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International Transmission of Information Across National Stock Markets: Evidence from the Stock Index Futures Markets

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Abstract

This paper contributes to the ongoing controversy over price and volatility spillovers across countries by providing new evidence with the futures data of the S&P 500 and Nikkei 225 index futures contracts from January 3, 1990 to April 16, 1996. Based on the two-stage symmetric and asymmetric GARCH models we document that both the U.S. and the Japanese daytime returns significantly influence the subsequent overnight returns of the other market. We find no signs of volatility spillovers between two international markets with the symmetric model. However, with the asymmetric models, we find that the magnitude of foreign negative shocks are different from the positive ones. The findings generally suggest that the two markets are more sensitive to the bad news originating in the other market. This nature of transmission between two markets would have important implications to the arbitragers who are trying to exploit the short-term dynamics of price and volatility movements across two security markets.

I. Introduction

Amid the deregulation trend of national capital markets in the past two decades, we have witnessed a growing tendence of inter-market linkages across countries, which

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has important implications to the investors and policy makers. If capital markets are integrated internationally, the relevant measure of risk arises from a global market, and thus, the pricing of assets in integrated markets would be different from that in segmented markets. A better hedging strategies would also be made according to the degree of market integration. In addition, under the integrated markets any unexpected turbulence in one market may be transmitted to the other markets regardless of fundamental changes in the economic conditions.

A growing body of literature has attempted to identify the extent the capital markets across countries interact. Earlier studies on international capital market relationship mainly have focused on the interdependence of price movements across different countries [Grubel (1968), Levy and Sarnat (1970), Agmon (1972), Solnik (1974), and Hillard (1979)]. They generally find that the correlations of weekly or monthly returns among different national equity markets are low, and thus that security returns are determined by domestic factors. Recent studies, however, have payed more attention to on the daily return dynamics across national capital markets. For example, Eun and Shim (1989) use the vector autoregressive (VAR) model for daily closing index prices of nine countries and find evidence supporting the notion that the international equity markets are informationally efficient with the most influential price leadership of U.S. market. Ko and Lee (1991) also document increasing U.S. leadership over other Asian stock markets while Jeon and von Furstenberg (1990) and Koch and Koch (1991) find declining U.S. impact with a growing regional interdependences over time.

More recent studies have focused on the mean and variance transmissions across national markets with intradaily data. For example, Hamao, Masulis, and Ng (1990) have used an ARCH-M model on daytime and overnight returns to test the volatility spillovers among the stock markets of New York, Tokyo, and London for the pre-October 1987 period. They find evidence of volatility spillovers from New York and London to Tokyo, but no spillovers in other directions. In contrast, Lin, Engle, and Ito (1994) find that transmission of information occurs bi-directionally between New York and Tokyo markets. They argue that the difference may be attributed to the stale quotes due to nonsynchronous trading around opening. (They have used index prices 30 minutes after the market officially opens to attenuate this problem.) Bae and Karolyi's (1994) asymmetric GARCH model which accounts for negative and positive foreign market shock to volatility provides additional insight into the transmission mechanism between New York and Tokyo. They document that the true magnitude of transmissions is significantly understated if the asymmetric effect is ignored.

This paper contributes to the ongoing controversy over price and volatility spillovers across countries by providing new evidence on the asymmetry in spillovers with the futures data from the S&P 500 and Nikkei 225 index futures contracts. Previous studies have used the stock index cash returns to measure the cross-market interdependence in returns and volatilities. The opening prices of the stock index contain the nonsynchronous trading problem. Although Lin, et al. (1994) have used prices for some time after the market officially opens, the problem still remains since the information from one market might be quickly dissipated to other markets. In fact, with high-frequency data Becker, Finnerty and Tucker (1992) and Susmel and Engle (1994) find that the transmission across national markets occurs within the first hour of trading.

The stock index futures prices are free from the nonsynchronous trading problem. Moreover, there is ample evidence that index futures prices are more efficient than index cash prices, and thus that futures market generally leads corresponding cash market. [Kawaller, Koch and Koch (1987), Stoll and Whaley (1990a), Corad, Gultekin, and Kaul (1991), and Abhyankar (1993)] This is not only because futures market can process new information more quickly but also because futures prices contain more information. Thus, we assume that any shock from the other stock market, if exists, is reflected more strongly in the stock index futures prices than in the index cash prices. The use of index futures data also help avoid problems associated with index cash data, such as price differences of the component stocks due to bid-ask spreads and discrete dividend payments of the component stocks. Therefore, we argue that the use of futures prices would be more appropriate to examine the information flows across national stock markets.

