Derivatives Trading, Volatility Spillover, and Regulation: Evidence from the Korean Securities Markets

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Abstract

Unlike the U.S. and Japanese securities markets, we find new evidence of volatility spillover between index stocks and non-index stocks following the introductions of index derivatives trading in the Korean securities markets. We further find that the degree of volatility spillover is closely related to the level of market deregulation; significant return volatility spills over from non-index to index stocks during deregulation period but in the opposite direction during post-deregulation period. Our empirical results show that the former volatility spillover from non-index to index stocks can be explained by the transitory contagion effect associated with the 1997 Korean financial crisis and the subsequent market deregulation, whereas the latter volatility spillover from index to non-index stocks is attributed to the permanent information spillover effect. This latter evidence suggests that the information regarding investors' expectations on the future common market factors is first reflected into the return volatility of index stocks and then transferred to the trading of non-index stocks against which derivatives are not traded. Our results are robust to different estimation and sample construction methods.

JEL classification: G10
Key words: Derivatives trading, Volatility spillover, KOSPI 200, Non-KOSPI 200, Market regulation

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I. Introduction

Since the introductions of index futures and options trading in various markets, a large body of studies has examined the effect of these derivatives trading on the price volatility in the underlying stock markets.[1] While the majority of these studies employ time-series models to test for the spot price volatility before and after the introduction of derivatives trading, little work has been done on the potential effects of the derivatives trading on the volatility spillover between index stocks and non-index stocks in the spot market and the potential causes of such volatility spillover. We intend to fill this void in our paper.

In a market structure where the derivatives market and the underlying stock market are connected through the arbitrage mechanism, if the information that triggers the trading of index derivatives is related to the underlying stocks, then this information would have no impact on the non-index stocks against which derivatives are not traded. The studies by Harris (1989) for the U.S. market and Chang, Cheng, and Pinegar (1999) for the Japanese market provide evidence supporting this conjecture. Harris (1989) shows that after the introductions of index futures and options trading, the spot price volatility of S&P 500 stocks rises relative to non-S&P 500 stocks, though the differences in volatilities are small in economic terms. Chang, Cheng, and Pinegar (1999) report that while spot volatility for Nikkei 225 stocks increases with the introduction of Nikkei 225 futures on the Osaka Securities Exchange, no such volatility effect is observed for non-Nikkei 225 stocks. The results of these studies indicate that futures trading increases spot market volatility but that there is no volatility spillover to stocks against which futures are not traded.

In sharp contrast, Bae, Kwon, and Park (2004) observe the possibility of volatility spillover

[1] These studies include Harris (1989), Brown-Hruska and Kuserk (1995), Conrad (1989), Darrat and Rahman (1995), Board, Sandman, and Sutcliffe (2001) for the U.S. market, Lee and Ohk (1992), Chang, Cheng, and Pinegar (1999), Dennis and Sim (1999), Kyriacou and Sarno (1999), Gullen and Mayhew (2002), Bae, Kwon, and Park (2004) for non-U.S. markets.

between the Korea Composite Stock Price Index (KOSPI) 200 stocks and non-KOSPI 200 stocks with the introduction of index futures and options trading in the Korean securities markets. Their findings suggest that information from the index derivatives markets may also affect non-index stocks as well as index stocks, and that the introduction of derivatives trading may promote information transfer among stocks in the stock market.

The observations by Bae, Kwon, and Park (2004) can be interpreted in several ways. First, due to regulations and trading restrictions present in the stock market, the information generated at the derivatives trading may not be transferred to the underlying stock market in an efficient manner. Under the market environment where market regulation measures have differential effects on the underlying index stocks than on the non-index stocks, the new information from the derivatives market may be reflected into the spot market at different times, rather than at the same time. Second, the information reflected into the derivatives trading can be common market, rather than firm-specific, information, hence affecting both the underlying index stocks and non-index stocks. If the market information is first reflected into the derivatives market and then into the underlying stock market, the timing of pricing adjustment to the information may vary among component stocks in the stock market, which may then cause information transfer between the underlying index stocks and non-index stocks. Third, the contagion effect may play a role. In particular, it has been frequently observed that, at least on a temporary basis, the correlation of return volatility among stocks increases sharply following certain catastrophic events such as a market crash. If the contagion effect exists, then there may be temporary volatility spillover among component stocks in the stock market.

In this paper, we extend the existing literature by examining two key issues pertaining to the derivatives trading. First, we examine explicitly whether the introduction of derivatives trading and the subsequent market deregulation in the Korean securities markets induce volatility spillover between index and non-index stocks. While focusing on the effect of introducing index derivatives trading on the spot price volatility, previous studies fail to examine if the introduction of derivatives trading naturally leads to the separation of the underlying stock market into index and non-index stocks and induces different spot price volatility between these two separated markets. The studies by Harris (1989), Chang, Cheng, and Pinegar (1999), and Bae, Kwon, and Park (2004) test indirectly for the existence of volatility spillover among underlying stocks by comparing the spot price volatility before and after the introduction of derivatives trading. Furthermore, although Bae, Kwon, and Park (2004) show contradictory evidence on the possibility of volatility spillover to the two earlier studies, they cover the sample period up to December 1998 and thus fail to examine the post period of the Korean financial crisis during which the market environments have changed considerably. Unlike these studies, we test directly for the existence of volatility spillover between index and non-index stocks by employing time-series analyses for an extended period of January 1992 through December 2003. In our empirical analyses, we explicitly take into consideration several control variables that supposedly affect the return volatility of underlying stock portfolios such as seasonal and special-event effects, common market factors, and firm-specific factors. We examine this issue over several subperiods based on both the timing of the introductions of various derivatives trading and the level of market regulation during out sample period.

Second, we go a step further by investigating the possible causes of the volatility spillover between index and non-index stocks in the spot market. Considering that various measures of deregulation such as the elimination of restrictions on foreign ownership and program trading were introduced following the Korean financial crisis, we first examine whether the volatility spillover is related to changes in the level of market regulation. For this purpose, we develop a regulation index by evaluating various measures of market regulation and deregulation and identify three distinctive phases of different levels of market regulation. We perform time-series analyses in three subperiods classified based on these three phases. Because information flow in the securities markets is also affected by the level of market regulation, we then test whether the volatility spillover is caused by factors such as temporary shock (contagion effect) or by factors related to permanent, common market information (information spillover effect). For this purpose, we employ the variance decomposition of forecast errors based on the vector auto-regression (VAR) model following Diebold and Yilmaz (2007) and develop the volatility spillover index.

The Korean securities markets offer a unique opportunity to examine these issues with several interesting events occurring in a relatively short period. These events include the introductions of index futures in May 1996, index options in July 1997, and exchange-traded funds (ETFs) in October 2002, the Korean financial crisis in late 1997, and the adoption of various market deregulation measures associated with these events. The Korean stock market is small in size compared to developed markets and is distinctively divided into index stocks and non-index stocks, induced mainly by the introductions of index derivatives trading and the foreign investors' trading behavior. Furthermore, the index futures and options that use KOSPI 200 as underlying base assets are exclusively listed on the Korea Exchange (KRX), and thus it is relatively easy to control for the effects of other external market factors.[2] These features allow us to directly measure the volatility spillover between index and non-index stocks traded on the same exchange and examine its potential causes.

Employing matching sample techniques on daily price data, we find the following three main results. First, there is no noticeable volatility spillover between KOSPI 200 and non-KOSPI 200 stocks before the introduction of the index futures trading. On the contrary, there exists significant volatility spillover between the two stock portfolios after the index futures trading. Second, the observed volatility spillover is closely related to the level of market regulation. Significant return volatility spills over from non-KOSPI 200 to KOSPI 200 stocks during the pre-deregulation and deregulation periods but spills over in a reverse way during the post-deregulation period. Third, the volatility spillover observed during the pre-deregulation and deregulation periods is attributed to the temporary volatility contagion associated with the 1997 Korean financial crisis and subsequent market deregulation measures. In contrast, the volatility spillover observed during the post-deregulation period is attributable largely to the permanent information spillover. The latter result suggests that the information regarding investors' expectations on the future common market factors generated from the derivatives markets is reflected into

[2] In January 2005, Korea Stock Exchange, KOSDAQ, and Korea Futures Exchange were merged into the single Korea Exchange (KRX). KRX currently consists of three divisions of Stock Market Division, KOSDAQ Market Division, and Futures Market Division.

the return volatility of KOSPI 200 stocks and then transferred to non-KOSPI 200 stocks in the same stock market. Our results also offer the volatility contagion effect as a potential explanation for the findings of Bae, Kwon, and Park (2004) that the volatility of non-index stocks is affected by the introduction of the derivatives trading and spills over to index stocks. Our results survive various robustness checks.

Section II reviews the characteristics of KOSPI 200 derivatives trading in the Korean securities markets. Section III presents sample construction and data for the study, and Section IV discusses empirical tests and results. Section V investigates the relation among volatility spillover, the level of market regulation, and the causes of the volatility spillover, with summary and conclusions in the final section.

II. Characteristics of KOSPI 200 Derivatives Trading in the Korean Markets

The majority of derivatives traded in the Korean securities markets use the KOSPI 200 as their underlying index consisting of 200 companies listed on the Stock Market Division of KRX.[3] These derivatives include index futures, index options, and ETFs.[4] In addition, exchange-traded individual stock options are also based on stocks consisting of the KOSPI 200. The number of firms listed on the Stock Market Division of the KRX is considerably less than that of firms listed on the NYSE or NASDAQ, and there is little trading of derivatives whose base assets are different from the KOSPI 200.[5] Hence, if the information on newly introduced derivatives and market deregulation measures such as the lift of restrictions on foreign ownership reaches the stock market, it could affect the volatility of the KOSPI 200 and non-KOSPI 200 stocks differently. Specifically, the following factors may contribute to

[3] This was formerly the Korea Stock Exchange (KSE). The initial KOSPI 200 list published by the KSE on June 15, 1994 consisted of top 200 companies from a total of 692 companies whose stocks traded on the KSE at that time and has since changed due to additions to and deletions from the list over the years.
[4] As of the end of 2003, six ETFs were traded in Korea: KODEX200 and KOSEF based on KOSPI 200 index; KODEX50 and KOSEF50 based on KOSPI 50 index; KODEX Q based on KOSDAQ 50 Index; KODEX Dividend based on Korea Dividend Stock Price Index (KODI). Of these six ETFs, KODEX50 and KOSEF50 were delisted due to weak trading on February 23, 2004 and January 19, 2004, respectively.
[5] The total number of listed companies is 686 in early 1992, which coincides with the opening of the Korean capital markets; 721 at the end of 1995 just before the introduction of index futures trading; 683 at the end of October 2002 just before the introduction of ETFs; and 684 at the end of 2003.

the potentially different patterns of volatility between KOSPI 200 and non-KOSPI 200 stocks.

