N_u, N_d, and N_z are the number of stocks moving upward, moving downward, and with no change. This proxy variable measures the net proportion of stocks moving together. The higher the ratio is, the more likely there is market-wide information affecting the stocks moving together. Whenever the stock market is moved by the market-wide information, futures prices react to those information faster than do cash prices, and the feedback from the futures market to the cash market is stronger. Table 3-14 displays the daily mean and median ratios of this proxy variable over the sample period. By construction, this proxy variable takes on zero value when the number of stocks moving upward is equal to the number of stocks moving downward. Suppose that the ex ante probabilities of stocks moving upward, downward, and without price change are all equal, and then if the number of stocks moving in one direction is twice as many as that of stocks moving in the opposite direction, the ratio takes on .222. Again, if the number of stocks moving in one direction is three times greater than that of stocks moving in the opposite direction, the ratio has a value of .333. In our sample, the average (median) value of this ratio is .279 (.269). This means that on daily basis, the number of stocks moving in one direction is on average about 2.5 times greater than the number of stocks moving in the opposite direction. This result clearly indicates the clustering of stocks moving in same direction over the sample period and supports Chan's (1992) hypothesis in that over the sample period, the Korean stock market is moved by the market-wide information and futures market reflects such information faster than does spot market. Moreover, as Bessembinder, Chan and Seguin (1996) insist, large capitalization stocks are more likely affected by market-wide information than small sized stocks. This high ratio is also consistent with our result that KOSPI 200 strongly leads KOSPI.

3-3-6. Lead and Lag relationship in Volatility

In Table 3-15, lead and lag relationships in volatility among stock indexes and futures are presented. As a volatility measure, absolute residuals from ARMA specifications (transformed by multiplying by $\sqrt{(\pi/2)}$) are used. Unlike Granger causality relationships observed in the return series, volatility causality results in mixed outcomes. For KOSPI 200 and futures, futures volatility Granger causes only KOSPI 200 volatility over the June contract period. Throughout September and December contract periods, neither KOSPI 200 nor futures contract leads the other. On the other hand, strong ARCH (autoregressive heteroscedasticity) effects are observed in KOSPI 200 over the entire sample periods and for futures during September contract period. Volatility tends to persist for both stock index and futures over September contract period. It is noticeable that for KOSPI and futures, significant bilateral causality is found over the sample period except during December contract period. ARCH effects are also prevalent in KOSPI. For KOSPI 200 and KOSPI, results are really mixed depending upon the sample period. Over the June and September contract periods, volatility of KOSPI 200 returns weakly leads volatility of KOSPI while during December contract period, KOSPI leads KOSPI 200. In addition, ARCH effect of KOSPI is diminished by volatility spillover effect from KOSPI 200 over the September contract period. In contrast, ARCH effect of KOSPI 200 is offset by the effect from lagged volatility of KOSPI during December contract period. In line with previous studies (for example, Karpoff 1987 ; Lamoureux and Lastrapes 1990), trading volume has significantly positive relationship with volatilities for all return series throughout the overall period, which is in contrast with the results found in return causality relationship. Consistent with Kawaller, Koch and Koch (1990), both futures and index volatility increase directly with futures trading volume , even stronger effect on stock index volatility than stock index volume itself. This result indicates either that greater futures activity (arbitrages or unwinding force) produces greater stock price volatility or that higher stock market volatility requires a greater reliance on futures for risk management. Overall, bilateral volatility causality relations are found in the Korean market, which is consistent with previous studies regarding other markets.

3-4. Conclusion

In this chapter, possible lead and lag relationships in returns and volatilities between cash and futures market are investigated. Granger causality test is extensively undertaken with several regression system methodologies including SEM,VAR and ECM. For returns relationship, futures market tend to strongly lead cash market by as long as 30 minutes. Results of SEM suggest that lagged futures returns explain more of variation in cash returns than contemporaneous futures returns. However, from time to time, it is also observed that spot market leads futures market . Between two stock indexes, KOSPI 200 has a strong tendency to lead KOSPI , the wider index. The above two results concerning returns causality test are basically consistent with previous studies conducted in the other market. As Chan (1992) hypothesizes, futures reflect more rapidly market wide information than spot market, and large cap stocks adjust faster to new information in the market than small cap stocks. Even after removing spurious positive autocorrelation in the stock returns, the above lead and lag relationships are basically unchanged. Regarding volatility interaction between cash and futures markets, results suggest that unlike lead and lag relationship in returns, a bi-directional causality is more prevalent between cash and futures market, and its relationship entirely depends on the sample period and spot index used. This fact is also consistent with earlier empirical studies in the other market. Unlike their impact on returns, trading volumes in each market have significant explanatory power in changes in volatility with a more strong effect of futures volume on the spot volatility as Kawaller, Koch and Koch (1990) document. Overall, market friction such as transaction costs and short sale restriction seem to hinder spot market from reacting faster to the new information than futures market.

Table 3-1.Summary Statistics for Intraday 10 Minute Returns on the KOSPI 200 Index Futures and the KOSPI 200 Stock Index, and the KOSPI Stock Index from May 3, 1996 to Oct.16, 1996

1. KOSPI 200 Futures

Statistic	Jun.	Sep.	Dec.	Total
Sample size	681	1528	506	2715
Mean	-.02166	-.00194	.00579	-.00545
Median	.00000	.00000	.00000	.00000
Std. Dev.	.16273	.22703	.21528	.21061
Skewness	-.06661	.71473	.00569	.52631
Kurtosis	4.63549	11.11816	3.54757	9.62781
J-Q statistic	76.40	4326.01	6.32	5094.67
(p- value)	(.00)	(.00)	(.04)	(.00)

2. KOSPI 200 stock index

Statistic	Jun.	Sep.	Dec.	Total
Sample size	681	1528	506	2715
Mean	-.02892	-.01001	-.01139	-.01501
Median	-.02800	-.01157	-.01227	-.01855
Std. Dev.	.17377	.14720	.16282	.15734
Skewness	.15990	.34107	.31175	.25491
Kurtosis	3.84652	5.56285	4.30839	4.77614
J-Q statistic	23.24	447.80	44.29	386.27
(p- value)	(.00)	(.00)	(.00)	(.00)

3. KOSPI stock index

Statistic	Jun.	Sep.	Dec.	Total
Sample size	681	1528	506	2715
Mean	-.02628	-.01031	-.00969	-.01420
Median	-.02125	-.01221	-.00904	-.01387
Std. Dev.	.16232	.13708	.14576	.14552
Skewness	.15902	.27032	.23805	.20659
Kurtosis	3.72780	5.16461	4.10663	4.52001
J-Q statistic	17.90	316.92	30.60	280.68
(p- value)	(.00)	(.00)	(.00)	(.00)

Under the null hypothesis of normality for return series, skewness(m3) and kurtosis (m4) are asymptotically distributed as m3 ~ N(0, 6/T) and m4 ~ N (3, 24/T), where T is the number of observations. The J-Q (Jarque-Bera) statistic tests whether a series is normally distributed. Under the null hypothesis of normality, the J-Q statistic is distributed χ^2 with 2 degrees of freedom.

Table 3-2. Summary Statistics for Session Break Returns (1 hrs and 40 min.) on the KOSPI 200 Index Futures and the KOSPI 200 Stock Index, and the KOSPI Stock Index from May 3, 1996 to Oct.16, 1996

1. KOSPI 200 Futures

Statistic	Jun.	Sep.	Dec.	Total
Sample size	28	63	21	112
Mean	.01976	-.03377	.03219	-.00802
Median	-.02363	-.05481	.00000	.00000
Std. Dev.	.15953	.18097	.32906	.21183
Skewness	.54783	.16094	.52902	.62436
Kurtosis	2.75070	3.00518	2.85272	4.52145
J-Q statistic	1.47	.27	1.00	18.08
(p-value)	(.46)	(.87)	(.61)	(.00)

2. KOSPI 200 stock index

Statistic	Jun.	Sep.	Dec.	Total
Sample size	28	63	21	112
Mean	.06654	.00529	.09688	.03778
Median	.05837	-.01130	.09915	.00000
Std. Dev.	.18630	.14574	.22508	.17579
Skewness	.82645	.74657	.69928	.96528
Kurtosis	3.22775	4.16411	2.75627	4.08660
J-Q statistic	3.25	9.41	1.76	22.90
(p-value)	(.20)	(.01)	(.41)	(.00)

3. KOSPI stock index

Statistic	Jun.	Sep.	Dec.	Total
Sample size	28	63	21	112
Mean	.06478	.00461	.10114	.03775
Median	.04324	.00000	.08688	.01337
Std. Dev.	.18025	.14081	.20202	.16703
Skewness	.51859	.51849	.53425	.71061
Kurtosis	2.60925	4.0170	2.62475	3.60043
J-Q statistic	1.43	5.54	1.12	11.11
(p-value)	(.49)	(.06)	(.57)	(.00)

Under the null hypothesis of normality for return series, skewness(m3) and kurtosis (m4) are asymptotically distributed as m3 ~ N(0, 6/T) and m4 ~ N (3, 24/T), where T is the number of observations. The J-Q (Jarque-Bera) statistic tests whether a series is normally distributed. Under the null hypothesis of normality, the J-Q statistic is distributed χ^2 with 2 degrees of freedom.

Table 3-3. Summary Statistics for Overnight Returns on the KOSPI 200 Index Futures and the KOSPI 200 Stock Index, and the KOSPI Stock Index from May 3, 1996 to Oct. 16, 1996

1. KOSPI 200 Futures

Statistic	Jun.	Sep.	Dec.	Total
Sample size	33	75	24	132
Mean	.02903	-.10305	-.01588	-.05418
Median	.00000	-.10899	-.14833	-.05713
Std. Dev.	.34725	.48866	.66917	.49633
Skewness	-.05843	-.14641	.74893	.211451
Kurtosis	2.81273	3.76950	2.90425	4.04114
J-Q statistic	.07	2.12	2.25	6.95
(p-value)	(.97)	(.35)	(.32)	(.03)

2. KOSPI 200 stock index

Statistic	Jun.	Sep.	Dec.	Total
Sample size	33	75	24	132
Mean	.16939	.01027	.30936	.10443
Median	.11231	.01089	.16971	.06684
Std. Dev.	.45417	.47164	.55143	.49322
Skewness	-.05337	1.62312	.57193	1.00118
Kurtosis	5.08803	16.13537	2.27593	9.12313
J-Q statistic	6.01	572.11	1.83	228.26
(p-value)	(.05)	(.00)	(.40)	(.00)

3. KOSPI stock index

Statistic	Jun.	Sep.	Dec.	Total
Sample size	33	75	24	132
Mean	.19905	.08227	.31164	.15317
Median	.17287	.06284	.31589	.09958
Std. Dev.	.49506	.45254	.52446	.48151
Skewness	-.06130	1.96338	.13597	.99925
Kurtosis	3.99281	12.41108	1.89032	6.73564
J-Q statistic	1.38	324.96	1.31	98.72
(p-value)	(.50)	(.00)	(.52)	(.00)

Under the null hypothesis of normality for return series, skewness(m3) and kurtosis (m4) are asymptotically distributed as $m3 \sim N(0, 6/T)$ and $m4 \sim N(3, 24/T)$, where T is the number of observations. The J-Q (Jarque-Bera) statistic tests whether a series is normally distributed. Under the null hypothesis of normality, the J-Q statistic is distributed χ^2 with 2 degrees of freedom.

Table 3-4. Autocorrelations of the KOSPI 200 Index, KOSPI Index and Futures Contract

1) June Contract (N=742)

KOSPI 200 Lag	AC	PAC	KOSPI Lag	AC	PAC	Futures Lag	AC	PAC
1	.303*	.303*	1	.315*	.315*	1	.142*	.142*
2	.014	-.085*	2	.053	-.051	2	-.051	-.073
3	-.085*	-.070	3	-.081*	-.092*	3	-.040	-.023
4	-.131*	-.090*	4	-.127*	-.079*	4	-.058	-.054
5	-.116*	-.059	5	-.109*	-.047	5	-.025	-.013
6	.006	.054	6	-.003	.046	6	.070	.070
7	.047	.013	7	.052	.030	7	.031	.005
8	.034	-.006	8	.049	.002	8	-.014	-.015
9	.000	-.022	9	-.010	-.008	9	.003	.011
10	-.033	-.026	10	-.010	-.008	10	-.002	.002
Q(10)=		99.93(.00)	Q(10) =		105.93(.00)	Q(10)=		25.84(.00)

2) September Contract (N=1666)

KOSPI 200 Lag	AC	PAC	KOSPI Lag	AC	PAC	Futures Lag	AC	PAC
1	.348*	.348*	1	.353*	.353*	1	.138*	.138*
2	.149*	.032	2	.187*	.071*	2	.025	.006
3	-.008	-.079*	3	.020	-.076*	3	-.041	-.046
4	-.061*	-.045	4	-.055*	-.061*	4	-.058*	-.047
5	-.069*	-.026	5	-.062*	-.016	5	-.017	-.001
6	-.024	.019	6	-.028	.017	6	.047	.051*
7	.022	.033	7	.034	.053*	7	.048	.032
8	.055	.034	8	.053*	.025	8	.054*	.039
9	.076*	.041	9	.073*	.033	9	.047	.037
10	.061*	.017	10	.062*	.019	10	.029	.024
Q(10)=		276.29(.00)	Q(10) =		302.27(.00)	Q(10)=		59.51(.00)

3) December Contract (N=551)

KOSPI 200 Lag	AC	PAC	KOSPI Lag	AC	PAC	Futures Lag	AC	PAC
1	.421*	.421*	1	.401*	.401*	1	.086*	.086*
2	.230*	.064	2	.223*	.074	2	.063	.056
3	.053	-.080	3	.032	-.097*	3	.009	-.001
4	-.036	-.056	4	-.060	-.070	4	-.041	-.046
5	-.044	.003	5	-.083	-.025	5	.003	.009
6	-.084	-.059	6	-.102*	-.047	6	-.010	-.005
7	-.034	.028	7	-.073	-.010	7	.019	.020
8	-.025	-.005	8	-.025	.023	8	-.017	-.022
9	.041	.058	9	.036	.046	9	.030	.031
10	.048	.009	10	.080	.046	10	.047	.044
Q(10)=		138.41(.00)	Q(10)=		136.67(.00)	Q(10)=		9.46(.49)

* indicates 5% significance level. Ljung-Box Q test is conducted at 10 lags for white noise test (p value).

Table 3-5.Cross-correlation of the KOSPI 200 Index, KOSPI Index and Futures Contract

1) June Contract (N=742)

Lag(k)	KOSPI 200(-k) vs Futures (k)	Lag(k)	KOSPI (-k) vs Futures (k)	Lag(k)	KOSPI (-k) vs KOSPI 200 (k)
-7	.0165	-7	.0158	-7	.0534
-6	-.0506	-6	-.0512	-6	-.0117
-5	-.1085*	-5	-.0943*	-5	-.1115*
-4	-.0756*	-4	-.0739*	-4	-.1216*
-3	.0305	-3	.0667	-3	-.0672
-2	.1756*	-2	.2248*	-2	.0629
-1	.4534*	-1	.4377*	-1	.3502*
0	**.6493***	**0**	**.6470***	**0**	**.9591***
1	-.0166	1	-.0429	1	.2855*
2	-.1281*	2	-.1142*	2	.0025
3	-.0454	3	-.0542	3	-.0980*
4	-.0218	4	-.0287	4	-.1351*
5	.0414	5	.0445	5	-.1133*
6	.1097*	6	.1177*	6	.0127
7	.0504	7	.0469	7	.0452

2) September Contract (N=1666)

Lag(k)	KOSPI 200(-k) vs Futures (k)	Lag(k)	KOSPI (-k) vs Futures (k)	Lag(k)	KOSPI (-k) vs KOSPI 200 (k)
-7	.0112	-7	.0145	-7	.0260
-6	-.0170	-6	-.0254	-6	-.0371
-5	-.0474	-5	-.0634*	-5	-.0753*
-4	-.0089	-4	.0147	-4	-.0546*
-3	.0890*	-3	.1250*	-3	.0121
-2	.2830*	-2	.3041*	-2	.1892*
-1	.3892*	-1	.3822*	-1	.3850*
0	**.5568***	**0**	**.5845***	**0**	**.9251***
1	.0442	1	.0085	1	.3353*
2	-.0644*	2	-.0726*	2	.1455*
3	-.0603*	3	-.0568*	3	-.0029
4	-.0376	4	-.0407	4	-.0654*
5	.0098	5	.0133	5	-.0578*
6	.0423	6	.0467	6	-.0191
7	.0460	7	.0461	7	.0282

Table 3-5. (Continued)

3) December Contract (N=551)

Lag(k)	KOSPI 200(-k) vs Futures (k)	Lag(k)	KOSPI (-k) vs Futures (k)	Lag(k)	KOSPI (-k) vs KOSPI 200 (k)
-7	-.0114	-7	-.0159	-7	-.0552
-6	-.0386	-6	-.0482	-6	-.0999*
-5	.0021	-5	-.0086	-5	-.0659
-4	.0484	-4	.0477	-4	-.0450
-3	.1243*	-3	.1497*	-3	.0546
-2	.3109*	-2	.3043*	-2	.2376*
-1	.3880*	-1	.3585*	-1	.4397*
0	.6558*	0	.6340*	0	.9544*
1	.0766	1	.0644	1	.4035*
2	-.0057	2	-.0226	2	.2117*
3	-.0229	3	-.0380	3	.0305
4	-.0378	4	-.0375	4	-.0546
5	-.0160	5	-.0201	5	-.0558
6	-.0433	6	-.0462	6	-.0852*
7	.0316	7	.0290	7	-.0439

Cross correlation at order k (-k) indicates the correlation between the k th lagged (k th leading) observation of one variable and the current observation of the other variable.
* indicates 5% level significance.

Table 3-6. Regression of Returns on Overnight and Session Break Dummy Variables

1. June contract

	Variable[a]	Coefficient	t-statistics	P value	R^2
KOSPI 200 Index	d_{SB}	.095	2.53	.01	.048
	d_O	.198	5.71	.00	
KOSPI Index	d_{SB}	.091	2.48	.01	.062
	d_O	.225	6.65	.00	
Futures Contract	d_{SB}	.041	1.22	.21	.005
	d_O	.050	1.62	.10	

2.September contract

	Variable	Coefficient	t-statistics	P value	R^2
KOSPI 200 Index	d_{SB}	.015	.68	.50	.001
	d_O	.020	.98	.32	
KOSPI Index	d_{SB}	.015	.70	.48	.013
	d_O	.093	4.75	.00	
Futures Contract	d_{SB}	-.032	-1.02	.31	.008
	d_O	-.101	-3.51	.00	

3.December contract

	Variable	Coefficient	t-statistics	P value	R^2
KOSPI 200 Index	d_{SB}	.108	2.46	.01	.105
	d_O	.321	7.77	.00	
KOSPI Index	d_{SB}	.111	2.76	.01	.062
	d_O	.321	8.52	.00	
Futures Contract	d_{SB}	.026	.46	.64	.001
	d_O	-.022	-.41	.68	

[a] d_{SB} and d_O represent the dummy variables indicating session break (lunch break) and overnight returns among 10 minute intraday returns.

Table 3-7.Results of Pre-whitening of the Stock Indexes and Futures Series Using ARMAX

	Filter[a]	AIC[b]	Ljung-Box Q(20) statistic[c]
1. June Contract			
KOSPI 200 Index	ARMA(2,3)	-3.38	14.12 (.824)
KOSPI Index	ARMA(2,3)	-3.53	9.48 (.977)
Futures Contract	AR(1)	-3.51	23.57 (.262)
2. September Contract			
KOSPI 200 Index	ARMA(2,2)	-3.62	14.39 (.810)
KOSPI Index	ARMA(2,2)	-3.75	11.18 (.941)
Futures Contract	ARMA(2,3)	-2.85	19.36 (.498)
3. December Contract			
KOSPI 200 Index	ARMA(2,5)	-3.49	8.52 (.988)
KOSPI Index	ARMA(2,5)	-3.62	15.76 (.731)
Futures Contract	AR(1)	-2.72	13.67 (.847)

[a] ARMA filtering is undertaken while simultaneously controlling for dummies for overnight and session break returns using ARMAX.

[b,c] The order of ARMA is based upon Akaike Information Criteria (AIC) and Ljung-Box Q test for residual autocorrelation.