In fact, we find that our data set is free from stale quote problem in that both the S&P500 and the Nikkei 225 futures prices used in this study show clear price reversal and no sign of price continuation (Stole and Whaley (1990b)) in contrast to the studies with cash indexes. As in Bae, et al. (1994) we also find that the negative foreign shocks have larger influence on the domestic return volatility. However, we further document that only the negative shock is statistically significant while Bae, et al. find both negative and positive shocks are significant. The rest of the paper is organized as follows. Section II describe the data and correlation analysis. Section III specifies the two-stage asymmetric GARCH models. We put the main results in Section IV and Section V concludes the paper.

II. Data and Preliminary Statistics

We use daily opening and closing futures prices to compute daytime (open-to-close) and overnight (close-to-open) returns on the S&P 500 stock index futures traded at the Chicago Mercantile Exchange (CME) and the Nikkei 225 stock index futures traded at the Singapore International Monetary Exchange (SIMEX). The data set is obtained from the Knight Ridder Financial Publishing, Inc. for the period January 2, 1990 to April 16, 1996.

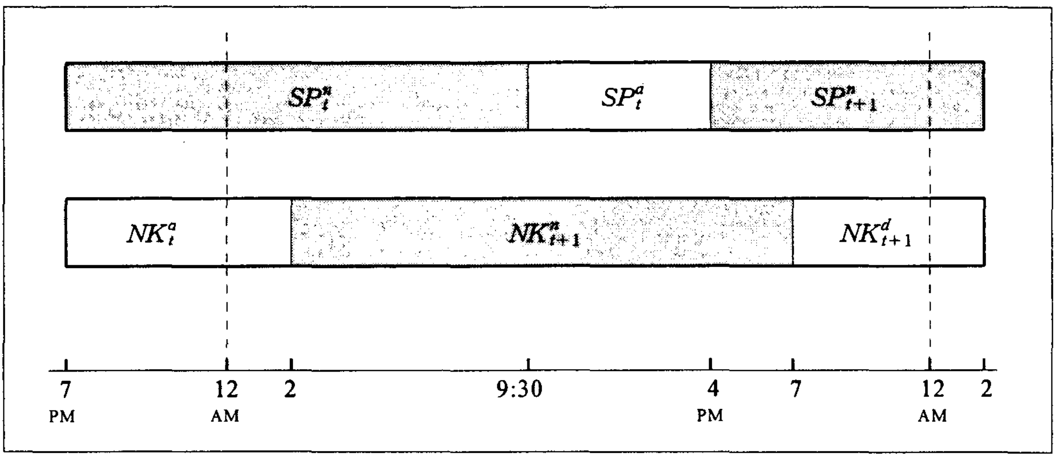
These index futures are chosen because there is evidence that they are, among other stock index futures in each market, most informationally efficient to study the transmission mechanism between two markets. In the United States, there are three actively traded index futures; the S&P 500, the NYSE (New York Stock Exchange) Composite, and the MMI (Major Market Index). Kim, Szakmary, and Schwarz (1997) find that among these index futures, the S&P 500 exhibits price leadership over other index futures possibly due to the low trading cost of S&P 500 index futures. The Nikkei 225 futures are traded in three different exchanges; OSE (Osaka Security Exchanges), SIMEX, and CME. Although Bacha and Vila (1993) report no evidence of lead-lag relationship among them, Booth, Lee, and Tse (1996) find that the three markets are driven by the same kind of information. They further find some evidence that the Nikkei futures traded in the SIMEX reacts more quickly to the common factor than that in the OSE despite the dominating trading volume in the OSE. They attribute this to the heavy regulations and high trading cost of the OSE.

Both the stock index futures contracts used in this study expire every three month

(March, June, September, and December). All futures prices are always those of nearby contracts, and the rollover within each contract is made two weeks before the last trading day to avoid any expiration day effect of the futures prices. When there is a missing trading day because of different holidays, the prices are assumed to remain constant over the previous trading day. The daytime returns are the log difference between closing and opening prices of a trading day, and the overnight returns are the log difference between the opening price of a trading day and the closing price of the previous trading day.