The first factor is the reduction in market frictions and the enhancement of market operation efficiency that the derivatives markets may induce for the underlying stock markets. While stock prices would adjust slowly to new information due to market frictions such as transaction costs, derivatives trading may play as an effective tool by reducing such frictions. Because derivatives markets such as index futures markets require lower transaction costs and less capital for trading, and make short sales easier than the underlying stock markets, derivatives trading will induce faster price adjustments to new information, reduce information asymmetry in the underlying stock markets, and thus enhance the efficiency of spot market operations (Cox (1976), Kawaller, Koch, and Koch (1987), Brorsen (1991), Subramanyam (1991), Gorton and Pennacchi (1993), Antoniou and Holmes (1995)). Therefore, it is reasonable to expect that these effects will appear first on KOSPI 200 stocks against which derivatives are traded before they will appear on non-KOSPI 200 stocks.

The second factor is the effect of information transfer through arbitrage mechanisms. While the information generated through the transactions of index derivatives that have the KOSPI 200 as base assets would be reflected into the spot market through arbitrage transactions between markets, differences may still exist in the timing of price adjustments between derivatives markets and stock markets and between index stocks and non-index stocks. Since prices of derivatives securities will respond first to disturbances made to the base assets of derivatives and common market factors, it is expected that KOSPI 200 stocks respond first to the disturbances and then non-KOSPI 200 stocks follow.

The third factor is foreign investors' trading behavior. In the Korean stock market, foreign investments have focused primarily on large blue-chip companies such as KOSPI 200 stocks since foreign investors select their stocks primarily based on firm size and liquidity (see, e.g., Choe, Kho, and Stulz (2005)). It is also conceivable that the elimination of the restrictions on foreign ownership in listed and public (government-affiliated) companies in Korea has a greater impact on KOSPI 200 stocks than non-KOSPI 200 stocks because of the foreign investors' preference of large blue chip stocks traded on the KRX. Consequently, the introduction of new index derivatives and the foreign investors' preference of large company stocks belonging to KOSPI 200 have naturally segregated KOSPI 200 stocks from non-KOSPI 200 stocks.

The fourth factor concerns several measures of market deregulation, most of which were introduced in the Korean securities markets in 1998 following the Korean financial crisis in late 1997. The deregulation of several market restrictions including daily price limits, circuit breakers, sidecar systems, ceilings on foreign ownership, and restrictions on short sales contributes to the increase in market efficiency.[6] Similar to the other three factors discussed above, these deregulation measures are expected to induce different effects on the stock return volatility between KOSPI 200 and non-KOSPI 200 stocks. For example, some large-cap listed companies, whose ownership was previously subject to foreign ownership restrictions, became primary trading targets following the removal of foreign ownership ceilings in 1998, but relatively small companies and those with a fewer number of tradable shares were little affected by such deregulation measures.

III. Sample Construction and Data Characteristics

A. Sample Period

Our sample period is from January 3, 1992 to December 30, 2003, and we use daily data so as to compare our results with those from previous studies by Harris (1989), Chang, Cheng, and Pinegar (1999), and Bae, Kwon, and Park (2004).

We partition our sample period into four subperiods based on the introductions of derivatives trading. Index futures trading was officially introduced on the KRX on May 3, 1996, followed by the introduction of index options trading on the KRX on July 7, 1997 and ETFs on October 14, 2002. Accordingly, Period I covers the time period prior to the introduction of futures trading, spanning from January 3, 1992 to May 2, 1996. Period II is the period after index futures trading was introduced and before index options trading was introduced, spanning from May 3, 1996 to July 6, 1997. Period Ⅲ is

[6] See Bae, Kwon, and Park (2004) for the detailed descriptions of these market regulations and deregulations introduced to the Korean securities markets.

the period after the introduction of options trading and before the introduction of ETFs, spanning from July 7, 1997 to October 13, 2002. Period IV is the period after ETF trading was introduced, spanning from October 14, 2002 to December 30, 2003. The last trading date of 2003 (December 30) is used as a cut-off date to include a reasonable number of trading days and sample firms for Period IV. Period I is used as a reference period for comparing it with the three subsequent periods since no event related to derivatives trading took place in this period.

If a derivative trading causes the volatility spillover between KOSPI 200 and non-KOSPI 200 stocks in the underlying stock markets, then the degree of volatility spillover may vary depending upon the attributes of each derivatives trading market. In this regard, the classification into subperiods will allow us to construct our sample firms in the stock market by taking into account the potentially different characteristics of each derivatives market.

B. Sample Construction

Our initial sample consists of all 200 companies whose stocks trade on the KRX. The exact number of companies used in our final sample, however, varies by period due to additions and deletions on the KOSPI 200 stock index during the corresponding subperiod. For our final sample, we include those companies whose stocks remained in the index throughout each corresponding subperiod. We also construct a matched sample of non-KOSPI 200 stocks from KRX stocks that are not included in the KOSPI 200 list during each corresponding period. Following Harris (1989) and Bae, Kwon, and Park (2004), we pair each KOSPI 200 company with a non-KOSPI 200 company that possesses the closest profile with respect to several firm-specific and market characteristics including industry, systematic risk, firm size, trading volume, stock price level, and foreign exchange exposure.[7] These variables are widely used in existing studies as being closely related to stock return volatility.

[7] Our selection process extends those used by Harris (1989) and Bae, Kwon, and Park (2004) by adding industry, foreign exchange exposure, and trading volume. Chang, Cheng, and Pinegar (1999) use Nikkei and non-Nikkei stocks without going through this selection process but with an alternative way to control for broad market influences.

We obtain data on stock price, trading volume, number of listed stocks on the KRX from the itemized trading database furnished by the Korea Securities Computer Corporation (KOSCOM) and stock returns adjusted for stock dividend and split from the Korea Securities Research Institute (KSRI) database. We also collect data on stock indexes from the KRX publications and the exchange rate data from the Bank of Korea reports.

Table 1 reports the sample distribution of KOSPI 200 stocks and matched non-KOSPI 200 stocks used in our paper by period and industry. The first number in Table 1 represents the number of KOSPI 200 companies included in our analysis, and the second number represents the number of initial non-KOSPI 200 companies from which the matched non-KOSPI 200 company group is constructed. For example, in Period II, the total number of KOSPI 200 and non-KOSPI 200 sample firms used for our analysis is 180 and 495, respectively; hence, the matched final sample of non-KOSPI 200 portfolio is composed of 180 companies, which were selected from 495 companies using the selection process described earlier (see also Harris (1989) and Bae, Kwon, and Park (2004)). Table 1 also shows that in Period II, about 70% of sample companies belong to the manufacturing industry, followed by the financial services industry, and the remaining companies are almost equally divided into two industries of construction and circulative services.

C. Estimation of Stock Return Volatility

According to Ross (1989), in an arbitrage-free economy, the volatility of prices is directly related to the rate of information flow to the market. He shows that, under no-arbitrage conditions, stock price variance is equal to the variance of information flow. Shalen (1993) shows that the autocorrelation between the absolute values of stock price changes is closely related to the distribution of investors' beliefs and that new changes in stock prices reflect new information entering into the market. Following these studies, we employ stock return volatility as proxy of the information flow in the market.

To estimate daily stock return volatility of individual stock and portfolios of KOSPI 200 and non-KOSPI 200 stocks, we employ a variance estimation model outlined in Chesney et al. (1993) and

Pastorello (1996). Chesney et al. (1993) propose a filtering procedure to recover a series of realized volatilities from discrete-time realization of a continuous time diffusion process, and Pastorello (1996) polishes the volatility estimation method.[8]

Let $P_{i,t}$ be the closing price of stock (or portfolio) i on day t, and $p_{i,t} = \ln(P_{i,t})$. Following Chesney et al. and Pastorello, an unbiased estimator of stock i's return variance at day t, $Var_{i,t}$, is approximated by:

$$Var_{i,t} = \frac{2}{\chi_i^2}[1 - e^{\chi_i(p_{i,t+1} - p_{i,t})} + \chi_i\,(\mathrm{p}_{i,t+1} - \mathrm{p}_{i,t})e^{\chi_i(p_{i,t+1} - p_{i,t})}] \quad (1)$$

where $\chi_i = -(2\mu_i/3\sigma_i^2)$, and $p_{i,t+1} - p_{i,t} \sim (\mu_i, \sigma_i^2)$, and μ_i and σ_i are the mean and standard deviation of returns of stock i, respectively. We first construct value-weighted portfolios of KOSPI 200 and non-KOSPI 200 stocks and then estimate daily return volatilities of two portfolios using equation (1). The daily returns used for our analysis are those converted into the continuous-time basis.

Figure 1 shows daily return volatilities of KOSPI 200 and non-KOSPI 200 portfolios estimated using equation (1) during our sample period. It is clearly shown that the patterns of the daily return volatility of both KOSPI 200 and non-KOSPI 200 portfolios are distinctively different between before and after the Korean financial crisis. Both stock portfolios exhibit huge spikes in volatility during the crisis period of October 1, 1997 to December 31, 1998.[9] After the crisis, the volatility becomes gradually stabilized with much smaller spikes time to time. Relative to the return volatility of KOSPI 200 stocks, the return volatility of non-KOSPI 200 stocks shows several large-scale spikes after the financial crisis as well as during the crisis period. These findings suggest that it would be necessary to take into account the potentially different characteristics of subperiods associated with major events such as the Korean financial crisis and to examine the return volatility in several subperiods partitioned based on this notion.

Table 2 reports summary statistics of daily return volatility of KOSPI 200 and non-KOSPI 200

[8] Chang, Cheng, and Pinegar (1999) apply this estimation model in their testing of the effect of the Nikkei index futures trading on stock market volatility.

[9] This Korean financial crisis period is determined by considering the application of IMF bailout, large changes in foreign exchange rates, and sharp changes in stock prices. During this period, monthly returns of KOSPI were -31% in Oct. 1997, -14.3% in Nov, 1997, 41.1% in Jan. 1998, -1.5% in Feb. 1998, 14.2% in Jul. 1998, -10.8% in

portfolios. The overall results are consistent with those as graphically presented in Figure 1. The return volatility of KOSPI 200 is on average greater than that of non-KOSPI 200 during the whole period and during most of the subperiods examined.[10] The return volatility is also considerably greater during both the crisis period and the post-crisis period than during the pre-crisis period. This finding is also corroborated by the greatest return volatility in Period III, which includes the financial crisis period. It is also interesting to observe that the mean of return volatility of non-KOSPI 200 is greater than that of KOSPI 200 in Period II and during the pre-crisis period. Although preliminary, these findings suggest a certain degree of volatility spillover from KOSPI 200 to non-KOSPI 200 stocks after the introduction of the index futures trading in the Korean markets.