Table 3-8.Results of Dynamic Simultaneous Equations Model (SEM)

1.June Contract

(1)Raw Returns

Dep. Var.	KOSPI 200		Futures	
	Coefficient	t-value	Coefficient	t-value
constant	-.077	-.55	.077	1.12
KOSPI200(t-0)			1.449	1.11
KOSPI200(t-1)	-.043	-.68	-.012	-.08
KOSPI200(t-2)	-.087	-1.50	.061	.31
KOSPI200(t-3)	-.056	-1.46	.084	.94
KOSPI200(t-4)	-.092	-2.42**	.141	1.11
KOSPI200(t-5)	-.125	-3.49***	.198	1.30
Futures(t-0)	.376	1.26		
Futures(t-1)	.448	5.49***	-.540	-.77
Futures(t-2)	.201	3.85***	-.247	-.78
Futures(t-3)	.109	2.29**	-.130	-.68
Futures(t-4)	.048	1.12	-.087	-1.13
Futures(t-5)	.068	1.59	-.121	-1.40
d_{SB}	.077	2.71**	-.092	-.71
d_O	.168	5.94***	-.211	-.82
$VOLUME_{KOSPI200}$	.005	.47		
$VOLUME_{futures}$			-.015	-.84
(Wald test)[a]				
Futures on Futures	2.88(.72)			
Futures on KOSPI200	215.52(.00)			
KOSPI200 on KOSPI200	28.68(.00)			
KOSPI200 on Futures	23.88(.00)			

(2)Return Innovations

Dep. Var.	KOSPI 200		Futures	
	Coefficient	t-value	Coefficient	t-value
constant	-.009	-.63	.086	1.22
KOSPI200(t-0)			1.473	1.27
KOSPI200(t-1)	-.363	-5.80***	.452	.94
KOSPI200(t-2)	-.149	-2.35**	.137	.58
KOSPI200(t-3)	-.025	-.58	.041	.64
KOSPI200(t-4)	-.011	-.26	.043	.80
KOSPI200(t-5)	-.068	-1.59	.132	1.73*
Futures(t-0)	.310	1.04		
Futures(t-1)	.506	9.94***	-.690	-1.10
Futures(t-2)	.282	5.33***	-.370	-1.01
Futures(t-3)	.158	3.29***	-.215	-1.03
Futures(t-4)	.073	1.53	-.143	-1.58
Futures(t-5)	.082	1.72*	-.158	-1.71*
$VOLUME_{KOSPI200}$	.007	.63		
$VOLUME_{futures}$			-.018	-1.22
(Wald test)				
Futures on Futures	4.31(.51)			
Futures on KOSPI200	191.04(.00)			
KOSPI200 on KOSPI200	52.19(.00)			
KOSPI200 on Futures	16.07(.01)			

Table 3-8. Continued (SEM)

(1)Raw Returns

Dep. Var.	**Futures** Coefficient	t-value	**KOSPI** Coefficient	t-value
constant	.069	.83	.048	.41
Futures(t-0)			.461	1.19
Futures(t-1)	-.049	-.70	.357	3.08***
Futures(t-2)	-.094	-.26	.218	4.33***
Futures(t-3)	-.041	-.15	.148	2.81***
Futures(t-4)	-.010	-.20	.022	.56
Futures(t-5)	-.078	-.83	.078	1.97**
KOSPI(t-0)	.674	.47		
KOSPI(t-1)	-.169	-1.41	.023	.24
KOSPI(t-2)	-.020	-.12	-.068	-1.30
KOSPI(t-3)	.039	.27	-.084	-2.19**
KOSPI(t-4)	.026	.31	-.050	-1.38
KOSPI(t-5)	.110	.76	-.119	-3.18***
d_{SB}	-.012	-.09	.067	2.18**
d_O	-.087	-.27	.197	6.31***
$VOLUME_{Futures}$	-.017	-.79		
$VOLUME_{KOSPI}$			-.004	-.44
(Wald test)				
Futures on Futures	6.15(.29)			
Futures on KOSPI	227.24(.00)			
KOSPI on KOSPI	57.77(.00)			
KOSPI on Futures	27.83(.00)			

(2)Return Innovations

Dep. Var.	**Futures** Coefficient	t-value	**KOSPI** Coefficient	t-value
constant	.086	.89	.047	.37
Futures(t-0)			.350	.88
Futures(t-1)	-.231	-.29	.426	6.06***
Futures(t-2)	-.178	-.35	.284	5.63***
Futures(t-3)	-.125	-.34	.202	4.21***
Futures(t-4)	-.060	-.59	.061	1.42
Futures(t-5)	-.116	-.80	.101	2.21**
KOSPI(t-0)	.786	.47		
KOSPI(t-1)	.091	.14	-.313	-3.26***
KOSPI(t-2)	.043	.13	-.161	-2.58***
KOSPI(t-3)	.047	.32	-.077	-1.83*
KOSPI(t-4)	-.005	-.13	.009	.22
KOSPI(t-5)	.087	1.14	-.059	-1.31
$VOLUME_{Futures}$	-.018	-.89		
$VOLUME_{KOSPI}$			-.003	-.37
(Wald test)				
Futures on Futures	4.40(.49)			
Futures on KOSPI	184.94(.00)			
KOSPI on KOSPI	37.36(.00)			
KOSPI on Futures	24.85(.00)			

Table 3-8. Continued (SEM)

(1)Raw Returns

Dep. Var.	KOSPI 200		KOSPI	
	Coefficient	t-value	Coefficient	t-value
constant	.252	.59	-.083	-1.54
KOSPI200(t-0)			1.085	3.98***
KOSPI200(t-1)	-.732	-.82	.238	2.71***
KOSPI200(t-2)	-.128	-.79	.074	1.72*
KOSPI200(t-3)	-.106	-.51	.014	.29
KOSPI200(t-4)	-.025	-.21	.008	.19
KOSPI200(t-5)	.032	.27	-.006	-.14
KOSPI(t-0)	1.866	1.15		
KOSPI(t-1)	.447	1.11	-.249	-5.81***
KOSPI(t-2)	.109	.52	-.017	-.34
KOSPI(t-3)	.135	.49	.002	.03
KOSPI(t-4)	.070	.37	.013	.27
KOSPI(t-5)	-.022	-.20	.025	.61
d_{SB}	-.064	-.45	-.023	-.73
d_O	-.202	-.62	.009	.17
$VOLUME_{KOSPI200}$	-.018	-.61		
$VOLUME_{KOSPI}$			.001	1.59
(Wald test)				
KOSPI200 on KOSPI200	.89(.97)			
KOSPI200 on KOSPI	201.60(.00)			
KOSPI on KOSPI	34.91(.00)			
KOSPI on KOSPI200	3.50(.74)			

(2)Return Innovations

Dep. Var.	KOSPI 200		KOSPI	
	Coefficient	t-value	Coefficient	t-value
constant	.216	.61	-.085	-1.52
KOSPI200(t-0)			1.065	3.74***
KOSPI200(t-1)	-.958	-1.19	.540	12.99***
KOSPI200(t-2)	-.308	-1.06	.173	3.80***
KOSPI200(t-3)	-.097	-.47	.009	.18
KOSPI200(t-4)	-.005	-.03	-.038	-.78
KOSPI200(t-5)	.021	.19	-.031	-.76
KOSPI(t-0)	1.857	1.16		
KOSPI(t-1)	.954	1.19	-.540	-12.32***
KOSPI(t-2)	.315	1.04	-.175	-3.71***
KOSPI(t-3)	.113	.54	-.026	-.50
KOSPI(t-4)	.000	.00	.044	.87
KOSPI(t-5)	-.022	-.17	.057	1.22
$VOLUME_{KOSPI200}$	-.016	-.61		
$VOLUME_{KOSPI}$			.006	1.53
(Wald test)				
KOSPI200 on KOSPI200	2.24(.82)			
KOSPI200 on KOSPI	178.07(.00)			
KOSPI on KOSPI	159.48(.00)			
KOSPI on KOSPI200	2.41(.88)			

Table 3-8. Continued (SEM)

2.September Contract

(1)Raw Returns

Dep. Var.	KOSPI 200		Futures	
	Coefficient	t-value	Coefficient	t-value
constant	-.275	-1.48	.041	.95
KOSPI200(t-0)			.781	2.52**
KOSPI200(t-1)	.117	3.31***	-.122	-2.51**
KOSPI200(t-2)	.051	.80	-.114	-3.01***
KOSPI200(t-3)	-.023	-.88	.003	.09
Futures(t-0)	.587	1.41		
Futures(t-1)	.128	1.99**	-.019	-.27
Futures(t-2)	.109	3.04***	-.045	-.84
Futures(t-3)	.039	2.22**	-.028	-1.00
d_{SB}	.016	.63	-.032	-1.25
d_0	.055	1.01	-.099	-4.09***
$VOLUME_{KOSPI200}$	.021	1.46		
$VOLUME_{futures}$			-.008	-.89

(Wald test)

Futures on Futures	2.06(.56)
Futures on KOSPI200	233.28(.00)
KOSPI200 on KOSPI200	15.31(.00)
KOSPI200 on Futures	24.47(.00)

(2)Return Innovations

Dep. Var.	KOSPI 200		Futures	
	Coefficient	t-value	Coefficient	t-value
constant	-.278	-1.35	.033	0.79
KOSPI200(t-0)			.687	2.52**
KOSPI200(t-1)	-.217	-6.02***	.129	1.77*
KOSPI200(t-2)	-.078	-1.19	-.005	-.09
KOSPI200(t-3)	-.009	-.25	-.017	-.45
Futures(t-0)	.746	1.56		
Futures(t-1)	.205	9.98***	-.134	-2.11**
Futures(t-2)	.142	4.90***	-.076	-1.43
Futures(t-3)	.031	1.19	-.004	-.14
$VOLUME_{KOSPI200}$	.022	1.35		
$VOLUME_{futures}$			-.007	-.80

(Wald test)

Futures on Futures	5.66(.13)
Futures on KOSPI200	173.16(.00)
KOSPI200 on KOSPI200	45.43(.00)
KOSPI200 on Futures	15.17(.00)

Table 3-8. Continued (SEM)

(1)Raw Returns

Dep. Var.	Futures Coefficient	Futures t-value	KOSPI Coefficient	KOSPI t-value
constant	.080	.84	-.172	-1.47
Futures(t-0)			.582	1.03
Futures(t-1)	.463	.85	.095	.89
Futures(t-2)	.299	.76	.088	1.49
Futures(t-3)	.082	.57	.044	2.45**
KOSPI(t-0)	-1.347	-.51		
KOSPI(t-1)	-.057	-.26	.166	1.79*
KOSPI(t-2)	-.132	-1.49	.097	1.11
KOSPI(t-3)	-.025	-.25	-.027	-1.14
d_{SB}	-.028	-.55	.015	.62
d_O	-.001	-.00	.129	2.14**
$VOLUME_{Futures}$	-.019	-.86		
$VOLUME_{KOSPI}$			.012	1.43

(Wald test)	
Futures on Futures	1.31(.73)
Futures on KOSPI	248.44(.00)
KOSPI on KOSPI	9.32(.05)
KOSPI on Futures	5.81(.12)

(2)Return Innovations

Dep. Var.	Futures Coefficient	Futures t-value	KOSPI Coefficient	KOSPI t-value
constant	.083	.83	-.189	-1.19
Futures(t-0)			.854	1.00
Futures(t-1)	.300	.59	.159	3.19***
Futures(t-2)	.269	.65	.104	1.63*
Futures(t-3)	.117	.74	.021	.48
KOSPI(t-0)	-1.212	-.48		
KOSPI(t-1)	-.440	-.70	-.130	-1.05
KOSPI(t-2)	-.345	-.86	-.029	-.22
KOSPI(t-3)	-.074	-.68	-.001	-.03
$VOLUME_{Futures}$	-.018	-.83		
$VOLUME_{KOSPI}$			.014	1.19

(Wald test)	
Futures on Futures	.82(.85)
Futures on KOSPI	132.69(.00)
KOSPI on KOSPI	6.63(.08)
KOSPI on Futures	6.09(.19)

Table 3-8. Continued (SEM)

(1)Raw Returns

Dep. Var.	KOSPI 200 Coefficient	KOSPI 200 t-value	KOSPI Coefficient	KOSPI t-value
constant	-1.640	-.39	-.098	-1.79
KOSPI200(t-0)			.493	3.88***
KOSPI200(t-1)	1.705	.31	.235	5.26***
KOSPI200(t-2)	-.004	-.01	.015	.47
KOSPI200(t-3)	-.558	-.32	-.056	-1.70*
KOSPI(t-0)	-4.243	-.27		
KOSPI(t-1)	.006	.17	-.069	-1.95*
KOSPI(t-2)	.454	.31	.048	1.42
KOSPI(t-3)	.147	.25	.027	.84
d_{SB}	.010	.09	-.001	-.08
d_O	.273	.26	.064	6.17***
$VOLUME_{KOSPI200}$	.127	.39		
$VOLUME_{KOSPI}$			.007	1.73*

(Wald test)

KOSPI200 on KOSPI200	.11(.99)
KOSPI200 on KOSPI	164.00(.00)
KOSPI on KOSPI	7.61(.05)
KOSPI on KOSPI200	.24(.99)

(2)Return Innovations

Dep. Var.	KOSPI 200 Coefficient	KOSPI 200 t-value	KOSPI Coefficient	KOSPI t-value
constant	-3.811	-.12	-.075	-1.40
KOSPI200(t-0)			.480	3.74***
KOSPI200(t-1)	4.468	.10	.397	11.78***
KOSPI200(t-2)	1.263	.09	.176	4.65***
KOSPI200(t-3)	-.654	-.13	.015	.42
KOSPI(t-0)	-13.275	-.11		
KOSPI(t-1)	-4.442	-.10	-.397	-10.75***
KOSPI(t-2)	-1.266	-.09	-.180	-4.41***
KOSPI(t-3)	.490	.13	-.026	-.72
$VOLUME_{KOSPI200}$	.301	.12		
$VOLUME_{KOSPI}$			.006	1.40

(Wald test)

KOSPI200 on KOSPI200	.04(.99)
KOSPI200 on KOSPI	150.66(.00)
KOSPI on KOSPI	123.83(.00)
KOSPI on KOSPI200	.05(.99)

Table 3-8. Continued (SEM)

3.December Contract

(1)Raw Returns

Dep. Var.	KOSPI 200		Futures	
	Coefficient	t-value	Coefficient	t-value
constant	-.228	-1.68*	.262	1.52
KOSPI200(t-0)			-.223	-.15
KOSPI200(t-1)	.181	4.68***	.027	.09
KOSPI200(t-2)	.043	.84	-.129	-1.51
KOSPI200(t-3)	-.043	-1.18	-.049	-.45
Futures(t-0)	.342	1.30		
Futures(t-1)	.165	4.67***	.132	.43
Futures(t-2)	.123	2.86***	.161	.62
Futures(t-3)	.035	1.09	.074	.71
d_{SB}	.047	1.66*	.066	.53
d_O	.321	11.78***	.088	.17
$VOLUME_{KOSPI200}$	.016	1.58		
$VOLUME_{futures}$			-.052	-1.41

(Wald test)

Futures on Futures	.87(.83)
Futures on KOSPI200	75.34(.00)
KOSPI200 on KOSPI200	24.46(.00)
KOSPI200 on Futures	3.52(.47)

(2)Return Innovations

Dep. Var.	KOSPI 200		Futures	
	Coefficient	t-value	Coefficient	t-value
constant	-.180	-1.37	.226	1.31
KOSPI200(t-0)			-.259	-.14
KOSPI200(t-1)	-.227	-4.96***	-.016	-.04
KOSPI200(t-2)	-.162	-2.91***	-.183	-.47
KOSPI200(t-3)	.009	.19	-.087	-.83
Futures(t-0)	.353	1.29		
Futures(t-1)	.183	6.15***	.031	.09
Futures(t-2)	.124	2.90***	.159	.51
Futures(t-3)	.020	.59	.070	.68
$VOLUME_{KOSPI200}$	.014	1.38		
$VOLUME_{futures}$			-.045	-1.32

(Wald test)

Futures on Futures	2.70(.44)
Futures on KOSPI200	55.84(.00)
KOSPI200 on KOSPI200	35.18(.00)
KOSPI200 on Futures	2.43(.66)

Table 3-8. Continued (SEM)

(1)Raw Returns

Dep. Var.	Futures Coefficient	Futures t-value	KOSPI Coefficient	KOSPI t-value
constant	.394	.61	-.126	-.93
Futures(t-0)			.309	1.13
Futures(t-1)	.528	.32	.126	3.68***
Futures(t-2)	.534	.35	.103	2.40**
Futures(t-3)	.303	.34	.061	1.96**
KOSPI(t-0)	-2.869	-.27		
KOSPI(t-1)	.520	.26	.192	5.05***
KOSPI(t-2)	-.108	-.41	.060	1.09
KOSPI(t-3)	-.309	-.33	-.069	-1.78*
d_{SB}	.274	.32	.059	2.13**
d_O	.970	.27	.324	12.50***
$VOLUME_{Futures}$	-.084	-.56		
$VOLUME_{KOSPI}$			.008	.84

(Wald test)

Futures on Futures	.18(.98)
Futures on KOSPI	68.73(.00)
KOSPI on KOSPI	30.93(.00)
KOSPI on Futures	1.03(.91)

(2)Return Innovations

Dep. Var.	Futures Coefficient	Futures t-value	KOSPI Coefficient	KOSPI t-value
constant	.286	.95	-.157	-1.14
Futures(t-0)			.329	1.07
Futures(t-1)	.265	.36	.163	5.97***
Futures(t-2)	.397	.56	.114	2.35**
Futures(t-3)	.210	.56	.057	1.62
KOSPI(t-0)	-1.688	-.38		
KOSPI(t-1)	-.332	-.35	-.216	-4.88***
KOSPI(t-2)	-.513	-.56	-.142	-2.09**
KOSPI(t-3)	-.238	-.67	-.032	-.57
$VOLUME_{Futures}$	-.057	-.95		
$VOLUME_{KOSPI}$			.011	1.14

(Wald test)

Futures on Futures	1.28(.74)
Futures on KOSPI	60.02(.00)
KOSPI on KOSPI	28.91(.00)
KOSPI on Futures	1.55(.82)

Table 3-8. Continued (SEM)

(1)Raw Returns

Dep. Var.	KOSPI 200 Coefficient	KOSPI 200 t-value	KOSPI Coefficient	KOSPI t-value
constant	-.208	-.27	.042	.66
KOSPI200(t-0)			1.009	3.57***
KOSPI200(t-1)	.310	.16	.166	1.29
KOSPI200(t-2)	.199	.28	-.027	-.32
KOSPI200(t-3)	.120	.32	-.033	-.55
KOSPI(t-0)	.197	.06		
KOSPI(t-1)	.004	.01	-.215	-4.34***
KOSPI(t-2)	-.144	-.31	.032	.47
KOSPI(t-3)	-.218	-.32	.051	.59
d_{SB}	.054	.23	.006	.23
d_O	.258	.25	.001	.01
$VOLUME_{KOSPI200}$	.015	.27		
$VOLUME_{KOSPI}$			-.003	-.64

(Wald test)

KOSPI200 on KOSPI200	.77(.86)
KOSPI200 on KOSPI	213.77(.00)
KOSPI on KOSPI	23.25(.00)
KOSPI on KOSPI200	5.86(.21)

(2)Return Innovations

Dep. Var.	KOSPI 200 Coefficient	KOSPI 200 t-value	KOSPI Coefficient	KOSPI t-value
constant	.249	.14	.034	.37
KOSPI200(t-0)			1.149	2.16**
KOSPI200(t-1)	-1.424	-.23	.576	7.48***
KOSPI200(t-2)	-.992	-.22	.360	3.92***
KOSPI200(t-3)	-.419	-.18	.076	.74
KOSPI(t-0)	2.197	.25		
KOSPI(t-1)	1.481	.23	-.588	-6.74***
KOSPI(t-2)	1.005	.21	-.337	-3.04***
KOSPI(t-3)	.383	.18	-.077	-.85
$VOLUME_{KOSPI200}$	-.019	-.14		
$VOLUME_{KOSPI}$			-.002	-.37

(Wald test)

KOSPI200 on KOSPI200	.90(.83)
KOSPI200 on KOSPI	178.15(.00)
KOSPI on KOSPI	76.97(.00)
KOSPI on KOSPI200	1.44(.84)

[a] The Wald test statistic is based on the following formula :

χ^2 (m) ~ [SSE(reduced) - SSE(full)]/ MSE (full),

SSE(reduced) = sum of squares of errors under restricted model ,

SSE(full)= sum of squares of errors under full model, m= number of restricted coefficients

The raw value is Wald test statistic value ,and the value in parenthesis is its p value.

*,**,*** indicate significance level at 10%,5%,1% respectively.

Table 3-9. Results of Vector Autoregressions (VAR) using Seemingly Unrelated Regression (SUR)

1.June Contract

(1)Raw Returns

Dep. Var.	KOSPI 200		Futures	
	Coefficient	t-value	Coefficient	t-value
constant	-.106	-.61	-.077	-.44
KOSPI200(t-1)	-.105	-2.18**	-.164	-3.42***
KOSPI200(t-2)	-.140	-2.92***	-.142	-2.96***
KOSPI200(t-3)	-.053	-1.09	.008	.16
KOSPI200(t-4)	-.086	-1.80*	.016	.33
KOSPI200(t-5)	-.111	-2.63***	.037	.86
Futures(t-1)	.538	10.88***	.240	4.85***
Futures(t-2)	.237	4.44***	.096	1.79*
Futures(t-3)	.133	2.47**	.063	1.17
Futures(t-4)	.034	.62	-.038	-.71
Futures(t-5)	.049	.96	-.051	-1.00
d_{SB}	.094	2.86***	.043	1.33
d_O	.194	6.23***	.070	2.24**
$VOLUME_{KOSPI200}$	.011	.81	.016	1.17
$VOLUME_{futures}$	-.012	-1.00	-.032	-2.65***

(Wald test)[a]	
Futures on Futures	28.94(.00)
Futures on KOSPI200	133.14(.00)
KOSPI200 on KOSPI200	23.33(.00)
KOSPI200 on Futures	24.80(.00)

(2)Return Innovations

Dep. Var.	KOSPI 200		Futures	
	Coefficient	t-value	Coefficient	t-value
constant	-.118	-.69	-.088	-.51
KOSPI200(t-1)	-.411	-8.21***	-.153	-3.07***
KOSPI200(t-2)	-.197	-3.76***	-.153	-2.92***
KOSPI200(t-3)	-.022	-.42	.008	.16
KOSPI200(t-4)	.004	.08	.049	.98
KOSPI200(t-5)	-.050	-1.08	.058	1.28
Futures(t-1)	.538	10.79***	.101	2.05**
Futures(t-2)	.307	5.57***	.082	1.49
Futures(t-3)	.167	2.96***	.031	.55
Futures(t-4)	.053	.95	.066	-1.19
Futures(t-5)	.060	1.15	-.069	-1.34
$VOLUME_{KOSPI200}$	.013	.93	.018	1.37
$VOLUME_{futures}$	-.010	-.86	-.033	-2.77***

(Wald test)	
Futures on Futures	9.30(.10)
Futures on KOSPI200	127.58(.00)
KOSPI200 on KOSPI200	71.49(.00)
KOSPI200 on Futures	17.04(.00)

Table 3-9. Continued (VAR)

(1)Raw Returns

Dep. Var.	**Futures** Coefficient	t-value	**KOSPI** Coefficient	t-value
constant	.147	1.05	.116	.84
Futures(t-1)	.278	5.58***	.485	9.95***
Futures(t-2)	.076	1.44	.253	4.89***
Futures(t-3)	.084	1.58	.187	3.58***
Futures(t-4)	.007	.12	.025	.48
Futures(t-5)	-.037	-.74	.061	1.24
KOSPI(t-1)	-.223	-4.54***	-.080	-1.66*
KOSPI(t-2)	-.095	-1.91*	-.112	-2.30**
KOSPI(t-3)	-.026	-.52	-.096	-1.97**
KOSPI(t-4)	-.011	-.22	-.055	-1.15
KOSPI(t-5)	.044	1.00	-.098	-2.31**
d_{SB}	.048	1.47	.089	2.77***
d_O	.067	2.14	.228	7.45***
$VOLUME_{Futures}$	-.024	-1.89*	-.011	-.89
$VOLUME_{KOSPI}$	-.004	-.34	-.005	-.52

(Wald test)	
Futures on Futures	35.37(.00)
Futures on KOSPI	126.48(.00)
KOSPI on KOSPI	29.85(.00)
KOSPI on Futures	19.49(.00)

(2)Return Innovations

Dep. Var.	**Futures** Coefficient	t-value	**KOSPI** Coefficient	t-value
constant	.169	1.24	.107	.80
Futures(t-1)	.143	2.85***	.476	9.68***
Futures(t-2)	.063	1.16	.306	5.79***
Futures(t-3)	.046	.84	.218	4.02***
Futures(t-4)	-.016	-.30	.055	1.03
Futures(t-5)	-.051	-.98	.083	1.63
KOSPI(t-1)	-.213	-4.16***	-.388	-7.70***
KOSPI(t-2)	-.115	-2.16**	-.201	-3.87***
KOSPI(t-3)	-.019	-.36	-.083	-1.62
KOSPI(t-4)	.002	.05	.010	.19
KOSPI(t-5)	.055	1.16	-.040	-.84
$VOLUME_{Futures}$	-.024	-1.97**	-.009	-.70
$VOLUME_{KOSPI}$	-.004	-.34	-.005	-.44

(Wald test)	
Futures on Futures	10.44(.06)
Futures on KOSPI	116.11(.00)
KOSPI on KOSPI	66.23(.00)
KOSPI on Futures	19.89(.00)

Table 3-9. Continued (VAR)

(1)Raw Returns

Dep. Var.	**KOSPI 200**		**KOSPI**	
	Coefficient	**t-value**	**Coefficient**	**t-value**
constant	-.095	-.48	-.186	-.92
KOSPI200(t-1)	.281	2.21**	.543	4.46***
KOSPI200(t-2)	-.011	-.08	.063	.49
KOSPI200(t-3)	.078	.58	.099	.77
KOSPI200(t-4)	.010	.08	.019	.15
KOSPI200(t-5)	-.021	-.17	-.029	-.24
KOSPI(t-1)	.016	.12	-.231	-1.83*
KOSPI(t-2)	-.008	-.56	-.099	-.76
KOSPI(t-3)	-.135	-.99	-.145	-1.11
KOSPI(t-4)	-.092	-.69	-.087	-.68
KOSPI(t-5)	-.024	-.19	-.001	-.09
d_{SB}	.104	2.88***	.090	2.61***
d_O	.181	5.42***	.205	6.41***
$VOLUME_{KOSPI200}$	.018	1.19	.019	1.34
$VOLUME_{KOSPI}$	-.012	-1.01	-.006	-.57

(Wald test)

KOSPI200 on KOSPI200	5.72(.33)
KOSPI200 on KOSPI	20.76(.00)
KOSPI on KOSPI	4.56(.47)
KOSPI on KOSPI200	1.37(.93)