Notations for the daytime and overnight returns are as defined in Figure 1, which also illustrates the timing conventions between two markets. Note that during the same calendar day the Japanese market opens first and closes before the U.S. market opens. That is, the overnight segment of foreign market completely encompasses the daytime segment of the domestic market without overlapping trading times. Thus, if markets are efficient, it would be resonable to assume that overnight information produced during the trading time in the foreign market (while the domestic market is closed) would be fully reflected in the opening price of domestic market.

<Figure 1> Trading Times for the S&P 500 and the Nikkei 225



[New York Time]

Notations are as follows ; SP_t^n, SP_t^d are the overnight and the daytime S&P 500 returns on a trading day t, respectively; NK_t^n, NK_t^d are the overnight and the daytime Nikkei 225 returns on a trading day t, respectively, All returns are computed as log changes of futures indexes multiplied by 100 from January 3, 1990 to April 16, 1996.

Table 1 reports the summary statistics for the daytime and overnight returns of the S&P 500 and the Nikkei 225. Reflecting the bearish market of Japan since 1990, the mean daytime return of Nikkei 225 index futures is negative. Also, both the daytime and overnight returns of the Nikkei 225 are more volatile than those of S&P 500 over the sample period. Consistent with French and Roll's (1986) conjecture that more information is released during the trading time, the daytime returns are more volatile than the overnight returns for both markets. Measures for skewness and excess

Table 1 Summary Statistics for the Daytime and Overnight Returns of the S&P 500 and the Nikkei 225

SP^n_t, SP^d_t are the overnight and the daytime S&P 500 returns on a trading day t, respectively; NK^n_t, NK^d_t are the overnight and the daytime Nikkei 225 returns on a trading day t, respectively, All returns are computed as log changes of futures indexes multiplied by 100 from January 3, 1990 to April 16, 1996. Q_kLB and Q^2_kLB are the Ljung-Box Q-statistics with $K=6,12$ lags of returns and squared returns, respectively. TR^2 is Engle's (1982) statistics from the Lagrange multiplier test for the ARCH effect. ** indicates significance at 1% level.

	Daytime Returns		Overnight Returns	
	SP^d_t	NK^d_t	SP^n_t	NK^n_t
Observations (T)	1633	1633	1632	1632
Mean	0.0307	-0.0341	-0.0098	0.0108
Variance	0.4896	1.2572	0.1097	0.5377
Skewness	-0.8123**	0.0702	-0.2124**	0.2238**
Kurtosis	12.0502**	3.2526**	22.8403**	8.8836**
Q_6LB	17.82**	6.45	22.19**	12.22
$Q_{12}LB$	30.26**	12.28	27.15**	16.35
Q^2_6LB	106.98**	250.57**	113.06**	184.96**
$Q^2_{12}LB$	108.36**	431.15**	132.50**	305.19**
TR^2	244.74**	406.76**	155.17**	268.44**

kurtosis indicate that all return series are significantly skewed (except the daytime return of Nikkei) and leptokurtic with respect to the normal distribution.

The Ljung-Box Q statistics for the serial correlation of the return and squared return series for k=6 and 12 lags are denoted as Q_kLB and Q_k^2LB, respectively. Under the null hypothesis of serial independence, both statistics converge to a chi-squared distribution with k=6 and 12 degrees of freedom. The Q(6,12) statistics for the returns of S&P 500 are statistically significant, indicating the presence of serial correlation (linear dependencies), and $Q^2(6,12)$ statistics for all return series are highly significant, indicating the presence of serial correlation in the squared return series (nonlinear dependences). 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). A more formal Lagrange multiplier test for ARCH effect, proposed by Engle (1982), is performed. With a sample of T residuals, under the null hypothesis of no ARCH errors, the test statistics TR^2 follows a chi-squared distribution. The reported test statistics in the last row are all high and indicate the presence ARCH effect in variance.