D. Adjustment for Seasonal and Special-Event Effects

To pinpoint the effect of the introduction of derivatives trading on the return volatility of index stocks more precisely, we control seasonal and special-event effects that are supposedly to affect stock return volatility regardless of the changes in the fundamental factors. It is well documented in the existing literature that seasonal and trading-related effects such as the days-of-the week effect, January effect, intra-month pattern, holiday effect, non-trading effect, and market crash effect may affect the daily return volatility of stocks to some extent. To control for these seasonal and special-event effects, we follow a filtering process by estimating the regression of daily return volatility against these factors (Gallant, Rossi, and Tauchen (1992)). Specifically, the following dummy variables are used in the filtering process:

- Weekday dummy variable for each weekday with Wednesday as base day;
- Monthly dummy variable for each month from March through November with February as base month;

Aug. 1998, and 26.3% in Dec. 1998.

[10] It is worth noting that this finding is different from that reported in Table 2 of Bae, Kwon, and Park (2004). The primary reason for this difference is that during the post-1999 period which Bae et al. (2004) do not cover, KOSPI 200 stocks exhibit significantly greater return volatility than non-KOSPI 200 stocks.

- Weekly dummy variable for each of four weeks (1^{st}, 2^{nd}, 3^{rd}, and 4^{th}) in January and December;
- Financial crisis dummy variable for the Korean financial crisis period of October 1, 1997 – December 31, 1998;[11]
- Non-trading (including weekend) dummy variable of GAP1, GAP2, GAP3, and GAP4 based on the number of non-trading days prior to the next trading day;[12]
- Market crash dummy variable for the day when the daily return on KOSPI declines by more than 10%.

Employing the dummy variables discussed above, we estimate the following regression equation for the filtering process:

$$Var_t = x_t \beta + \varepsilon_t \tag{2}$$

where x_t is the vector of dummy variables and β is the vector of parameters.

Table 3 reports the estimation results. For both KOSPI 200 and non-KOSPI 200 portfolios, most of the estimated coefficients are statistically significant at least at the 10% level. Compared to non-KOSPI 200, KOSPI 200 shows a larger number of significant estimates on weekly and monthly dummy variables, indicating more significant weekly and monthly effects on the return volatility of KOSPI 200 portfolio. As expected, the estimated coefficients of dummy variables on the financial crisis and market crash are both positive and significant at the 1% level for both KOSPI 200 and non-KOSPI 200 portfolios, signifying that special events such as the Korean financial crisis and the market crash significantly increase the return volatility of stocks across the KRX. On the other hand, the non-trading day has no significant coefficient, and hence little effect on the return volatility of index or non-index portfolios. The overall results in Table 3 corroborate the need to control seasonal and special-event

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[11] It is well documented that there are significant changes in return volatility surrounding the 1997 Korean financial crisis (e.g., Bae, Kwon, and Park (2004)). We use the financial crisis dummy variable to control for the changes in return volatility.

[12] For example, if there is no trading for one day prior to day t, then the dummy is equal to GAP1.

effects in studies of the effects of derivatives trading on stock return volatility.

E. Preliminary Analysis of the Effect of Derivatives Trading on Stock Return Volatility

Before we perform our main analyses in the next section, we estimate the following regression model with three period dummy variables to obtain preliminary evidence on the impact of the introduction of derivatives trading on stock return volatility:

$$Var_t = \alpha + x_t \beta + \sum_{j=2}^{4} c_j D_j + \varepsilon_t \qquad (3)$$

In equation (3), x_t is the vector for seasonal and special-event effects estimated in equation (2). D_j is the period dummy variables such that D_2 equals 1 for period II and 0 otherwise; D_3 equals 1 for period III and 0 otherwise; and D_4 equals 1 for period IV and 0 otherwise.

Table 4 reports the estimation results. For brevity's sake, we report estimated regression coefficients on the period dummy variables only. The Newey and West (1994) method is used to accommodate heteroscedasticity and serial correlations. The period dummy variables for KOSPI 200 all carry positive regression coefficients, and two of them are significant at the 1% level. Similarly, the period dummies for non-KOSPI 200 have positive regression coefficients, and the coefficients are all significant at least at the 10% level. Hence, the return volatility for both KOSPI and non-KOSPI 200 portfolios increases following the introduction of derivatives (futures, options, and ETFs) trading. Although these results are preliminary without further statistical tests, non-KOSPI 200 portfolio exhibit substantially greater return volatility after the introduction of futures trading but considerably less return volatility following the introduction of ETFs than KOSPI 200 portfolio. The former finding suggests a possibility of volatility spillover from KOSPI 200 stocks to non-KOSPI 200 stocks following the introduction of futures trading.

IV. Examination of the Existence of Volatility Spillover in Stock Markets

A. Time-Series Analysis with Period Dummies

As demonstrated in previous studies (e.g., Harris (1989), Bacha and Vila (1994), and Chang, Cheng, and Pinegar (1999)), it is crucial to control for the effects of common market factors so as to pinpoint the effect of the introduction of derivatives trading on stock return volatility. In particular, Chang, Cheng, and Pinegar (1999) employ a regression model in which the average return volatility of individual stocks consisting of the index portfolio is used to control for the effects of the common market factors on the return volatility of index portfolio.

While the approach by Chang, Cheng, and Pinegar (1999) is effective in separating the two effects of the introduction of derivatives trading and the changes in common market factors on the return volatility of the underlying stock markets, their model is based on equally-weighted portfolios. In addition, the effects of common market factors can be controlled more directly by using different proxy variables. In this paper, we employ the return volatility of the more broadly-based KOPSI to control for the common market factors instead of the average return volatility of KOSPI 200 stocks as used in Chang, Cheng, and Pinegar (1999).

The changes in common market factors would affect KOSPI, KOSPI 200, and non-KOSPI 200 equally. However, the arbitrage associated with the introduction of index derivatives trading would affect the underlying KOSPI 200 portfolio only. Accordingly, the magnitude of the effect that the introduction of new derivatives trading will have on the stock return volatility is expected to be in the order of KOSPI 200, KOSPI, and non-KOSPI 200 portfolios. In other words, if the arbitrage transactions are made based on the information related to the underlying KOSPI 200 stock portfolio, there would be differences in the return volatility between KOSPI 200 that represents the underlying stock basket and non-KOSPI 200 that does not belong to the underlying basket after the introduction of derivatives trading. Hence, with the return volatility of KOSPI being used as a proxy variable for common market factors, the introduction of new derivatives trading is expected to have a positive effect on the return volatility of KOSPI 200 but no effect on the return volatility of non-KOSPI 200.[13]

In order to test the above hypotheses, we construct equations (4) and (5) as follows:

$$Var_{K,t} = \alpha_K + x_t\,\beta_K + f_t\,\theta_K + y_{K,t}\lambda_K + b_K Var_{M,t} + \sum_{j=2}^{4} c_{Kj} D_j + \varepsilon_{K,t} \tag{4}$$

$$Var_{NK,t} = \alpha_{NK} + x_t\,\beta_{NK} + f_t\,\theta_{NK} + y_{NK,t}\lambda_{NK} + b_{NK} Var_{M,t} + \sum_{j=2}^{4} c_{NKj} D_j + \varepsilon_{NK,t} \tag{5}$$

where K denotes KOSPI 200, and NK denotes non-KOSPI 200. In equations (4) and (5), we use the return volatility of KOSPI (Var_M) as an explanatory variable to control for the effects of common market factors and three period dummy variables (D_j) representing different timings of the introduction of derivatives (index futures, index options, and ETFs) trading as defined in equation (3).

In both equations, three sets of control variables are employed. x_t is the vector for seasonal and special-event effects estimated in equation (2) and reported in Table 3. f_t is the vector for control variables representing common market factors other than the return variability of KOSPI; we use the volatility of changes in the Korean currency (won) against the U.S. dollar during each subperiod as representing the external economic conditions of Korean companies.[14] Lastly, $y_{K(or\ NK)}$ is the vector for firm- (or portfolio-) specific factors such as firm (or portfolio) size and debt ratio that can also affect the portfolio return variability. To control for these factors, we employ three additional control variables including the natural logarithm of firm size measured as the market value of equity, the weighted average debt ratio based on the market value as weight, and the reciprocal of weighted average price level based on the market value as weight.

The key testing variables in equations (4) and (5) are the regression coefficients of the period dummy variables, c_{Kj} and c_{NKj}. On the one hand, the regression coefficients of c_{Kj} in the regression model of KOSPI 200 (equation (4)) are expected to be positive and significant if there is an increase in return volatility caused by the arbitrage transactions associated with the introduction of derivatives trading. On the other hand, the regression coefficients of c_{NKj} in the regression model of non-KOSPI 200

[13] The proofs of these predictions are provided in Appendix A.

[14] Existing studies show that foreign exchange risk is a key factor in determining stock returns (Choi and Rajan (1997), Kwon, Bae, and Chung (2005)).

(equation (5)) are expected to be zero since they are not supposedly affected by the arbitrage transactions. In equations (4) and (5), the Newey and West (1994) method is used to accommodate heteroscedasticity and serial correlations.

Table 5 presents the estimation results from equations (4) and (5). For brevity's sake, we do not report the regression estimates of control variables except for the return volatility of the more-broadly based KOSPI (Var_M). As expected, Var_M is significantly (at the 1% level) positively related to the return volatility of both KOSPI 200 and non-KOSPI 200 stock portfolios. The results show that after controlling for the effects of common market factors and other firm-specific factors in addition to seasonal and special-event effects, there is no significant increase in the return volatility of KOSPI 200 in Period II, relative to the base period of Period I, as evidenced by the positive but insignificant (at the 10% level) estimated coefficient of the period dummy variable D_2. Even the subsequent two subperiods of Periods II and III are not associated with an increase in return volatility of KOSPI 200. In contrast, non-KOSPI 200 portfolio is associated with a significant increase in return volatility in both Period II and Period III, as evidenced by the positive and significant (at least at the 10% level) estimated coefficients of the period dummies of D_2 and D_3.

It is interesting to observe that the return volatility of both KOSPI 200 and non-KOSPI 200 portfolios declines significantly in Period IV, the period after the introduction of ETFs, as evidenced by the negative and significant (at least a the 10% level) regression coefficients of D_4. These finding are in contradictory to those reported in Table 4. In later sections of our paper, we show that these findings can be largely explained by the effective implementation of various deregulation measures during this post-deregulation period.