(2)Return Innovations

Dep. Var.	**KOSPI 200**		**KOSPI**	
	Coefficient	**t-value**	**Coefficient**	**t-value**
constant	-.060	-.29	-.149	-.75
KOSPI200(t-1)	-.045	-.37	.491	4.12***
KOSPI200(t-2)	-.015	-.10	.158	1.16
KOSPI200(t-3)	.082	.57	.096	.70
KOSPI200(t-4)	.078	.55	.045	.33
KOSPI200(t-5)	.038	.30	.009	.07
KOSPI(t-1)	.050	.39	-.487	-3.91***
KOSPI(t-2)	.009	.06	-.165	-1.17
KOSPI(t-3)	-.067	-.45	-.097	-.68
KOSPI(t-4)	-.085	-.59	-.046	-.33
KOSPI(t-5)	-.086	-.68	-.035	-.29
$VOLUME_{KOSPI200}$	.017	1.12	.018	1.25
$VOLUME_{KOSPI}$	-.012	-1.02	-.006	-.57

(Wald test)

KOSPI200 on KOSPI200	.67(.98)
KOSPI200 on KOSPI	18.06(.00)
KOSPI on KOSPI	16.17(.01)
KOSPI on KOSPI200	.80(.98)

Table 3-9. Continued (VAR)

2.September Contract

(1)Raw Returns

Dep. Var.	**KOSPI 200**		**Futures**	
	Coefficient	**t-value**	**Coefficient**	**t-value**
constant	-.464	-3.78***	-.032	-1.69*
KOSPI200(t-1)	.085	2.84***	-.055	-1.20
KOSPI200(t-2)	-.030	-1.02	-.137	-3.03***
KOSPI200(t-3)	-.040	-1.48	-.028	-.67
Futures(t-1)	.215	11.24***	.149	5.01***
Futures(t-2)	.153	7.79***	.075	2.45**
Futures(t-3)	.042	2.13**	.005	.16
d_{SB}	-.005	-.27	-.036	-1.16
d_O	-.005	-.29	-.103	-3.50***
$VOLUME_{KOSPI200}$	.040	4.12***	.031	2.07**
$VOLUME_{futures}$	-.009	-1.25	-.016	-1.37

(Wald test)	
Futures on Futures	30.26(.00)
Futures on KOSPI200	181.35(.00)
KOSPI200 on KOSPI200	11.01(.01)
KOSPI200 on Futures	13.88(.00)

(2)Return Innovations

Dep. Var.	**KOSPI 200**		**Futures**	
	Coefficient	**t-value**	**Coefficient**	**t-value**
constant	-.520	-4.31***	-.324	-1.73*
KOSPI200(t-1)	-.248	-8.27***	-.041	-.88
KOSPI200(t-2)	-.168	-5.65***	-.121	-2.62***
KOSPI200(t-3)	-.044	-1.54	-.047	-1.06
Futures(t-1)	.216	11.16***	.014	.48
Futures(t-2)	.174	8.65***	.043	1.39
Futures(t-3)	.058	2.88***	.036	1.14
$VOLUME_{KOSPI200}$	.045	4.71***	.031	2.09
$VOLUME_{futures}$	-.011	-1.57	-.014	-1.36

(Wald test)	
Futures on Futures	2.74(.43)
Futures on KOSPI200	172.06(.00)
KOSPI200 on KOSPI200	88.88(.00)
KOSPI200 on Futures	7.33(.06)

Table 3-9. Continued (VAR)

(1)Raw Returns

Dep. Var.	Futures Coefficient	Futures t-value	KOSPI Coefficient	KOSPI t-value
constant	.175	1.17	-.071	-.78
Futures(t-1)	.187	6.13***	.204	10.97***
Futures(t-2)	.101	3.23***	.147	7.73***
Futures(t-3)	.013	.42	.051	2.74***
KOSPI(t-1)	-.157	-3.14***	.074	2.44**
KOSPI(t-2)	-.147	-3.00***	.011	.38
KOSPI(t-3)	.007	.15	-.023	-.84
d_{SB}	-.027	-.85	-.001	-.05
d_O	-.098	-3.28***	.072	3.97***
$VOLUME_{Futures}$	-.011	-.92	-.006	-.88
$VOLUME_{KOSPI}$	-.009	-.83	.007	1.02

(Wald test)

Futures on Futures	47.03(.00)
Futures on KOSPI	180.00(.00)
KOSPI on KOSPI	6.67(.08)
KOSPI on Futures	23.28(.00)

(2)Return Innovations

Dep. Var.	Futures Coefficient	Futures t-value	KOSPI Coefficient	KOSPI t-value
constant	.153	1.08	-.058	-.67
Futures(t-1)	.053	1.70*	.204	10.68***
Futures(t-2)	.070	2.17**	.164	8.28***
Futures(t-3)	.045	1.37	.060	3.00***
KOSPI(t-1)	-.139	-2.72***	-.249	-7.98***
KOSPI(t-2)	-.152	-2.98***	-.159	-5.11***
KOSPI(t-3)	-.036	-.73	-.032	-1.06
$VOLUME_{Futures}$	-.009	-.79	-.008	-1.10
$VOLUME_{KOSPI}$	-.008	-.76	.007	1.03

(Wald test)

Futures on Futures	7.51(.06)
Futures on KOSPI	161.05(.00)
KOSPI on KOSPI	77.54(.00)
KOSPI on Futures	13.83(.00)

Table 3-9. Continued (VAR)

(1)Raw Returns

Dep. Var.	KOSPI 200		KOSPI	
	Coefficient	t-value	Coefficient	t-value
constant	-.395	-2.39**	-.293	-1.91*
KOSPI200(t-1)	.229	3.81***	.348	6.23***
KOSPI200(t-2)	-.022	-.36	.004	.07
KOSPI200(t-3)	-.104	-1.73*	-.107	-1.92*
KOSPI(t-1)	.116	1.80*	-.012	-.21
KOSPI(t-2)	.081	1.26	.088	1.48
KOSPI(t-3)	.011	.17	.032	.56
d_{SB}	.004	.21	.001	.06
d_O	.001	.03	.064	3.45***
$VOLUME_{KOSPI200}$	.041	4.07	.020	2.16**
$VOLUME_{KOSPI}$	-.010	-1.30	.002	.33

(Wald test)

KOSPI200 on KOSPI200	18.22(.00)
KOSPI200 on KOSPI	43.44(.00)
KOSPI on KOSPI	2.49(.48)
KOSPI on KOSPI200	4.30(.23)

(2)Return Innovations

Dep. Var.	KOSPI 200		KOSPI	
	Coefficient	t-value	Coefficient	t-value
constant	-.382	-2.43**	-.258	-1.76*
KOSPI200(t-1)	-.109	-1.81*	.345	6.16***
KOSPI200(t-2)	-.145	-2.24**	.106	1.76
KOSPI200(t-3)	-.115	-1.89*	-.041	-.72
KOSPI(t-1)	.113	1.74*	-.343	-5.69***
KOSPI(t-2)	.152	2.21**	-.107	-1.66*
KOSPI(t-3)	.113	1.78*	.028	.48
$VOLUME_{KOSPI200}$	.041	4.11***	.020	2.12**
$VOLUME_{KOSPI}$	-.010	-1.40	.001	.11

(Wald test)

KOSPI200 on KOSPI200	7.05(.07)
KOSPI200 on KOSPI	42.23(.00)
KOSPI on KOSPI	35.28(.00)
KOSPI on KOSPI200	6.63(.08)

Table 3-9. Continued (VAR)

3.December Contract

(1)Raw Returns

Dep. Var.	KOSPI 200		Futures	
	Coefficient	t-value	Coefficient	t-value
constant	-.129	-.65	.290	1.00
KOSPI200(t-1)	.177	3.35***	-.012	-.16
KOSPI200(t-2)	-.001	-.02	-.129	-1.68*
KOSPI200(t-3)	-.056	-1.19	-.037	-.53
Futures(t-1)	.195	5.09***	.088	1.55
Futures(t-2)	.165	4.25***	.124	2.16**
Futures(t-3)	.056	1.49	.062	1.11
d_{SB}	.065	1.61	.052	.87
d_O	.326	8.45***	.015	.26
$VOLUME_{KOSPI200}$	.015	1.09	-.003	-.16
$VOLUME_{futures}$	-.017	-.95	-.048	-1.88*

(Wald test)

Futures on Futures	7.06(.07)
Futures on KOSPI200	40.18(.00)
KOSPI200 on KOSPI200	12.14(.00)
KOSPI200 on Futures	4.22(.24)

(2)Return Innovations

Dep. Var.	KOSPI 200		Futures	
	Coefficient	t-value	Coefficient	t-value
constant	-.091	-.51	.249	.92
KOSPI200(t-1)	-.213	-3.52***	.039	.42
KOSPI200(t-2)	-.207	-3.38***	-.129	-1.40
KOSPI200(t-3)	-.020	-.33	-.082	-.91
Futures(t-1)	.178	4.43***	-.015	-.25
Futures(t-2)	.165	3.97***	.116	1.85*
Futures(t-3)	.041	.99	.059	.96
$VOLUME_{KOSPI200}$	.012	.94	-.003	-.16
$VOLUME_{futures}$	-.015	-.94	-.041	-1.77*

(Wald test)

Futures on Futures	4.17(.24)
Futures on KOSPI200	29.33(.00)
KOSPI200 on KOSPI200	19.91(.00)
KOSPI200 on Futures	3.03(.39)

Table 3-9. Continued (VAR)

(1)Raw Returns

Dep. Var.	Futures Coefficient	Futures t-value	KOSPI Coefficient	KOSPI t-value
constant	.400	1.55	-.002	-.01
Futures(t-1)	.088	1.61	.153	4.48***
Futures(t-2)	.127	2.30**	.142	4.13***
Futures(t-3)	.068	1.27	.082	2.44**
KOSPI(t-1)	-.017	-.21	.187	3.71***
KOSPI(t-2)	-.149	-1.87*	.014	.29
KOSPI(t-3)	-.058	-.80	-.087	-1.91*
d_{SB}	.055	.92	.076	2.03**
d_O	.021	.37	.331	9.23***
$VOLUME_{Futures}$	-.045	-1.72*	-.013	-.85
$VOLUME_{KOSPI}$	-.012	-.69	.004	.39

(Wald test)	
Futures on Futures	8.52(.04)
Futures on KOSPI	38.86(.00)
KOSPI on KOSPI	16.54(.00)
KOSPI on Futures	5.95(.11)

(2)Return Innovations

Dep. Var.	Futures Coefficient	Futures t-value	KOSPI Coefficient	KOSPI t-value
constant	.354	1.49	-.041	-.27
Futures(t-1)	-.006	-.11	.161	4.45***
Futures(t-2)	.132	2.20**	.157	4.22***
Futures(t-3)	.073	1.24	.081	2.20**
KOSPI(t-1)	.021	.23	-.209	-3.60***
KOSPI(t-2)	-.175	-1.85*	-.200	-3.41***
KOSPI(t-3)	-.118	-1.28	-.071	-1.24
$VOLUME_{Futures}$	-.036	-1.52	-.012	-.81
$VOLUME_{KOSPI}$	-.012	-.70	.007	.67

(Wald test)	
Futures on Futures	5.76(.12)
Futures on KOSPI	33.58(.00)
KOSPI on KOSPI	20.61(.00)
KOSPI on Futures	4.81(.19)

Table 3-9. Continued (VAR)

(1)Raw Returns

Dep. Var.	KOSPI 200 Coefficient	KOSPI 200 t-value	KOSPI Coefficient	KOSPI t-value
constant	-.249	-1.17	-.210	-1.09
KOSPI200(t-1)	.429	3.29***	.599	5.10***
KOSPI200(t-2)	.241	1.79*	.217	1.78
KOSPI200(t-3)	.141	1.06	.110	.92
KOSPI(t-1)	-.047	-.33	-.263	-2.04**
KOSPI(t-2)	-.172	-1.18	-.142	-1.08
KOSPI(t-3)	-.260	-1.83*	-.211	-1.65*
d_{SB}	.069	1.73*	.008	2.09**
d_O	.322	8.38***	.326	9.41***
$VOLUME_{KOSPI200}$	.019	1.18	.002	1.33
$VOLUME_{KOSPI}$	-.001	-.05	-.004	-.29

(Wald test)

KOSPI200 on KOSPI200	13.00(.00)
KOSPI200 on KOSPI	27.37(.00)
KOSPI on KOSPI	7.01(.07)
KOSPI on KOSPI200	4.05(.26)

(2)Return Innovations

Dep. Var.	KOSPI 200 Coefficient	KOSPI 200 t-value	KOSPI Coefficient	KOSPI t-value
constant	-.213	-1.08	-.210	-1.18
KOSPI200(t-1)	.104	.83	.695	6.14***
KOSPI200(t-2)	.131	.93	.511	3.97***
KOSPI200(t-3)	.165	1.28	.266	2.27**
KOSPI(t-1)	-.124	-.90	-.730	-5.86***
KOSPI(t-2)	-.173	-1.14	-.536	-3.90***
KOSPI(t-3)	-.140	-1.05	-.238	-1.96**
$VOLUME_{KOSPI200}$	.012	.80	.014	1.02
$VOLUME_{KOSPI}$	.004	.27	.002	.14

(Wald test)

KOSPI200 on KOSPI200	1.85(.61)
KOSPI200 on KOSPI	38.60(.00)
KOSPI on KOSPI	35.33(.00)
KOSPI on KOSPI200	1.70(.64)

[a] The Wald test statistic is based on the following formula :
χ^2 (m) ~ [SSE(reduced) - SSE(full)]/ MSE (full) ,
SSE(reduced) = sum of squares of errors under restricted model ,
SSE(full)= sum of squares of errors under full model, m= number of restricted coefficients
The raw value is Wald test statistic value ,and the value in parenthesis is its p value.
*,**,*** indicate significance level at 10%,5%,1% level respectively.

Table 3-10.Test for Unit Root in the Stock Market Indexes and Futures Prices

	ADF pseudo t statistics [a]	
	Level Series	1st Differeced Series
1.June Contract		
KOSPI 200 Index	- .0548	-14.0398***
KOSPI Index	.0843	-12.8666***
Futures	-.0299	-13.7286***
2.September Contract		
KOSPI 200 Index	-1.4952	-18.1875***
KOSPI Index	-2.2755	-18.7524***
Futures	-1.7045	-17.9868***
3.December Contract		
KOSPI 200 Index	-.6867	-10.2714***
KOSPI Index	-.4521	-10.1732***
Futures	-.4660	-10.8836***

[a] ADF denotes the augmented Dickey-Fuller test with 4 lags
*,**,*** indicates statistical significance at 10%, 5% and 1% level. Critical values for June sample are -3.4418(1%), -2.8658(5%), -2.5691(10%) and for September sample are -3.4372(1%), -2.8638(5%), -2.5680(10%), and for December sample are -3.4447(1%),-2.8671(5%) and -2.5697(10%) respectively. All critical values are based upon MacKinnon(1991).

Table 3-11.Tests for Cointegration between Stock Market Indexes and Futures

	Cointegration Coefficient	ADF pseudo t statistics[a]
1. June Contract		
KOSPI 200 vs. Futures	.9524	-3.5872**(5)
KOSPI vs. Futures	.7773	-3.1298* (5)
KOSPI 200 vs. KOSPI	1.2074	-2.7165 (2)
2. September Contract		
KOSPI 200 vs. Futures	1.1213	-2.3747 (4)
KOSPI vs. Futures	.9818	-2.6051 (4)
KOSPI 200 vs. KOSPI	1.1116	-.6965 (5)
3. December Contract		
KOSPI 200 vs. Futures	.9441	-3.8029**(4)
KOSPI vs. Futures	.8973	-3.7946**(6)
KOSPI 200 vs. KOSPI	1.0371	-1.9353 (1)

[a] ADF denotes the augmented Dickey-Fuller test. The number in parenthesis is the lag order in the augmented DF test to insure the white noise of the residuals. For that purpose, Ljung-Box Q test is conducted at 20 lags.
*,**,*** indicates statistical significance at 10%,5% and 1% level. Critical values for June sample are -3.9143(1%),-3.3458(5%),-3.0517(10%) and for September sample are -3.9064(1%),-3.3413(5%), -3.0486(10%), and for December sample are -3.9193(1%),-3.3486(5%) and -3.0536(10%) respectively. All critical values are based upon MacKinnon(1991).

Table 3-12. Trend of Monthly Returns for Large Cap, Medium Cap and Small Cap Stocks[a]

	Monthly Return		
	Large Cap	Medium Cap	Small Cap
May	-11.96%	-1.99%	+.31%
June	-9.14%	-11.41%	-9.46%
July	-3.09%	+1.29%	+9.68%
August	-3.99%	-5.79%	-6.56%
September	-.32%	-.46%	+5.02%
October	-5.69%	+1.03%	-2.93%
Total	**-30.03%**	**-16.67%**	**-5.12%**

[a] Large cap stocks belong to the stocks whose paid in capital exceeds 75 billion Won.
Medium cap stocks ranges from 35 bil.Won up to 75 bil.Won in paid in capital.
Small cap stocks belong to the stocks whose paid in capital is below 35 bil.Won.
Source) Korea Stock Exchange

Table 3-13. Results of Error Correction Model (ECM) using OLS.

1.June Contract

(1)Raw Returns

Dep. Var.	KOSPI 200		Futures	
	Coefficient	t-value	Coefficient	t-value
constant	-.113	-.64	-.075	-.43
Z(t-1)	-3.848	-2.30**	1.153	.69
KOSPI200(t-1)	-.085	-1.73*	-.170	-3.45***
KOSPI200(t-2)	-.122	-2.49**	-.148	-3.01***
KOSPI200(t-3)	-.036	-.72	.003	.05
KOSPI200(t-4)	-.070	-1.44	.011	.23
KOSPI200(t-5)	-.095	-2.19**	.032	.73
Futures(t-1)	.518	10.22***	.246	4.84***
Futures(t-2)	.224	4.15***	.099	1.84*
Futures(t-3)	.124	2.29**	.065	1.20
Futures(t-4)	.025	.47	-.035	-.65
Futures(t-5)	.039	.76	-.048	-.93
d_{SB}	.091	2.76***	.044	1.34
d_O	.192	6.12***	.070	2.24**
$VOLUME_{KOSPI200}$	.012	.85	.016	1.14
$VOLUME_{futures}$	-.013	-1.03	-.032	-2.61***

(Wald test)[a]

Futures on Futures	28.76(.00)
Futures on KOSPI200	116.02(.00)
KOSPI200 on KOSPI200	14.49(.01)
KOSPI200 on Futures	28.76(.00)

(2)Return Innovations

Dep. Var.	KOSPI 200		Futures	
	Coefficient	t-value	Coefficient	t-value
constant	-.119	-.69	-.088	-.51
Z(t-1)	-3.978	-2.34**	.816	.48
KOSPI200(t-1)	-.388	-7.57***	-.158	-3.08***
KOSPI200(t-2)	-.167	-3.08***	-.157	-2.93***
KOSPI200(t-3)	.008	.14	.002	.04
KOSPI200(t-4)	.029	.56	.044	.85
KOSPI200(t-5)	-.033	-.70	.055	1.18
Futures(t-1)	.514	10.03***	.107	2.09**
Futures(t-2)	.286	5.09***	.086	1.54
Futures(t-3)	.149	2.60***	.035	.60
Futures(t-4)	.037	.66	-.063	-1.12
Futures(t-5)	.049	.94	-.068	-1.28
$VOLUME_{KOSPI200}$	.013	.95	.018	1.35
$VOLUME_{futures}$	-.011	-.92	-.033	-2.73***

(Wald test)

Futures on Futures	9.35(.10)
Futures on KOSPI200	108.34(.00)
KOSPI200 on KOSPI200	60.71(.00)
KOSPI200 on Futures	16.95(.00)

Table 3-13. Continued (ECM)

(1)Raw Returns

Dep. Var.	Futures		KOSPI	
	Coefficient	t-value	Coefficient	t-value
constant	.139	.98	.100	.72
Z(t-1)	1.216	1.35	-2.627	-3.00***
Futures(t-1)	.269	5.29***	.465	9.40***
Futures(t-2)	.071	1.32	.241	4.62***
Futures(t-3)	.081	1.51	.180	3.43***
Futures(t-4)	.004	.08	.021	.40
Futures(t-5)	-.040	-.81	.052	1.07
KOSPI(t-1)	-.216	-4.33***	-.065	-1.33
KOSPI(t-2)	-.088	-1.75*	-.097	-1.97**
KOSPI(t-3)	-.020	-.40	-.084	-1.71*
KOSPI(t-4)	-.005	-.11	-.043	-.90
KOSPI(t-5)	.050	1.12	-.086	-1.99**
d_{SB}	.047	1.42	.086	2.68***
d_O	.065	2.06	.224	7.28***
$VOLUME_{Futures}$	-.023	-1.79*	-.009	-.70
$VOLUME_{KOSPI}$	-.004	-.32	-.005	-.48

(Wald test)

Futures on Futures	31.90(.00)
Futures on KOSPI	112.13(.00)
KOSPI on KOSPI	13.52(.02)
KOSPI on Futures	27.44(.00)

(2)Return Innovations

Dep. Var.	Futures		KOSPI	
	Coefficient	t-value	Coefficient	t-value
constant	.163	1.18	.093	.69
Z(t-1)	1.349	1.48	-2.832	-3.18***
Futures(t-1)	.132	2.57***	.452	9.07***
Futures(t-2)	.054	.98	.287	5.38***
Futures(t-3)	.039	.71	.204	3.74***
Futures(t-4)	-.021	-.38	.046	.85
Futures(t-5)	-.054	-1.03	.076	1.49
KOSPI(t-1)	-.205	-3.94***	-.370	-7.29***
KOSPI(t-2)	-.104	-1.92*	-.178	-3.38***
KOSPI(t-3)	-.009	-.16	-.062	-1.18
KOSPI(t-4)	.011	.21	.028	.56
KOSPI(t-5)	.062	1.27	-.027	-.56
$VOLUME_{Futures}$	-.024	-1.88*	-.007	-.55
$VOLUME_{KOSPI}$	-.003	-.32	-.004	-.41

(Wald test)

Futures on Futures	8.81(.12)
Futures on KOSPI	100.48(.00)
KOSPI on KOSPI	58.14(.00)
KOSPI on Futures	18.17(.00)

Table 3-13. Continued (ECM)

(1)Raw Returns

Dep. Var.	KOSPI 200		KOSPI	
	Coefficient	t-value	Coefficient	t-value
constant	-.128	-.60	-.221	-1.08
Z(t-1)	4.636	2.92***	4.789	3.16***
KOSPI200(t-1)	.239	1.86*	.499	4.06***
KOSPI200(t-2)	-.044	-.33	.028	.22
KOSPI200(t-3)	.047	.35	.067	.52
KOSPI200(t-4)	-.018	-.14	-.010	-.08
KOSPI200(t-5)	-.043	-.34	-.051	-.42
KOSPI(t-1)	.056	.42	-.190	-1.49
KOSPI(t-2)	-.041	-.30	-.063	-.48
KOSPI(t-3)	-.103	-.75	-.111	-.85
KOSPI(t-4)	-.063	-.47	-.057	-.44
KOSPI(t-5)	-.004	-.03	.020	.16
d_{SB}	.103	2.84***	.089	2.56***
d_O	.180	5.35***	.204	6.33***
$VOLUME_{KOSPI200}$	.018	1.23	.020	1.39
$VOLUME_{KOSPI}$	-.010	-.86	-.005	-.41

(Wald test)

KOSPI200 on KOSPI200	4.49(.48)
KOSPI200 on KOSPI	17.62(.00)
KOSPI on KOSPI	2.93(.71)
KOSPI on KOSPI200	0.91(.97)

