International Market Linkages between the U.S. and Korea OTC futures Markets: Information Transmission from NASDAQ 100 Index Cash and Futures Markets to KOSDAQ 50 Index Cash and Futures Markets

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ABSTRACT

This study tests the international transmission from NASDAQ100 index cash and NASDAQ100 index futures to KOSDAQ50 index cash and KOSDAQ50 index futures markets for the period of Jan. 2001 – Dec. 2002. Based on the time-varying AR(1)-GARCH(1,1)-M models, the results show that the open-to-close returns of the NASDAQ100 index cash and futures have predictive power over both the open-to-close and close-to-open returns of KOSDAQ50 index cash and futures. In particular, the open-to-close returns of both NASDAQ100 index cash and futures have much stronger effect over the close-to-open returns of KOSDAQ50 index cash. We also find that the NASDAQ100 index futures returns have strong predictive power over the KOSDAQ50 index futures returns similar to the results from the NASDAQ100 index cash.

In addition, the tests show that the close-to-open returns of the NASDAQ100 index futures, rather than those of NASDAQ100 index cash have stronger information spillover effect over the open-to-close returns of both the KOSDAQ50 index cash and futures. The results also represent that there is co-movement between the KOSDAQ50 index cash and the NASDAQ100 index cash and between the KOSDAQ50 index futures and the NASDAQ100 index futures.

These findings support that the market efficiency and the international stock market integration are on the increasing trend in terms of both mean and time varying volatility. Specifically, the results of the information spillover effects between NASDAQ100 index futures market and the KOSDAQ50 index futures market would provide useful information in country diversification and industry diversification.

INTRODUCTION

International transmission of stock market movements has been widely studied focusing on the national stock markets and OTC markets. Earlier studies [Eun and Shim (1989), Koch and Koch (1991), Campbell and Hamao (1992), Bekaert and Harvey (1997), Karolyi and Stultz (1996), Ng (2000), to name a few] report, among others, that returns in major stock exchanges are interdependent and that there are information spillovers from the U.S. to other major stock exchanges.

There are two broad categories of explanations on the co-movement of stock market returns.[1] One is that aggregate shocks from one country affect both directly and indirectly the fundamentals of stock prices in more than one country. These are shocks related to the information on stock prices. The other is contagion, which is not explained by fundamentals. To test the hypothesis of contagion, Forbes and Rigobon (2002) examine if cross-market correlation of stock market returns increase during the period of crisis, such as the 1997 East Asian crisis, the 1994 Mexican peso collapse, and the 1987 U.S. stock market crash. Suggesting that standard estimates of cross-market correlation are upward biased during the market turmoil, they find virtually no contagion based on the test of adjusted correlation coefficients.

Kim and Kim (2002) test the hypotheses of information and contagion using the return series from S&P500, NIKKEI225, KOSPI200, NASDAQ, JASDAQ, and KOSDAQ index. Their study indicates that S&P500 index returns have predictive power over both NIKKEI225 and KOSPI200 index returns only before the 1997 Korean currency crisis period, while NASDAQ index returns have significant predictive power over both JASDAQ and KOSDAQ index returns both before and after the 1997 Korean currency crisis.[2]

This paper undertakes a further investigation of this international transmission in futures index markets between the U.S. and Korea. The amount of information, related to the value of the stocks listed, would be different among national stock exchanges markets, OTC markets and OTC index futures markets. It is worth investigating the price co-movement among OTC index futures markets. Until now, the majority of researches in the price co-movement

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1 Engle, Ito, and Lin (1990) seek to explain the causes of volatility clustering in exchange rates under two hypotheses —heat waves and meteor showers. While their heat wave hypothesis is that the volatility has only country-specific autocorrelation, the meteor shower is a phenomenon of intra-daily volatility spillover from one market to the next. The study rejected the heat wave hypothesis exhibiting volatility persistence possibly due to private information or heterogeneous beliefs, or with stochastic policy coordination or competition.

2 The study virtually supports the information hypothesis that investors both in Korean and Japanese markets infer information on the value changes from the NASDAQ market movements.

among stock markets were limited to the national stock exchanges and OTC markets. Index futures data might solve some problems: non-synchronous trading, bid-ask spread, and uncertain dividend payment that national stock exchanges and OTC markets still have.[3]

The other reason why we employ the OTC index futures data is that the degree of co-movement among OTC index futures market is higher than that among the OTC markets because investors can make investment decision on index futures market with lower cost and leverage effect.

Additionally, we expect that the information transmission from NASDAQ100 index futures market to KOSDAQ50 index futures market may grow stronger because the NASDAQ100 index futures market is operating 24 hours owing to the Globex2 system.[4]

The analysis employs the time varying AR(1)-GARCH(1,1)-M model to study the dynamics of price co-movements between NASDAQ100 index futures market and KOSDAQ50 index futures market using the open-to-close returns and the close-to-open returns. The test period is two years —from January 2, 2001 to December 31, 2002. We also include the NASDAQ100 index cash and the KOSDAQ50 index cash markets for further research.

The results indicate that the open-to-close returns of the NASDAQ100 index cash and futures have predictive power over both the open-to-close and close-to-open returns of KOSDAQ50 index cash and futures. In particular, the open-to-close returns of both NASDAQ100 index cash and futures have much stronger effect over the close-to-open returns of KOSDAQ50 index cash. We also find that the NASDAQ100 index futures returns have strong predictive power over the KOSDAQ50 index futures returns similar to the results from the NASDAQ100 index cash.

In addition, the tests show that the close-to-open returns of the NASDAQ100 index futures rather than those of NASDAQ100 index cash have stronger information spillover effect over the open-to-close returns of both the KOSDAQ50 index cash and futures. We infer that investors in Korea reflect the real-time price change of the NASDAQ100 index futures and cash due to active ECN trading.

The results also represent that there is co-movement between the KOSDAQ50 index

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3 To solve these problems, most of researchers used data of national stock exchanges and OTC markets after some minutes suggested by Lin, et al (1994).

4 Since January, 1997, SEC has made investors trade for 24 hours in the NASDAQ cash market by ECN (electronic communications network) system. As a result, Korean investors can use real-time information of NASDAQ100 index futures market for their investment decision-making. For more intuition of market efficiency and research, this study examines the information transmission effects from the close-to-open returns of the NASDAQ cash market and NASDAQ100 index futures market where ECN trading occupies above 50% in 2001 to the open-to-close returns of the KOSDAQ50 index cash market.

cash and the NASDAQ100 index cash and between the KOSDAQ50 index futures and the NASDAQ100 index futures. These findings are consistent with the previous results, for example, Hamao, Masulis, and Ng (1990), Kim and Kim (2002).

In conclusion, these findings support that the market efficiency and the international stock market integration are on the increasing trend in terms of both mean and time varying volatility. Specifically, the results of the information spillover effects between NASDAQ100 index futures market and the KOSDAQ50 index futures market would provide useful information in country diversification and industry diversification.

The rest of this paper is organized as follows. Section Ⅰ explains the NASDAQ100 index futures market and the KOSDAQ50 index futures market, while section Ⅱ presents the data and preliminary statistics. The methodology is presented in section Ⅲ. We put the main result in section Ⅳ and section Ⅴ concludes the paper.

Ⅰ. NASDAQ100 and KOSDAQ50 index futures market

NASDAQ's success has helped Korea promptly to set up or formalize its OTC markets in 1990s. KOSDAQ (Korea Securities Dealers Automated Quotation) market was established in July 1996 in order to provide investment opportunities for high tech start-ups and small companies to raise capitals and for investors seeking high risk-high return investment opportunities, benchmarking NASDAQ. The companies listed on KOSDAQ are categorized into three sectors composed of non-venture companies, venture business with a high potential growth rate, and securities investment companies. Venture companies account for about 22% of total companies traded on the KOSDAQ market. Before the establishment of KOSDAQ, an OTC intermediary floor was set up in October 1991.