The results in Table 5 indicate that the changes (or increases) in return volatility of KOSPI 200 portfolio for the subperiods of Periods II, III, and IV reported in Table 4 can be explained largely by the common market factors and/or firm-specific factors. On the contrary, non-KOSPI 200 portfolio still shows significant increases in return volatility for the subperiods of Periods II and III after the introduction of index futures and index options trading, respectively, even after controlling for the common market factors and firm-specific factors. Hence, the introduction of index futures and options trading in the Korean securities markets brings in a significant impact on non-KOSPI 200 stocks against which no futures or options are traded. These results are new and important because no other derivatives markets so far exhibit similar evidence of volatility spillover among stocks in the spot markets. Our findings are contrary to those in Harris (1989) and Chang, Cheng, and Pinegar (1999) but are consistent with those in Bae, Kwon, and Park (2004).

B. Time-Series Analysis with Lag Variables

We now turn to the analysis of alternative time-series models to examine further the possibility of volatility spillover between KOSPI 200 and non-KOSPI 200 stock portfolios. The portfolio return volatility used for the analysis is the daily volatility of value-weighted index returns as used in the cross-sectional analysis.

We first construct a lag polynomial regression model that contains both lag variables of the return volatility of its own portfolio and lag variables of the return volatility of the counterpart portfolio in each subperiod. We then test the model using the likelihood ratio (LR) test to examine if lag variables of each portfolio can explain the return volatility of the other portfolio. In the regression models, we include the common market factors that supposedly affect the portfolio return volatility such as return volatility of KOSPI and changes in exchange rates (Korean currency against the U.S. dollar) along with seasonal and specific-event effects and firm-specific factors as additional control variables as used in equations (4) and (5). Putting these factors together, we estimate the following time-series models in each of the four subperiods:

$$Var_{K,t} = a_o + x_t\,\beta_K + y_{K,t}\lambda_K + \gamma_K(z)Var_{K,t} + \gamma_{NK}(z)Var_{NK,t} + \gamma_M(z)V(c_i)_t + \upsilon_{K,t} \tag{6}$$

$$Var_{NK,t} = b_o + x_t\,\beta_{NK} + y_{NK,t}\lambda_{NK} + \delta_{NK}(z)Var_{NK,t} + \delta_K(z)Var_{K,t} + \delta_M(z)V(c_i)_t + \upsilon_{NK,t} \tag{7}$$

In equations (6) and (7), *K* and *NK* denote KOSPI 200 and non-KOSPI 200, respectively. x_t is the vector for seasonal and special-event effects estimated in equation (2) and reported in Table 3.

$y_{K,t\ (or\ NK,t)}$ is the vector for firm-specific factors. $V(c_i)$ is the vector for common market factors that include the return volatility of KOSPI (Var_M), changes in the Korean currency against the U.S. dollar, and the volatility of call rates representing short-term interest rates. Hence, $V(c_i)$ combines the two control variable sets of y_t and Var_M as employed in equations (4) and (5).

The key testing variables in equations (6) and (7) are $\gamma(z)$ and $\delta(z)$, which are regression coefficients of lag polynomial variables with certain lags.. In order to examine whether the lag variables of the return volatility of KOSPI 200 and non-KOSPI 200 portfolios can each explain the return volatility of the other portfolio, we test the null hypotheses that the estimated coefficients of $\gamma_{NK}(z)$ are equal to zero collectively in equation (6) and that the estimated coefficients of $\delta_K(z)$ are equal to zero collectively in equation (7). In equations (6) and (7), we consider the length of lag variables up to three lags and adjust heteroscedasticity and serial correlations by the Newey and West (1994) method.

We present the estimation results in Table 6. Panel A (B) report LR test statistics of the lag variables of return volatility for non-KOSPI 200 (KOSPI 200) portfolio in the regressions of KOSPI (non-KOSPI) 200 return volatility both before and after controlling for the common market factors. For conciseness, we do not report the regression estimates on the control variables.

Panel A shows that LR statistics of the lag variables of non-KOSPI 200 portfolio are significant at least at the 10% level in Periods I, II, and IV after controlling for common market factors. These results indicate that the lag variables of non-KOSPI 200 portfolios have significant predictive power in explaining the future return volatility of KOSPI 200 after both index futures and options are introduced in the Korean markets. On the contrary, as shown in Panel B, the explanatory power of the return volatility of KOSPI 200 portfolio in predicting the future return volatility of non-KOSPI 200 portfolio is significantly weakened after controlling for the common market factors. The lag variables of KOSPI 200 return volatility fail to explain the future return volatility of non-KOSPI 200 portfolio in Periods I, II, and III, as evidenced by the insignificant LR statistics, but have a marginally significant (at the 10% level) explanatory power in Period IV.

The results in Table 6 indicate that following the introduction of futures trading in the Korean market (Period II), there is significantly greater volatility spillover from non-KOSPI 200 to KOSPI 200 portfolio than from KOSPI 200 to non-KOSPI 200 portfolio. We also observe significant volatility spillover between these two portfolios during the period after the introduction of ETFs (Period IV).

It is also worth noting that the explanatory power of KOSPI 200 return volatility on the return volatility of non-KOSPI 200 diminishes considerably after controlling for the common market factors as shown in Panel B. These findings indicate that the information on the common market factors is reflected first into KOSPI 200 stocks and then transferred to non-KOSPI 200 stocks through the volatility spillover from KOSPI 200 to non-KOSPI 200 stocks.

V. Effects of Market Regulation and Causes of Volatility Spillover

A. Analysis of the Effects of Changes in the Level of Market Regulation on Volatility Spillover

The volatility spillover between KOSPI 200 and non-KOSPI 200 stocks we observed in the previous section may be related to changes in the level of market regulation. Brenner, Subramanyam, and Uno (1989) find that there exist significant deviations in the market prices of Nikkei 225 futures from their theoretical prices by period and that these deviations are significantly affected by the market regulation and trading mechanism which may be more beneficial or detrimental to certain investment groups in the market. Several studies on the effects of market regulation measures such as price limits and circuit breakers document that these market regulation measures increase, rather than reduce, the information asymmetry in the market (see, e.g., Amihud and Mendelson (1987, 1991), Greenwald and Stein (1991), Gerety and Mulherin (1992), and Harris, Sofianos, and Shapiro (1998)).

As discussed earlier, there have been several measures of deregulation and improvement of market mechanisms in the Korean securities markets since the Korean financial crisis. Hence, the deregulation and elimination of restrictions on foreign ownership and program trading, for example, may bring in differential effects on the return volatility of index stocks relative to non-index stocks and further affect volatility spillover among stocks in the Korean stock markets. This also suggests that it would be necessary for our kind of studies to take into consideration the effects of major deregulations and changes in market mechanisms that were introduced to the Korean securities markets during our sample period.

In this section, we investigate how changes in the level of regulation (and deregulation) affect the interrelation of return volatility between KOSPI 200 and non-KOSPI 200 stocks. For this purpose, during our sample period of January 3, 1994 – December 30, 2003, we develop a regulation index representing the level of regulation in the Korean securities markets by employing the approach discussed in Appendix B. The trend of the regulation index is graphically presented in Figure 2 and illustrates that the level of regulation in the Korean securities markets during our sample period can be partitioned into three phases.

Consistent with these three phases, we partition our sample period into three subperiods related to the level of regulation index and estimate the regression models (6) and (7) in each of the three subperiods. The three subperiods are: (i) the pre-deregulation period after the introduction of futures trading and before the introduction of deregulation measures, spanning the 18-month period from May 3, 1996 to November 2, 1997; (ii) the deregulation period during which both futures and options were traded and significant deregulation measures were introduced to the market, spanning from November 3, 1997 to July 23, 2001; and (iii) the post-deregulation period during which the level of regulation was maintained in a stable manner, spanning the 18-month period from July 24, 2001 to December 30, 2003.

Table 7 shows estimation results of equations (6) and (7) in each of the three subperiods partitioned based on the level of regulation. As Panel A shows, the LR statistics for non-KOSPI 200 return volatility are significant at least at the 5% level during the deregulation period after controlling for the common market factors. Hence, the lag variables of the return volatility of non-KOSPI 200 portfolio have significant predictive power in explaining the future return volatility of KOSPI 200 portfolio during the deregulation period. Such explanatory power of non-KOSPI 200 return volatility for KOSPI 200 return volatility, however, diminishes considerably during the post-deregulation period. On the contrary, as shown in Panel B, the LR statistics for KOSPI 200 return volatility are not significant during either the pre-deregulation or deregulation period after controlling for the common market factors. Hence, the lag variables of KOSPI 200 return volatility fail to explain the future return volatility of non-KOSPI 200 portfolio. The relation, however, turns to a significant (at the 1% level) one during the post-deregulation period.

These findings suggest that the volatility spillover from non-KOSPI 200 to KOSPI 200 portfolio occurring after the introduction of futures trading as documented in Table 6 is closely related to the level of market regulation (and deregulation). Specifically, during the deregulation period, the lag variables of the return volatility of non-KOSPI 200 portfolio exhibit strong explanatory power in predicting the future return volatility of KOSPI 200 portfolio, indicating significant volatility spillover from non-KOSPI 200 to KOSPI 200 stocks during this period. In contrast, during the post-deregulation period, significant return volatility spills over in the reverse way from KOSPI 200 to non-KOSPI 200 portfolio.

When combined with results in Tables 5 and 6, the results in Table 7 have two important implications. First, there exists volatility spillover between KOSPI 200 and non-KOSPI 200 portfolios in the Korean securities markets after the introduction of derivatives trading that uses KOSPI 200 as base assets. There is weak volatility spillover from KOSPI 200 to non-KOSPI 200 stocks following the introduction of index futures and options trading (Periods II and III), and most of this volatility spillover diminishes after controlling for the common market factors. These results are consistent with a market mechanism through which KOSPI 200 stocks first reflect the information on the common market factors into their pricing and then transfer it to non-KOSPI 200 stocks. On the contrary, during the same periods, there is significant volatility spillover from non-KOSPI 200 to KOSPI 200 stocks. Furthermore, this volatility spillover effect remains significant even after controlling for the common market factors. This evidence suggests that certain information affecting non-KOSPI 200 portfolio also affects KOSPI 200 portfolio.

Second, the volatility spillover from non-KOSPI 200 to KOSPI 200 portfolio and vice versa is closely related to the level of market deregulation. During the deregulation period, there is strong volatility spillover from non-KOSPI 200 to KOSPI 200 portfolio. On the contrary, during the post-deregulation period (after July 2001), there is strong volatility spillover from KOSPI 200 to non-KOSPI 200. These findings suggest that although the index futures trading was introduced in the Korean securities markets in May 1996, the information created in the futures markets was not fully or quickly transmitted among component stocks in the underlying stock market during the period when the level of market regulation is relatively high. In this regard, the results in Bae, Kwon, and Park (2004) can be interpreted as outcomes of the period in which the regulation measures were not fully implemented in the Korean markets and the derivatives markets were not fully grown.