(2)Return Innovations

Dep. Var.	KOSPI 200		KOSPI	
	Coefficient	t-value	Coefficient	t-value
constant	-.094	-.45	-.183	-.92
Z(t-1)	4.956	3.08***	5.018	3.25***
KOSPI200(t-1)	-.095	-.75	.441	3.67***
KOSPI200(t-2)	-.071	-.49	.101	.74
KOSPI200(t-3)	.027	.19	.041	.30
KOSPI200(t-4)	.031	.22	-.003	-.02
KOSPI200(t-5)	.007	.06	-.022	-.18
KOSPI(t-1)	.095	.73	-.441	-3.51***
KOSPI(t-2)	.065	.44	-.108	-.76
KOSPI(t-3)	-.009	-.06	-.039	-.27
KOSPI(t-4)	-.034	-.23	.006	.05
KOSPI(t-5)	-.054	-.42	-.002	-.02
$VOLUME_{KOSPI200}$	.017	1.16	.018	1.29
$VOLUME_{KOSPI}$	-.010	-.85	-.004	-.40

(Wald test)

KOSPI200 on KOSPI200	.79(.98)
KOSPI200 on KOSPI	14.81(.01)
KOSPI on KOSPI	13.48(.02)
KOSPI on KOSPI200	.75(.98)

Table 3-13. Continued (ECM)

2.September Contract

(1)Raw Returns

Dep. Var.	**KOSPI 200**		**Futures**	
	Coefficient	**t-value**	**Coefficient**	**t-value**
constant	-.493	-3.94***	-.297	-1.53
Z(t-1)	-.319	-1.34	.280	.76
KOSPI200(t-1)	.085	2.84***	-.056	-1.20
KOSPI200(t-2)	-.029	-.99	-.138	-3.03***
KOSPI200(t-3)	-.040	-1.47	-.028	-.67
Futures(t-1)	.213	11.04***	.151	5.04***
Futures(t-2)	.151	7.65***	.077	2.49**
Futures(t-3)	.040	2.06**	.006	.20
d_{SB}	-.006	-.29	-.036	-1.14
d_O	-.006	-.32	-.103	-3.47***
$VOLUME_{KOSPI200}$	.042	4.28***	.029	1.90*
$VOLUME_{futures}$	-.009	-1.26	-.016	-1.36

(Wald test)

Futures on Futures	30.59(.00)
Futures on KOSPI200	173.76(.00)
KOSPI200 on KOSPI200	10.96(.01)
KOSPI200 on Futures	13.90(.00)

(2)Return Innovations

Dep. Var.	**KOSPI 200**		**Futures**	
	Coefficient	**t-value**	**Coefficient**	**t-value**
constant	-.552	-4.50***	-.297	-1.57
Z(t-1)	-.374	-1.57	.306	.83
KOSPI200(t-1)	-.248	-8.25***	-.040	-.88
KOSPI200(t-2)	-.168	-5.63***	-.121	-2.62***
KOSPI200(t-3)	-.043	-1.52	-.047	-1.07
Futures(t-1)	.213	10.97***	.016	.54
Futures(t-2)	.172	8.51***	.045	1.44
Futures(t-3)	.057	2.80***	.037	1.18
$VOLUME_{KOSPI200}$	.048	4.90***	.029	1.91*
$VOLUME_{futures}$	-.011	-1.59	-.015	-1.34

(Wald test)

Futures on Futures	2.94(.40)
Futures on KOSPI200	165.78(.00)
KOSPI200 on KOSPI200	83.43(.00)
KOSPI200 on Futures	7.32(.06)

Table 3-13. Continued (ECM)

(1)Raw Returns

Dep. Var.	**Futures**		**KOSPI**	
	Coefficient	**t-value**	**Coefficient**	**t-value**
constant	.188	1.25	-.083	-.91
Z(t-1)	-.373	-.89	-.375	-1.46
Futures(t-1)	.190	6.16***	.202	10.78***
Futures(t-2)	.103	3.27***	.146	7.61***
Futures(t-3)	.014	.46	.050	2.67***
KOSPI(t-1)	-.157	-3.13***	.074	2.43**
KOSPI(t-2)	-.147	-2.99***	.011	.37
KOSPI(t-3)	.007	.16	-.024	-.86
d_{SB}	-.026	-.83	-.001	-.07
d_O	-.097	-3.23***	.071	3.90***
$VOLUME_{Futures}$	-.011	-.93	-.006	-.86
$VOLUME_{KOSPI}$	-.010	-.90	.007	1.14

(Wald test)	
Futures on Futures	47.45(.00)
Futures on KOSPI	173.11(.00)
KOSPI on KOSPI	6.64(.08)
KOSPI on Futures	23.05(.00)

(2)Return Innovations

Dep. Var.	**Futures**		**KOSPI**	
	Coefficient	**t-value**	**Coefficient**	**t-value**
constant	.165	1.16	-.071	-.82
Z(t-1)	-.438	-1.04	-.449	-1.75*
Futures(t-1)	.055	1.76*	.202	10.51***
Futures(t-2)	.072	2.22**	.162	8.16***
Futures(t-3)	.046	1.41	.058	2.92***
KOSPI(t-1)	-.138	-2.70***	-.250	-7.99***
KOSPI(t-2)	-.151	-2.96***	-.160	-5.13***
KOSPI(t-3)	-.035	-.71	-.032	-1.08
$VOLUME_{Futures}$	-.009	-.79	-.007	-1.08
$VOLUME_{KOSPI}$	-.009	-.84	.008	1.16

(Wald test)	
Futures on Futures	7.88(.05)
Futures on KOSPI	155.70(.00)
KOSPI on KOSPI	77.75(.00)
KOSPI on Futures	13.59(.00)

Table 3-13. Continued (ECM)

(1)Raw Returns

Dep. Var.	KOSPI 200		KOSPI	
	Coefficient	t-value	Coefficient	t-value
constant	-.467	-2.79***	-.367	-2.36**
Z(t-1)	1.947	2.86***	1.979	3.13***
KOSPI200(t-1)	.216	3.58***	.335	5.98***
KOSPI200(t-2)	-.030	-.50	-.004	-.08
KOSPI200(t-3)	-.111	-1.84*	-.114	-2.05**
KOSPI(t-1)	.124	1.93*	-.004	-.06
KOSPI(t-2)	.086	1.34	.094	1.57
KOSPI(t-3)	.016	.25	.037	.64
d_{SB}	.002	.10	-.001	-.05
d_O	-.003	-.15	.060	3.24***
$VOLUME_{KOSPI200}$	.043	4.23***	.022	2.35**
$VOLUME_{KOSPI}$	-.006	-.80	.006	.86

(Wald test)

KOSPI200 on KOSPI200	17.18(.00)
KOSPI200 on KOSPI	41.13(.00)
KOSPI on KOSPI	2.76(.43)
KOSPI on KOSPI200	4.95(.18)

(2)Return Innovations

Dep. Var.	KOSPI 200		KOSPI	
	Coefficient	t-value	Coefficient	t-value
constant	-.446	-2.81***	-.319	-2.16**
Z(t-1)	1.998	2.95***	1.925	3.05***
KOSPI200(t-1)	-.124	-2.05**	.330	5.88***
KOSPI200(t-2)	-.158	-2.44**	.093	1.54
KOSPI200(t-3)	-.125	-2.05**	-.050	-.89
KOSPI(t-1)	.124	1.91*	-.333	-5.51***
KOSPI(t-2)	.162	2.34**	-.098	-1.53
KOSPI(t-3)	.121	1.88*	.035	.59
$VOLUME_{KOSPI200}$	.042	4.25***	.021	2.27**
$VOLUME_{KOSPI}$	-.007	-.92	.004	.59

(Wald test)

KOSPI200 on KOSPI200	8.49(.04)
KOSPI200 on KOSPI	39.44(.00)
KOSPI on KOSPI	33.54(.00)
KOSPI on KOSPI200	7.54(.06)

Table 3-13. Continued (ECM)

2.December Contract

(1)Raw Returns

Dep. Var.	KOSPI 200		Futures	
	Coefficient	t-value	Coefficient	t-value
constant	-.097	-.49	.390	1.36
Z(t-1)	-3.320	-2.57***	-10.593	-5.66***
KOSPI200(t-1)	.192	3.61***	.038	.50
KOSPI200(t-2)	.014	.28	-.079	-1.03
KOSPI200(t-3)	-.044	-.92	.001	.01
Futures(t-1)	.177	4.53***	.031	.54
Futures(t-2)	.149	3.77***	.073	1.28
Futures(t-3)	.042	1.09	.017	.31
d_{SB}	.069	1.69*	.064	1.09
d_O	.332	8.54***	.033	.59
$VOLUME_{KOSPI200}$	.013	.97	-.008	-.41
$VOLUME_{futures}$	-.019	-1.07	-.055	-2.19**

(Wald test)

Futures on Futures	1.78(.62)
Futures on KOSPI200	30.59(.00)
KOSPI200 on KOSPI200	13.91(.00)
KOSPI200 on Futures	1.24(.74)

(2)Return Innovations

Dep. Var.	KOSPI 200		Futures	
	Coefficient	t-value	Coefficient	t-value
constant	-.075	-.42	.298	1.19
Z(t-1)	-3.575	-2.85***	-10.825	-5.86
KOSPI200(t-1)	-.197	-3.23***	.089	.99
KOSPI200(t-2)	-.183	-2.95***	-.057	-.62
KOSPI200(t-3)	.002	.03	-.018	-.20
Futures(t-1)	.159	3.89***	-.074	-1.23
Futures(t-2)	.146	3.47***	.058	.94
Futures(t-3)	.026	.64	.016	.26
$VOLUME_{KOSPI200}$	.012	.86	-.006	-.31
$VOLUME_{futures}$	-.015	-.98	-.043	-1.89

(Wald test)

Futures on Futures	3.10(.38)
Futures on KOSPI200	22.18(.00)
KOSPI200 on KOSPI200	16.51(.00)
KOSPI200 on Futures	1.77(.06)

Table 3-13. Continued (ECM)

(1)Raw Returns

Dep. Var.	Futures		KOSPI	
	Coefficient	t-value	Coefficient	t-value
constant	.309	1.20	-.034	-.21
Z(t-1)	-6.966	-4.56***	-2.382	-2.47**
Futures(t-1)	.049	.90	.140	4.02***
Futures(t-2)	.094	1.70*	.131	3.74***
Futures(t-3)	.043	.80	.073	2.16**
KOSPI(t-1)	.008	.10	.196	3.85***
KOSPI(t-2)	-.120	-1.52	.024	.48
KOSPI(t-3)	-.041	-.56	-.081	-1.77*
d_{SB}	.057	.96	.077	2.04
d_O	.023	.41	.332	9.20***
$VOLUME_{Futures}$	-.049	-1.89*	-.015	-.93
$VOLUME_{KOSPI}$	-.004	-.24	.007	.63

(Wald test)

Futures on Futures	3.84(.28)
Futures on KOSPI	30.68(.00)
KOSPI on KOSPI	17.51(.00)
KOSPI on Futures	3.42(.33)

(2)Return Innovations

Dep. Var.	Futures		KOSPI	
	Coefficient	t-value	Coefficient	t-value
constant	.242	1.03	-.076	-.51
Z(t-1)	-7.307	-4.78***	-2.283	-2.37**
Futures(t-1)	-.049	-.84	.148	4.02***
Futures(t-2)	.089	1.49	.144	3.80***
Futures(t-3)	.044	.74	.072	1.93*
KOSPI(t-1)	.051	.55	-.200	-3.42***
KOSPI(t-2)	-.128	-1.36	-.185	-3.13***
KOSPI(t-3)	-.080	-.88	-.059	-1.03
$VOLUME_{Futures}$	-.040	-1.68*	-.013	-.88
$VOLUME_{KOSPI}$	-.003	-.17	.010	.93

(Wald test)

Futures on Futures	3.76(.29)
Futures on KOSPI	26.63(.00)
KOSPI on KOSPI	17.84(.00)
KOSPI on Futures	3.05(.38)

Table 3-13. Continued (ECM)

(1)Raw Returns

Dep. Var.	**KOSPI 200** Coefficient	t-value	**KOSPI** Coefficient	t-value
constant	-.327	-1.47	-.247	-1.24
Z(t-1)	3.203	1.39	1.551	.75
KOSPI200(t-1)	.419	3.19***	.594	5.00***
KOSPI200(t-2)	.229	1.68*	.211	1.71*
KOSPI200(t-3)	.132	.99	.105	.87
KOSPI(t-1)	-.041	-.28	-.260	-2.00**
KOSPI(t-2)	-.162	-1.10	-.137	-1.03
KOSPI(t-3)	-.254	-1.78*	-.209	-1.61
d_{SB}	.067	1.66*	.074	2.04**
d_O	.318	8.17***	.324	9.22***
$VOLUME_{KOSPI200}$	.023	1.41	.021	1.43
$VOLUME_{KOSPI}$	.001	.07	-.003	-.22

(Wald test)

KOSPI200 on KOSPI200	11.98(.01)
KOSPI200 on KOSPI	26.20(.00)
KOSPI on KOSPI	6.68(.08)
KOSPI on KOSPI200	3.73(.29)

(2)Return Innovations

Dep. Var.	**KOSPI 200** Coefficient	t-value	**KOSPI** Coefficient	t-value
constant	-.264	-1.29	-.241	-1.30
Z(t-1)	2.409	1.08	1.447	.71
KOSPI200(t-1)	.102	.81	.694	6.07***
KOSPI200(t-2)	.128	.90	.509	3.92***
KOSPI200(t-3)	.164	1.26	.265	2.24**
KOSPI(t-1)	-.124	-.90	-.730	-5.81***
KOSPI(t-2)	-.173	-1.13	-.535	-3.87***
KOSPI(t-3)	-.143	-1.06	-.240	-1.95*
$VOLUME_{KOSPI200}$	.015	.97	.016	1.11
$VOLUME_{KOSPI}$	.004	.34	.002	.18

(Wald test)

KOSPI200 on KOSPI200	1.78(.62)
KOSPI200 on KOSPI	37.76(.00)
KOSPI on KOSPI	34.74(.00)
KOSPI on KOSPI200	1.70(.64)

[a] The Wald test statistic is based on the following formula :
χ^2 (m) ~ [SSE(reduced) - SSE(full)]/ MSE (full) ,
SSE(reduced) = sum of squares of errors under restricted model ,
SSE(full)= sum of squares of errors under full model, m= number of restricted coefficients
The raw value is Wald test statistic value ,and the value in parenthesis is its p value.
*,**,*** indicate significance level at 10%,5%,1% level respectively.

Table 3-14. A Measure of the Degree of Stock Market Co-Movement[a]

	Mean	Median
June contract period	.293	.308
September contract period	.279	.258
December contract period	.256	.269
Total contract periods	.279	.269

[a] The extent of stock market co-movement is measured by $| N_u - N_d | / (N_u + N_d + N_z)$, where N_u, N_d, and N_z are the number of stocks moving upward, moving downward, and with no change.This ratio measures the net proportion of stocks moving together. The ratio takes on value between 0 (the number of stocks moving upward is equal to that of stocks moving downward) to 1 (all stocks are moving in the same direction). The higher its value is, the more stocks are moving together.

Table 3-15. Lead and Lag Relationship in Volatility between Stock Indexes and Futures using OLS.

1.June Contract

Dep. Var.	KOSPI 200		Futures	
	Coefficient	t-value	Coefficient	t-value
constant	-.244	-1.62	-.014	-.10
KOSPI200(t-1)	.231	6.16***	.084	2.28**
KOSPI200(t-2)			-.026	-.69
KOSPI200(t-3)			.022	.62
Futures(t-1)	.112	2.63***	.005	.13
Futures(t-2)			.021	.51
Futures(t-3)			.058	1.44
d_{SB}	.024	.83	.010	.40
d_O	.263	9.67***	.157	6.08***
$VOLUME_{KOSPI200}$	.011	.93	-.006	-.53
$VOLUME_{futures}$	.039	3.73***	.045	4.46***
	R^2= .24		R^2= .12	
	AIC= -3.83		AIC=-3.94	
	DW= 2.02		DW= 1.99	

(Wald test)

Futures on Futures	2.31(.51)
Futures on KOSPI200	6.92(.01)
KOSPI200 on KOSPI200	38.01(.00)
KOSPI200 on Futures	5.71(.13)

Dep. Var.	Futures		KOSPI	
	Coefficient	t-value	Coefficient	t-value
constant	-.026	-.22	-.393	-3.46***
Futures(t-1)	-.005	-.11	.092	2.32**
Futures(t-2)	.022	.54		
Futures(t-3)	.062	1.54		
KOSPI(t-1)	.102	2.68***	.257	7.14***
KOSPI(t-2)	-.034	-.87		
KOSPI(t-3)	.016	.44		
d_{SB}	.013	.47	.014	.51
d_O	.162	6.23***	.319	12.49***
$VOLUME_{Future}$	.046	4.35***	.031	2.97***
$VOLUME_{KOSPI}$	-.005	-.54	.024	2.68***
	R^2= .12		R^2= .31	
	AIC= -3.94		AIC=-3.98	
	DW= 1.99		DW= 1.98	

(Wald test)

Futures on Futures	2.61(.46)
Futures on KOSPI	5.38(.02)
KOSPI on KOSPI	51.03(.00)
KOSPI on Futures	7.61(.05)

Table 3-15. Continued (Volatility)

Dep. Var.	KOSPI 200		KOSPI	
	Coefficient	t-value	Coefficient	t-value
constant	-.346	-2.00**	-.484	-3.05***
KOSPI200(t-1)	.275	3.32***	.145	1.92
KOSPI200(t-2)	.032	.38		
KOSPI200(t-3)	-.013	-.16		
KOSPI(t-1)	.018	.21	.167	2.14**
KOSPI(t-2)	-.062	-.73		
KOSPI(t-3)	.091	1.08		
d_{SB}	.023	.78	.013	.50
d_O	.278	10.12***	.330	13.03***
$VOLUME_{KOSPI200}$	.016	1.33	.011	.96
$VOLUME_{KOSPI}$	.016	1.66*	.031	3.51***
	R^2= .22		R^2= .30	
	AIC= -3.80		AIC=-3.96	
	DW= 2.04		DW= 2.01	
(Wald test)				
KOSPI200 on KOSPI200	11.75(.01)			
KOSPI200 on KOSPI	3.67(.06)			
KOSPI on KOSPI	4.60(.03)			
KOSPI on KOSPI200	1.59(.66)			

[a] Volatility is measured by absolute value of residuals from ARMA model, multiplied by $\sqrt{(\pi/2)}$, following Schwert's method (1989,1990). The order of lagged terms are determined by Akaike Information Criteria.

*,**,*** indicates 10%, 5%,1% significance level respectively.

Table 3-15. Continued (Volatility)

2.September Contract

Dep. Var.	**KOSPI 200**		**Futures**	
	Coefficient	**t-value**	**Coefficient**	**t-value**
constant	-.597	-5.33***	-.861	-5.53***
KOSPI200(t-1)	.246	9.92***	-.015	-.44
KOSPI200(t-2)	-.032	-1.24	-.026	-.73
KOSPI200(t-3)	.093	3.75***	-.028	-.77
KOSPI200(t-4)			-.075	-2.10**
KOSPI200(t-5)			-.004	-.12
KOSPI200(t-6)			.019	.55
Futures(t-1)	.029	1.61	.176	6.92***
Futures(t-2)	-.009	-.47	.040	1.56
Futures(t-3)	.006	.33	.126	4.89***
Futures(t-4)			.059	2.31**
Futures(t-5)			.044	1.73*
Futures(t-6)			.061	2.39**
d_{SB}	-.016	-.86	-.042	-1.63
d_O	.197	11.20***	.187	7.67***
$VOLUME_{KOSPI200}$	.037	4.23***	.049	4.05***
$VOLUME_{futures}$	.044	6.28***	.075	7.76***
	R^2= .22		R^2= .22	
	AIC= -3.90		AIC=-3.25	
	DW= 1.97		DW= 1.96	

(Wald test)

Futures on Futures	160.81(.00)
Futures on KOSPI200	2.85(.42)
KOSPI200 on KOSPI200	117.39(.00)
KOSPI200 on Futures	8.69(.19)

Dep. Var.	**Futures**		**KOSPI**	
	Coefficient	**t-value**	**Coefficient**	**t-value**
constant	-.534	-4.36***	-.493	-6.16***
Futures(t-1)	.197	7.52***	.043	2.53**
Futures(t-2)	.053	2.00**	-.000	-.01
Futures(t-3)	.128	4.82***	.024	1.44
Futures(t-4)	.073	2.75***		
Futures(t-5)	.052	1.98**		
Futures(t-6)	.053	2.01**		
KOSPI(t-1)	-.052	-1.38	.189	7.61***
KOSPI(t-2)	-.031	-.82	-.000	-.01
KOSPI(t-3)	-.022	-.58	.056	2.28**
KOSPI(t-4)	-.103	-2.69***		
KOSPI(t-5)	-.022	-.57		
KOSPI(t-6)	.046	1.22		
d_{SB}	-.041	-1.56	-.021	-1.22
d_O	.179	7.19***	.230	14.11***

Table 3-15. Continued (Volatility)

$VOLUME_{Future}$	.074	7.45***	.041	6.30***
$VOLUME_{KOSPI}$	.022	2.39**	.028	4.56***
	R^2= .22		R^2= .25	
	AIC= -3.25		AIC=-4.09	
	DW= 1.96		DW= 1.99	
(Wald test)				
Futures on Futures	181.64(.00)			
Futures on KOSPI	10.26(.02)			
KOSPI on KOSPI	67.20(.00)			
KOSPI on Futures	14.76(.02)			

Dep. Var.	KOSPI 200		KOSPI	
	Coefficient	t-value	Coefficient	t-value
constant	-.730	-5.07***	-.970	-7.48***
KOSPI200(t-1)	.293	6.81***	.162	4.19***
KOSPI200(t-2)	-.017	-.38	-.040	-1.01
KOSPI200(t-3)	.106	2.46**	.069	1.78*
KOSPI(t-1)	-.020	-.42	.081	1.94*
KOSPI(t-2)	-.015	-.32	.030	.73
KOSPI(t-3)	.010	.22	.027	.66
d_{SB}	-.007	-.36	-.019	-1.10
d_O	.214	11.99***	.240	14.94***
$VOLUME_{KOSPI200}$	.046	5.16***	.042	5.34***
$VOLUME_{KOSPI}$	.017	2.55**	.037	6.29***
	R^2= .20		R^2= .25	
	AIC= -3.88		AIC=-4.09	
	DW= 1.98		DW= 2.00	
(Wald test)				
KOSPI200 on KOSPI200	54.54(.00)			
KOSPI200 on KOSPI	21.15(.00)			
KOSPI on KOSPI	.33(.95)			
KOSPI on KOSPI200	5.18(.16)			

[a] Volatility is measured by absolute value of residuals from ARMA model, multiplied by $\sqrt{(\pi/2)}$, following Schwert's method (1989,1990). The order of lagged terms are determined by Akaike Information Criteria.

*,**,*** indicates 10%, 5%,1% significance level respectively.