Table 1 reports the background of NASDAQ100 index and KOSDAQ50 index market. As Korean government gradually relaxed regulations regarding KOSDAQ listings beginning late 1990s, telecommunication companies and other similar companies could easily list on the KOSDAQ market. In addition, tax incentives were extended to small venture companies listed on the KOSDAQ market. As results, in spite of the 1997 Asian foreign currency crisis, KOSDAQ has been growing rapidly. As of the end of May 2003, the total number of listed companies on KOSDAQ is 855 which are bigger than listed companies (679) on Korea Stock Exchange. Its market value is 37,403 billion won (3,117 million US dollars) and average trading volume per day is 378 million shares. According to the statistics of WFE (World Federation Exchange) on the National Stock Exchange and Non-national Stock Exchanges around the world, in terms of listed companies as of the end of May 2003, KOSDAQ and Korea Stock Exchange are ranked as the 14^{th} and 17^{th} largest stock markets in the world, respectively.

As KOSDAQ market grows rapidly, the demands of market participants to hedge the market risk in stock price in KOSDAQ also gradually increase. To satisfy the needs of KOSDAQ investors, KOSDAQ 50 index futures was introduced to Korea Futures Exchanges (KOFEX) on January 30, 2001. The development of new index resulted in the increase in the participation of foreign and institutional investors and also was helpful for the market liquidity and market stability. KOSDAQ50 index cash is the basis of determining the price of KOSDAQ50 index futures.

After listing the KOSDAQ50 index futures, it has been used to hedge the investment risk in cash market and employed as the means to hedge the risk of portfolio consisted of KOSDAQ50 index cash. KOSDAQ50 index cash is composed of 50 companies with highest market value and liquidity among more than 800 companies listed on KOSDAQ. The trading volume of KOSDAQ50 index futures in 2001 and 2002 were 466,479 and 380,491 contracts, respectively. The average trading volume per day in 2001 and 2002 were 2,037 and 1,559 contracts. But as of April 2003, the average volume per day increased to 3,592 contracts. In addition, the outstanding interests of 2001 and 2002 were 463 and 1,263 contracts but it was increased to 1,728 contracts by April 2003.

Although the market size, length of history, listing and information disclosure requirements, and other administrative regulations between NASDAQ and KOSDAQ are different, there is a similarity in the objectiveness of the markets, in providing a trading place for small businesses and venture capitals and having similar industrial characteristics in which most companies listed on these markets are IT and high-tech companies with high growth potential. Therefore, we can presume the degree of price co-movement between the cash and futures markets of KOSDAQ and NASDAQ is high.

Since NASDAQ100 index futures market began trading in 1985 on Chicago Mercantile Exchange (CME), the NASDAQ100 index futures is based on NASDAQ 100 index cash. The NASDAQ100 index comprises 100 of the largest domestic, non-financial common stocks listed on the NASDAQ Stock Market. Created in 1985, this index is owned and maintained by the NASDAQ Stock Market. The NASDAQ100 index is rebalanced quarterly and has a modified capitalization weighting to ensure a more diversified index.

The NASDAQ100 index is a modified capitalization weighted stock index of 100 of the largest non-financial stocks traded on the NASDAQ National Market. According to WFE (World Federation Exchange), as of the end of May 2003, 3,429 companies are listed on the NADSAQ which is the largest OTC market and the 3rd largest stock market if we take into account the national stock markets in the world. Although the trading volume of NASDAQ 100 index futures of 2002 compared with that of 2001 decreased because of the world wide economic recession, the trading volume trend of NASDAQ100 index futures has been increased

continuously.

Ⅱ. Data and Preliminary Statistics

This study examines daily and intraday stock-price activity over a roughly two-year period from January 2, 2001 to December 31, 2002. The daily index cash and futures market returns for the NASDAQ100 and KOSDAQ50 are obtained from Bloomberg database. Daily returns are calculated as log changes in each index. For further research, we divide daily close-to-close returns into their close-to-open and open-to-close components.

Because of differences in time zones, the daily return in Korea overlaps with the U.S. trading day return. Figure 1 presents the timing of the markets and daily returns used in this study. In order to compare the market trading hours, we align Korea market trading hours with New York market trading hours. During the analysis periods, trading volume in the NASDAQ100 index futures and the KOSDAQ50 index futures markets grew rapidly. Figure 2 shows paired graphs for NASDAQ100 index futures and cash markets for the U.S., and the KOSDAQ50 index futures and cash markets for Korea, respectively.

Table 2 reports the summary statistics for the open-to-close and close-to-open returns of the NASDAQ100 index cash/futures and the KOSDAQ50 index cash/futures. The open-to-close returns of the NASDAQ100 index cash, the KOSDAQ50 index futures, and close-to-open returns of KOSDAQ50 index cash are positive, while the others are negative. Also, the open-to-close returns of both the NASDAQ100 index cash/futures and KOSDAQ50 index cash/futures are more volatile than their close-to-open returns over the sample period. These results are consistent with French and Roll's (1986) claim that more information is released during the trading time.

Table 3 reports the serial correlation of the close-to-close, close-to-open, and open-to-close returns on the NASDAQ100 index cash/futures and the KOSDAQ50 index cash/futures for the full sample period. We find much stronger serial correlation in NASDAQ100 index cash and futures than KOSDAQ50 index cash and futures.[5]

Furthermore, all the stock index series are tested to ensure they are I (1). The results of the ADF and the PP tests are shown in the Table 4. The stock index series tests demonstrate that each has a unit root in its autoregressive representation. This indicates that each series is non-stationary, necessitating the calculation of first differences and the difference series are then checked for the presence of a unit root. We see that the ADF and the PP tests clearly reject the null hypothesis of the presence of a unit root for each series, implying that the difference series

5 This result also supports the use of the time-varying statistic model like ARCH and GARCH in this research.

are indeed I (0). Therefore, we conclude the stock indices are I (1) for all indices.

Since it is established that each series is I (1), the next step is to test whether there exists a linear combination of two corresponding indices that is I (0). If this is found, the two series must be co-integrated. Results of the tests of co-integration are presented in Table 5. The Johansen test does not reject the null hypothesis of no co-integration for all series. We need not consider including in our model the error-correction term suggested by Engle and Granger (1987)

Measures for skewness and excess kurtosis indicate that all return series are significantly skewed and leptokurtic with respect to the normal distribution. The Bera-Jacque statistics for the return series of the NASDAQ100 index cash/futures and KOSDAQ50 index cash/futures are statistically significant, indicating the presence of serial correlation (linear dependencies). This suggests the presence of autoregressive conditional heteroskedasticity, i.e. volatility clustering, which can be properly modeled by the ARCH framework of Engle (1982) and Bollerslev (1986).

Ⅲ. Methodology

Based on the results of the preliminary statistics, we have specified two-stage GARCH-based models. The Generalized ARCH (GARCH) model of Bollerslev (1986) restricts the conditional variance of a time series to depend upon past squared residuals of the process. Since we are interested in interrelations between index cash and futures markets, we introduce a vector of predetermined variables both in the mean and conditional variance. Therefore, we introduce MA(1)-GARCH(1,1)-M formulation suggested by Hamao et.al.(1990) which is a different normal GARCH formulation.[6] Such a model for the open-to-close returns is given below:

$$R_{\tau} = \alpha + \beta\sigma_t + \delta D_{t-1} + \gamma\varepsilon_{t-1} + \varepsilon_t$$

$$\sigma_t = a + b\sigma_{t-1} + c\varepsilon^{2}_{t-1} + dD_t \qquad (1)$$

Where b represents the conditional variance of the stock index return, R_t, at time t, and D represents a dummy variable that takes a value of 1 on days following weekends and holidays and is 0 otherwise.

Therefore, we can estimate the equation for the conditional mean and variance

6 This study employed standard deviation instead of variance different from Hamao, Measulis, and Ng (1990).

spillover effect from the open-to-close return of NASDAQ100 index futures to both the open-to-close and the close-to-open returns of KOSDAQ50 index futures.

$$KQFO(I_t) = \alpha + \beta\sigma_t + \delta D_{t-1} + \gamma NDFI_{t-1} + \theta\varepsilon_{t-1} + \varepsilon_t$$
$$\sigma_t = a + b\sigma_{t-1} + c\varepsilon_{t-1}^2 + dD_{t-1} + fNQFIE_{t-1} \quad (2)$$

Where $KQFO(I_t)$ is the close-to-open (open-to-close) returns of KOSDAQ50 index futures at time t, $NDFI_{t-1}$ is the open-to-close returns of NASDAQ100 index futures at time $t-1$, and $NDFIE_{t-1}$ represents the residuals squared estimated from the open-to-close of NASDAQ100 index futures at time $t-1$ by the equation (1).