Table 2 reports the cross-correlations across daytime and overnight returns of S&P 500 and Nikkei 225 index futures. Consistent with Lin, Engle and Ito (1994) and Bae and Karolyi (1994), we find the highest correlation of 0.415 between the daytime S&P(SP_t^d) and overnight Nikkei(NK_{t+1}^n) returns with the next one of 0.243 between the daytime Nikkei(NK_n^t) and overnight S&P(SP_t^n) returns. We also find that there exists the price reversal, but not the price continuation, for both the S&P and the Nikkei. That is, we find significant and negative correlation between S&P (Nikkei) overnight and following daytime returns of the same trading day (-0.066 for SP_t^n/SP_t^d and -0.057 for NK_{t+1}^n/NK_{t+1}^d), indicating the price reversal as documented by Stoll and Whaley (1990) and Amihud and Mendelson (1991).[1] We, however, find no significant correlation S&P (Nikkei) daytime and next day's overnight returns (0.018

1) In contrast, however, Lin, et al. (1994) find that positive autocorrelation around the opening and price reversal afterward for the spot S&P and Nikkei index. They attribute this to nonsynchronous trading of individual stocks.

for SP^d_t/SP^n_{t+1} and 0.006 for NK^d_t/NK^n_{t+1}), revealing that there is no price continuation effect.[2)] Our findings here support the notion that the stale quote problem is negligible with the futures data.

Table 2 Cross-Correlations across Daytime and Overnight Returns of the S&P 500 and the Nikkei 225 index futures

SP^n_t, SP^d_t are the overnight and the daytime S&P 500 returns on a trading day t, respectively; NK^n_t, NK^d_t are the overnight and the daytime Nikkei 225 returns on a trading day t, respectively, All returns are computed as log changes of futures indexes multiplied by 100 from January 3, 1990 to April 16, 1996. Bartlett's standard errors are computed by the square root of the reciprocal of the number of observations. The number of observations is 1633, and the standard error is 0.0247. **, * indicates significance at 1% and 5% level, respectively.

	S&P 500			Nikkei 225		
	SP^n_t	SP^d_t	SP^n_{t+1}	NK^d_t	NK^n_{t+1}	NK^d_{t+1}
SP^n_t	1.000					
SP^d_t	-.066*	1.000				
SP^n_{t+1}	-.062*	.018	1.000			
NK^d_t	.243**	.042	-.024	1.000		
NK^n_{t+1}	.193**	.415**	.107**	.006	1.000	
NK^d_{t+1}	-.017	-.052*	.243**	-.001	-.057*	1.000

III. Model Specification

Based on the findings of the previous section, we have specified two-stage GARCH-based models. In the first stage, the foreign daytime returns are conditioned on the preceding overnight returns to account for the price reversal effect and to use the residuals as foreign shocks. In the second stage, the domestic overnight returns

2) The result is consistent with the finding of Lin, et al. (1994) for the spot S&P index, but not consistent with that for spot Nikkei index, where they find a significant positive correlations.

are conditioned on the foreign shocks to figure out the influence of unexpected foreign daytime shocks to the domestic overnight returns. We also appropriately model to account for the asymmetric responses of conditional mean and variance to positive and negative foreign shocks.

GARCH framework is particularly useful in modelling the dynamic nature of daily security returns because it captures possible presence of time-varying volatility as well as the fat-tailed nature of return distribution (see Bollerslev, Chou, and Kroner (1992) for a survey and French, Schwert & Stambaugh (1987), Lamoureux & Lastrapes (1990), Baillie & DeGennaro (1990), Lee & Ohk (1992), Engle & Ng (1993) for empirical evidence). Recently, however, it has been shown that traditional GARCH framework, despite its appealing features, is unable to model the asymmetric response of conditional variance to positive and negative innovations. To capture the asymmetric nature several alternative GARCH models have been suggested; exponential GARCH (EGARCH) model of Nelson(1991), quadratic GARCH (QGARCH) model of Engle (1990), and Glosten, Jagannathan, & Runkle's (1989) GARCH (GJR-GARCH) model. Monte Carlo experiments by Engle and Ng (1993) have shown that the GJR-GARCH specification dominates other two specifications in modelling the asymmetric effect. The variance function of the GJR-GARCH model is described as follows;

$$h_t = a_1 + b_2 h_{t-1} + c_2 \varepsilon_{t-1}^2 + d_2 \varepsilon_{t-1}^2 N_{t-1},$$

where N_t is a dummy variable which equals 1 if ε_t is negative, and zero otherwise. The term, $\varepsilon_{t-1}^2 N_{t-1}$, represents the asymmetric nature of volatility reaction to innovations. Significant d value tells us that the negative shocks differ statistically from the positives shocks in modelling the time-varying volatility of security returns.