Table 3-15. Continued (Volatility)

3.December Contract

Dep. Var.	KOSPI 200		Futures	
	Coefficient	t-value	Coefficient	t-value
constant	-.184	-1.24	-.763	-3.35***
KOSPI200(t-1)	.140	3.04***	.037	.53
Futures(t-1)	.008	.26	-.027	-.56
d_{SB}	-.003	-.09	.005	.11
d_O	.337	11.41***	.312	6.88***
$VOLUME_{KOSPI200}$	.006	.58	.027	1.64
$VOLUME_{futures}$	.043	3.27***	.125	6.13***
	R^2= .28		R^2= .22	
	AIC= -4.07		AIC=-3.21	
	DW= 2.09		DW= 1.97	

(Wald test)

Futures on Futures	.32(.57)
Futures on KOSPI200	.07(.79)
KOSPI200 on KOSPI200	9.28(.00)
KOSPI200 on Futures	.28(.60)

Dep. Var.	Futures		KOSPI	
	Coefficient	t-value	Coefficient	t-value
constant	-.586	-2.87***	-.282	-2.37**
Futures(t-1)	-.021	-.44	-.034	-1.21
KOSPI(t-1)	.039	.54	.207	4.84***
d_{SB}	.009	.19	-.012	-.43
d_O	.318	6.94***	.378	14.10***
$VOLUME_{Futures}$	.124	5.99***	.039	3.24
$VOLUME_{KOSPI}$	.013	.90	.013	1.63
	R^2= .21		R^2= .38	
	AIC= -3.21		AIC=-4.28	
	DW= 1.96		DW= 2.05	

(Wald test)

Futures on Futures	.20(.66)
Futures on KOSPI	1.47(.25)
KOSPI on KOSPI	23.39(.00)
KOSPI on Futures	.29(.59)

Table 3-15. Continued (Volatility)

Dep. Var.	KOSPI 200		KOSPI	
	Coefficient	t-value	Coefficient	t-value
constant	-.047	-.30	-.148	-1.06
KOSPI200(t-1)	.027	.35	-.068	-.98
KOSPI200(t-2)			-.026	-.37
KOSPI(t-1)	.158	1.98**	.239	3.30***
KOSPI(t-2)			.098	1.36
d_{SB}	.027	.92	.020	.74
d_O	.370	12.86***	.409	15.74***
$VOLUME_{KOSPI200}$	.004	.32	.000	.06
$VOLUME_{KOSPI}$	.008	.75	.016	1.77*
	R^2= .28		R^2= .37	
	AIC= -4.06		AIC=-4.26	
	DW= 2.04		DW= 2.01	
(Wald test)				
KOSPI200 on KOSPI200	.12(.73)			
KOSPI200 on KOSPI	1.17(.56)			
KOSPI on KOSPI	13.65(.00)			
KOSPI on KOSPI200	3.90(.05)			

[a] Volatility is measured by absolute value of residuals from ARMA model, multiplied by $\sqrt{(\pi/2)}$, following Schwert's method (1989,1990). The order of lagged terms are determined by Akaike Information Criteria.

*,**,*** indicates 10%, 5%,1% significance level respectively.

CHAPTER IV

COMPARISON OF VOLATILITIES BETWEEN CASH AND FUTURES

4-1. Literature Review

Wood, McInish and Ord (1985), Harris (1986), Lockwood and Linn (1990) examine the volatility features of intraday stock returns and find that the market volatility is high near the open and close of the trading day, forming the U shape curvature. Finnerty and Park (1988), Chan, Chan, Karolyi (1991), Ekman (1992), Lee and Linn (1994) and Daigler (1997) similarly report that stock index futures market also reveals such U shaped intraday volatility feature. For explanations to this observed patterns of intraday volatility, Kyle (1985) and Admati and Pfleiderer (1988) suggest that the U shaped volatility patterns result from interaction between informed traders and (uninformed) liquidity traders, and concentration of trading by them over the specific time interval within trading hours. Liquidity traders prefer to trade when the market is thick and thus their trading has little effect on prices, because they want to minimize adverse selection costs. Informed traders also prefer to trade when there is more noise trading by liquidity demands since they can effectively hide their private information and maximize their profit by increasing its informativeness. Therefore, all strategic traders choose to trade at the same time.[46] They argue that non-discretionary

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[46] Unlike Kyle (1985), Admati and Pfleiderer (1988) differentiate the types of traders by liquidity demands. In their model, non discretionary liquidity traders are traders who must trade a particular number of shares at particular time. Discretionary liquidity traders are traders who also have liquidity demands but who can be strategic in choosing when to execute these trades within a given period of time to minimize the expected cost of their transaction.

liquidity demands increase before and after the exchange is closed since it is difficult or impossible to trade during that period of time. This in turn induces both discretionary liquidity trading and informed trading to increase at the open and close. Brock and Kleidon (1992) insist that the U shaped volatility pattern is a result of the impact of market closure (non-trading hours) on trading preference. They suggest that liquidity demands traders rebalance their portfolio before and after market closure and this increased liquidity demands create larger bid-ask spread at the open and close. Market makers have more monopoly power in setting up the price and tend to increase bid-ask spread when liquidity demand is the highest. This results is the U shaped patterns in volatility and volume. Daigler (1997) insists that the U shaped pattern is ubiquitous across the markets so that it is not associated with one type of market making system or system of determining opening prices.

French and Roll (1986) document that market volatility is also greater during trading hours than during nontrading periods. They argue that most of return volatility is caused by private information and that this information only affects prices through the trading of the informed investors. Stoll and Whaley (1990b) also document that the variance of day time returns is about five times larger than the overnight returns in NYSE common stocks. Similarly, Lee and Linn (1994) report that intraday return volatility exceeds overnight return volatility for both futures return and spot return. In addition, Stoll and Whaley (1990b) find that the open to open returns has been systematically greater than the close to close returns.[47]

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[47] They insist that the information hypothesis can not explain the difference in volatility between the close to close and the open to open returns since they have the same time span. Rather, they maintain that specialists have greater monopoly power at the open than at other times of the day in establishing price at which order imbalances by informed traders and liquidity traders are serviced. Therefore, they try to extract a premium for their

Regarding the volatility comparison between stock and futures markets, Chu and Bubnys (1990) report that spot market volatilities for both S&P 500 and NYSE indexes are found to be less than their respective futures price volatilities, concluding that information may flow faster in the futures markets than in the corresponding stock market, which is consistent with Ross's (1989) information-volatility hypothesis.[48] Kawaller, Koch and Koch (1990) find that the mean futures volatility typically exceeds the comparable mean index volatility by five to ten times. They attribute this inertia in index prices relative to futures price to the infrequent trading of index stocks, and to the fact that bid-ask bounce is more salient in futures price than spot index because bid-ask bounce effects tend to be averaged out in cash index price.

The impact of market microstructure effects on volatilities of spot market index or futures price changes is well reported in the literatures. MacKinlay and Ramaswamy (1988) and Miller, Muthuswamy and Whaley (1994) show that spot index returns display significantly positive autocorrelation due to effects of infrequent trading while the autocorrelations of the futures returns are close to zero. Fleming (1994, p.p.33) comments about this asynchronous trading effect as follows: "The effect of infrequent trading[49] is to effectively smooth the

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services by setting prices that vary more than the normal bid-ask spread.

[48] He argues that in an arbitrage free economy, the volatility of prices is directly related to the rate of information flow to the market.

[49] According to Miller, Muthuswamy and Whaley (1994), infrequent trading is divided into non-trading and asynchronous trading. Non-trading means that not every security in the index portfolio trades at the end of price change measurement interval. Asynchronous trading indicates that all securities in the index portfolio trade at least once during each interval but not necessarily at the endpoint. If a stock does not trade at the interval's endpoint, the observed stock price change in a particular period is attributable not only to true price change innovation in that period but also to true price change innovation in the previous period.

observed (spot) index level. Stocks tend to move together but when the market moves up and not all of the stocks in the index have traded, the observed spot index fails to reach the true height of the market. Similarly, when the market falls, the observed index does not reach the true low. These tendencies provide the usual consequence of autocorrelated returns and, in general reduce the variability of the observed (spot) index." He finds the negative relationship between trading volume and the size of the first order autocorrelation in the S&P 500 index returns, and the negative relationship between the extent to which futures volatility exceeds spot index volatility and the size of the first order autocorrelation in the index returns, supporting his argument. Fleming (1994) also adds that the comparison of close to close return volatilities allows a more accurate assessment for true volatility measure between futures and spot index, because the opening spot index is stale and accordingly, the overnight (close to open) index return is misleadingly biased to zero.

Lo and MacKinlay (1988) insist that if stock prices are generated by random walks, the variance of stock returns (log price relatives) increases linearly with the sampling interval.[50] However, variance estimates should be equal regardless of observation intervals (or intervals aggregated for calculation of variance) once variance estimates are normalized. They argue that the ratio of variances computed with aggregation value q relative to those with aggregation value 1 (first differences) is asymptotically normal-distributed and that this variance ratio statistic is approximately linear combination of the first q-1 autocorrelation coefficient estimators of the first differences. This means that if autocorrelations at each lag

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[50] That is, the variance of monthly sampled log price relatives must be 4 times as large as the variance of a weekly sample.

are large and positive, then the variance aggregated for longer intervals is higher than that aggregated over shorter intervals or vice versa. In empirical tests, they find that variances of stock returns tend to increase with the observation intervals aggregated for calculation of variances, which is an evidence against random walk process. They also observe that when variance ratios are compared over different intervals with different aggregation values, evidence against random walks for equally weighted index return (small sized stocks) is stronger than for value weighted index return (large sized stocks) since infrequent trading induces spurious positive correlation in stock returns and effectively dampens the volatility of stock returns over short intervals for equally weighted index or portfolios of small sized stocks.[51] In the similar vein, Chu and Bubnys (1990) report that the volatility of NYSE index including smaller stocks is lower than the S&P 500 index volatility. Board and Sutcliffe (1995) also support their findings in that extra futures volatility over the FT-SE 100 index return are found to decrease with the length of measurement interval (input frequency). As MacKinlay and Ramaswamy (1988) insist that the problem of non-synchronous data in the index series is mitigated by employing longer measurement interval, they find that futures return volatility is greater than the corresponding spot volatility by 82% in hourly returns while volatility for futures is greater than that for spot index by 18% in weekly return.

Alternatively, Roll (1984) insists that the bid-ask bounce induces the negative first order autocorrelation in observed price change of an individual stock. Lo and MacKinlay (1988) find that unlike stock index returns or returns on portfolio, the first order

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[51]They estimated that the 1st order autocorrelation for a portfolio of small sized NYSE-AMEX stocks is .42 while that for largest stocks is mere .14.

autocorrelation of an individual stock return is small, but negative regardless of aggregation intervals. Miller, Muthuswamy and Whaley (1994) maintain that the bid-ask bounce shows up more strongly in futures return than spot return, because the spot index is an average of prices across stocks at given point in time and the trading by some stocks traded most recently at bid prices is offset by other stocks trading most recently at ask levels while futures contract is a single traded security. They add that positive first order autocorrelation in the observed spot index return may underestimate the true volatility for spot index return while negative first order autocorrelation in futures return may possibly overestimate the true volatility for futures return.[52] However, they observe that the effect of bid-ask spread in

[52] The model which accounts for infrequent trading in the spot index level can be expressed by 1st order autoregressive (AR(1)) process as follows.

$$S_t^o = \phi S_{t-1}^o + (1 - \phi)S_t$$

where S_t = the true index level change , S_t^o = the observed index level change
ϕ = the degree of trading infrequency or 1st order autocorrelation ($0 \leq \phi \leq 1$)
According to this model, the variance of observed changes in the stock index level is,

$$\sigma_{S^o}^2 = \left(\frac{1 - \phi}{1 + \phi} \right) \sigma_s^2$$

On the other hand, the model which accounts for bid-ask bounce in futures price can be expressed by 1st order moving average (MA(1)) process as follows.

$$F_t^o = F_t + \theta F_{t-1}$$

where F_t = true futures price change , F_t^o = the observed futures price change
θ = the bid-ask bounce parameter or 1st order autocorrelation in futures price change ($-1 < \theta < 0$)
According to this model, the variance of observed changes in futures price is,

futures price changes is trivial and can be ignored in the empirical test. Similarly, Harris, Sofianos and Shapiro (1994) record that variance of one minute (five minute) futures return is 4.6 (1.9) times larger than that of index return for S&P 500 index . Moreover, they also find that ratios of five minute return variances to one minute return variances are 12.5 for S&P 500 index and 5 for its corresponding nearby futures contract, confirming that futures returns are largely uncorrelated while S&P 500 index returns are positively correlated. They argue that futures market seems to discover index values faster than the cash index market since the absence of significant negative correlation in the futures returns suggests that futures' high volatility is not due to short-term liquidity problems, i.e., bid-ask bounce.

Previous studies suggest that smoothing effects from infrequent trading or bid-ask bounce are not sources of fundamental volatility, but either a statistical illusion (Miller,et al. 1994) or an artifact of the process by which liquidity demands are routinely satisfied (Harris, et al.1994). Therefore, before any comparison is made regarding the volatilities between futures price and corresponding spot index, these spurious microstructural effects are sifted out from fundamental volatilities by pre-whitening procedures and residual volatilities between two assets should be compared to determine whether futures market really adjust

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$$\sigma^2_{F^o} = (1 + \theta^2)\sigma^2_F$$

faster than spot market to the new information in the market.

Even though problems of infrequent trading are not explicitly accounted for, Brenner, Subrahmanyam and Uno (1989,1990) observe in the Japanese market, futures market are more volatile than respective stock market in the early introduction period (September 1986 to June 1988), but in the later periods (December 1988 to September 1989), the volatilities of the futures contracts are lower than the volatility of the underlying index. Using five minute transaction data, Lim (1992) reports no apparent positive or negative autocorrelation in either returns of Nikkei average futures contract or respective cash index, concluding that staleness of spot prices is not a significant problem beyond five minutes and that Nikkei spot market is at least weakly efficient with respect to information on futures prices at SIMEX. Over his sample period (1988.6-9), he also observes that there are considerably many trading days when futures price is less volatile.

As for the U.K. futures market (FTSE-100 futures contract), Yadav and Pope (1990) report that average intraday volatility of price changes (based upon daily high and low prices) in the futures market is significantly higher than in the cash market.They also document, even though less apparent, that interday volatility based upon open to open or close to close price changes is higher for futures market than for cash market.

In addition to the microstructural effect explanation for extra volatility of futures contract over spot index, Chan, Chan and Karolyi (1991) suggest that bilateral volatility spillover between futures and cash index or between futures and individual stocks are not likely driven only by such microstructural effect as infrequent trading. They argue that if the index futures market plays a greater role in reflecting the market-wide information, the volatility of index futures returns are expected to be greater than volatility in the stock market when the markets are driven by that information. Kawaller, Koch and Koch (1990) also indicate that futures price may be more speedy in reflecting information and thus more volatile than spot index, because market participants can take position in index futures quickly with low transaction costs when new information becomes available.

With respect to the expiration date effect on the stock market volatility, Stoll and Whaley (1987) report that the volatility of S&P 500 index is significantly high with the stock market tending to fall along with increase in volume when index futures and index options expire together. However, they also report that when only index futures expires[53], volatility of the stock market does not increase abnormally compared to those on the non-expiration days. Moreover, they present evidence that volatility increase on the expiration day is associated only with stocks included in the S&P 500 index, not with stocks that are not part of the stock index since unwinding of arbitrage position at expiration affects only those stocks in the S&P 500 index. They also find that the expiration effect on the stock market is concentrated during a very short period of time, within the last three hours or sometimes last 15 minutes of trading. Similarly, Edwards (1988) reports that volatility shock on spot index

[53] Prior to June 15, 1984, the last trading day for S&P 500 index futures contract was the third Thursday of the delivery month and the last marking to market was based on the last spot S&P 500 index value on that day. From June 15,1984 until March 20,1987, the last trading day was the third Friday of the delivery month. For this period, the effect of triple witching hours (stock index futures, stock index option and individual stock option expire on the same day)on abrupt stock market volatility emerged as a great concern for market regulators.Therefore, the CME changed the final settlement procedures for its S&P 500 futures contract such that trading of futures contract ceases at the close on Thursday and all open positions are marked to market for the last time based on a special opening quotation for the S&P 500 index on the third Friday of the delivery month.

on the expiration dates is short-lived and confined only to the last trading hours. Consistent with Stoll and Whaely (1987), he also finds no excess volatility in spot market when only index option expires. In addition, using the same S&P 500 index futures, Bessembinder and Seguin (1992) find no evidence of a relation between the future life cycle and spot equity volatility. They report that S&P 500 index volatility on futures expiration days is on average, .14% higher than on typical days, but this difference is statistically insignificant and conclude that the expiration of the nearest index futures contract has no expiratory power for S&P spot index volatility. In contrast, Kawaller, Koch and Koch (1990) find negative relationship between S&P 500 index and time to maturity over 1985-86 period while futures volatility displays no systematic trend along the life cycle. In the Japanese market, Bacha and Vila (1994) document that futures expiration days does not cause any higher cash market volatility than ordinary non expiration days. In the Australian market, Gannon (1994) documents reduced futures volatility near expiration of the futures contract (last five days), but the spot index does not show any extraordinary volatility fluctuation on the expiration date.

4-2. Methodology

4-2-1. Equality of Volatilities between Cash and Futures Under Efficient Market

In the world of deterministic and frictionless capital market, the cost of carry relationship dictates the equilibrium prices for futures and spot as follows.

$$F_t = S_t \exp^{[\frac{(T-t)(r-d)}{365}]} \qquad \text{-------------------(4-1)}$$

where F_t = current futures price at time t

S_t = current spot price at time t

T = expiration date

t = current date

r = annualized interest rate (non stochastic)

d = annualized dividend yield (non stochastic)

If we take the natural logarithm for both sides of equation, then we get

$$\ln^{F_t} = \ln^{S_t} + [\frac{(T - t)(r - d)}{365}] \quad \text{------------------(4-2)}$$

Let $R_{ft} = \ln[F_t / F_{t-1}]$ and $R_{st} = \ln[S_t / S_{t-1}]$ be continuous compounding futures return and spot return respectively. Then we have

$$R_{ft} = R_{st} + (r - d)/365 \quad \text{--------------------------(4-3)}$$

and accordingly

$$Var(R_{ft}) = Var(R_{st}) \quad \text{----------------------------(4-4)}$$

$$(\because Var[(r - d)/365] = 0, Cov[R_{st}, (r-d)/365] = 0)$$

This means that the return volatility for the futures contract equals the return volatility for the spot index when we assume that capital markets are frictionless and deterministic.

4-2-2. Measurement of Price Volatilities Using Historical Data

First, we investigate price volatilities for cash and futures markets using historical daily price data. The classical estimator of price volatility employs only the closing price from each holding period.[54] Parkinson (1980) develops the extreme value method for estimating return volatility using the high and low prices and insists that his method generates at least five times more efficient volatility estimator than the classical method. Based upon the historical opening, high, low and closing price data, Garman and Klass (1980) further extend Parkinson's (1980) method and elaborate at least seven times more efficient volatility estimator than that relied upon the only daily closing data. Although both Parkinson and Garman-Klass' volatility estimators are likely to be downward biased for stocks with low trading volumes, Wiggins (1992) documents that these estimators are only slightly downward biased and are significantly more efficient than the close to close estimator for assets with high trading volumes such as S&P 500 futures. Since estimators incorporating more information about stock price change over an interval are found to be more efficient than those using less information, we first compare the price volatility between cash and futures markets using Garman and Klass' (1980) volatility estimation method.

Garman and Klass volatility estimator (hereinafter G-K estimator) can be measured in two ways and calculated by the following formulas :

[54] The classical volatility estimator can be measured as square of natural logarithm of the closing price ratio over two periods.

$$\hat{\sigma}^2_{GK\,1} = 0.511(\,u - d\,)^2 - 0.019[\,c(u + d) - 2ud\,] - 0.383c^2 \text{------}(4\text{-}5)$$

$$\hat{\sigma}^2_{GK\,2} = 0.12\,\frac{\ln\,(O_1\,/\,C_0)^2}{f} + 0.88\,\frac{\hat{\sigma}^2_{GK\,1}}{(\,1 - f\,)} \text{------}(4\text{-}6)$$

where C_0 = previous closing price.

O_1 = today's opening price.

u = natural logarithm of the ratio of today's high to today's opening price.

d = natural logarithm of the ratio of today's low to today's opening price.

c = natural logarithm of the ratio of today's closing to today's opening price.

f = fraction of non-trading hours in a single day when the time from yesterday's market close to the today's market close is assumed to be one.

In Korean market, $f \approx .7708$.

The first measure (σ^2_{GK1}) assumes that trading is made continuously around the clock and the second one (σ^2_{GK2}) accounts for the existence of non-trading hours, and hence takes into account the fact that the today's opening price may differ from the previous closing price.

4-2-3.Tests for the Homogeneity of Variances

The statistical power of usual F test which compares the sample variances of two groups ($F = S_1^2\,/\,S_2^2$) relies on the assumption that the underlying populations are from Gaussian normal distribution. That is, when the underlying distribution are non-normal, F test loses its power. Since we already know that the return distributions of futures and spot index take on non-normal distribution, we have to apply other statistical tests to our sample that are robust to non-normality. Brown-Forsythe's (1974) modified Levene test is one of those that is used to test for the homogeneity of variances between two samples and robust to the departures from normality.[55]

Suppose we have i groups (i = 1,2,....g) and j observations (j = 1,2,......,N_i) for each i group and sample values (X_{ij}) can be expressed as sum of the population mean (μ) for each group and error term (ϵ_{ij}), that is, $X_{ij} = \mu_i + \epsilon_{ij}$. The means μ_i are neither known nor assumed equal and the ϵ_{ij} are independent and similarly distributed with zero mean and possibly unequal variances. Then Brown-Forsythe's (1974) modified Levene test statistic[56] is as follows :

$$W = \frac{\sum_{i=1}^{g} N_i (\bar{Z}_{i.} - \bar{Z}_{..})^2 / (g - 1)}{\sum_{i=1}^{g} \sum_{j=1}^{N_i} (Z_{ij} - \bar{Z}_{i.})^2 / \sum_{i=1}^{g} (N_i - 1)} \sim F_{g-1, \sum_{i=1}^{g} (N_i - 1)} \quad ----(4-7)$$

$$Z_{ij} = | X_{ij} - \tilde{X}_i | \text{ where } \tilde{X}_i \text{ is median of i group, } \bar{Z}_{i.} = \frac{\sum_{j=1}^{N_i} Z_{ij}}{N_i}, \ \bar{Z}_{..} = \frac{\sum_{j=1}^{g} \sum_{j=1}^{N_i} Z_{ij}}{\sum_{i=1}^{g} N_i}$$

[55] Brown-Forsythe modified Levene test (1974) is used widely in empirical finance research such as Lockwood and Linn (1990), Lee and Linn (1994), Chang, Jain and Locke (1995) and Crain and Lee (1996).

[56] Levene test (1960) uses the sample mean for each group instead of the median in Brown-Forsythe's modification in calculating Z_{ij} statistic.

With the null hypothesis of equal variances among groups, W statistic is compared with the critical value of F distribution with degree of freedom of (g-1)for numerator and (Σ [N_i - 1]) for denominator. In our study, the number of groups becomes two (g =2) for futures and spot index and the number of observations (N_i) for each group becomes 2715 for 10 minute intraday returns, 132 for volatilities of open to open, close to close, close to open, 112 for open to close[57], noon to close (more precisely speaking, from the beginning of afternoon session to its close) returns and session break returns and 135 for volatilities of open to noon (more precisely from open to the end of the morning session) returns.