The coefficients, γ and f are the conditional mean and variance spillover effect from the open-to-close returns of NASDAQ100 index futures to both the open-to-close and the close-to-open returns of KOSDAQ50 index futures, respectively.

$$KQFI_t = \alpha + \beta\sigma_t + \delta D_{t-1} + \gamma NQFO_{t-1} + \theta\varepsilon_{t-1} + \varepsilon_t$$
$$\sigma_t = a + b\sigma_{t-1} + c\varepsilon_{t-1}^2 + dD_{t-1} + fNQFOE_{t-1} \quad (3)$$

Where $KQFI_t$ is the open-to-close returns of KOSDAQ50 index futures at time t, $NDFO_{t-1}$ is the close-to-open returns of NASDAQ100 index futures at time $t-1$, and $NDFOE_{t-1}$ represents the residuals squared estimated from the close-to-open of NASDAQ100 index futures at time $t-1$ by the equation (1).

The coefficients, γ and f are the conditional mean and variance spillover effect from the close-to-open returns of NASDAQ100 index futures to the open-to-close returns of KOSDAQ50 index futures.

We use nonlinear optimization techniques to calculate the maximum-likelihood estimates based on the Berndt-Hall-Hall-Hausman algorithm. The primary specification tests for the model involve the Ljung-Box statistic, which is used to test for a lack of serial correlation in the model residuals and in the residual squared. This statistic has been shown by McLeod and Li (1983) to be asymptotically chi-square distributed. Skewness and kurtosis coefficients for the normalized residuals are also reviewed. The descriptive validity of the estimated model can be evaluated with a likelihood ratio (LR) statistic that is chi-square distributed.

We also employ the same procedures to examine the conditional mean and variance spillover effects from the NASDAQ100 index cash to KOSDAQ50 index cash.

Ⅳ. Empirical Results

A. Model Specification

This study examines the appropriateness of the GARCH-M specification for both open-to-close and close-to-open daily stock returns employing an MA(1)-GARCH(1,1)-M model. Table 6 shows the results of our initial estimation of the GARCH-M model for both the open-to-close and close-to-open returns series in the U.S. and Korea OTC markets. The likelihood ratio statistics, which allow us to test the null hypothesis that the returns are normally distributed against the alternative and that they are generated by an MA(1)-GARCH(1,1)-M model, are significant at the 1% level in all two markets. We cannot observe any indications of serious model misspecification. For example, none of the Ljung-Box Q statistics for the serial correlation of the return and squared return series for k=12 lags, denoted as $LB^2(12)$ and $LB(12)$, are significant at 1% levels.

For stability of the volatility process, the coefficients of the lagged errors and lagged conditional variances must sum to less than 1. We find the coefficients of the conditional variance in the open-to-close and close-to-open returns of NASDAQ100 index cash/futures and KOSDAQ50 index cash/futures, b and c, are positive at 1% or 5% level. Therefore, we recognize that the standard deviation (σ_t) can be explained by the residuals squared (ε_{t-1}^2) and conditional standard deviation (σ_{t-1}), confirming the specification of MA(1)-GARCH(1,1)-M model.

B. Price and Volatility Spillover from NASDAQ100 index cash and futures to KOSDAQ50 index cash

We consider the possibility of a spillover effect in the stock returns of NASDAQ100 index cash and futures on the conditional mean as well as conditional variance in the KOSDAQ50 index cash to trade, using open-to-close and close-to-open returns data. Table 7 and 8 represent the results. For the first test, we find the conditional mean (γ = -0.39214) and variance (f = 0.03271) spillover effect from the open-to-close returns of NASDAQ100 index cash to the close-to-open returns of KOSDAQ50 index cash at 1% level, respectively. However, there is only the conditional mean (γ = 0.12383) spillover effect from the open-to-close returns of NASDAQ100 index cash to the open-to-close returns of KOSDAQ50 index cash at 1% level. We can also see the conditional variance spillover effects from the open-to-close returns of KOSDAQ50 index to both the open-to-close and close-to-open returns of

NASDAQ100 index cash at 5% and 1% levels, respectively.

The results of the second test are somewhat different from Table 7, which report the estimation of the spillover effect from NASDAQ100 index cash to KOSDAQ50 index cash. We document that only the conditional mean (γ = 0.34649) spillover effect from the open-to-close returns of NASDAQ100 index futures to the close-to-open returns of KOSDAQ50 index cash is at 1% level. Also, we find the conditional mean (γ = -0.13110) spillover effect from the open-to-close returns of NASDAQ100 index futures to the open-to-close returns of KOSDAQ50 index cash is at 1% level.

From these results, not only NASDAQ100 index cash but also NASDAQ100 index futures influences KOSDAQ50 index cash. And we also find that the NASDAQ100 index futures, like NASDAQ100 index cash, has predictive power over both the open-to-close and close-to-open returns of KOSDAQ50 index cash. In particular, the open-to-close returns of both NASDAQ100 index cash and futures have much stronger effect over the close-to-open returns of KOSDAQ50 index cash. The co-movement from the KOSDAQ50 index cash to the NASDAQ100 index cash is also observed.

C. Price and Volatility Spillover from NASDAQ100 index futures to KOSDAQ50 index futures

We consider the possibility of a spillover effect from the NASDAQ100 index futures to KOSDAQ50 index futures. Table 9 reports the estimation results from the open-to-close returns of the NASDAQ100 index futures to both the close-to-open and open-to-close returns of KOSDAQ50 index futures. For the first test, there is only the conditional mean (γ = 0.33446 significant at 1% level) spillover effect from the open-to-close returns of the NASDAQ100 index futures to the close-to-open return of the KOSDAQ50 index futures. Similarly, we can find just the conditional mean spillover effect from the open-to-close returns of the NASDAQ100 index futures to those of KOSDAQ50 index futures with a t-statistic of γ = -0.10413 significantly at a 1% level. However, the test does not show any statistically significant spillover effects at the variance.

For the second test, the Table 9 also shows that both the conditional mean (γ = 0.10997) and variance (f = 0.01379) spillover effects from the open-to-close return of the KOSDAQ50 index futures to the close-to-open returns of NASDAQ100 index futures is at 1% level. Different from the results of the close-to-open returns, the open-to-close returns of KOSDAQ50 index futures have the predictive power over the open-to-close of NASDAQ100 index futures only at the variance (f = 0.01815) significant at 5% level.

In sum, similar to the result from the NASDAQ100 index cash, the NASDAQ100

index futures returns have strong predictive power over the KOSDAQ50 index futures returns. We also find that there exist a slight feedback relation between the NASDAQ100 index futures and the KOSDAQ50 index futures.

D. Price and Volatility Spillover from the close-to-open returns of NASDAQ100 index cash and futures to the open-to-close returns of KOSDAQ50 index cash and futures

We also consider the possibility of a spillover effect from close-to-open returns of NASDAQ100 index cash and futures to the open-to-close returns of KOSDAQ50 index cash and futures. Table 10 shows the results. For the first test, the close-to-open returns of NASDAQ100 index futures have predictive power over the open-to-close returns of KOSDAQ50 index cash in both the conditional mean (γ = 0.28827) and variance (f = 0.08868) spillover effect at 1% level, respectively, while the close-to-open returns of the NASDAQ100 index cash have predictive power in the variance with t-statistic of f = 0.01196 significantly at 10% level.