To examine the international volatility spillovers, this type of model has been extend to incorporate foreign return shocks (as well as domestic shocks) by Susmel and Engle's (1994) quadratic GARCH, and Bae and Karolyi's (1994) GJR-GARCH models. Here, we use the asymmetric GARCH model similar to Bae and Karolyi based on the two-stage estimations in Lin, Engle, and Ito (1994). Specifically, we estimate the following two-stage GARCH model to test the influence of unexpected

S&P 500 daytime return shocks to the overnight Nikkei 225 overnight returns.

First Stage:

$$SP_t^d = a_1 + b_1 SP_t^n + c_1 M_t + \varepsilon_t$$

$$h_t^d = a_2 + b_2 h_{t-1}^d + c_2 M_t + d_2 \varepsilon_{t-1}^2 + e_2 \varepsilon_{t-1}^2 N_{t-1}$$

Second Stage:

$$NK_t^n = a_3 + b_3 NK_{t-1}^d + c_3 M_t + d_3 \varepsilon_{t-1} + e_3 \varepsilon_{t-1} N_{t-1} + \nu_t$$

$$h_t^n = a_4 + b_4 h_{t-1}^n + c_4 M_t + d_4 \nu_{t-1}^2 + e_4 \nu_{t-1}^2 N_{t-1}^- + f_4 \varepsilon_{t-1}^2 + g_4 \varepsilon_{t-1}^2 N_{t-1}$$

where SP_t and NK_t are the S&P 500 and Nikkei 225 index returns with the superscripts d and n represent daytime (open-to-close) and overnight (close-to-open) returns, respectively. The dummy variables M_t equals 1 if t is a Monday or a day following a holiday, and zero otherwise. N_t (N_t^-) equals 1 if ε_t (ν_t) is negative, and zero, otherwise. ε_t (ν_t) is the residual which is assumed to follow normal distribution with zero-mean, and a time varying variance, h_t^d (h_t^n).

The first stage specifies that the S&P 500 daytime return is a function of preceding overnight return to account for the price reversal (Stoll and Whaley (1990)), and a weekend/holiday dummy to capture negative weekend/holiday effect (French (1980), and French & Roll (1986)). The unexpected S&P daytime return series, ε_t will be used to measure the spillover effect from S&P to Nikkei in the second stage. The conditional variance equation, h_t^d, include a dummy variable, N_t to account for the asymmetric reactions of volatility to news.[3)]

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3) Note that the coefficient from the Nt dummy variable reveals the existence of asymmetry in volatility reaction to innovations. What significant coefficient tells us is that negative news are statistically different from the positive news in forming the time-varying volatility. It does not show the magnitude of negative shocks (as compared to that of positive shocks). To compare the magnitude of the negative and positive shocks we include another dummy variable, Pt, which equals 1 if εt is positive, and zero, otherwise as follows;

$$h_t^d = a'_3 + b'_2 h_{t-1}^d + c'_2 M_t + d'_2 \varepsilon_{t-1}^2 P_{t-1} + e'_2 \varepsilon_{t-1}^2 N_{t-1}$$

We have made the same adjustment the conditional mean and variance equations of the second

In the second stage, Nikkei 225 overnight return is expressed as a function of the previous day's daytime return to allow for the price continuation effects, and a weekend/holiday dummy variable. It is further conditioned to measure the mean return spillover effect from the S&P daytime returns to Nikkei overnight returns by including the unexpected daytime innovation, ε_t, obtained from the first stage estimation. The estimated d_3 coefficient would measure the mean spillover effect, and e_3 coefficient would reveal whether there exists asymmetry in the mean spillover. Any unexpected news revealed after the close of S&P and before opening of the Nikkei is denoted as ν_t. The conditional variance of the Nikkei overnight returns is condition on ν_t and ε_t. Thus, the estimated f_4 coefficient would measure the volatility spillover from S&P to Nikkei, and the g_4 would capture the asymmetry in volatility spillover. For the mean and volatility spillovers from Nikkei to S&P we estimate the same two-stage model with the appropriate substitutions of notions and timing differential between U.S. and Japan.

V. Estimation and Empirical Findings

The parameter estimations of the two-stage models are made by maximizing the log-likelihood functions with the algorithm of Berndt, Hall, Hall and Hausman (1974) under the assumption that the residuals follow normal distribution with zero-mean and a time-varying variance. However, as the skewness and kurtosis of the standardized residuals from the GARCH models reject the null hypothesis of normal distribution, we use the robust asymptotic standard errors of Bollerslev and Wooldrige (1992) to obtain test statistics.