4-3. Empirical Results Concerning Comparison of Volatilities between Cash and Futures Market

4-3-1. Intraday Patterns of Volatilities

As is shown in Table 4-1 and Chart 4-1, The intraday volatility pattern of the Korean stock market (including index futures market) shows a similar U curvature when the standard deviation of the 10 minute returns is used as volatility measure just as documented in other country markets. The U type pattern is more conspicuous in the spot markets than in index futures market. Index futures show more fluctuation during the trading hours than the spot market. For both futures and spot markets, the 10 minute returns tend to rise around the end of the morning session as well as near the end of the afternoon session. Therefore, the Korean stock market displays double U curvatures over the whole trading hours, one in the morning

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[57] There is only a morning session on Saturday and the open to close returns on Saturday are included in the open to noon returns in our study.

session and the other in the afternoon session. Daigler (1997) reports the similar double U shapes of intraday volatility structure in Treasury bond futures trading. In Table 4-2, volatilities in the stock and futures markets are compared according to the time intervals. Consistent with previous studies in other countries' markets, the overnight returns during non-trading hours shows less volatility than day time returns (open to close) during trading hours. Almost similar to the studies in the U.S. market by Stoll and Whaley (1990b), the volatility (variance) of trading hour returns is about 4-6 times larger than that of non-trading hour return in the Korean securities market. As the theory dictates, the positive autocorrelation resulting from asynchronous trading in the stock index seems to dampen the volatilities in the spot index, making futures more volatile than KOSPI 200, and subsequently KOSPI 200's volatility greater than that for KOSPI. Also consistent with Stoll and Whaley study (1990b), the variance of open to open returns is greater by 30 - 40 % than that of close to close returns, whose difference is somewhat larger than the case in the U.S.[58] In panel 3 of Table 4-2, standard deviation of session break return is almost as much as that of 10 minute intraday returns during trading hours. Since the time span for session break returns is 9 times longer than that for 10 minute returns, this result also supports that volatility in non trading hours is lower than the comparable volatility in trading hours.

In Table 4-3, the first autocorrelation coefficients of returns for various time horizons are presented to examine to what extent return reversal tend to take place for each of the

[58] Stoll and Whaley (1990b) report the variance of open to open returns on NYSE common stocks is 13% greater than that of close to close returns. They argue that the greater volatility of open to open returns reflects the specialist's implied cost of supplying immediacy upon price pressure by traders at the open.

return series. Stoll and Whaley (1990b) report that serial correlation in open to open returns is more consistently negative and larger in magnitude than close to close returns, suggesting that open to open returns are more likely to be reversed and accordingly, more volatile than close to close return. Over the June contract period, 1st order autocorrelation of both open to open and close to close returns are negative, but the magnitude is larger for open to open than close to close returns. For September contract periods, the autocorrelations are almost close to zero for open to open returns except for futures with negative autocorrelation and significantly positive for all close to close returns. Over the December contract periods, open to open returns show positive autocorrelation and close to close returns display close to zero serial correlation. Therefore, daily open to open return tend to reverse itself more frequently (leading to higher volatility) than the corresponding close to close return until September contract period, but over December period this tendency does not hold. It is observable that futures contract returns have strong tendencies to reverse relative to its respective spot index returns across the measurement intervals. Throughout the whole sample period, daily futures returns have larger negative autocorrelation in magnitude than spot index returns during June contract period and less positive or close to zero autocorrelation than the corresponding spot index returns over the September and December contract periods. Negative autocorrelation (or mean reversal) of daily futures returns indicates that futures tend to be more volatile (fluctuate more wildly) than spot indexes. This fact in turn supports that information flows faster in the futures market than in the spot market and that futures market provides an important price discovery function to the investors.

As a whole, daily returns in the Korean stock market and index futures market have strong tendencies to reverse over the June contract periods where futures contract price moves relatively within its cost of carry boundary, but as the stock market gets depressed after September contract period, consistently negative daily market returns make the 1st order serial correlations positive. Chan and Chung (1993) document a negative relationship between mispricing of futures contract and market volatility. Consistent with their findings, market inertia results in persistence of returns rather than mean reversal. Due to lack of arbitrages, reduced volatility across the markets consequently brings about a persistent mispricing of futures contract over these two periods. In Table 4-4, correlation between daytime (open to close) returns in a previous day seems to be consistently positively correlated with overnight returns for the next day. This indicates that the market direction shown in trading hours in one day tends to persist and is not likely reversed during non trading hours. In contrast, overnight returns are more likely to be reversed during trading hours and at least not correlated with day time returns. Stoll and Whaley (1990b) observe this phenomenon in the U.S. market and this result is consistent with French and Roll's (1986) argument that information arrives more during trading hours than during non trading hours. It is also observed in Table 4-4 that correlation between overnight and daytime futures returns are on average less positive or more negative than those for the spot indexes. This also supports a strong tendency of futures price for mean reversal.

4-3-2. Comparison of Volatility using Extreme Value Method

In Table 4-5, we compare volatilities among stock indexes and futures contract using the Garman Klass (1980, hereinafter G-K) price volatility estimators. In each return series, two measures of G-K volatility estimators are presented. One assumes that trading is continuously executed and the other accounts for existence of the non-trading hours. Over the whole contract periods and by either of two measures of G-K price volatility estimators, futures contract shows the greatest volatility of three return series. KOSPI 200 displays the second largest volatility and KOSPI is the least volatile. This result is consistent with previous studies since KOSPI and KOSPI 200 tend to have positive serial correlation due to infrequent trading of component stocks or reporting lag while futures does not. In addition, infrequent trading is more severe among small sized stocks that are more included in KOSPI rather than in KOSPI 200. When volatility comparison is made between expiration day week and non-expiration day weeks, two stock indexes are slightly more volatile during the expiration day week than non-expiration day weeks but neither of them is significantly different. In contrast, futures market tends to be more tranquil in expiration day week than non-expiration day weeks. During expiration day week, futures market' volatility is even lower than those of stock indexes. Tauchen and Pitts (1983) insist that price volatility increases with the extent to which traders disagree with each other in relation to the market equilibrium price. Kyle (1985) also maintains that price volatility is determined by the amount of noise (liquidity demand) trading. He argues that the market depth is proportional to the amount of liquidity trading and inversely proportional to informed trading. These suggest that as the futures contract is about to expire, the amount of noise trading relative to information based trading tends to increase since the market is more likely driven by liquidity demand trades according to unwinding process of the existing positions. Discrepancy regarding fair futures price also tends to be converged and these effects result in reduction of volatility of futures price. In addition, slight increase in spot volatility may indicate the effect of arbitrage unwinding on spot market.

4-3-3. Test Results of Homogeneity of Variances between Cash and Futures Markets

In Table 4-6, results of standard F test and Brown-Forsythe's (1974) modified Levene F test (hereinafter B-F-L test) on homogeneity of variance are presented. Since most of returns have non-normal distribution as seen in Chapter III, the B-F-L F test can be more robust than the standard F test to examine homogeneity of variance between futures and cash market. Generally, results indicate that on average, futures returns are consistently more volatile than stock indexes, especially during trading hours. In non-trading hours, futures' volatility is not significantly greater than stock indexes, signaling that futures tend to reflect more rapidly than spot market only when new information reaches the market. Consistent with earlier studies (for example, MacKinlay and Ramaswamy 1988 ; Board and Sutcliffe 1995 ; Harris, Sofianos and Shapiro 1994), asynchronous data in the index is mitigated by employing longer measurement interval and futures'extra volatility over spot decreases with sample interval (e.g., compare standard F test ratio in 10 minute interval with those in other measurement interval).

In Table 4-7, the first order autocorrelation present in each return series is corrected by revising raw return data with AR(1) specification used in Miller, Muthuswamy and Whaley (1994). Before applying AR(1) modification, the first differenced original price series of KOSPI, KOSPI 200 and the nearby futures have significantly high positive autocorrelation amounting to .35, .36 and .12. After the first order autoregressive modification, their first order autocorrelation coefficients are reduced to less than .01 in absolute value.[59] Although we arbitrarily revise actual raw prices, results are very similar to the cases when actual raw returns are used. Futures again tend to be more volatile than stock indexes and KOSPI 200 tends to be more volatile than KOSPI.[60] Therefore, infrequent trading alone can not explain the extra volatility of futures over stock indexes. Information arrives constantly in the markets, more during trading hours than during non-trading hours, and traders in the futures market seem to respond to that information faster due to various reasons such as lower transaction and adverse selection costs.

4-3-4. Analyses of Volatility and Trading Volumes around Futures Expiration Dates

In Table 4-8, comparison is made using raw returns between volatilities in expiration week and non-expiration week. For all return series, the volatilities of non-expiration week are slightly higher than those for expiration week. Except for 10 minute intraday returns for KOSPI 200 and futures, and overnight returns for futures, however, the B-F-L test for homogeneity of variance can not reject the null hypothesis of equal variance between expiration week and non-expiration week. On average, futures tend to show less volatility in expiration week than in non-expiration week compared to the stock index. This is consistent

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[59] As Miller, Muthuswamy and Whaley (1994) put it, the AR(1) model is too simple and insufficient to get rid of all spurious positive autocorrelation embedded in stock indexes. However, an attempt to at least correct for such autocorrelation would be worthwhile.

[60] However, there is one exception in this result. For overnight returns after AR(1) modification, it turns out that volatilities for stock indexes tend to more volatile than futures. However, it is not unexpected since the standard deviation of futures is the closest to those for stock indexes in case of the close to open returns, i.e., during non-trading hours. This may be another spurious side effect the AR(1) modification might bring in.

with results obtained from G-K price volatility estimators. Generally, in the Korean market, there is no tendency for stock market volatility to rise around the expiration date, which is generally consistent with what has been documented in other countries.

Table 4-9 displays the comparison of trading volumes in the spot and futures markets, particularly changes in the volume of respective market between expiration week and non-expiration weeks. Stoll and Whaley (1987) report that NYSE stock trading volume is substantially higher than normal when index futures and index options expire on the same day. Over the period of 1984-85, they find that spot trading volume increases by 13% per week basis, 17% per daily basis and 95% in the last trading hour, suggesting that expiration effect on the spot volume is confined rather to the last trading hours. Bessembinder, Chan and Seguin (1996) document that over 1982-91 period, futures trading volumes gradually increased as expiration date approaches but on the expiration date, they are significantly reduced. On the other hand, increase in NYSE volumes is confined only to the expiration date of futures contract. They use changes in futures open interest as a proxy for changes in the dispersion of traders' belief and find that trading volumes in the both the spot and futures markets rises with increase in open interest (divergence of investors' opinions) while decrease in open interest (convergence of investors' opinion) is less associated with any discernible effect on the volumes in each market. They notice that expiration of futures contract reduces the number of open interest without triggering volume increase (on the contrary, a significant decline in futures volume) and interpret this as a result of evidence of convergence in traders' opinion.

As for trading volumes in the June contract period in Table 4-9, both spot and futures volumes in the Korean market tend to drop in the expiration week (June 10-13) relative to non-expiration weeks. On expiration date (June 13), both trading volumes in futures and spot market decrease by 59% and 39% respectively. Over the September contract period, there is little difference in both futures and spot trading volumes in between expiration week and non-expiration weeks. Due to the depressed market condition, significant drop in spot trading volume is observed. On the expiration date of September contract (September 12), volume in futures contract is significantly reduced (- 41%) while spot volume increases by 13.8%. Reduced trading volumes in futures contract around the expiration dates are consistent with reduced volatility of futures contract around the expiration date. They are also generally consistent with Bessembinder, Chan and Seguin's (1996) convergence of traders' opinion hypothesis. Absence of systematic increase in spot trading volumes around the expiration dates of futures contract is also consistent with a result that spot index does not show any extreme volatility around the expiration dates. MacKinlay and Ramaswamy (1988), Merrick (1989),Yadav and Pope (1990) insist that early unwinding or rolling over makes expiration day effect unlikely. Merrick (1989) argue that simple net mispricing days rule[61] has a poor prediction ability to forecast cash index price changes on the expiration date because arbitrageurs' early closing out or rolling over existing futures contracts mitigates unwinding force on the expiration date. He reports that about 57% of expiration dates in the sample

[61] Simple net mispricing rule of thumb asserts that a contract which has been underpriced (overpriced) more days than it has been underpriced (overpriced) will be associated with an accumulation of net short (net long) cash stock positions by arbitrageurs. Such short (long) cash position must be covered by stock purchase (sales) at expiration. Thus net underpricing (overpricing) would predict a stock price rise (drop) at expiration (see Merrick 1989, p.p. 109).

period (1982.6- 1986.3) are presumed not to be associated with expiration day unwinding. MacKinlay and Ramaswamy (1988) also suggest that early unwinding opportunity makes expiration day predictions based on the identification of mispricing difficult. In Korea, risk averse investors (especially subject to institutionally imposed risk exposure) tend to behave more like day traders or scalpers rather than position traders. They are likely to unwind their position whenever their profits exceed their expected returns or their losses exceed their maximum allowed losses.[62] Table 4-10 displays the 10 minute intraday returns and variances as well as close to close interday returns of spot index and futures contract on the expiration dates (June 13th and September 12th). Consistent with previous results, futures and spot index do not reveal high volatility at the expiration. Although spot index shows somewhat greater price fluctuation on the expiration date of June contract than does it over the non-expiration weekdays, its volatility on the expiration date of September contract is lower than those for ordinary non-expiration weekdays. For both expiration dates, futures' volatility tends to diminish as evidenced in the previous results (see Table 4-8). Expiration day returns for KOSPI 200 are on average negative except for close to close return on June contract expiration date. Frequent underpricing of futures contract over the September contract period is expected to cause price run up in spot index on expiration date if reverse transactions by arbitrageurs' unwinding were heavy in the spot market. However, consistent with results obtained in the Chapter II, insufficient arbitrage transactions do not trigger either stock

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[62] In its report on June 4,1996, Korea Economic Daily says that most of Korean investors in futures market are engaged more heavily in speculative trading rather than hedge trading. It adds that about 73% of futures open positions are closed within a day in the Korean market.

purchases by reverse transactions or price rise in the spot index on the expiration date. This result supports Merrick's (1989) findings and suggests that in the face of sluggish stock market condition, Korean futures market has been mainly driven by speculative traders rather than hedgers or arbitrageurs, and early unwinding by traders weakens the impact of expiration on spot market volatility. In addition, the absence of volume increase around expiration dates is consistent with the argument that investors'early unwinding practice in the Korean futures market makes the effect of futures'expiration on volatility and volume diminished. Chart 4-2 graphically shows the changes in the trading volumes and open interest in the Korean market over the sample period.

Table 4-11 shows the ratio of open interest change to daily trading volume of futures contract for each contract period. Chart 4-3 displays the trend of this ratio graphically. Over the whole sample period, daily trading volume in futures on average brings about mere 1-2% increase in open interest for non-expiration weeks. This fact indicates that the transactions (volumes) resulting from traders' early unwindings take a significant portion of the total trading volumes. Convergence of traders' opinion (downward revision) toward the expected future spot price triggers frequent early closing of the established futures positions. Open interest increase relative to daily futures volume have the least average (median) value during September contract period. This result is also consistent with huge mispricing of futures contract over September contract period shown in the chapter one. Due to lack of sufficient data, however, it is premature to draw any conclusion on patterns of changes in trading volumes around the expiration dates.

4-4. Conclusion

In this chapter, we compare volatilities between cash and future markets in the early introduction period of index futures. We examine the volatility of each market with the extreme value method proposed by Garman and Klass (1980) and test the homogeneity of variance using Brown- Forsythe (1974) modified Levene F statistics. Consistent with earlier studies, futures market on average tend to be more volatile than cash market over the whole sample period. Even after correcting for positive autocorrelation in the stock index, the results basically are not changed. If price variability reflects the rate of information arrival as proposed by Ross (1989), these results suggest that futures adjusts more quickly than spot to the new information occurred in the marketplace, which is consistent with outcomes obtained in Chapter III. We also investigate whether the degree of volatility changes for each market around the expiration of futures contract. Also consistent with earlier research, spot market does not show any extreme volatility around the expiration date of futures contract. On the other hand, futures tend to be more tranquil around the expiration, which is consistent with what is predicted in Tauchen and Pitts (1983) and Kyle (1985).

The analysis of trading volume in both spot and futures markets also supports our results regarding volatility changes around the futures expiration. Investors' early unwinding of the existing futures contracts before expiration is presumed to make expiration day effect unlikely.

Table 4-1.Standard Deviations of the Intraday 10 Minute Percentage Returns for the KOSPI 200 Cash Index, Futures Contract and for KOSPI Composite Index for the Periods of May 3, 1996 - October 16, 1996

TIME	KOSPI200	Futures	KOSPI
9:50	0.199215	0.208427	0.181809
10:00	0.168342	0.179391	0.157233
10:10	0.164955	0.199382	0.156337
10:20	0.188384	0.204109	0.171849
10:30	0.161727	0.180075	0.152794
10:40	0.162040	0.198563	0.149702
10:50	0.137706	0.187046	0.131963
11:00	0.142112	0.164083	0.131138
11:10	0.148915	0.191097	0.136524
11:20	0.165844	0.256434	0.159317
11:30	0.145799	0.178072	0.127965
13:10[a]	**0.175791**	**0.211826**	**0.167028**
13:20	0.140946	0.222206	0.133106
13:30	0.139234	0.170575	0.129057
13:40	0.139376	0.225442	0.130830
13:50	0.133381	0.181561	0.128988
14:00	0.120994	0.216294	0.105158
14:10	0.134987	0.219470	0.127702
14:20	0.129953	0.240064	0.125683
14:30	0.155016	0.252268	0.151026
14:40	0.170542	0.262816	0.175161
14:50	0.177926	0.274225	0.170060
15:00	0.138935	0.164182	0.032038

[a] Standard deviation in this time span covers standard deviation during session break (1 hours and 30 minutes), not standard deviation of 10 minute intraday return.

Chart 4-1. Patterns of intraday volatilities

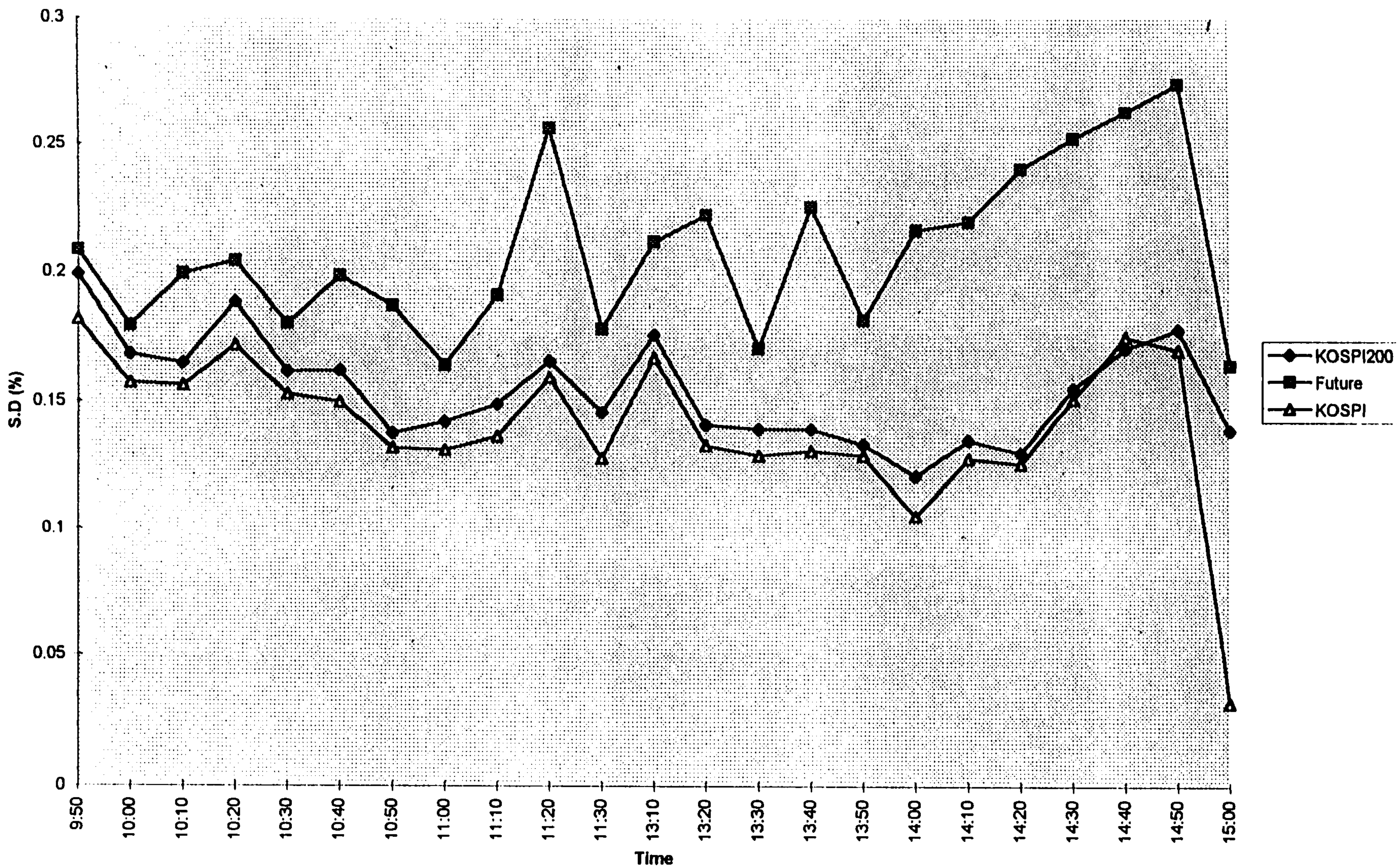


Table 4-2. Comparison of Volatilities according to Trading Hours[a]

	Day Time(A) (Open to Close) STD(%)[b]	Overnight(B) (Close to Open) STD(%)	Ratio(A/B)
KOSPI 200	1.0482	.4932	2.13
KOSPI	.9497	.4815	1.97
Futures	1.2088	.4963	2.43
	Open to Open STD(%) (A)	Close to Close STD(%) (B)	Ratio (A/B)
KOSPI 200	1.2667	1.1135	1.14
KOSPI	1.2111	1.0480	1.16
Futures	1.4178	1.1962	1.19
	Session Break STD(%) (A)	10 minute STD(%) (B)	Ratio (A/B)
KOSPI 200	.1758	.1573	1.12
KOSPI	.1670	.1455	1.15
Futures	.2118	.2106	1.01

[a] Returns on the expiration dates are excluded for comparison purpose.

[b] If the open to close returns on Saturday is included in calculation, the standard deviations of day time returns for KOSPI 200, KOSPI and futures are .9927%, .8982% and 1.1362% respectively and the ratios of day time returns to overnight returns are 2.01, 1.86 and 2.29 respectively.

Table 4-3.The First Order Autocorrelation of Returns according to Trading Hours

	June	September	December
1. Open to Close			
KOSPI 200	-.263	.156	-.005
KOSPI	-.193	.144	.019
Futures	-.198	-.014	.001
2. Close to Open			
KOSPI 200	-.150	-.122	.475
KOSPI	-.134	-.103	.317
Futures	-.139	-.196	.139
3. Open to Open			
KOSPI 200	-.227	.049	.192
KOSPI	-.162	.078	.164
Futures	-.188	-.143	.162
4. Close to Close			
KOSPI 200	-.178	.236	.093
KOSPI	-.094	.296	.073
Futures	-.108	.162	-.044

Table 4-4.Correlation between Open to Close (Daytime) and Close to Open(Overnight) Returns

1. Correlation between Daytime at t-1 and Overnight at t

	June	September	December
KOSPI 200	.489	.446	.418
KOSPI	.492	.516	.409
Futures	.301	.521	.273

2. Correlation between Overnight t and Daytime at t

	June	September	December
KOSPI 200	-.093	.155	.037
KOSPI	-.100	.180	.029
Futures	.064	-.137	-.002

Table 4-5. Comparison of the Average Garman-Klass (G-K) Price Volatility Estimators[a] among KOSPI Stock Index, KOSPI 200 Index and Index Futures.

	KOSPI		KOSPI 200		Futures	
	G-K 1	G-K 2	G-K 1	G-K 2	G-K 1	G-K 2
June	5.15E-05	.000201	7.16E-05	.000272	7.83E-05	.000304
September	4.55E-05	.000177	5.83E-05	.000224	.000110	.000426
December	5.90E-05	.000232	9.91E-05	.000382	.000127	.000498
Expiration[b] Week	5.15E-05	.000198	7.19E-05	.000276	4.28E-05	.000165
Non-Expiration Week	4.94E-05	.000193	6.90E-05	.000265	.000109	.000425
Total	4.95E-05	.000193	6.92E-05	.000265	.000105	.000409

[a]G-K1 estimator is based on the continuous trading around the clock and G-K 2 estimator accounts for the existence of non trading periods.