For the second test, there is the conditional variance (f = 0.01078) spillover effect from the close-to-open returns of NASDAQ100 index cash to the open-to-close returns of KOSDAQ50 index futures at 5% level, while the close-to-open returns of NASDAQ100 index futures have predictive power over the open-to-close returns of KOSDAQ50 index futures in the conditional mean (γ = 0.31532) and variance (f = 0.02492 significant at 10% level) spillover effect, respectively at 1% and 10%.

In sum, the close-to-open returns of the NASDAQ100 index futures rather than those of NASDAQ100 index cash have stronger information spillover effect over the open-to-close of both the KOSDAQ50 index cash and futures.

Ⅴ. Conclusion

This study attempts to examine the information transmission from the NASDAQ100 index cash and futures to the KOSDAQ50 index cash and futures using the open-to-close, close-to-open, and close-to-close returns during from Jan. 2, 2001 to Dec. 31, 2002. Most of the previous researches of information transmission are limited to the national exchanges and OTC markets. The futures markets of both the NASDAQ100 index and the KOSDAQ50 index are growing and are becoming more important in its national economy. In particular, the index futures markets supply a function of prediction to the index cash markets as suggested by many previous researches. This study is the first to report the co-movements of the OTC futures

markets.

The results in this paper indicate the degree of co-movement in the stock prices among the NASDAQ100 index cash, the NASDAQ100 index futures, the KOSDAQ50 index cash, and the KOSDAQ50 index futures. We employ the time-varying AR(1)-GARCH(1,1)-M models. The results report that the open-to-close returns of the NASDAQ100 index cash and futures have predictive power over both the open-to-close and close-to-open returns of KOSDAQ50 index cash and futures. In particular, the open-to-close returns of both NASDAQ100 index cash and futures have much stronger effect over the close-to-open returns of KOSDAQ50 index cash. We also find that the NASDAQ100 index futures returns have strong predictive power over the KOSDAQ50 index futures returns similar to the result from the NASDAQ100 index cash.

In addition, the tests show that the close-to-open returns of the NASDAQ100 index futures rather than those of NASDAQ100 index cash have stronger information spillover effect over the open-to-close of both the KOSDAQ50 index cash and futures. The results represent also that there is co-movement between the KOSDAQ50 index cash and the NASDAQ100 index cash and between the KOSDAQ50 index futures and the NASDAQ100 index futures.

In conclusion, we claim that the results tend to support the information hypothesis that investors in Korean markets infer the value changes from the NASDAQ100 index futures and cash market movements. We also conclude that there are still large advantages if we take position in the KOSDAQ50 index cash and futures markets in the sense of international CAPM due to the independence of the NASDAQ100 index cash and futures markets.

These findings also support that the market efficiency and the international stock market integration are on the increasing trend in terms of both mean and time varying volatility. Specifically, the results of the information spillover effects between NASDAQ100 index futures market and the KOSDAQ50 index futures market would provide useful information in country diversification and industry diversification.

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Table 1

Panel 1: The trading volume and open interest of NASDAQ100 index futures in CME

(Unit: Contracts)

	1996	1997	1998	1999	2000	2001	2002
Trading Volume	380,963	807,604	1,063,328	2,360,938	5,094,042	5,586,750	4,903,287
Open Interest	5,009	5,877	8,668	23,416	42,077	46,723	61,120

Panel 2: The current status of KOSDAQ index cash and KOSDAQ50 index futures

(Unit: Contracts, million US dollar)

		2000	2001	2002
KOSDAQ50 Index Futures	Trading Volume	-	466,479	380,491
	Trading Value	-	3,279	4,916
	Open Interest	-	463	1,263

US 1dollar: 1,200 Won

Panel 3: The Comparison between Korea Stock Exchange (National Stock Exchange) and KOSDAQ Markets

(Unit: million shares, million US dollar)

		1999	2000	2001	2002
Korea Stock Exchange	Listing Company	725	704	689	683
	Market Capitalization	29,125	15,670	21,320	21,557
	Average daily trading volume	300	306	610	826
	Average daily trading value	380	134	263	178
KOSDAQ	Listing Company	453	604	721	843
	Market Capitalization	8,225	2,418	4,318	3,117
	Average daily trading volume	126	284	367	378
	Average daily trading value	**178**	**95**	**127**	**84**

* US 1dollar: 1,200 Won

Table 2

Data summary statistics for open-to-close returns, close-to-open returns and close-to-close returns of KOSDAQ50 and NASDAQ100 index cash and futures from January 2001 to December 2002

We get the daily opening and closing data for KOSDAQ50 and NASDAQ100 index cash and futures from Bloomberg. Open-to-close returns (daytime returns) are calculated from each trading day's opening price to the same day's closing price; Close-to-open returns (overnight returns) are computed from each trading day's closing price to the next trading day's opening price; Close-to-close returns (daily closing price returns) are the log difference between each trading day's closing price and previous trading day's closing price. ***, ** indicate the significance of data statistics at the 99% and 95% confidence levels, respectively.

		NASDAQ100 index		KOSDAQ50 index	
		Cash	Futures	Cash	Futures
Open-to-close returns	Mean	+0.00166	-0.00161	-0.00124	+0.00018
	Median	+0.00126	-0.00173	-0.00114	+0.00126
	Maximum	+0.09139	+0.08599	+0.07514	+0.09916
	Minimum	-0.08747	-0.09922	-0.06588	-0.08967
	Standard deviation	+0.02580	+0.02542	+0.02025	+0.02457
	Skewness	-0.11358	+0.01281	-0.14444	-0.11990
	Kurtosis	+3.19121	+3.34257	+3.60798	+4.06867
	J-B	+1.76335	+23.6023***	+9.06202***	+23.9914***
Close-to-open returns	Mean	-0.00362	-0.00046	+0.00032	-0.00086
	Median	-0.000355	-0.00070	+0.00092	-0.00020
	Maximum	+0.13128	+0.07369	+0.05903	+0.06108
	Minimum	-0.11887	-0.06792	-0.19955	-0.21710
	Standard deviation	+0.01915	+0.01529	+0.01901	+0.01925
	Skewness	+0.24180	+0.29072	-2.33428	-3.01625
	Kurtosis	+3.24921	+5.49299	+27.7519	+36.0046
	J-B	+5.91974**	+131.061***	+12689.1***	+22513.9***
Close-to-close returns	Mean	-0.00196	-0.00207	-0.00092	-0.00084
	Median	-0.00167	-0.00084	+0.00000	+0.00000
	Maximum	+0.11164	+0.10267	+0.07528	+0.09077
	Minimum	-0.09098	-0.09043	-0.26196	-0.30463
	Standard deviation	+0.03124	+0.02934	+0.02647	+0.02990
	Skewness	+0.17800	+0.11661	-1.95970	-2.19652
	Kurtosis	+3.46908	+3.34815	+22.1563	+24.8255
	J-B	+6.93574**	+35.1209***	+7546.53***	+9913.06***

Table 3

Estimation results of autocorrelations for the returns of KOSDAQ50 and NASDAQ100 index cash and futures from January 2001 to December 2002

Open-to-close returns (daytime returns) are calculated from each trading day's opening price to the same day's closing price; Close-to-open returns (overnight returns) are computed from each trading day's closing price to the next trading day's opening price; Close-to-close returns (daily closing price returns) are the log difference between each trading day's closing price and previous trading day's closing price. ***, **, * indicate the significance of data statistics at the 99%, 95% and 90% confidence levels, respectively.