1. Price and Volatility Spillover from U.S. to Japan

Table 3 reports the first-stage maximum likelihood estimations of the S&P daytime

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stage, and report d' and e' coefficients in the appropriate tables because other coefficients are qualitatively the same.

Table 3 Maximum Likelihood Estimation of Symmetric GARCH and Asymmetric GJR-GARCH Models for the S&P 500 Daytime Returns (First-Stage Estimation)

The estimation is based on the following first-stage model of daytime S&P 500 returns.

$$SP_t^d = a_1 + b_1 SP_t^n + c_1 M_t + \varepsilon_t$$

$$h_t^d = a_2 + b_2 h_{t-1}^d + c_2 M_t + d_2 \varepsilon_{t-1}^2 + e_2 \varepsilon_{t-1}^2 N_{t-1}$$

where SP_t is the S&P 500 index futures returns with the superscripts d and n represent daytime (open-to-close) and overnight (close-to-open) returns, respectively. The dummy variables M_t equals 1 if t is a Monday or a day following a holiday, and zero otherwise. N_t equals 1 if ε_t is negative, and zero, otherwise. ε_t is the residual which is assumed to follow normal distribution with zero-mean, and a time varying variance, h_t^d. Robust t-values are reported in parentheses. ***, **, * indicates significance at 1%, 5%, and 10% level, respectively.

Parameters	Symmetric Model		Asymmetric Model	
	Coefficient	t-value	Coefficient	t-value
a_1	-.0010	(-.05)	.0160	(.97)
b_1	-.1070	(-2.87)**	-.1617	(-2.04)**
c_1	.1689	(3.73)***	.0967	(2.75)**
a_2	.0618	(1.22)	.0177	(1.46)
b_2	.8491	(10.04)***	.9464	(35.27)***
c_2	-.1683	(-2.56)**	-.0548	(-.93)
d_2	.0939	(3.77)***	.0161	(1.61)
e_2	-		.0417	(1.77)*
(d'_2)	-		.0161	(1.63)
(e'_2)	-		.0578	(2.14)**
Skewness	-.2010***		-.2782***	
Kurtosis	1.7000***		1.8551***	
Q_6LB	2.8786		3.2551	
$Q_{12}LB$	4.4897		5.3919	
Q_6^2LB	5.3019		1.9146	
Q_{12}^2LB	9.7463		4.1305	

Table 4. Maximum Likelihood Estimation of Symmetric GARCH and Asymmetric GJR-GARCH Models for the Nikkei Overnight Returns (Second-Stage Estimation)

The estimation is based on the following second-stage model of overnight Nikkei returns.

$$NK_t^n = a_3 + b_3 NK_{t-1}^d + c_3 M_t + d_3 \varepsilon_{t-1} + e_3 \varepsilon_{t-1} N_{t-1} + \nu_t$$

$$h_t^n = a_4 + b_4 h_{t-1}^n + c_4 M_t + d_4 \nu_{t-1}^2 + e_4 \nu_{t-1}^2 N_{t-1}^- + f_4 \varepsilon_{t-1}^2 + g_4 \varepsilon_{t-1}^2 N_{t-1}$$

where NK_t is the Nikkei 225 index futures returns with the superscripts d and n represent daytime (open-to-close) and overnight (close-to-open) returns, respectively. The dummy variables M_t equals 1 if t is a Monday or a day following a holiday, and zero otherwise. N_t (N_t^-) equals 1 if ε_t (ν_t) is negative, and zero, otherwise. ε_t (ν_t) is the residual which is assumed to follow normal distribution with zero-mean, and a time varying variance, h_t^d (h_t^n). Robust t-values are reported in parentheses. ***, **, * indicates significance at 1%, 5%, and 10% level, respectively.