[b] Expiration week sample covers total eight days , June 10-13 and September 9-12,1996.

Table 4-6. Results of Test for Homogeneity of Variances with Raw Returns[a]

(1) 10 minute intraday returns (N=2715)

	STD (%)		B-F-L Revised F test	Standard F test
KOSPI 200	.1573	KOSPI 200 vs Future	68.60***	1.79***
Future	.2106	KOSPI 200 vs KOSPI	5.89***	1.17***
KOSPI	.1455	Future vs KOSPI	82.93***	2.09***

(2) Open to Open returns (N=132)

	STD (%)		B-F-L Revised F test	Standard F test
KOSPI 200	1.2667	KOSPI 200 vs Futures	.69	1.26*
Futures	1.4178	KOSPI 200 vs KOSPI	.06	1.09
KOSPI	1.2111	Futures vs KOSPI	1.15	1.37**

(3) Open to Close returns (N=112)[b]

	STD (%)		B-F-L Revised F test	Standard F test
KOSPI 200	1.0482	KOSPI 200 vs Futures	1.09	1.33*
Futures	1.2088	KOSPI 200 vs KOSPI	1.02	1.22
KOSPI	.9497	Futures vs KOSPI	3.90*	1.62***

(4) Close to Open returns (N=132)

	STD (%)		B-F-L Revised F test	Standard F test
KOSPI 200	.4932	KOSPI 200 vs Futures	.56	1.01
Futures	.4963	KOSPI 200 vs KOSPI	.39	1.05
KOSPI	.4815	Futures vs KOSPI	.10	1.06

(5) Close to Close returns (N=132)

	STD (%)		B-F-L Revised F test	Standard F test
KOSPI 200	1.1135	KOSPI 200 vs Futures	.35	1.15
Futures	1.1962	KOSPI 200 vs KOSPI	.10	1.13
KOSPI	1.0480	Futures vs KOSPI	.84	1.30*

(6) Session Break returns (N=112)

	STD (%)		B-F-L Revised F test	Standard F test
KOSPI 200	.1758	KOSPI 200 vs Futures	2.51	1.45**
Futures	.2118	KOSPI 200 vs KOSPI	.95	1.11
KOSPI	.1670	Futures vs KOSPI	.35	1.61***

Table 4-6. Continued

(7) Morning Session (Open to Noon) returns (N=135)

	STD (%)		B-F-L Revised F test	Standard F test
KOSPI 200	.6475	KOSPI 200 vs Futures	1.77	1.18
Futures	.5942	KOSPI 200 vs KOSPI	.31	1.19
KOSPI	.5943	Futures vs KOSPI	.72	1.01

(8) Afternoon Session (Noon to Close) returns (N=112)

	STD (%)		B-F-L Revised F test	Standard F test
KOSPI 200	.7231	KOSPI 200 vs Futures	1.37	1.44**
Futures	.8676	KOSPI 200 vs KOSPI	.49	1.24
KOSPI	.6502	Futures vs KOSPI	3.42*	1.78***

[a] Open to Open , Close to Close, Close to Open returns on the expiration dates (June 13th and September 12th) are excluded from the sample due to futures price changes.
[b] Open to Close returns on Saturday are included in the Morning Session returns.
*,**,*** indicates 10%,5%,1% significance level respectively.

Table 4-7. Results of Test for Homogeneity of Variances with the 1st order Autocorrelation modified Returns[a]

(1) 10 minute intraday returns (N=2714)

	STD (%)		B-F-L Revised F test	Standard F test
KOSPI 200	.2245	KOSPI 200 vs Future	3.16*	1.12***
Future	.2379	KOSPI 200 vs KOSPI	11.70***	1.22***
KOSPI	.2029	Future vs KOSPI	26.57***	1.37***

(2) Open to Open returns (N=131)

	STD (%)		B-F-L Revised F test	Standard F test
KOSPI 200	1.4671	KOSPI 200 vs Futures	.01	1.01
Futures	1.4722	KOSPI 200 vs KOSPI	.01	1.06
KOSPI	1.4220	Futures vs KOSPI	.00	1.07

(3) Open to Close returns (N=111)[b]

	STD (%)		B-F-L Revised F test	Standard F test
KOSPI 200	1.0901	KOSPI 200 vs Futures	.77	1.29**
Futures	1.2359	KOSPI 200 vs KOSPI	1.40	1.28**
KOSPI	.9635	Futures vs KOSPI	4.30**	1.65***

(4) Close to Open returns (N=132)

	STD (%)		B-F-L Revised F test	Standard F test
KOSPI 200	.7259	KOSPI 200 vs Futures	1.53	1.64***
Futures	.5662	KOSPI 200 vs KOSPI	.55	1.04
KOSPI	.7392	Futures vs KOSPI	4.63**	1.70***

(5) Close to Close returns (N=132)

	STD (%)		B-F-L Revised F test	Standard F test
KOSPI 200	1.1941	KOSPI 200 vs Futures	.17	1.08
Futures	1.2398	KOSPI 200 vs KOSPI	.23	1.20
KOSPI	1.0887	Futures vs KOSPI	.70	1.30*

(6) Session Break returns (N=112)

	STD (%)		B-F-L Revised F test	Standard F test
KOSPI 200	.2244	KOSPI 200 vs Futures	.09	1.12
Futures	.2371	KOSPI 200 vs KOSPI	.29	1.15
KOSPI	.2090	Futures vs KOSPI	.70	1.29*

Table 4-7. Continued

(7) Morning Session (Open to Noon) returns (N=134)

	STD (%)		B-F-L Revised F test	Standard F test
KOSPI 200	.7109	KOSPI 200 vs Futures	2.41	1.30*
Futures	.6221	KOSPI 200 vs KOSPI	.09	1.19
KOSPI	.6522	Futures vs KOSPI	1.87	1.10

(8) Afternoon Session (Noon to Close) returns (N=112)

	STD (%)		B-F-L Revised F test	Standard F test
KOSPI 200	.7796	KOSPI 200 vs Futures	.46	1.28*
Futures	.8809	KOSPI 200 vs KOSPI	1.53	1.37**
KOSPI	.6658	Futures vs KOSPI	3.37*	1.75***

[a] Each of KOSPI 200 index, KOSPI index and the respective futures price series are modified to remove the first autocorrelation resulting from infrequent trading or the reporting lag effects by the way in Miller, Muthuswamy and Whaley (1994). Respective price series are re-generated by applying the following AR(1) model.

$$s_t^o = \phi\, s_{t-1}^o + (1 - \phi)s_t$$

where s_t^o = the observed changes in the index level, ie, $S_t^o - S_{t-1}^o$

Each of the first differenced original price series (ΔP_t) of the KOSPI 200 index, KOSPI index and the corresponding futures has the significant 1st order autocorrelation amounting to .361, .350 and .123. By removing spurious autocorrelation effect from the original price changes, the 1st order autocorrelation for each of those series are successfully reduced to -.006 for both KOSPI 200 index and KOSPI index and to .000 for futures contract after filtering. Open to Open , Close to Close, Close to Open returns on the expiration dates (June 13th and September 12th) are also excluded from the sample due to futures price changes.

[b] Open to Close returns on Saturday are included in the Morning Session returns.

*,**,*** indicates 10%,5%,1% significance level respectively.

Table 4-8. Test for the Homogeneity of Variances between Expiration week[a] and Non-Expiration Weeks.

(1) 10 minute intraday returns (N= 2541)

	Non-expiration Week STD(%)(N=2541)	Expiration Week STD(%) (N=174)	B-F-L Revised F Test	Standard F Test
KOSPI 200	.1588	.1343	3.83*	1.40***
KOSPI	.1465	.1294	1.93	1.28**
Futures	.2150	.1306	17.01***	2.71***

(2) Open to Open returns (N= 132)

	Non-expiration Week STD(%)(N=127)	Expiration Week STD(%) (N=8)	B-F-L Revised F Test	Standard F Test
KOSPI 200	1.2778	1.1491	.18	1.23
KOSPI	1.2179	1.1668	.30	1.09
Futures	1.4445	.9622	1.66	2.26

(3) Open to Close returns (N= 112)

	Non-expiration Week STD(%)(N=104)	Expiration Week STD(%) (N=8)	B-F-L Revised F Test	Standard F Test
KOSPI 200	1.0539	1.0361	.04	1.04
KOSPI	.9483	1.0209	.05	1.16
Futures	1.2231	1.0606	.35	1.34

(4) Close to Open returns (N= 132)

	Non-expiration Week STD(%)(N=124)	Expiration Week STD(%) (N=8)	B-F-L Revised F Test	Standard F Test
KOSPI 200	.5064	.2140	1.78	5.60***
KOSPI	.4933	.2523	1.87	3.82**
Futures	.5093	.2059	2.99*	6.12***

(5) Close to Close returns (N= 132)

	Non-expiration Week STD(%)(N=124)	Expiration Week STD(%) (N=8)	B-F-L Revised F Test	Standard F Test
KOSPI 200	1.1204	1.0641	.02	1.12
KOSPI	1.0477	1.1117	.04	1.13
Futures	1.2041	1.1329	.07	1.13

Table 4-8.Continued

(6) Session Break returns (N= 112)

	Non-expiration Week STD(%)(N=104)	Expiration Week STD(%) (N=8)	B-F-L Revised F Test	Standard F Test
KOSPI 200	.1751	.1928	.10	1.21
KOSPI	.1658	.1941	.32	1.37
Futures	.2148	.1764	1.26	1.48

(7) Morning Session (Open to Noon) returns (N= 135)

	Non-expiration Week STD(%)(N=127)	Expiration Week STD(%) (N=8)	B-F-L Revised F Test	Standard F Test
KOSPI 200	.6464	.7006	.00	1.17
KOSPI	.5899	.6902	.02	1.37
Futures	.6037	.4449	.32	1.84

(8) Afternoon Session (Close to Noon) returns (N= 112)

	Non-expiration Week STD(%)(N=104)	Expiration Week STD(%) (N=8)	B-F-L Revised F Test	Standard F Test
KOSPI 200	.7417	.4063	2.30	3.33**
KOSPI	.6612	.4420	1.29	2.24
Futures	.8822	.6540	.35	1.82

*,**,*** indicates 10%,5%,1% significance level respectively.

[a] Expiration week sample covers total eight days , June 10-13 and September 9-12,1996.

Table 4-9. Trends of Daily Trading Volumes in Futures and KOSPI 200

1. June Contract Period (1996.5.3 - 1996.6.13)

(1)KOSPI200 (1,000 shares)

	Expiration Week[a]	Non-Expiration Weeks	Total
Mean	10,503	15,666	15,058
Median	10,662	13,548	12,994

(2)Futures (Contracts)

	Expiration Week	Non-Expiration Weeks	Total
Mean	2,580	3,245	3,167
Median	2,872	3,498	3,413

2. September Contract Period (1996.6.14 - 1996.9.12)

(1)KOSPI200 (1,000 shares)

	Expiration Week	Non-Expiration Weeks	Total
Mean	7,551	7,377	7,386
Median	7,766	7,317	7,317

(2)Futures (Contracts)

	Expiration Week	Non-Expiration Weeks	Total
Mean	2,871	2,889	2,888
Median	3,009	3,028	3,028

3. December Contract Period (1996.9.13 - 1996.10.16)

(1)KOSPI200 (1,000 shares)

	Before 1996.10.1[b]	After 1996.10.1	Total
Mean	8,617	19,706	14,383
Median	8,862	18,597	12,251

(2)Futures (Contracts)

	Before 1996.10.1	After 1996.10.1	Total
Mean	3,967	4,384	4,183
Median	4,225	4,721	4,449

[a] Expiration week covers June 10-13 for June contract period and September 9-12 for September contract period.

[b] The ceiling of foreign share ownership in the Korean stock market was raised by additional 2% from 18% to 20% on October 1, 1996. Therefore, stock trading volumes after this date may reflect temporary increase in buying force by foreign investors.

Table 4-10. Returns and Volatilities in Cash and Futures Markets on the Expiration Dates

1. June 13th, 1996

	Close to Close Interday Return[a]	10 Minute Mean Return[b]	10 Minute Median Return	10 Minute Return Std. Dev.
KOSPI 200	.305%	-.015%	-.053%	.203%
Futures	.635%	-.008%	.000%	.164%

2. September 12th, 1996

	Close to Close Interday Return	10 Minute Mean Return	10 Minute Median Return	10 Minute Return Std. Dev.
KOSPI 200	-.754%	-.025%	-.036%	.080%
Futures	-.767%	-.024%	-.030%	.070%

[a] The close to close returns are measured by computing price change between the day before expiration dates and expiration dates.

[b] Session break returns are omitted from calculation.

Table 4-11. Change in Open Interest Relative to Daily Trading Volume[a]

1. June contract period

	Non-Expiration Weeks	Expiration Week[b]
Mean[c]	2.04%	-33.56%
Median	1.83%	-10.53%
STD	3.78%	52.85%

2. September contract period

	Non-Expiration Weeks	Expiration Week
Mean	1.19%	-44.22%
Median	0.92%	-5.92%
STD	5.14%	78.62%

3. December contract period

	Non-Expiration Weeks	Expiration Week
Mean	2.57%	-
Median	1.77%	-
STD	6.85%	-

[a]The ratio is calculated by [open interest at t- open interest at t-1]/ daily trading volume at t.

[b]Expiration week covers June 10-13 for June contract period and September 9-12 for September contract period.

[c] On expiration dates (June 13 and September 12), the ratio drops to -112.53%(June 13) and -162.12%(September 12).

Chart 4-2. Trends of Volumes and Open Interest

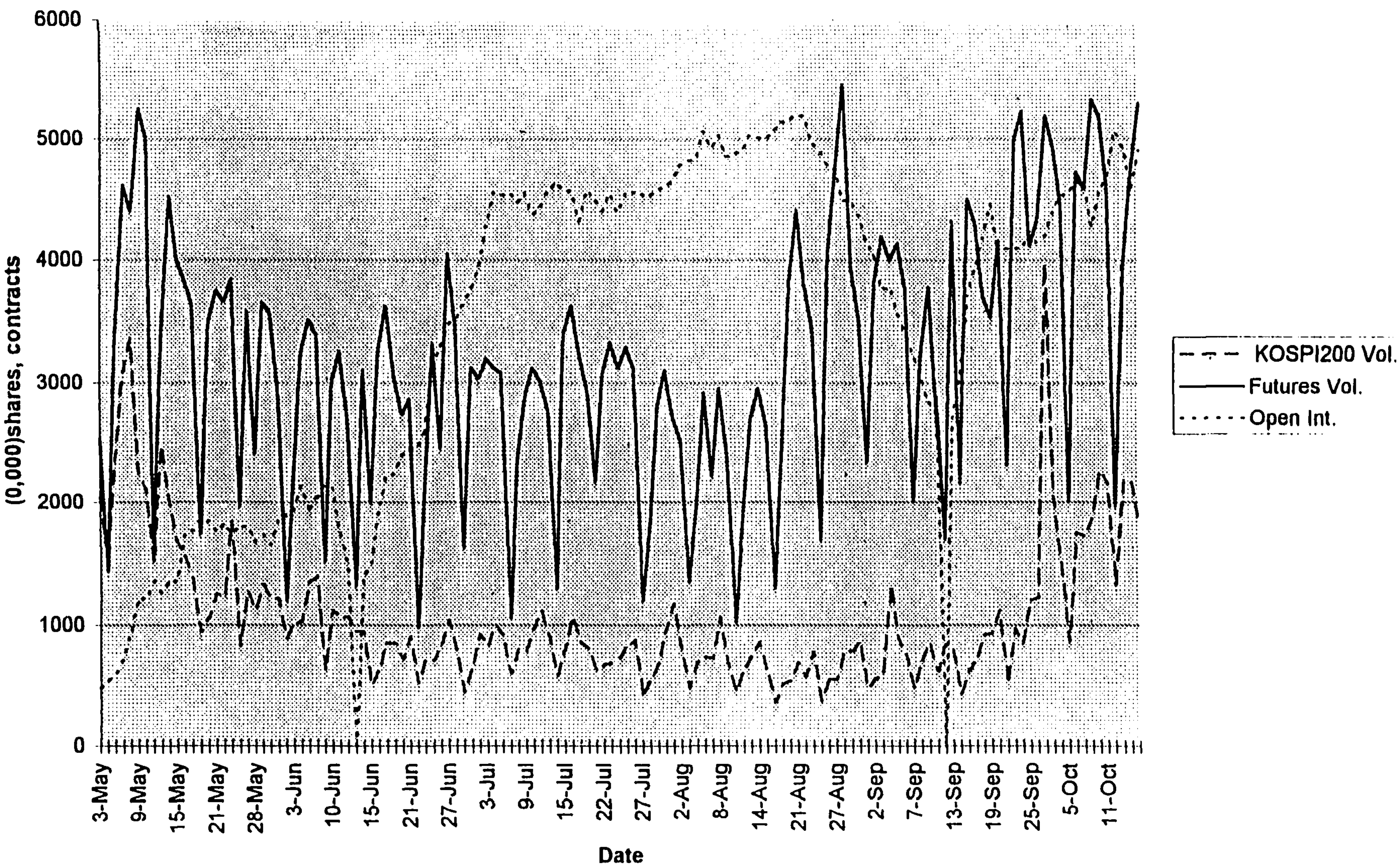
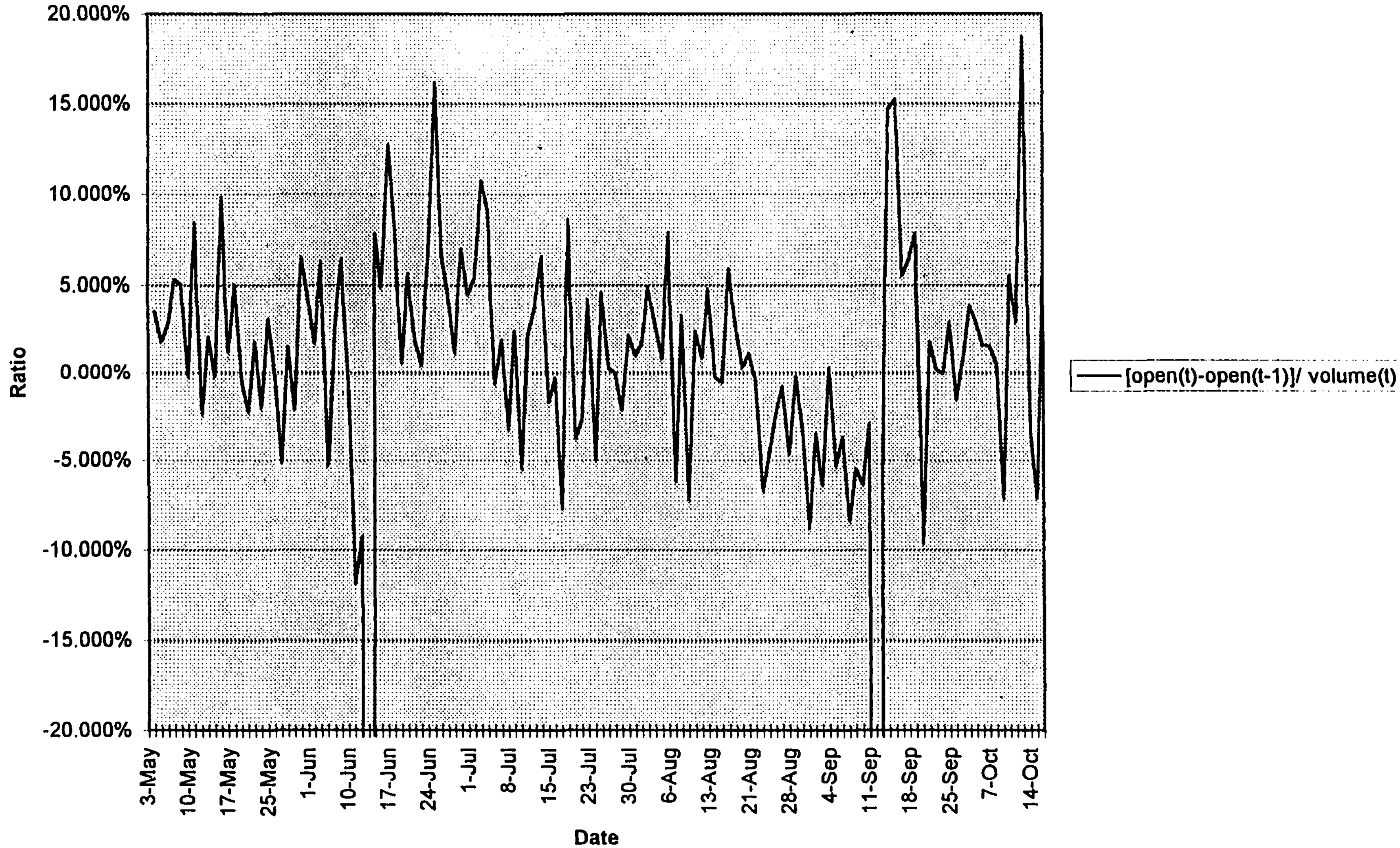


Chart 4-3. Trend of the Ratio of Change in Open Interest to Daily Futures Volume



BIBLIOGRAPHY

Abhyankar, A.H., 1995, Return and Volatility Dynamics in the FT-SE 100 Stock Index and Stock Index Futures Markets , *The Journal of Futures Markets* 15, 457-488.

Admati,A.R. and Pfleiderer, P., 1988, A Theory of Intraday Trading Patterns : Volume and Price Variability, *The Review of Financial Studies* 1, 3-40.

Bacha, O. and Vila,A.F., 1994, Futures Markets, Regulation and Volatility : The Case of the Nikkei Stock Index Futures Markets, *Pacific-Basin Finance Journal* 2, 201-225.

Bailey,W., 1989, The Market for Japanese Stock Index Futures : Some Preliminary Evidence, *Journal of Futures Markets* 9, 283-295.

Battacharya, A.K. and Sundaram, S., 1986, The Effect of Futures Price Volatility on the Price Volatility of Treasury Bonds, *Advances in Futures and Options Research* 1, 193-213.

Bessembinder, H. and P.J.Seguin, 1992, Futures -Trading Activity and Stock Price Volatility, *Journal of Finance* 47, 2015-2034.

Bessembinder, H. and P.J.Seguin, 1993, Price Volatility, Trading Volume, and Market Depth : Evidence from Futures Markets, *Journal of Financial and Quantitative Analysis* 28, 21- 39.

Bessembinder,H., Chan, K. and P.J.Seguin, 1996, An Empirical Examination of Information, Differences of Opinion, and Trading Activity, *Journal of Financial Economics* 40, 105-134.

Black, F.,1976, The Pricing of Commodity Contracts , *Journal of Financial Economics* 3, 167-179.

Block, W.A. and Kleidon, A.W., 1992, Periodic Market Closure and Trading Volume : A Model of Intraday Bids and Asks, *Journal of Economic Dynamics and Control* 16, 451-489.

Board, J. and C.Sutcliffe, 1995, The Relative Volatility of the Markets in Equities and Index Futures, *Journal of Business Finance and Accounting* 22, 201-223.

Brennan, M. J., 1986, A Theory of Price Limits in Futures Markets, *Journal of Financial Economics* 16, 213-233.

Brennan, M. and Schwartz, E.,1990, Arbitrage in Stock Index Futures, *Journal of Business* 63, S7-S31.

Brenner, M., Subrahmanyam, M.G. and Uno, J. , 1989, The Behavior of Prices in the Nikkei Spot and Futures Market, *Journal of Financial Economics* 23, 363-383.

Brenner, M., Subrahmanyam, M.G. and Uno, J. ,1990, Arbitrage Opportunities in the Japanese Stock and Futures Markets, *Financial Analysts Journal* 46, 14-24.