Return	Lag	NASDAQ100		KOSDAQ50	
		Cash	Futures	Cash	Futures
Open-to-close returns	1	-0.073*	-0.052	+0.009	+0.009
	2	-0.085**	-0.077	-0.079	+0.053
	3	+0.024*	+0.022	-0.011	+0.038
	4	-0.016	-0.008	-0.072	-0.063
	5	-0.062	-0.045	-0.013	-0.063
	6	+0.053	+0.053	+0.080	+0.086
Close-to-open returns	1	+0.339***	-0.096**	-0.081*	-0.071
	2	-0.088***	-0.030**	-0.005	-0.045
	3	-0.042***	-0.082**	-0.083*	-0.022
	4	-0.006***	+0.093**	+0.046*	+0.076
	5	-0.033***	-0.051**	+0.023	+0.062
	6	+0.007***	-0.087*	-0.070	-0.055
Close-to-close returns	1	-0.120***	+0.017*	-0.024	-0.104**
	2	-0.021**	-0.100*	-0.003	+0.032**
	3	-0.016*	-0.011*	+0.034	+0.051*
	4	+0.031*	+0.019	+0.006	-0.051*
	5	-0.062*	-0.024	+0.044	+0.008
	6	+0.014	-0.036	-0.044	-0.011

Table 4

Estimation results of unit root test for the returns of KOSDAQ50 and NASDAQ100 index cash and futures from January 2001 to December 2002

(1) includes only intercept term in the Augmented Dickey-Fuller (ADF) and Phillips and-Perron (PP) test equations. On the other hand, (2) include both intercept and trend terms in the ADF and PP test equations. Open-to-close returns (daytime returns) are calculated from each trading day's opening price to the same day's closing price; Close-to-open returns (overnight returns) are computed from each trading day's closing price to the next trading day's opening price; Close-to-close returns (daily closing price returns) are the log difference between each trading day's closing price and previous trading day's closing price. ***, **, * indicate the significance of data statistics at the 99%, 95% and 90% confidence levels, respectively.

Stock	Price/return		ADF		PP	
			(1)	(2)	(1)	(2)
NASDAQ 100 index cash	Level price	Opening price	-2.1807	-2.9933	-2.4408	-2.3092
		Closing price	-2.5038	-3.2295*	-3.4942***	-3.2540**
	Return	Open-to-close	-10.9946	-11.057***	-23.705***	-23.765***
		Close-to-open	-9.9164***	-9.9643***	-14.907***	-14.932***
		Close-to-close	-10.572***	-10.611***	-24.801***	-24.847***
NASDAQ 100 index futures	Level price	Opening price	-2.8316	-3.1164	-3.3706**	-2.5050
		Closing price	-2.8843	-3.6983**	-3.4400**	-4.2985***
	Return	Open-to-close	-10.613***	-10.770***	-23.127***	-23.271***
		Close-to-open	-10.339***	-10.384***	-24.226***	-24.246***
		Close-to-close	-10.327***	-10.362***	-21.501***	-21.525***
KOSDAQ 50 index cash	Level price	Opening price	-1.3875	-1.5095	-1.4313	-1.5284
		Closing price	-1.3126	-1.4374	-1.4086	-1.4972
	Return	Open-to-close	-10.747**	-10.844***	-21.769***	-21.808***
		Close-to-open	-9.8014***	-9.7870***	-23.766***	-23.750***
		Close-to-close	-8.9522***	-8.9735***	-22.374***	-22.365***
KOSDAQ 50 index futures	Level price	Opening price	-1.3772	-1.4285	-1.5109	-1.5469
		Closing price	-1.3407	-1.4072	-1.4821	-1.5204
	Return	Open-to-close	-8.4985***	-8.7291***	-21.675***	-21.777***
		Close-to-open	-8.6597***	-8.7416***	-23.469***	-23.574***
		Close-to-close	-9.0961***	-9.1338***	-24.182***	-24.172***

Table 5

The estimation results of co-integrations between KOSDAQ50 index cash and futures' level variables and NADSDAQ100 index cash and futures' level variables from January 2001 to December 2002

Where KQO (KQC) and KQFO (KQFC) mean the opening and closing price of KOSDAQ50 index cash and futures, respectively. Similarly, NQO (NQC) and NQFO (NQFC) mean the opening and closing price of NASDAQ100 index cash and futures, respectively. Critical values: $r = 0$ (16.31), $r \leq 0$ (6.51) at 1% level, $r = 0$ (12.53), $r \leq 0$ (3.84) at 5% level.

Stock	Lag	Returns	Null	Eigenvalue	Likelihood ratio
Cash	Lag=5	NQC/KQC	$r = 0$	+0.02205	+11.8679
			$r \leq 0$	+0.00299	+1.40882
		NQC/KQO	$r = 0$	+0.02381	+11.2680
			$r \leq 0$	+0.00345	+1.62171
		NQO/KQC	$r = 0$	+0.01873	+10.3549
			$r \leq 0$	+0.00316	+1.48593
	Lag=10	NQC/KQC	$r = 0$	+0.01245	+7.04276
			$r \leq 0$	+0.00280	+1.29114
		NQC/KQO	$r = 0$	+0.01249	+6.98089
			$r \leq 0$	+0.00263	+1.20966
		NQO/KQC	$r = 0$	+0.01206	+6.92881
			$r \leq 0$	+0.00295	+1.35855
Futures	Lag=5	NQFC/KQFC	$r = 0$	0.02193	+12.3366
			$r \leq 0$	+0.00362	+1.73476
		NQFC/KQFO	$r = 0$	+0.02104	+11.7855
			$r \leq 0$	+0.00348	+1.65944
		NQFO/KQFC	$r = 0$	+0.03261	+15.8566
			$r \leq 0$	+0.00450	+2.13820
	Lag=10	NQFC/KQFC	$r = 0$	+0.02056	+11.2699
			$r \leq 0$	+0.00324	+1.52347
		NQFC/KQFO	$r = 0$	+0.02200	+11.8592
			$r \leq 0$	+0.00308	+1.44371
		NQFO/KQFC	$r = 0$	+0.02170	+11.4123
			$r \leq 0$	+0.00244	+1.14418

Table 6

Estimation results of AR(1)-GARCH(1,1)-M model specification for open-to-close return (daytime returns) and close-to-open returns (overnight returns) of KOSDAQ50 index cash and futures and NASDAQ100 index cash and futures from January 2001 to December 2002

Panel 1: Estimation results of AR(1)-GARCH(1,1)-M model for open-to-close returns (daytime returns) of KOSDAQ50 index cash and futures and NASDAQ100 index cash and futures

$$R_\tau = \alpha + \beta\sigma_t + \delta D_{t-1} + \gamma\varepsilon_{t-1} + \varepsilon_t$$
$$\sigma_t = a + b\sigma_{t-1} + c\varepsilon^2_{t-1} + dD_t$$

Where b represents the conditional variance of the stock index return, R_t, at time t, and D represents a dummy variable that takes a value of 1 on days following weekends and holidays and is 0 otherwise. ε_t is the residual which is assumed to follow normal distribution with zero-mean, and a time varying standard deviation, σ_t. ***, **, * indicate the significance of data statistics at the 99%, 95% and 90% confidence levels, respectively.

	NASDAQ100 index				KOSDAQ50 index			
	Cash		Futures		Cash		Futures	
Number of obs. Parameters	Coeff.	t-stat.	Coeff.	t-stat.	Coeff.	t-stat.	Coeff.	t-stat.
α	+0.01239*	+1.80	-0.01291***	-4.70	-0.00178	-0.33	-0.00593	-1.01
β	-0.39274	-1.40	+0.54027***	+3.93	+0.03972	+0.13	+0.29247	+1.08
δ	+0.00312	+1.08	-0.00499**	-2.22	-0.00147	-0.54	-0.00461	-1.43
γ	-0.05539	-1.07	-0.07371*	-1.81	+0.00741	+0.14	-0.00668	-0.14
a	-0.00001	-0.28	-0.00005***	-2.75	+0.00003	+0.13	-0.00002	-0.71
b	+0.05939**	+2.38	+0.06509***	+4.17	+0.10955**	+2.48	+0.07731**	+2.50
c	+0.91787***	+29.0	+0.91334***	+65.4	+0.77615***	+9.62	+0.81695***	+18.5
d	+0.00014	+0.57	+0.00031***	+4.84	+0.00020***	+2.66	+0.00041***	+7.77
Log-likelihood	+1086.43		+1093.83		+1204.54		+1116.35	
Ljung-Box(12) for normalized residuals	+9.05		+11.05		+12.69		+10.65	
Ljung-Box(12) for normalized squared residuals	+16.27		+12.05		+18.11		+13.27	

Panel 2: Estimation results of AR(1)-GARCH(1,1)-M model for o close-to-open returns (overnight returns) of KOSDAQ50 index cash and futures and NASDAQ100 index cash and futures

$$R_\tau = \alpha + \beta\sigma_t + \delta D_{t-1} + \gamma\varepsilon_{t-1} + \varepsilon_t$$

$$\sigma_t = a + b\sigma_{t-1} + c\varepsilon^2_{t-1} + dD_t$$

Where b represents the conditional variance of the stock index return, R_t, at time t, and D represents a dummy variable that takes a value of 1 on days following weekends and holidays and is 0 otherwise. ε_t is the residual which is assumed to follow normal distribution with zero-mean, and a time varying standard deviation, σ_t. ***, **, * indicate the significance of data statistics at the 99%, 95% and 90% confidence levels, respectively.