B. Causes of Volatility Spillover: Information Spillover Effect or Contagion Effect?

Our analysis so far provides strong evidence that the volatility spillover between KOSPI 200 and non-KOSPI 200 portfolios is closely related to the level of market deregulation. Because the flow of information is also affected by the level of market deregulation, a follow-up question is what type of information effect causes the volatility spillover observed in the Korean markets. The relation of volatility spillover between KOSPI 200 and non-KOSPI 200 stocks may be explained by one or both of the following two effects.

The first effect is the information spillover effect that the information created from the trading of non-KOSPI 200 (KOSPI 200) stocks induces the future return volatility of KOSPI 200 (non-KOSPI 200) portfolio. The return volatility of non-KOSPI 200 (KOSPI 200) stocks may reflect investors' expectations on the common market factors, and the portion of information that the current and lag variables of the common market factors fail to capture is first reflected into the trading of non-KOSPI 200 (KOSPI 200) stocks and then with some delay into the trading of KOSPI 200 (non-KOSPI 200) stocks.

The second effect is the contagion effect. A contagion effect can be defined as a significant change in the correlation of stock returns across markets (King and Wahdwani (1990)) or as a significant increase in cross-market linkages after a shock to one country or a group of countries (Forbes and Rigobon (2002)). Even if the stock return volatility created in the trading of non-KOSPI 200 stocks is caused by the information unrelated to the trading of KOSPI 200 stocks, the return volatility of KOSPI 200 stocks may still be caused by other contagion factors such as investors' overreaction, noise trading, and speculation. Several studies attempt to explain the relations of return volatility across markets using the contagion effect. Engle, Ito, and Lin (1990) analyze the trend in daily volatility of the foreign exchange rates of the U.S. dollar and the Japanese yen and show the existence of volatility spillover in the foreign exchange markets. Hamao, Masulis, and Ng (1990) find that there is short-term volatility spillover among the stock markets in New York, London, and Tokyo surrounding the 1987 stock market crash. Similarly, King and Wahdwani (1990) show that there exists a contagion effect among stock returns of these three markets after the 1987 market crash. Edwards (1999) and Edwards and Susmel (2001) show that the increase in the interdependence between interest rate volatility and stock return volatility for South American countries can be explained by the contagion effect.

Drawing from our discussions above, we test two hypotheses to explain the volatility spillover between KOSPI 200 and non-KOSPI 200 stocks. The first hypothesis is the information spillover hypothesis. If the information created from the trading of KOSPI 200 or non-KOSPI 200 stocks reflects the future information on common market factors, the return volatility of both portfolios will provide a useful guide in predicting the future return volatility of common market factors. The second hypothesis is the contagion effect hypothesis. If the volatility spillover between KOSPI 200 and non-KOSPI 200 stocks is caused by factors such as temporary shock, market fashion or fads, noise trading, or revisions of heterogeneous expectation among investors, then the volatility spillover from one portfolio to another will exist only in a limited time periods.

Following Diebold and Yilmaz (2007), we employ the variance decomposition of forecast errors based on the vector auto-regression (VAR) model to test the two hypotheses on the interrelation of return volatility between KOSPI 200 and non-KOSPI 200 stocks.[15] We develop the VAR model that uses the daily return volatility of KOSPI 200 and non-KOSPI 200 portfolios estimated from equation (1). The control variables of the VAR model include seasonal and special-event effects, volatility of common market factors, and firm-specific factors measured in equation (2). In the process of estimating the VAR

[15] The variance decomposition of forecast errors allows one to separate and estimate the effect of one portfolio's return volatility on the other portfolio's return volatility from the effect of each portfolio's own unique shock.

model, we employ the variance decomposition of forecast errors to measure the effect of the return volatility of each stock portfolio (KOSPI 200 and non-KOSPI 200) on the return volatility of the counter stock portfolio.

To be more specific, we estimate the VAR(3) model by rolling forward by one week on the basis of the 3-year VAR model estimation period and, for each estimation, by computing the ratio of the return volatility of KOSPI 200 (non-KOSPI 200) portfolio that can be explained by non-KOSPI 200 (KOSPI 200) portfolio.[16] This ratio is a single measure of volatility spillover from one portfolio to another portfolio, and is used to develop the volatility spillover index by combining all estimated ratios through continuous estimations of the VAR(3) model on a weekly rolling basis. By analyzing the trend of this index, we test whether the contagion effect or information spillover effect causes the interrelation of return volatility between the two stock portfolios.

In Figure 3, we show the movement of the volatility spillover index estimated using the return volatilities of KOSPI 200 and non-KOSPI 200 portfolios during our sample period. Panel A of Figure 3 presents the changes in the volatility spillover from non-KOSPI 200 to KOSPI 200 stocks. Before the Korean financial crisis in late 1997, the volatility spillover from non-KOSPI 200 to KOSPI 200 stocks remains at a relatively low level with no significant changes. In contrast, during the period after the 1997 financial crisis and up to the end of 2001 (a period which largely coincides with Period III, the crisis and post-crisis periods, and the deregulation period in our study), the volatility spillover from non-KOSPI 200 to KOSPI 200 stocks increases substantially with large swings, and its level varies significantly depending upon the period examined. After 2001, however, the changes in volatility spillover remain relatively stable at a low level again. These findings suggest that the volatility spillover from non-KOSPI 200 to KOSPI 200 stocks in Period II, Period III, and during the deregulation period found earlier in our paper can be explained at least in part by the contagion effect associated with the Korean financial crisis in late 1997 and subsequent deregulation measures introduced in the Korean securities

[16] The length of the lag in the VAR model is determined as three using the Akaike and Schwartz basis.

markets.

Panel B of Figure 3 presents the volatility spillover from KOSPI 200 to non-KOSPI 200 stocks. Note that the scale of volatility spillover index (Y-axis) in Panel B is substantially larger than that in Panel A. The volatility spillover stays initially at a very low level until the end of 1996 and then increases gradually with some large swings in the subsequent years of 1997 through 2001. After 2001, however, the volatility spillover rises sharply to a considerably high level and increases gradually during the remaining sample period. These findings indicate that the volatility spillover from KOSPI 200 to non-KOSPI 200 stocks in Period IV (after the introduction of ETFs) and the post-deregulation period as shown in Tables 6 and 7 is not a temporary but a more permanent phenomenon and is hence attributed to the permanent information spillover effect, rather than the temporary contagion effect. Furthermore, the volatility spillover observed after 2001 appears to be closely related to the effective implementation of several market deregulation measures, which were introduced in the previous deregulation period.

C. Robustness Tests

As we find evidence on the role of the information spillover effect in explaining the volatility spillover between KOSPI 200 and non-KOSPI 200 stocks, we conduct an additional analysis to examine whether the changes in the volatility spillover between these two portfolios indeed reflect the information on investors' expectations on the future common market factors proxied by the return volatility of KOSPI in the following time-series model.

$$Var_{M,t} = \alpha_o + x_t\beta + \gamma_K(z)Var_{K,t} + \gamma_{NK}(z)Var_{NK,t} + \gamma_M(z)Var_{M,t} + \upsilon_{M,t} \tag{8}$$

where the dependent variable, Var_M, is the portfolio return volatility of KOSPI used as market index, and $\gamma(z)$ denotes regression coefficients of lag polynomial variables with three lags. Specifically, we examine in equation (8) if the lag variables of the return volatility of non-KOSPI 200 and/or KOSPI 200 stocks can predict the return volatility of KOSPI that is the common market factor for both KOSPI 200 and non-KOSPI 200 portfolios. For this purpose, we test the null hypotheses that the regression coefficients of $\gamma_K(z)$ and $\gamma_{NK}(z)$ are equal to zero collectively.

Table 8 presents the estimation results from equation (8) by several subperiods. Panels A and B report results by four subperiods classified based on the introduction of derivatives trading and by three subperiods classified based on the level of market deregulation, respectively. For brevity, we report the LR statistics for KOSPI 200 and non-KOSPI 200 portfolios only. Panel A shows that the LR statistics of the lag variables of KOSPI 200 return volatility are significant at least at the 5% level in Periods II and IV. These results indicate that the past and current return volatility of KOSPI 200 stocks have significant predictive power for the future return volatility of KOSPI in Periods II and IV. In contrast, the LR statistics for non-KOSPI 200 stocks are significant at the 10% level only in Period III, suggesting relatively weak explanatory power for the prediction of the future return volatility of KOSPI in this period.

Panel B of Table 8 shows significant (at the 5% level) LR statistics for the lag variables of the KOSPI 200 portfolio in the post-deregulation period, indicating significant explanatory power of the past and current return volatility of KOSPI 200 portfolio in predicting the future return volatility of KOSPI during the post-deregulation period. On the other hand, the LR statistics for non-KOSPI 200 stocks are significant at the 10% level only during the deregulation period. Hence, similar to the evidence shown in Panel A, the past and current return volatility of non-KOSPI 200 stocks have limited explanatory power of predicting the future return volatility of KOSPI during the deregulation period, and this explanatory power disappears during the post-deregulation period.

The regression results in Table 8 indicate that the volatility spillover from KOSPI 200 to non-KOSPI 200 portfolio found in Period IV and during the post-deregulation period is indeed explained by the information spillover effect that investors' expectation on the future return volatility of KOSPI is first captured in the past and current return volatility of KOSPI 200 portfolio and then transferred to non-KOSPI 200 portfolio. On the contrary, the past and current return volatility of non-KOSPI 200 portfolio has limited, if any, power in predicting the future return volatility of common market factors of KOSPI. These results provide weak evidence supporting that the volatility spillover from non-KOSPI

200 to KOSPI 200 stocks is attributed to the information spillover effect.

In order to further ensure the robustness of our findings on the volatility spillover between KOSPI 200 and non-KOSPI 200 portfolios, we perform two additional robustness tests.

First, we apply an alternative approach of constructing the two sample portfolios for three subperiods classified based on the level of market deregulation, rather than for the four subperiods classified based on the introduction of derivatives trading. In this approach, we first divide the entire sample period into three subperiods of pre-deregulation period, deregulation period, and post-deregulation period and then construct the KOSPI 200 portfolio and the matching non-KOSPI 200 portfolio. While this alternative approach to sample construction yields a slightly larger number of stocks for both portfolios than that reported in Table 1, the regression results using the sample portfolios of KOSPI 200 and non-KOSPI 200 stocks constructed by this alternative approach are qualitatively the same as those reported in our paper. Hence, our results remain robust to different sample construction methods.

Second, we vary VAR estimation basis periods to 1 year, 2 years, and 3 years and advanced periods to measure forecast errors to 1, 2, and 5 periods in developing and examining the volatility spillover index. The estimation results from these alternative analyses remain unchanged relative to those reported in Figure 3 and Table 8, indicating that our results are robust to the choices of VAR estimation basis periods and advanced periods to measure forecast errors.