Brown, M.B. and Forsythe, A.B., 1974, Robust Tests for the Equality of Variances, *Journal of the American Statistical Association* 69, 364-367.

Bühler,W.and Kempf, A., 1995, DAX Index Futures : Mispricing and Arbitrage in German Markets, *Journal of Futures Market* 15, 833-859.

Cakici N. and Chatterjee, S., 1991, Pricing Stock Index Futures with Stochastic Interest Rates, *Journal of Futures Markets* 1991, 441-452.

Chan, K., 1992, A Further Analysis of the Lead-Lag Relationship between the Cash Market and Stock Index Futures Market, *The Review of Financial Studies* 5, 123-152.

Chan, K., K.C.Chan and G.A.Karolyi, 1991, Intraday Volatility in the Stock Index and Stock Index Futures Market,*The Review of Financial Studies* 4, 657-684.

Chan, K. and Y.P.Chung , 1993, Intraday Relationships among Index Arbitrage, Spot and Futures Price Volatility, and Spot Market Volume : A Transaction Data Test, *Journal of Banking and Finance* 17, 663-687.

Chan, K. and Y.P. Chung , 1995, Vector Autoregression or Simultaneous equations Model? The Intraday relationship Between Index Arbitrage and Market Volatility, *Journal of Banking and Finance* 19, 173-179.

Chang, E.C., Jain, P.C. and Locke, P.R., 1995, Standard & Poor's 500 Index Futures Volatility and Price Changes around the New York Stock Exchange Close, *Journal of Business* 68, 61-84.

Chartrath, A., Ramchander, S. and Song, F., 1995, Does Options Trading Lead to Greater Cash Market Volatility ?, *Journal of Futures Markets* 15, 785-803

Chen, N.F., Cuny,C.J. and Haugen, R.A., 1995, Stock Volatility and the Levels of the Basis and Open Interest in Futures Contracts, *Journal of Finance* 50, 281-300.

Cheung, Y.W. and Ng, L.K., 1990, The Dynamics of S&P 500 Index and S&P 500 Futures Intraday Price Volatilities, *The Review of Futures Market* 9, 458-486.

Cheung, Y.W. and Ng, L.K., 1996, A Causality in Variance Test and its Application to Financial Market Prices, *Journal of Econometrics* 72, 33-48.

Chu, C.C. And Bubnys, E.L., 1990, A Likelihood Ratio Test of Price Volatilities : Comparing Stock Index Spot and Futures , *Financial Review* 25, 81-94.

Chung, Y.P, 1991, A Transactions Data Test of Stock Index Futures Market Efficiency and Index Arbitrage Profitability, *Journal of Finance* 46, 1791-1809.

Cornell,B. and Reinganum, M.R., 1981, Forward and Futures Prices : Evidence From the Foreign Exchange Markets, *Journal of Finance* 36, 1035-1045

Cornell, B and French, K.R., 1983, The Pricing of Stock Index Futures, *Journal of Futures Markets* 3, 1-14.

Cornell,B., 1985, Taxes and the Pricing of Stock Index Futures : Empirical Results, *Journal of Futures Markets* 5, 89-101.

Cox, J.C., Ingersoll Jr., J.E. and Ross,S.A., 1981, The Relation between Forward prices and Futures Prices, *Journal of Financial Economics* 9, 321-346.

Crain, S.J. and Lee, J.H., 1996, Volatility in Wheat Spot and Futures Markets, 1950-1993: Government Farm Programs, Seasonality, and Causality, *Journal of Finance* 51,325-343.

Daigler, R.T., 1997, Intraday Futures Volatility and Theories of Market Behavior, *Journal of Futures Markets* 17, 45-74.

Davidian, M and Carroll, R.J., 1987, Variance Function Estimation, *Journal of American Statistical Association* 82, 1079-1091.

Dickey, D.A. and Fuller, W.A., 1979, Distribution of the Estimates for Autoregressive Time Series with a Unit Root , *Journal of the American Statistical Association* 24, 427-431.

Dubofsky, D.A., 1992, *Options and Financial Futures : Valuation and Uses*, (McGraw-Hill, New York).

Dusak, K., 1973, Futures Trading and Investor Return: An Investigation of Commodity Market Risk Premiums, *Journal of Political Economy* 81, 1387-1406.

Dwyer, Jr.G.P., Locke, P. and Yu, W., 1996, Index Arbitrage and Nonlinear Dynamics Between the S&P 500 Futures and Cash, *Review of Financial Studies* 9, 301-332.

Edwards, F.R.,1988, Does Futures Trading Increase Stock Market Volatility ?, *Financial Analysts Journal* 44, 63-69

Ekman, P.D., 1992, Intraday Patterns in the S&P 500 Index Futures Market, *Journal of Futures Markets* 12, 365-381.

Elton,E.J., Gruber, M.J. and Rentzler, J.C., 1984, Intraday Tests of the Efficiency of the Treasury Bill Futures Market, *Review of Economics and Statistics* 66, 129-137.

Engle, R.F. and Granger, C.W.J., 1987, Co-Integration and Error Correction : Representation, Estimation, and Testing , *Econometrica* 55, 251-276.

Engle, R.F. and Granger, C.W.J., 1991, Long Run Economic Relationships, *Readings in Cointegration* , (New York, Oxford University Press).

Engle, R.F. and B.S.Yoo, 1987, Forecasting in Co-Integrated Systems , *Journal of Econometrics* 35, 143-159.

Engle, R.F. and Ng,V.K., 1993, Measuring and Testing the Impact of News on Volatility, *Journal of Finance* 48, 1749-1778.

Figlewski, S., 1984a, Hedging Performance and Basis Risk in Stock Index Futures, *Journal of Finance* 39, 657-669.

Figlewski, S., 1984b, Explaining the Early Discounts on Stock Index Futures : The Case for Disequilibrium, *Financial Analysts Journal* 40, 43-47.

Finnerty, J.E. and Park, H.Y., 1987, Stock Index Futures : Does the Tail Wag the Dog ?, *Financial Analysts Journal* 43, 57-61.

Finnerty, J.E. and Park,H.Y., 1988, Intraday Returns and Volatility Patterns in the Stock Market: Futures Versus Spot, *Advances in Futures and Options Research* 3 : Fabozzi F. J. ed, 301-317.

Fleming, J., 1994, On the Comparison of Index Volatility in the Stocks and Futures Markets: A Commentary on Intraday and Overnight Volatility of Stock Index and Stock Index Futures Returns, *Review of Futures Markets* 13, 31-38.

Fleming, J., Ostdiek,B. and Whaley, R.E., 1996, Trading Costs and the Relative Rates of Price Discovery in Stock, Futures, and Option Markets, *Journal of Futures Markets* 16, 353-387.

Flesaker, B., 1991, The Relationship between Forward and Futures Contracts : A Comment, *Journal of Futures Markets* 11, 113-115.

French, K.R., 1983, A Comparison of Futures and Forward Prices, *Journal of Financial Economics* 12, 311-342.

French, K.R. and Roll, R., 1986, Stock Returns Variances : The Arrival of Information and the Reaction of Traders, *Journal of Financial Economics* 17, 5-26.

French,K.R., Schwert, G. and Stambaugh, R.F., 1987, Expected stock Returns and Volatility, *Journal of Financial Economics* 19, 3-29.

Garbade, K.D. and Silber, W.D., 1983, Price Movements and Price Discovery in Futures and Cash Markets, *Review of Economics and Statistics* 65, 289-297.

Garman, M.B. and Klass,M.J., 1980, On the Estimation of Security Price Volatilities from Historical Data, *Journal of Business* 53, 67- 78.

Geweke, J., Meese, R., and Dent, W., 1983, Comparing Alternative Tests of Causality in Temporal Systems : Analytic Results and Experimental Evidence, *Journal of Econometrics* 21, 161-194.

Hamao,Y., Mauslis, R.W., and Ng. V., 1990, Correlations in Price Changes and Volatility across International Stock Markets, *The Review of Fiancial Studies* 3, 281-307.

Harris, L., 1986, A Transaction Data Study of Weekly and Intraday Patterns in Stock Returns, *Journal of Financial Economics* 16, 99-117.

Harris, L., Sofianos,G. and Shapiro,J.E., 1994, Program Trading and Intraday Volatility, *The Review of FinancialStudies* 7, 653-685.

Herbst, A.F., McCormack, J.P. and West,E.N., 1987, Investigation of a Lead-Lag Relationship between Spot Stock Indices and Their Futures Contracts, *Journal of Futures Markets* 7, 373-381.

Hsia,C.C., Fuller,B.R. and Kao,G.W., 1994, A Modified Method for Inferring the Effective Bid-Ask Spread from Security Returns, *Journal of Business Finance and Accounting* 21, 243-253.

G.L.Gannon, 1994, Simultaneous Volatility Effects in Index Futures, *Review of Futures Markets* 13, 1027-1066.

Gastineau, G.L. and Madansky.A.,1984, Standard & Poor's 500 Composite Index Futures Evaluation Tables, in : Fabozzi, F.J. and Kipnis,G.M., eds.: *Stock Index Futures,* (Dow Jones-Irwin, Homewood).

Grossman,S.J., 1989, *The Informational Role of Prices,* (Cambridge, The MIT Press).

Hamilton, J.D., 1994, *Time Series Analysis,* (New Jersey, Princeton Univeristy Press).

Hanson,H.N. and Kopprasch, R.W., 1984, Pricing of Stock Index Futures, in : Fabozzi, F.J. and Kipnis,G.M., eds.: *Stock Index Futures,* (Dow Jones-Irwin ,Homewood).

Iihara, Y., Kato, K. and Tokunaga,T., 1996, Intraday Return Dynamics between the Cash and the Futures Markets in Japan, *Journal of Futures Markets* 16, 147-162.

Jarrow,R.A. and Oldfield, G.S., 1981, Forward Contracts and Futures Contracts, *Journal of Financial Economics* 9, 373-382.

Jokivuolle, E., 1995, Measuring True Stock Index Value in the Presence of Infrequent Trading, *Journal of Financial and Quantitative Analysis* 30, 455-464.

Kim, I.W. and Yoon, T.S., 1992, *An Investor's Guide to the Korean Capital Market,* (Quorum Books, Westport, Connecticut).

Kipnis,G.M. and Tsang,S., 1984, Classical Theory, Dividend Dynamics, and Stock Index Futures Pricing, in : Fabozzi, F.J. and Kipnis,G.M., eds.: *Stock Index Futures,* (Dow Jones-Irwin , Homewood).

Kipnis,G.M. and Tsang,S., 1984, Arbitrage , in : Fabozzi, F.J. and Kipnis,G.M., eds.: *Stock Index Futures,* (Dow Jones-Irwin ,Homewood).

Kyle, A.S., 1985, Continous Auctions and Insider Trading, *Econometrica* 53, 1315-1335.

Kawaller,I.G., 1987, A Note : Debunking the Myth of the Risk-Free Return, *Journal of Futures Markets* 7, 327-331.

Kawaller,I.G., 1991, Determining the Relevant Fair Value(s) of S&P 500 Futures: A Case Study Approach, *Journal of Futures Markets* 11, 453-460.

Kawaller,I.G., Koch, P.D. and Koch,T.W., 1987, The Temporal Price Relationship between S&P 500 Futures and the S&P 500 Index , *Journal of Finance* 42, 1309-1329.

Kawaller,I.G., Koch, P.D. and Koch,T.W., 1990, Intraday Relationships between Volatility in S&P 500 Futures Prices and Volatility in the S&P 500 Index, *Journal of Banking and Finance* 14, 373-397.

Koch, P.D., 1993, Re-examining Intraday Simultaneity in Stock Index Futures Markets, *Journal of Banking and Finance* 17, 1191-1205.

Korean Economic Daily (KED)

Lamoureux, C.G., and Lastrapes, W.D., 1990, Heteroskedasticity in Stock Return Data : Volume versus GARCH Effects , *Journal of Finance* 45, 221- 229.

J.H.Lee and S.C.Linn , 1994, Intraday and Overnight Volatility of Stock Index and Stock Index Futures Returns, *Review of Futures Markets* 13, 1-30.

Levene, H., 1960, Robust Tests for Equality of Variances, *Contributions in Probability and Statistics,* Olkin I. (edited), (Palo Alto, California, Stanford University Press)

Levy,A.,1989, A Note on the Relationship between Forward and Futures contracts, *Journal of Futures Markets* 9, 171-173.

Lo, A.C. and A.C. MacKinlay, 1988, Stock Market Prices Do Not Follow Random Walks : Evidence From a Simple Specification Test, *The Review of Financial Studies* 1, 41-66.

Lim, K.G., 1992, Arbitrage and Price Behavior of the Nikkei Stock Index Futures, *Journal of Futures Markets* 1992, 151-161.

A.C.MacKinlay and K.Ramaswamy, 1988, Index-Futures Arbitrage and the Behavior of Stock Index Futures Prices, *The Review of Financial Studies* 1, 137-158.

MacKinnon, J., 1991, Critical values for Cointegration Tests , Long-Run Economic Relationships, *Readings in Cointegration,* R.F.Engle and C.W.J. Granger (edited), (New York , Oxford University Press).

Maddala, G.S.,1992, *Introduction to Econometrics*, 2nd Edition, (New York, MacMillan).

Martikainen,T., Perttunen, J. and Puttonen, V., 1995, On the Dynamics of Stock Index Futures and Individual Stock Returns, *Journal of Business Finance and Accounting* 22, 87-100.

Merrick, J.J.Jr.,1989, Early Unwinding and Rollovers of Stock Index Futures Arbitrage Programs : Analysis and Implications for Predicting Expiration Day Effects, *Journal of Futures Market* 9, 101-111.

Miller, M.H., Muthuwamy, J. and Whaley, R.E., 1994, Mean Reversion of Standard & Poor's 500 Index Basis Changes: Arbitrage-induced or Statistical Illusion ?, *Journal of Finance* 49, 479-513.

Modest, D.M. and Sundaresan, 1983, The Relationship between Spot and Futures Prices in Stock Index Futures Markets : Some Preliminary Evidence, *Journal of Futures Markets* 3, 15-41.

Ng, N., 1987, Detecting Spot Prices Forecasts in Futures Prices in Futures Prices Using Causality Tests, *Review of Futures Markets* 6, 250-267.

Park,K.K.H. and Van Agtmael, A.W., 1993, The World's Emerging Stock Markets, (Probus Publishing Company, Chicago).

Parkinson,M., 1980, The Extreme Value Method for Estimating the Variance of the Rate of Return, *Journal of Business* 53, 61-66.

Pirrong, C., 1996, Market Liquidityand Depth on Computerized and Open Outcry Trading Systems : A Comaprison of DBT and LIFFE Bund Contracts, *Journal of Futures Markets* 16, 519-543.

Quan, J., 1992, Two-Step Testing Procedure for Price Discovery Role of Futures Prices, *Journal of Futures Markets* 12, 139-149.

Rhee, S.G., 1992, *Securities Markets and Systematic Risks in Dynamic Asian Economies*, (OECD, Paris).

Roll, R, 1984, A Simple Implicit Measure of the Effective Bid-Ask Spread in an Efficient Market, *Journal of Finance* 39, 1127-1139.

Ross, S.A.,1989, Information and Volatility : The No-Arbitrage Martingale Approach to Timing and Resolution Irrelevancy, *Journal of Finance* 44, 1-17.

Sims, C., 1972, Money, Income and Causality, *American Economic Review* 62, 540-552.

Sims, C., 1980, Macroeconomics and Reality, *Econometrica* 48, 1-48.

Schwarz,T.V., 1991, The Relationship between Stock Indices and Stock Index Futures from 3:00 to 3:15 : A Clarification, *Journal of Futures Markets* 11, 647-649.

Schwert, G.W., 1989, Why does stock market volatility change over time ?, *Journal of Finance* 44, 1115-1153.

Schwert, G.W., 1990, Stock Volatility and the Crash of '87, *The Review of Financial Studies* 3, 77-102.

Shyy, G., Vijayraghavan, V. and Scott-Quinn, B., A Further Investigation of the Lead-Lag Relationship between the Cash Market and Stock Index Futures Market with the Use of Bid/Ask Quotes: The case of France, *Journal of Futures Markets* 16, 405-420.

Smirlock, M. and L. Starks, 1986, Day of the Week and Intraday Effects in Stock Returns, *Journal of Financial Economics* 17, 197-210.

Sofianos,G., 1993, Index Arbitrage Profitability, *Journal of Derivatives* 1, 7-20.

Stoll, H.R. and Whaley, R.E., 1987, Program Trading and Expiration Day Effects, *Financial Analysts Journal* 43, 16-28.

Stoll, H.R. and Whaley, R.E., 1990a, The Dynamics of Stock Index and Stock Index Futures Returns, *Journal of Financial and Quantitative Analysis* 25, 441-468.

Stoll,H.R. and Whaley, R.E., 1990b, Stock Market Structure and Volatility, *The Review of Financial Studies* 3, 37-71.

Subrahmanyam, A., 1991, A Theory of Trading in Stock Index Futures, *The Review of Financial Studies* 4, 17-51.

Tauchen, G.E. and Pitts, M., 1983, The Price Variability-Volume Relationship on Speculative Markets, *Econometrica* 51, 485-505.

Wiggins, J.B., 1992, Estimating the Volatility of S&P 500 Futures Prices Using the Extreme-Value Method, *Journal of Futures Markets* 12, 265-273.

Wood, R.A., McInish,T.H. and Ord, J.K., 1985, An Investigation of Transaction Data for NYSE stocks, *Journal of Finance* 40, 723-741.

Yadav, P.K. and Pope, P.F., 1990, Stock Index Futures Arbitrage : International Evidence, *Journal of Futures Markets* 10, 573-603.

APPENDIX

This appendix contains a list of daily trading volumes of the KOSPI 200 and the nearby futures contract and daily open interest of the nearby futures contract from May 3rd, 1996 - October 16th, 1996

Date	KOSPI200 Volume (10,000shrs)	Futures Volume	Open Interest
3-May	20,451	2,527	479
4-May	15,374	1,428	530
6-May	23,734	3,385	592
7-May	30,901	4,614	726
8-May	33,578	4,401	958
9-May	22,640	5,250	1,222
10-May	21,228	5,015	1,208
11-May	15,065	1,667	1,349
13-May	24,706	3,435	1,265
14-May	20,129	4,521	1,359
15-May	16,770	4,010	1,349
16-May	15,462	3,835	1,725
17-May	13,720	3,627	1,768
18-May	9,455	1,731	1,855
20-May	10,598	3,489	1,836
21-May	12,510	3,751	1,751
22-May	12,374	3,654	1,816
23-May	18,369	3,842	1,738
25-May	8,282	1,961	1,800
27-May	12,759	3,575	1,790
28-May	11,216	2,407	1,666
29-May	13,230	3,647	1,722
30-May	12,282	3,566	1,647
31-May	12,154	2,932	1,838
1-Jun	8,952	1,200	1,892
3-Jun	10,110	2,232	1,930
4-Jun	10,293	3,254	2,135
5-Jun	13,375	3,506	1,949
7-Jun	13,934	3,392	2,042
8-Jun	6,323	1,509	2,139
10-Jun	11,189	3,017	2,119
11-Jun	10,731	3,259	1,735
12-Jun	10,593	2,726	1,482
13-Jun**	**9,500**	**1,317**	**0**
14-Jun	9,453	3,109	1,403
15-Jun	5,022	1,989	1,500
17-Jun	6,343	3,265	1,916
18-Jun	8,520	3,622	2,218

Appendix Continued

19-Jun	8,481	3,052	2,236
20-Jun	7,185	2,731	2,390
21-Jun	9,039	2,859	2,444
22-Jun	5,215	975	2,448
24-Jun	7,143	2,125	2,581
25-Jun	7,083	3,320	3,117
26-Jun	8,299	2,449	3,281
27-Jun	10,374	4,045	3,469
28-Jun	7,929	3,444	3,507
29-Jun	4,440	1,616	3,620
1-Jul	6,537	3,128	3,760
2-Jul	9,145	3,032	3,923
3-Jul	8,236	3,196	4,267
4-Jul	9,951	3,123	4,551
5-Jul	9,258	3,086	4,531
6-Jul	5,965	1,057	4,551
8-Jul	7,964	2,368	4,475
9-Jul	7,835	2,873	4,546
10-Jul	9,679	3,122	4,376
11-Jul	11,107	3,024	4,444
12-Jul	9,019	2,762	4,552
13-Jul	5,816	1,297	4,637
15-Jul	7,853	3,394	4,579
16-Jul	10,671	3,616	4,568
18-Jul	8,666	3,241	4,317
19-Jul	8,025	2,933	4,569
20-Jul	6,278	2,177	4,487
22-Jul	6,692	3,084	4,404
23-Jul	6,814	3,327	4,544
24-Jul	7,335	3,122	4,390
25-Jul	8,241	3,289	4,543
26-Jul	8,743	3,122	4,552
27-Jul	4,418	1,201	4,552
29-Jul	5,399	1,789	4,513
30-Jul	6,768	2,808	4,574
31-Jul	9,680	3,106	4,605
1-Aug	11,748	2,710	4,651
2-Aug	8,149	2,517	4,774
3-Aug	4,874	1,353	4,814
5-Aug	6,838	1,998	4,830
6-Aug	7,338	2,907	5,059
7-Aug	7,231	2,219	4,922
8-Aug	10,578	2,945	5,020
9-Aug	6,825	2,387	4,848
10-Aug	4,482	1,026	4,873
12-Aug	6,377	1,915	4,889

Appendix Continued

13-Aug	7,298	2,685	5,018
14-Aug	8,526	2,955	5,010
16-Aug	6,166	2,643	4,995
17-Aug	3,605	1,300	5,072
19-Aug	5,083	2,456	5,138
20-Aug	5,413	3,814	5,150
21-Aug	6,782	4,408	5,199
22-Aug	5,799	3,797	5,183
23-Aug	7,745	3,418	4,954
24-Aug	3,754	1,683	4,877
26-Aug	5,506	4,048	4,784
27-Aug	5,480	4,758	4,747
28-Aug	7,653	5,454	4,493
29-Aug	7,856	3,941	4,484
30-Aug	8,583	3,506	4,368
31-Aug	4,849	2,336	4,162
2-Sep	5,549	3,815	4,029
3-Sep	6,165	4,191	3,762
4-Sep	13,228	4,000	3,774
5-Sep	8,758	4,134	3,555
6-Sep	7,506	3,774	3,415
7-Sep	4,786	2,003	3,246
9-Sep	7,130	3,237	3,068
10-Sep	8,452	3,771	2,829
11-Sep	6,225	2,780	2,748
12-Sep**	**8,397**	**1,695**	**0**
13-Sep	7,950	4,311	2,698
14-Sep	4,340	2,168	3,017
16-Sep	6,286	4,495	3,702
17-Sep	7,188	4,299	3,939
18-Sep	9,177	3,700	4,175
19-Sep	9,295	3,528	4,452
20-Sep	11,153	4,150	4,051
21-Sep	5,546	2,313	4,092
23-Sep	9,653	4,986	4,101
24-Sep	8,548	5,222	4,097
25-Sep	12,019	4,116	4,219
30-Sep	12,251	4,316	4,152
1-Oct	39,659	5,190	4,199
2-Oct	20,491	4,935	4,390
4-Oct	14,680	4,449	4,521
5-Oct	8,701	2,005	4,553
7-Oct	17,470	4,721	4,626
8-Oct	17,142	4,583	4,650
9-Oct	18,597	5,326	4,270
10-Oct	22,578	5,181	4,555

Appendix Continued

11-Oct	21,784	4,560	4,689
12-Oct	13,273	1,971	5,058
14-Oct	21,868	4,007	4,926
15-Oct	21,688	4,762	4,585
16-Oct	18,245	5,299	4,900

** indicates the expiration dates

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