	NASDAQ100 index				KOSDAQ50 index			
	Cash		Futures		Cash		Futures	
Number of obs.								
Parameters	Coeff.	t-stat.	Coeff.	t-stat.	Coeff.	t-stat.	Coeff.	t-stat.
α	-0.01280*	-1.88	+0.00210	+0.78	+0.00094	+0.78	+0.00222	+0.65
β	+0.31906	+1.55	-0.12412	-0.22	+0.03902	+0.17	-0.15426	-0.72
δ	-0.00171	-0.46	-0.00197	-1.15	-0.00241	-0.78	-0.00014	-0.04
γ	+0.31284***	+7.20	-0.01726	-0.42	-0.05503	-1.02	-0.06604	-1.29
a	-0.0003	-0.59	+0.00003	+0.34	-0.00003**	-2.45	-0.00003***	-3.45
b	+0.09279***	+2.83	+0.01668**	+2.53	+0.08281***	+2.62	+0.06676**	+2.21
c	+0.89080***	+33.1	+0.93113***	+27.5	+0.83397***	+14.9	+0.87382***	+21.1
d	+0.00028***	+3.28	+0.00002***	+6.44	+0.00029***	+12.5	+0.00025***	+13.0
Log-likelihood	+917.72		+1328.49		+1255.67		+1247.72	
Ljung-Box(12) for normalized residuals	+12.50		+13.61		+14.01		+9.04	
Ljung-Box(12) for normalized squared residuals	+11.16		+10.69		+3.74		+2.40	

Table 7

Estimation results of information spillover effect between NASDAQ100 index cash and KOSDAQ50 index cash with AR(1)-GARCH(1,1)-M model from January 2001 to December 2002.

$$KQO_t(I_t) = \alpha + \beta\sigma_t + \delta D_{t-1} + \gamma NQI_{t-1} + \theta\varepsilon_{t-1} + \varepsilon_t$$
$$\sigma_t = a + b\,\sigma_{t-1} + c\varepsilon_{t-1}^2 + dD_{t-1} + fNQIE_{t-1}$$

Where $KQO_t(I_t)$ is the close-to-open (open-to-close) returns of KOSDAQ50 index cash at time t, NQI_{t-1} is the open-to-close returns of NASDAQ100 index cash at time $t-1$, and $NQIE_{t-1}$ represents the residuals squared estimated from the open-to-close of NASDAQ100 index cash at time $t-1$ by the equation (1). ε_t is the residual which is assumed to follow normal distribution with zero-mean, and a time varying standard deviation, σ_t. ***, **, * indicate the significance of data statistics at the 99%, 95% and 90% confidence levels, respectively. The coefficients, γ and f are the conditional mean and variance spillover effect from the open-to-close returns of NASDAQ100 index cash to both the close-to-open and the open-to-close returns of KOSDAQ50 index cash, respectively. They also show the conditional mean and variance spillover effect from the open-to-close returns of KOSDAQ50 index cash to both the close-to-open and the open-to-close returns of NASDAQ100 index cash, respectively

	NASDAQ100 index cash => KOSDAQ50 index cash				KOSDAQ50 index cash => NASDAQ100 index cash			
	NQI => KQO		NQI => KQI		KQI => NQO		KQI => NQI	
Parameters	Coeff.	t-stat.	Coeff.	t-stat.	Coeff.	t-stat.	Coeff.	t-stat.
α	-0.02215***	-64.8	-0.00593	-0.90	-0.01512**	-2.48	+0.02106***	+5.07
β	+0.31949***	+98.6	+0.25195	+0.72	+0.37849**	+1.96	-0.85492***	-4.06
δ	-0.00386***	-3.35	-0.00183	-0.79	-0.00080	-0.20	+0.00659***	+3.65
γ	-0.39214***	-40.0	+0.12383***	+3.33	+0.13856*	+1.68	-0.05294	-1.31
θ	+0.04194**	+2.42	+0.02282	+0.45	+0.33534***	+7.47	-0.09436***	-2.77
a	+0.00001***	+3.68	+0.00004	+1.36	-0.00001	-0.42	-0.0003**	-2.50
b	+0.18315***	+13.7	+0.10943**	+2.45	+0.08230***	+3.71	+0.03280***	+3.06
c	+0.63064***	+44.9	+0.74270***	+7.04	+0.87530***	+34.2	+0.90135***	+50.0
d	+0.00014***	+19.3	+0.00003	+0.56	+0.00018	+0.88	+0.00020***	+2.68
f	+0.03271***	+8.85	+0.01221	+0.87	+0.00874**	+2.08	+0.04715***	+4.30
Log-likelihood	+1259.58		+1206.65		+921.72		+1078.84	
Ljung-Box(12) for normalized residuals	+13.26		+9.24		+16.24		+8.96	
Ljung-Box(12) for normalized squared residuals	+0.25		+12.64		+11.91		+13.17	

Table 8

Estimation results of information spillover effect from open-to-close (daytime) returns of NASDAQ100 index futures to both close-to-open (overnight) returns and open-to-close (daytime) returns of KOSDAQ50 index cash with AR(1)-GARCH(1,1)-M model from January 2001 to December 2002.

$$KQO_t(I_t) = \alpha + \beta\sigma_t + \delta D_{t-1} + \gamma NQFI_{t-1} + \theta\varepsilon_{t-1} + \varepsilon_t$$

$$\sigma_t = a + b\,\sigma_{t-1} + c\varepsilon_{t-1}^2 + dD_{t-1} + fNQFIE_{t-1}$$

Where $KQO_t(I_t)$ is the close-to-open (open-to-close) returns of KOSDAQ50 index cash at time t, $NQFI_{t-1}$ is the open-to-close returns of NASDAQ100 index futures at time $t-1$, and $NQFIE_{t-1}$ represents the residuals squared estimated from the open-to-close of NASDAQ100 index futures at time $t-1$ by the equation (1). ε_t is the residual which is assumed to follow normal distribution with zero-mean, and a time varying standard deviation, σ_t. ***, **, * indicate the significance of data statistics at the 99%, 95% and 90% confidence levels, respectively. The coefficients, γ and f are the conditional mean and variance spillover effect from the open-to-close returns of NASDAQ100 index futures to both the open-to-close and the close-to-open returns of KOSDAQ50 index cash, respectively.