VI. Summary and Conclusions

The existing literature shows mixed evidence on the effect of the introduction of derivatives trading on the volatility spillover between the underlying stock market portfolios. In this paper, we examine this issue more closely by employing a matching sample approach to the index and non-index stocks in the Korean securities markets during an extensive period of 1992-2003. In particular, we first test for the existence of volatility spillover between the underlying KOSPI 200 stock portfolio and the matching non-KOSPI 200 portfolio and then test the contagion effect and the information spillover hypotheses as potential causes of the volatility spillover phenomena in the Korean securities markets.

Our results provide convincing evidence that the introduction of derivatives trading affects the return volatility of the non-index stock portfolio against which no futures or options are traded as well as that of the index stock portfolio. These findings are in sharp contrast to those of studies of the U.S. market by Harris (1989) and the Japanese market by Chang, Cheng, and Pinegar (1999). In particular, we find that the volatility spillover from non-KOSPI 200 to KOSPI 200 stocks rises significantly after the introduction of futures trading and up to the end of 1998 as found in Bae, Kwon, and Park (2004), but declines sharply and remains at a low level during the post-1998 period. Hence, the volatility spillover observed up to the end of 1998 is a temporary phenomenon and explained mostly by the contagion effect associated with the market deregulation measures introduced after the 1997 financial crisis. In contrast, the significant volatility spillover from KOSPI 200 to non-KOSPI 200 stocks found after the market deregulation can be explained largely by the information spillover effect; the information regarding the investors' expectation on future common market factors is first reflected in the trading of KOSPI 200 stocks and then transferred to the trading of non-KOSPI 200 stocks.

The results of our paper offer two important policy implications. First, our evidence of the sharp initial increase followed by a gradual increase in the volatility spillover from KOSPI 200 to non-KOSPI 200 stocks during the post-deregulation period suggests that only after the market regulations are substantially reduced or eliminated, information will be quickly and efficiently transferred between the derivatives markets and the underlying stock markets, and among stocks in the underlying stock markets. Hence, the deregulation of market restrictions that might hinder the efficient information flows and trading along with the improvement of trading mechanisms should be implemented in order to gain full benefits from a newly-introduced derivatives trading. Second, our results suggest that in a study of examining the effects of new derivatives trading on the return volatility of the underlying stock markets, it is crucial to consider the indirect effect associated with the volatility spillover between index stocks and non-index stocks as well as the direct effect on the underlying index stocks.

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Table 1

Sample Distribution of KOSPI 200 and Non-KOSPI 200 Companies by Industry and Period

The first number represents the number of KOSPI 200 companies included in the analysis, and the second number represents the number of initial non-KOSPI 200 companies from which the matched non-KOSPI 200 company group is constructed. Period I covers the period prior to the introduction of index futures trading. Period II covers the period after the introduction of index futures trading until the introduction of index options trading. Period III covers the period after the introduction of index options trading until the introduction of exchange-traded funds. Period IV covers the period after the introduction of exchange traded funds.

Period	Industry				
	Manufacturing	Construction	Circulative services	Financial services	Total
Period I	122	13	12	22	169
(1/3/92-5/2/96)	298	28	40	59	425
Period II	124	14	14	28	180
(5/3/96-7/6/97)	348	33	48	66	495
Period III	71	2	6	7	88
(7/7/97-10/13/02)	235	23	31	25	314
Period IV	136	5	8	13	162
(10/14/02-12/30/03)	267	31	49	34	381

Table 2
Summary Statistics of Daily Return Volatility of KOSPI 200 and Non-KOSPI 200 Portfolios

The table reports means, medians, and standard deviations of daily return volatility of KOSP 200 portfolio and non-KOSPI 200 portfolio. Period I covers the period prior to the introduction of index futures trading (1/3/1992 - 5/2/1996). Period II covers the period after the introduction of index futures trading until the introduction of index options trading (5/3/1996 - 7/6/1997). Period III covers the period after the introduction of index options trading until the introduction of exchange traded funds (7/7/1997 - 10/13/2002). Period IV covers the period after the introduction of exchange traded funds (10/14/2002 - 12/30/2003). Pre-Korean financial crisis period is from 5/3/1996 to 9/30/1997. Crisis period is from 10/1/1997 to 12/30/1998. Post-crisis period is from 1/3/1999 - 5/31/2000.

		Portfolio Return Volatility		
Period	Portfolio	Mean (x1000)	Median (x1000)	Std. Dev. (x1000)
Whole Period	KOSPI 200	0.4689	0.0986	0.4450
	Non-KOSPI 200	0.2947	0.0719	0.3770
Period I	KOSPI 200	0.1583	0.0580	0.1150
	Non-KOSPI 200	0.1281	0.0453	0.0988
Period II	KOSPI 200	0.1789	0.0667	0.0850
	Non-KOSPI 200	0.2078	0.0666	0.1390
Period III	KOSPI 200	0.8703	0.2337	0.4840
	Non-KOSPI 200	0.5035	0.1351	0.4800
Period IV	KOSPI 200	0.3052	0.0956	0.1610
	Non-KOSPI 200	0.1578	0.0492	0.1450
Pre-Crisis Period	KOSPI 200	0.1560	0.1390	0.0822
	Non-KOSPI 200	0.1704	0.1300	0.1350
Crisis Period	KOSPI 200	1.1210	1.0040	0.5810
	Non-KOSPI 200	0.7110	0.5440	0.5510
Post-Crisis Period	KOSPI 200	0.8420	0.7570	0.3290
	Non-KOSPI 200	0.7213	0.6000	0.4500

Table 3
Seasonal and Special-Event Effects of Portfolio Return Volatility

$$Var_t = x_t\ \beta + \varepsilon_t \qquad (2)$$

The table reports seasonal and special-event effects of return volatility of KOSPI 200 and non-KOSPI 200 estimated from model (2). In regression model (2), the dependent variable is the return volatility of each of KOSPI 200 and non-KOSPI 200. x_t is the vector of dummy variables for seasonal and special-event effects including: weekday dummy for each weekday with Wednesday as base day; monthly dummy for each month from March through November with February as base month; weekly dummy for each of four weeks (1st, 2nd, 3rd, and 4th) in January and December; financial crisis dummy for the financial crisis period of 10/1/97 – 12/31/98; non-trading (including weekend) dummy of GAP1, GAP2, GAP3, and GAP4 based on the number of non-trading days prior to the immediately-following trading day; market crash dummy for the day when the daily return on KOSPI declines by more than 10%. *, **, *** denote significance at the 10%, 5%, and 1% level, respectively.

	KOSPI 200		Non-KOSPI 200	
Seasonal Effect Factors	Reg. Coef.	t-value	Reg. Coef.	t-value
Weekday Effect				
Monday	-0.00003	-0.44	0.000006	0.07
Tuesday	0.00020	2.89***	0.0001	2.88***
Thursday	0.00010	2.66***	0.0001	2.27**
Friday	0.00020	3.12***	0.0002	3.86***
Saturday	-0.00002	-0.48	0.0001	2.31**
Weekly and Monthly Effect				
March	0.0001	2.36**	0.0001	2.21**
April	0.0003	3.21***	0.0002	1.99**
May	0.0002	2.93***	0.0002	2.31**
June	0.0003	3.13***	0.0001	2.18**
July	0.0002	2.77***	0.0001	1.67*
August	0.0001	2.62***	0.0001	1.35
September	0.0003	3.02***	0.0002	1.70*
October	0.0003	4.17***	0.0001	1.86*
November	0.0002	3.01***	0.0001	2.26**
December 1st wk	0.0004	2.75***	0.0002	1.51
December 2nd wk	0.0006	2.79***	0.0005	2.16**
December 3rd wk	0.0003	4.34***	0.0003	1.78*
December 4th wk	0.0003	2.72***	0.00004	2.30**
January 1st wk	0.0005	2.31**	0.0003	2.81***
January 2nd wk	0.0003	3.79***	0.0003	2.67***
January 3rd wk	0.0003	2.38**	0.0002	2.04**
January 4th wk	0.0004	3.40***	0.0002	4.28***
Financial Crisis Effect	0.0008	8.09***	0.0005	4.99***
Non-trading Day Effect				
GAP1	0.0001	1.08	0.0001	1.16
GAP2	0.0002	1.45	0.0002	1.13
GAP3	0.0001	0.78	0.0002	1.32
GAP4	0.0003	1.08	-0.0001	-1.05
Market Crash Effect	0.0031	4.95***	0.0009	3.55***

Table 4
Preliminary Analysis of the Effects of the Introduction of Derivatives Trading on Portfolio Return Volatility

$$Var_t = \alpha + x_t\beta + \sum_{j=2}^{4} c_j D_j + \varepsilon_t \qquad (3)$$

In regression model (3), the dependent variable is the return volatility of each of KOSPI 200 and non-KOSPI 200 portfolios. x_t is the vector for seasonal and special-event effects estimated in model (2) and reported in Table 3. D_j is period dummy variables for the introduction of derivatives trading: D_2 equals 1 for period II and 0 otherwise; and D_3 equals 1 for period III and 0 otherwise; D_4 equals 1 for period IV and 0 otherwise. Period II covers the period after the introduction of index futures trading until the introduction of index options trading (5/3/1996 - 7/6/1997). Period III covers the period after the introduction of index options trading until the introduction of exchange traded funds (7/7/1997 - 10/13/2002). Period IV covers the period after the introduction of exchange traded funds (10/14/2002 - 12/30/2003). For brevity, this table reports estimated regression coefficients on period dummy variables only. The Newey and West (1994) method is used to accommodate heteroscedasticity and serial correlations. T-values are in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

Portfolio	Period Dummy Variable			Adjusted R^2
	D_2	D_3	D_4	
KOSPI 200	0.00002	0.0005	0.0001	0.13
	(0.89)	(11.58)***	(4.03)***	
Non-KOSPI 200	0.00005	0.0004	0.00002	0.06
	(1.91)*	(7.51)***	(1.65)*	

Table 5
Time-Series Analysis of Volatility Spillover with Period Dummies

$$Var_{K,t} = \alpha_K + x_t\,\beta_K + f_t\,\theta_K + y_{K,t}\lambda_K + b_K Var_{M,t} + \sum_{j=2}^{4} c_{Kj} D_j + \varepsilon_{K,t} \quad (4)$$

$$Var_{NK,t} = \alpha_{NK} + x_t\,\beta_{NK} + f_t\,\theta_{NK} + y_{NK,t}\lambda_{NK} + b_{NK} Var_{M,t} + \sum_{j=2}^{4} c_{NKj} D_j + \varepsilon_{NK,t} \quad (5)$$