	NASDAQ100 index futures => KOSDAQ50 index cash			
	NQFI => KQO		NQFI => KQI	
Parameters	Coeff.	t-stat.	Coeff.	t-stat.
α	-0.00248	-1.46	-0.00560	-0.86
β	+0.45810***	+3.83	+0.23625	+0.68
δ	-0.00078	-0.57	-0.00190	-0.81
γ	+0.34649***	+15.5	-0.13110***	-3.50
θ	-0.21495***	-4.60	+0.02144	+0.42
a	+0.00002**	+2.53	+0.00004	+1.42
b	+0.11163***	+4.22	+0.11003**	+2.41
c	+0.70586***	+13.4	+0.73540***	+6.81
d	-0.00004	-1.26	+0.00004	+0.72
f	-0.00808	-1.06	+0.01334	+0.93
Log-likelihood	+1311.53		+1207.00	
Ljung-Box(12) for normalized residuals	+19.85*		+8.38	
Ljung-Box(12) for normalized squared residuals	+1.35		+12.29	

Table 9

Estimation results of information spillover effect from NASDAQ100 index futures to KOSDAQ50 index futures with AR(1)-GARCH(1,1)-M model from January 2001 to December 2002.

$$KQFO_t(I_t) = \alpha + \beta\sigma_t + \delta D_{t-1} + \gamma NQFO_{t-1} + \theta\varepsilon_{t-1} + \varepsilon_t$$
$$\sigma_t = a + b\,\sigma_{t-1} + c\varepsilon_{t-1}^2 + dD_{t-1} + fNQFOE_{t-1}$$

Where $KQFO_t(I_t)$ is the close-to-open (open-to-close) returns of KOSDAQ50 index futures at time t, $NQFO_{t-1}$ is the close-to-open returns of NASDAQ100 index futures at time $t-1$, and $NQFOE_{t-1}$ represents the residuals squared estimated from the close-to-open of NASDAQ100 index futures at time $t-1$ by the equation (1). ε_t is the residual which is assumed to follow normal distribution with zero-mean, and a time varying standard deviation, σ_t. ***, **, * indicate the significance of data statistics at the 99%, 95% and 90% confidence levels, respectively. The coefficients, γ and f are the conditional mean and variance spillover effect from the close-to-open returns of NASDAQ100 index futures to the (close-to-open) open-to-close returns of KOSDAQ50 index futures.

	NASDAQ100 index futures => KOSDAQ50 index futures				KOSDAQ50 index futures => NASDAQ100 index futures			
	NQFI => KQFO		NQFI => KQFI		KQFI => NQFO		KQFI => NQFI	
Parameters	Coeff.	t-stat.	Coeff.	t-stat.	Coeff.	t-stat.	Coeff.	t-stat.
α	+0.00670**	+2.37	-0.01823***	-12.2	+0.00277	+0.79	-0.01070***	-5.75
β	-0.50320**	-2.31	+0.79108***	+7.41	-0.20806	-0.78	+0.39563***	+3.84
δ	+0.00438	+0.83	+0.00117	+1.08	-0.00127	-0.77	-0.00307**	-2.07
γ	+0.33446***	+10.5	-0.10413***	-6.25	+0.10997***	+4.31	+0.03194	+1.12
θ	-0.06661	-1.27	-0.04720**	+2.08	-0.05344	-1.05	-0.05354	-1.61
a	-0.00005**	+2.01	+0.00004***	+5.71	+0.00001	+1.18	-0.00004	-1.18
b	+0.03745***	+3.12	+0.05574***	+8.52	+0.03503***	+2.90	+0.06138***	+3.85
c	+0.83689***	+61.3	+0.87101***	+79.0	+0.90407***	+43.5	+0.91336***	+92.1
d	+0.00045***	+5.00	-0.00003***	-4.76	-0.00004	-1.08	+0.00022	+1.35
f	+0.00617	+1.41	-0.00294	-1.05	+0.01379***	+3.36	+0.01815**	+2.15
Log-likelihood	+1284.80		+1106.91		+1352.82		+1096.12	
Ljung-Box(12) for normalized residuals	+8.28		+9.85		+10.80		+9.85	
Ljung-Box(12) for normalized squared residuals	+0.85		+19.24*		+9.58		+18.83	

Table 10

Estimation results of information spillover effect from close-to-open (overnight) returns of NASDAQ100 index cash and futures to open-to-close (daytime) returns of both KOSDAQ50 index cash and futures with AR(1)-GARCH(1,1)-M model from January 2001 to December 2002.

$$KQI_t = \alpha + \beta\sigma_t + \delta D_{t-1} + \gamma NQFO_{t-1}(NQO_{t-1}) + \theta\varepsilon_{t-1} + \varepsilon_t$$
$$\sigma_t = a + b\,\sigma_{t-1} + c\varepsilon_{t-1}^2 + dD_{t-1} + fNQFIE_{t-1}(NQOE_{t-1})$$

$$KQFI_t = \alpha + \beta\sigma_t + \delta D_{t-1} + \gamma NQFO_{t-1}(NQO_{t-1}) + \theta\varepsilon_{t-1} + \varepsilon_t$$
$$\sigma_t = a + b\,\sigma_{t-1} + c\varepsilon_{t-1}^2 + dD_{t-1} + fNQFIE_{t-1}(NQOE_{t-1})$$

Where KQI_t, is $KQFI_t$ the open-to-close returns of KOSDAQ50 index cash and futures at time t, $NQFO_{t-1}, NQO_{t-1}$ are the close-to-open returns of NASDAQ100 index futures and cash at time $t-1$, and $NQFIE_{t-1}$, $NQOE_{t-1}$ represent the residuals squared estimated from the open-to-close of NASDAQ100 index futures and cash at time $t-1$ by the equation (1). ε_t is the residual which is assumed to follow normal distribution with zero-mean, and a time varying standard deviation, σ_t. ***, **, * indicate the significance of data statistics at the 99%, 95% and 90% confidence levels, respectively. The coefficients, γ and f are the conditional mean and variance spillover effect from the open-to-close returns of NASDAQ100 index cash and futures to both the open-to-close returns of KOSDAQ50 index cash and futures, respectively.

	NASDAQ100 index cash/futures => KOSDAQ50 index cash				NASDAQ100 index cash/futures => KOSDAQ50 index futures			
	NQO => KQI		NQFO => KQI		NQO => KQFI		NQFO => KQFI	
Parameters	Coeff.	t-stat.	Coeff.	t-stat.	Coeff.	t-stat.	Coeff.	t-stat.
α	-0.00284	-0.59	-0.00317	-0.92	-0.00782**	-2.29	-0.01094***	-4.69
β	+0.09582	+0.35	+0.11067	+0.52	+0.36639**	+2.05	+0.52246***	+3.79
δ	-0.00158	-0.59	-0.00046	-0.22	-0.00472	-1.56	-0.00456*	-1.86
γ	-0.00369	-0.15	+0.28827***	+5.37	+0.01632	+0.66	+0.31532***	+6.73
θ	+0.00364	+0.07	+0.00455	+0.11	+0.00132	+0.03	-0.00258	-0.08
a	-0.00006	-0.24	+0.00001	+0.58	-0.00003	-1.60	-0.00001	-1.00
b	+0.10413**	+2.25	+0.08478***	+3.35	+0.07262***	+3.79	+0.07809***	+4.67
c	+0.76295***	+8.63	+0.75695***	+18.1	+0.81316***	+28.6	+0.80628***	+47.7
d	+0.00020***	+2.79	+0.00012*	+1.84	+0.00043***	+4.05	+0.00036***	+2.54
f	+0.01196*	+1.64	+0.08868***	+2.85	+0.01078**	+2.28	+0.02492*	+1.62
Log-likelihood	+1200.05		+1214.59		+1112.11		+1122.75	
Ljung-Box(12) for normalized residuals	+12.46		+12.45		+11.96		+13.35	
Ljung-Box(12) for normalized squared residuals	+18.33		+18.47		+17.31		+13.14	

Table 11

The status of KOSDAQ50 Index Futures

Underlying Asset	KOSDAQ50 Index

Trading Unit	KRW200,000 per KOSDAQ50 Index Point
Contract Months	The first four consecutive month in the quarterly cycle (March, June, September and December)
Trading Hours	- 09:00 a.m. ~ 3:15 p.m. (Mon. ~ Fri.) - 09:00 a.m. ~ 2:50 p.m. (last trading day)
Circuit Breakers	When the last month contract hits +/- 7% of the previous day's closing price for 1 minute, and the deviation rate of the current futures price from the theoretical price is , or more than +/- 3%, the trading of all contracts are halted for next five. The market is halted for the same time the stock market's halt if the stock market suspends
Price Quotation	Index Point
Minimum Price Fluctuation	0.05 point, representing a value of KRW 10,000
Last Trading Day	Second Thursday of the contract month
Final Settlement Day	The following day of the last trading day
Settlement Method	Cash settlement
Daily Price Limit	10% of the previous closing price
Position Limit	Adopted when KOFEX determines to be necessary
Listing Date	January 30, 2001

Source: Korea Futures Exchange (KOFEX) http://www.kofex.com

Table 12

The status of NASDAQ100 Index Futures

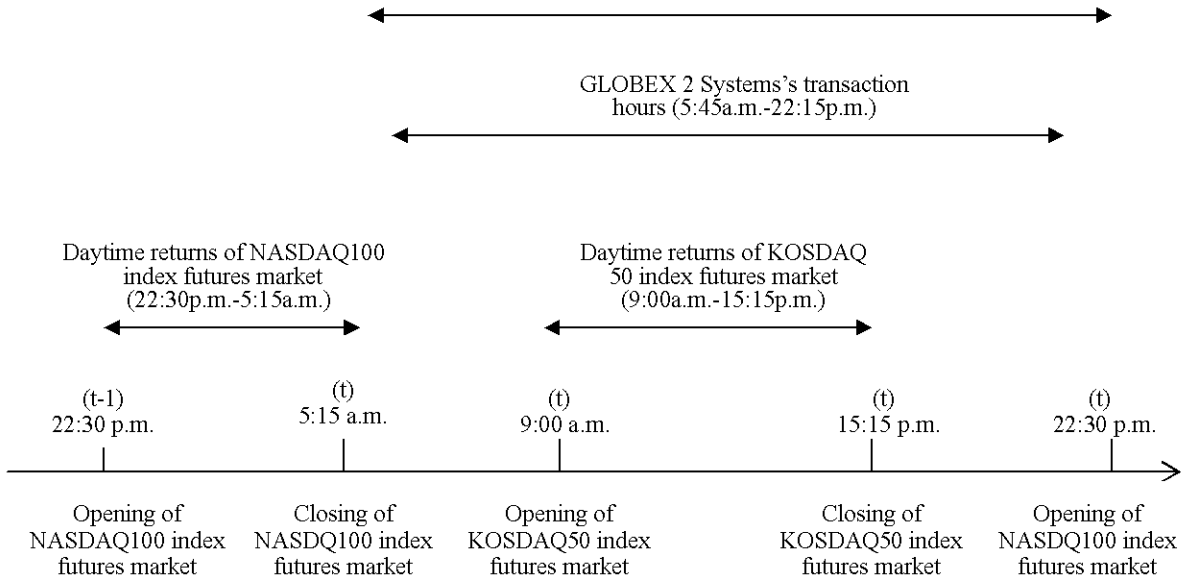
Underlying Asset	NASDAQ100 Index

Trading Unit (Contract Size)	US$ 100 times NASDAQ100 Index Futures Price
Contract Months	March, June, September and December
Trading Hours	Floor: 08:30 a.m. ~ 3:15 p.m. (CST) GLOBEX: 3:45 p.m. ~ 08:15 a.m.
Trading Halts	Daily price limits and trading halts of the Nasdaq 100 Index futures contract are coordinated with trading halts of the underlying stocks listed for trading in the securities markets. If there is a trading halt declared in the primary securities market, trading is halted. Once trading in the primary securities market resumes after a trading halt, trading on the Nasdaq 100 Index futures contract shall resume.
Price Quotation	Index Point
Minimum Price Fluctuation	0.50 index points = U$50 per contract
Last Trading Day	The business day immediately preceding the day of determination of the Final Settlement Price (normally, the Thursday prior to the 3rd Friday of the contract month).
Final Settlement Day	The third Friday of the contract month
Settlement Method	Cash settlement
Daily Price Limit	5%, 10%, 15%, 20%, These limits set quarterly - Floor: Price Limits corresponding to a 5.0%, 10.0% and 20.0% decline below the Settlement Price of the preceding RTH session. [Regular: 0.5 (US$50), Calendar Spread: 0.05 (US$5)] - Globex2: Price limit corresponding to a 5% INCREASE or DECREASE from the Reference RTH price. If the market is limit bid two minutes prior to the opening of RTH, the 5% limit above the reference RTH price is removed. [Regular: 0.5 (US$50), Calendar Spread: 0.05 (US$5)]
Listing Date	April. 10, 1996
Position Limits	5,000 net long or short in all contract months combined

Source: Chicago Mercantile Exchange (CME) http://www.cme.com

Figure 1. Timing and notations for market open and close and daily returns for the U.S., Korea stock index futures markets based on Korean time.

Overnight returns of NASDAQ 100
index futures market
(5:15a.m.-22:30p.m.)



The trading hour of NASDAQ100 index futures listed on Chicago Mercantile Exchange is from 8:30 a.m. which is one hour earlier than the opening of New York Stock Exchange to 15:15 p.m. In terms of Korean time, it is from 9:30 p.m. of previous day (t-1) to 5:15 a.m. of next day(t). Also, the electronic OTC trading of NASDAQ100 index futures through GLOBEX 2 System begins at 3:45 p.m. and closes at 8:15 a.m. of the next day. The opening time of trading on GLOBEX will be the same as the opening time of GLOBEX trading of S&P 500 contracts. In particular, the opening time of GLOBEX trading will be delayed until 6:00 p.m. if GLOBEX trading of S&P 500 contracts is delayed until 6:00 p.m.

On the other, the trading hour of KOSDAQ 50 index futures listed on Korea Futures Exchange (KOFEX) begins from 9:00 a.m. which is 3:45 later after closing of Chicago Mercantile Exchange and close 15:15 p.m. The trading hours between Korea Futures Exchange and Chicago Mercantile Exchange are non-synchronous. We, therefore, are able to test the spillover effect from U.S. market to Korean stock markets. We can infer that the information on price and volatility changes in NASDAQ 100 index futures at previous day could be impact on the overnight and daytime returns and volatilities of KOSDAQ index futures markets because KOSDAQ futures market open after the closing Chicago Mercantile Exchange.

Figure 2. The Trend of NASDAQ100 index futures and KOSDAQ50 index futures from January, 2001 to December, 2002.

Note: KQFC and NQFC mean the close-to-close returns of KOSDAQ50 and NASDAQ100 index futures

respectively

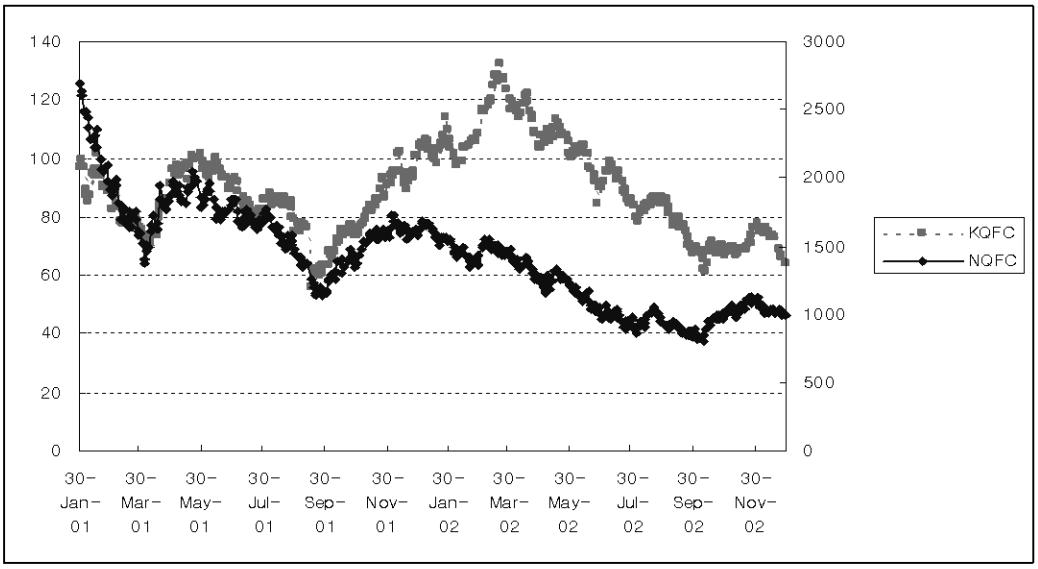


Figure 3. The Trend of NASDAQ100 index cash and KOSDAQ50 index cash from January, 2001 to December, 2002.

Note: KQ and NQ mean the close-to-close returns of KOSDAQ50 and NASDAQ100 index cash respectively