In regression models (4) and (5), the dependent variables, Var_K and Var_{NK}, are portfolio return volatility of KOSPI 200 stocks and non-KOSPI 200 stocks, respectively. K and NK denote KOSPI 200 and non-KOSPI 200, respectively. Var_M is portfolio return volatility of KOSPI used as market index. x_t is the vector for seasonal and special-event effects estimated in model (2) and reported in Table 3. y_t is the vector for firm-specific factors. f_t is the vector for common mar x_t is the vector for seasonal effects estimated in model (2) and reported in Table 3. y_t is the vector for firm-specific factors.et factors other than the return variability of KOSPI. D_j is period dummy variables for the introduction of derivatives trading: D_2 equals 1 for period II and 0 otherwise, D_3 equals 1 for period III and 0 otherwise, and D_4 equals 1 for period IV and 0 otherwise. Period II covers the period after the introduction of index futures trading until the introduction of index options trading (5/3/1996 - 7/6/1997). Period III covers the period after the introduction of index options trading until the introduction of exchange traded funds (7/7/1997 - 10/13/2002). Period IV covers the period after the introduction of exchange traded funds (10/14/2002 - 12/30/2003). For brevity, this table reports estimated regression coefficients on Var_M and period dummy variables only. The Newey and West (1994) method is used to accommodate heteroscedasticity and serial correlations. T-values are in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

	Dependent Variable	
Explanatory Variable	Var_K	Var_{NK}
Intercept	0.00000	0.00000
	(1.07)	(0.01)
Var_M	1.12370	0.50820
	(40.88)***	(13.42)***
D_2	0.00000	0.00001
	(0.20)	(1.72)*
D_3	-0.00007	0.00012
	(-0.39)	(2.95)**
D_4	-0.00005	-0.00013
	(-1.95)*	(-1.96)**
Adjusted R^2	0.8881	0.3465

Table 6

Time-Series Analysis of Volatility Spillover with Lag Variables

$$Var_{K,t} = a_o + x_t\,\beta_K + y_{K,t}\lambda_K + \gamma_K(z)Var_{K,t} + \gamma_{NK}(z)Var_{NK,t} + \gamma_M(z)V(c_i)_t + \upsilon_{K,t} \qquad (6)$$

$$Var_{NK,t} = b_o + x_t\,\beta_{NK} + y_{NK,t}\lambda_{NK} + \delta_{NK}(z)Var_{NK,t} + \delta_K(z)Var_{K,t} + \delta_M(z)V(c_i)_t + \upsilon_{NK,t} \qquad (7)$$

In regression models (6) and (7), the dependent variables, Var_K and Var_{NK}, are portfolio return volatility of KOSPI 200 stocks and non-KOSPI 200 stocks, respectively. K and NK denote KOSPI 200 and non-KOSPI 200, respectively. x_t is the vector for seasonal and special-event effects estimated in model (2) and reported in Table 3. y_t is the vector for firm-specific factors. $V(c_i)$ is the vector for common market factors including the return volatility of KOSPI. $\gamma(z)$ and $\delta(z)$ are regression coefficients of lag polynomial variables with three lags. Panel A(B) reports likelihood ratio test statistics for the lag variables of non-KOSPI (KOSPI) 200 stock return volatility in regressions of KOSPI (non-KOSPI) 200 stock return volatility in four different periods. Period I covers the period prior to the introduction of index futures trading (1/3/1992 – 5/2/1996). Period II covers the period after the introduction of index futures trading until the introduction of index options trading (5/3/1996 - 7/6/1997). Period III covers the period after the introduction of index options trading until the introduction of exchange traded funds (7/7/1997 - 10/13/2002). Period IV covers the period after the introduction of exchange traded funds (10/14/2002 - 12/30/2003). The Newey and West (1994) method is used to accommodate heteroscedasticity and serial correlations. *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

	Period			
Method	Period I	Period II	Period III	Period IV
Panel A. Likelihood Ratio Test Statistics of Lag Variables of Non-KOSPI 200 Return Volatility in Regressions of KOSPI 200 Return Volatility				
Before controlling for Common Market Factors	5.25	6.37*	2.33	10.63**
After Controlling for Common Market Factors	7.75*	10.62**	3.85	11.57***
Panel B. Likelihood Ratio Test Statistics of Lag Variables of KOSPI 200 Return Volatility in Regressions of non-KOSPI 200 Return Volatility				
Before controlling for Common Market Factors	1.91	6.25*	3.42	14.65***
After Controlling for Common Market Factors	4.51	2.49	1.38	6.42*

Table 7

Time-Series Analysis of Volatility Spillover by Level of Market Deregulation

For conciseness, Panel A(B) of this table reports likelihood ratio (LR) test statistics for the lag variables of non-KOSPI (KOSPI) 200 stock return volatility in regressions of the return volatility of KOSPI (non-KOSPI) 200 stocks in three different periods classified by the level of market deregulations estimated from models (6) and (7). The pre-deregulation period is from 5/3/1996 to 11/2/1997; the deregulation period is from 11/3/1997 to 7/23/2001; and the post-deregulation period is from 7/24/2001 to 12/30/2003. The Newey and West (1994) method is used to accommodate heteroscedasticity and serial correlations. *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

	Period		
Method	Pre-Deregulation Period	Deregulation Period	Post-Deregulation Period
Panel A. Likelihood Ratio Test Statistics of Lag Variables of Non-KOSPI 200 Return Volatility in Regressions of KOSPI 200 Return Volatility			
Before Controlling for Common Market Factors	13.30***	10.39**	5.74
After Controlling for Common Market Factors	3.85	8.41**	5.84
Panel B. Likelihood Ratio Test Statistics of Lag Variables of KOSPI 200 Return Volatility in Regressions of Non-KOSPI 200 Return Volatility			
Before Controlling for Common Market Factors	24.50***	0.59	26.41***
After Controlling for Common Market Factors	3.87	2.84	18.87***

Table 8
Time-Series Analysis of the Effects of Return Volatility of KOSPI 200
and Non-KOSPI 200 Portfolios on Return Volatility of KOSPI Market Index

$$Var_{M,t} = \alpha_o + x_t \beta + \gamma_K(z)Var_{K,t} + \gamma_{NK}(z)Var_{NK,t} + \gamma_M(z)Var_{M,t} + \upsilon\varepsilon_{M,t} \quad (8)$$

In regression model (8), the dependent variable, Var_M, is the portfolio return volatility of KOSPI used as market index. *K, NK,* and *M* denote KOSPI 200, non-KOSPI 200, and KOSPI, respectively. x_t is the vector for seasonal effects estimated in model (2) and reported in Table 3. γ(z) are regression coefficients of lag polynomial variables with three lags. For brevity, the table reports likelihood ratio test statistics for the lag variables of KOSPI 200 Stocks and Non-KOSPI 200 Stocks. Period I covers the period prior to the introduction of index futures trading (1/3/1992 - 5/2/1996). Period II covers the period after the introduction of index futures trading until the introduction of index options trading (5/3/1996 - 7/6/1997). Period III covers the period after the introduction of index options trading until the introduction of exchange traded funds (7/7/1997 - 10/13/2002). Period IV covers the period after the introduction of exchange traded funds (10/14/2002 - 12/30/2003). The pre-deregulation period is from 5/3/1996 to 11/2/1997. The deregulation period is from 11/3/1997 to 7/23/2001. The post-deregulation period is from 7/24/2001 to 1/31/2003. The Newey and West (1994) method is used to accommodate heteroscedasticity and serial correlations. *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

Panel A: Likelihood Ratio Test Statistics of Lag Variables by Periods Classified Based on the Introduction of Derivatives Trading

Independent Variable	Period I	Period II	Period III	Period IV
KOSPI 200	5.00	49.69***	5.25	11.15**
Non-KOSPI 200	5.08	1.37	7.14*	3.93

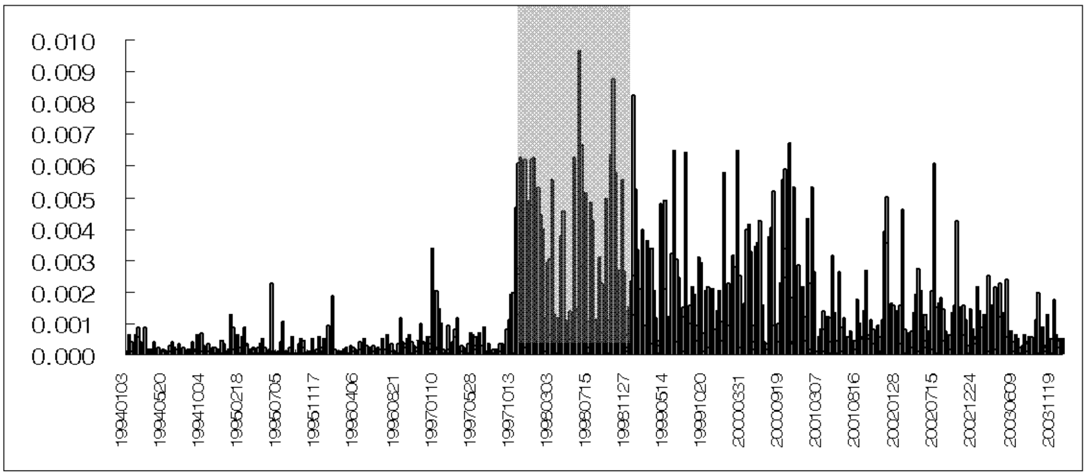
Panel B. Likelihood Ratio Test Statistics of Lag Variables by Periods Classified Based on the Level of Market Deregulation

Independent Variable	Pre-Deregulation Period	Deregulation Period	Post-Deregulation Period
KOSPI 200	6.84*	4.44	9.95**
Non-KOSPI 200	5.48	8.37*	5.44

Figure 1
Daily Return Volatility of KOSPI 200 and Non-KOSPI 200 Portfolios

In the following figures, the gray area represents the Korean financial crisis period from October 1, 1997 to December 31, 1998.

KOSPI 200 Portfolio



Non-KOSPI 200 Portfolio

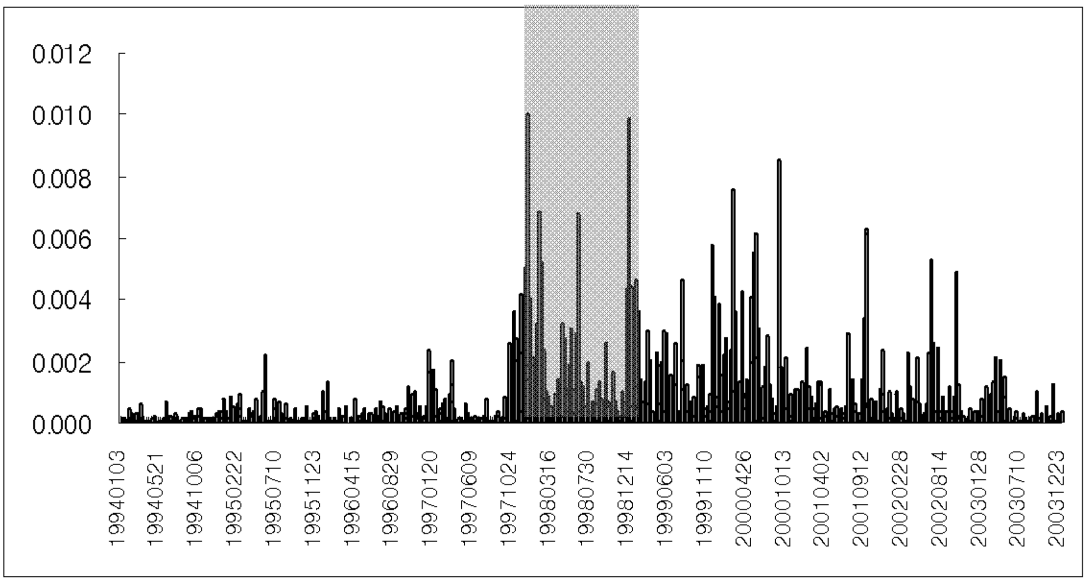


Figure2
Regulation Index

The following figure presents the level of regulation in the Korean securities markets during the sample period of January 3, 1994 – December 30, 2003. The regulation index is developed using the approach discussed in Appendix B.

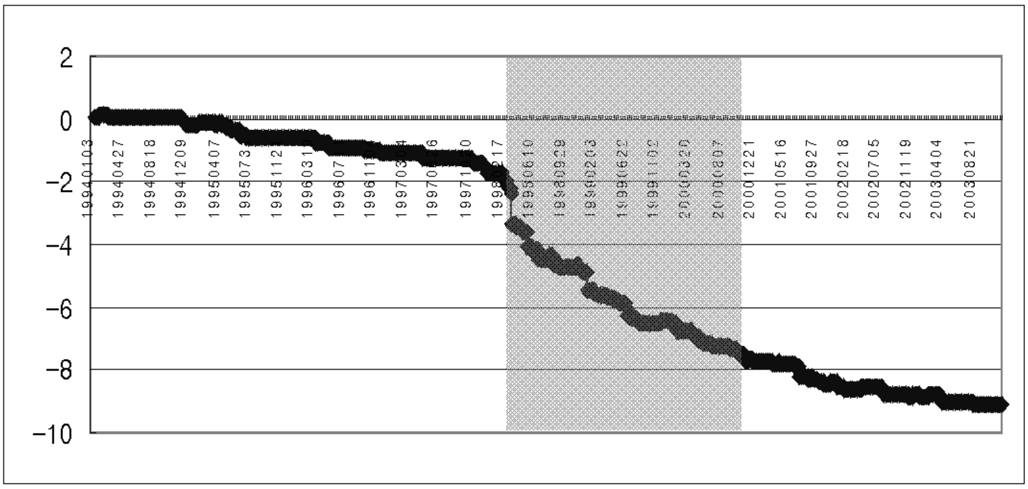
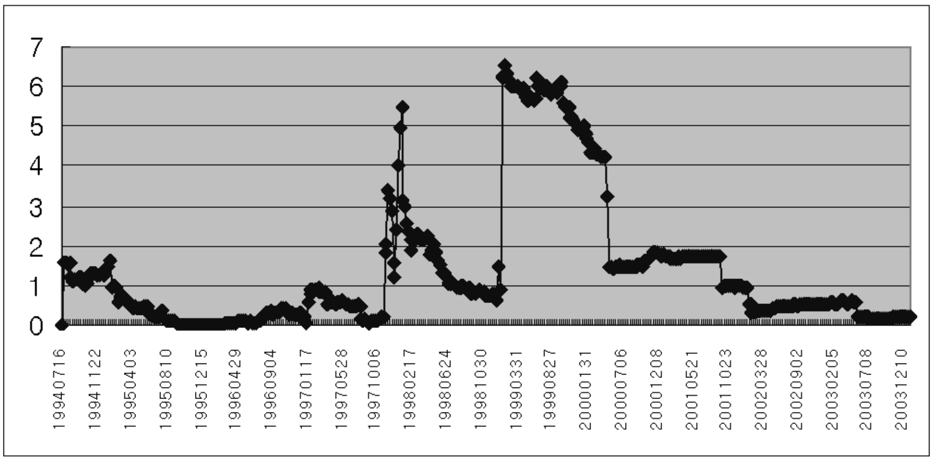
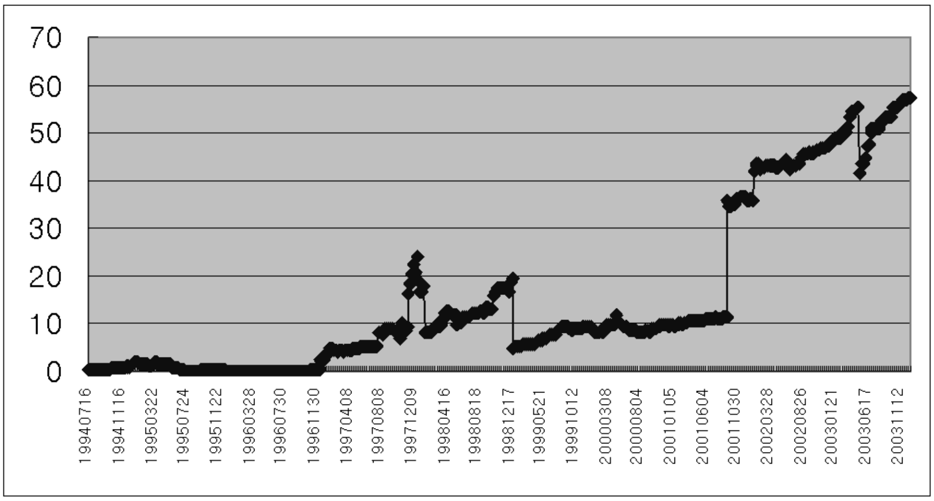


Figure 3
Volatility Spillover Index

Panel A. Index of Volatility Spillover from Non-KOSPI 200 to KOSPI 200



Panel B. Index of Volatility Spillover from KOSPI 200 to Non-KOSPI 200



Appendix A: Proof of the Expected Signs

Assume that stock return (r) of firm i can be expressed as a function of common market factors (F), and arbitrage transaction factors (A) are associated with the introduction of derivatives trading and firm-specific factors (ε). Assuming further that there is only one common market factor, then the return generating model will be given as: $r_i = a_i + b_iF + A + \varepsilon_i$. Let N_1 be the number of stocks included in the KOSPI 200 portfolio, and N_2 be the number of stocks included in the non-KOSPI 200 portfolio. Assume that all stocks in KOSPI 200 and non-KOSPI 200 portfolios are sorted by total value in descending order and that the total number of stocks included in the KOSPI, N, is equal to: $N = N_1 + N_2$. Then, the return volatility of each portfolio can be expressed as:

Return Volatility of KOSPI 200: $Var_K = [\sum_{i=1}^{N_1} w_i^2 b_i^2 + 2\sum_{i \neq j}\sum w_i w_j b_i b_j]\sigma_F^2 + \sigma_A^2 + \sum_{i=1}^{N_1} w_i^2 \sigma_{\varepsilon_i}^2$

Return Volatility of Non-KOSPI 200: $Var_{NK} = [\sum_{i=N_1+1}^{N_1+N_2} w_i^2 b_i^2 + 2\sum_{i \neq j}\sum w_i w_j b_i b_j]\sigma_F^2 + (0)\sigma_A^2 + \sum_{i=N_1+1}^{N_1+N_2} w_i^2 \sigma_{\varepsilon_i}^2$

Return Volatility of KOSPI: $Var_M = [\sum_{i=1}^{N} w_i^2 b_i^2 + 2\sum_{i \neq j}\sum w_i w_j b_i b_j]\sigma_F^2 + \frac{N_1}{N}\sigma_A^2 + \sum_{i=1}^{N} w_i^2 \sigma_{\varepsilon_i}^2$

Therefore, $\frac{\partial Var_K}{\partial \sigma_A^2} = 1, \quad \frac{\partial Var_M}{\partial \sigma_A^2} = \frac{N_1}{N}, \quad and \quad \frac{\partial Var_{NK}}{\partial \sigma_A^2} = 0.$

Appendix B: Development of the Regulation Index

For our analysis, we develop a quantified regulation index to examine the level of market regulations in the Korean securities markets during our sample period. For this purpose, we classify various measures of market regulations/deregulations into four major categories of investor protection, trading system, information disclosure and supervision, and foreign investor relation. Then, we reclassify related items into each of these four major categories. We collect detailed contents and dates for changes in these items from "Stocks" magazines published by the Korea Exchange. We evaluate the contents and dates of each of these changes and assign a numeric point of negative 1 (-1) if the change is related to any of the following market deregulation: enhancement of the level of investor (primarily, minority investor) protection, promotion of free trading activities, enforcement of information disclosure and transparency of supervision systems, and elimination or relaxation of restrictions on foreign investor ownership or other relations. If such a change is against the market deregulation, then a numeric value of positive 1 (+1) is assigned. We then sum up all points on each event day for each major category and compute the average value by dividing the total points by the total items in each major category. Finally, we add the average values in all four major categories on each event day to obtain the total daily points, which are used as the regulation index on a given event day. The detailed items in the four major categories used to measure the regulation index are presented below:

Category I: Investor protection (6 items) – minority shareholder right; shadow voting; shareholder proposal system; cumulative voting system; value-based dividend; employee stock ownership association.

Category II: Trading system (16 items) – ex-dividend and dividend system; bid-ask price; margin trading; restriction on price limits (or range); value per share; off-hour block trading system; circuit breaker system; pre- and post-market differentiation and simultaneous bid-ask price; book building; securities transaction tax; consignment guarantee money; daily marking-to-marking system; investment trust companies' fund management; asset management companies; limit on stock ownership of public enterprise; new entry into securities business.

Category III: Information disclosure and supervision (17 items) – disclosing system for closing bid-ask spread; bond yield; market-price-based securities valuation; limits on total investment into subsidiaries; tender offer system; limits on cross ownership; regulation on financial positions of securities companies; prompt corrective action; stock price index computation method; insider trading; financial holding companies; share destruction; business group consolidated (or combined) financial statements; disclosure system; limits on investment in privately-placed bonds; internal accounting management system; stock trade reserve fund system.

Category IV: foreign investor-related system (6 items) – margin trading; limits on tender offer subscription; limits on investment; board of directors' requisite for share purchase target companies; limits on industries (or types of business) for investment; securities companies incorporation.