Parameters	Symmetric Model		Asymmetric Model	
	Coefficient	t-value	Coefficient	t-value
a_3	.0025	(.16)	.0155	(.62)
b_3	-.0252	(-1.31)	-.0268	(-1.31)
c_3	.0186	(.42)	-.0081	(-.24)
d_3	.4166	(11.32)***	.3864	(6.91)***
e_3	-		.0753	(.77)
(d'_3)	-		.3864	(7.66)**
(e'_3)	-		.4618	(9.67)**
a_4	.1194	(2.12)**	.1313	(2.54)**
b_4	.5844	(3.49)***	.5466	(3.69)***
c_4	-.1274	(-1.11)	-.1712	(-1.94)*
d_4	.1831	(3.05)***	.1068	(2.78)**
e_4	-		.1689	(1.18)
f_4	.0925	(.82)	.0716	(.98)
g_4	-		.1261	(1.88)*
(f'_4)	-		.0716	(1.18)
(g'_4)	-		.1975	(1.64)*
Skewness	-.1358***		.0527	
Kurtosis	12.7456***		12.9584***	
Q_6LB	2.2402		2.6828	
$Q_{12}LB$	8.8977		8.9987	
Q_6^2LB	5.1942		4.8618	
Q_{12}^2LB	6.5827		6.8003	

returns for both symmetric and asymmetric models. Significant negative b_1 coefficients confirm the price reversal effect in the S&P 500 index futures as documented in Table 2. The b_2 and d_2 coefficients, which represent the time-varying volatility, are all significant in the symmetric model, implying that it is well suited to model the conditional heteroskedasticity. Note that the asymmetric coefficient e_2 is positive and significant (e_2=0.417 with robust t-value of 1.77), indicating the response of volatility to past innovation is asymmetric in the S&P index futures. It is confirmed by the coefficients, d'_2 and e'_2 from the two dummy model of positive and negative shocks, respectively. Only the negative shock is significant and about 2.6 times larger than the positive shock (d'_2=0.0161 and e'_2=0.0578). We evaluate the robustness of the results using the Ljung-Box Q statistics of standardized and squared standardized residuals up to lags 6 and 12, and find that both symmetric and asymmetric models fit the data well. The statistics are all lower than their critical values at five percent level.

The estimation results of the second-stage model, which is designed to access the degree of S&P unexpected daytime influence on the contemporaneous Nikkei overnight return and return volatility, are presented in Table 4. Insignificant price continuation effect documented in Table 2 is confirmed by insignificant b_3 coefficients. The S&P daytime returns significantly influence the Nikkei overnight returns (d_3=0.4166 with robust t-value of 11.32 in the symmetric model) with no asymmetric mean spillover effect (e_3=0.0753 with robust t-value of 0.77). Positive and negative news are all significantly influence Nikkei overnight returns, and the magnitude of negative shock is slightly larger than that of positive shock (d'_3=0.3864 and e'_3=0.4618). The result is similar to Hamao, et al (1990), and Lin, et al. (1994), who find significant mean spillover from S&P daytime returns to Nikkei overnight returns. However, in contrast to Hamao, et al. (1990) we find no volatility spillovers from U.S. to Japan with the symmetric model. But once the asymmetric terms are considered, we find an asymmetry in volatility spillover (g_4=0.1216 with robust t-value of 1.88), and only the negative news from U.S. impact on Japanese overnight return volatility (g'_4=0.1975 with robust t-value of 1.64). Although marginally significant at ten percent level, the conditional volatility coefficient on negative news from U.S., g'_4, is almost twice as large as that on positive news. This finding is in line with the Bae,

Table 5 Maximum Likelihood Estimation of Symmetric GARCH and Asymmetric GJR-GARCH Models for the Nikkei Daytime Returns (First-Stage Estimation)

The estimation is based on the following first-stage model of daytime Nikkei 225 returns.

$$NK_t^d = a_1 + b_1 NK_t^n + c_1 M_t + \varepsilon_t$$

$$h_t^d = a_2 + b_2 h_{t-1}^d + c_2 M_t + d_2 \varepsilon_{t-1}^2 + e_2 \varepsilon_{t-1}^2 N_{t-1}$$

where NK_t is the Nikkei 225 index futures returns with the superscripts d and n represent daytime (open-to-close) and overnight (close-to-open) returns, respectively. The dummy variables M_t equals 1 if t is a Monday or a day following a holiday, and zero otherwise. N_t equals 1 if ε_t is negative, and zero, otherwise. ε_t is the residual which is assumed to follow normal distribution with zero-mean, and a time varying variance, h_t^d . Robust t-values are reported in parentheses. ***, **, * indicates significance at 1%, 5%, and 10% level, respectively.

Parameters	Symmetric Model		Asymmetric Model	
	Coefficient	t-value	Coefficient	t-value
a_1	.0351	(1.96)**	-.0139	(-.48)
b_1	-.1884	(-3.36)***	-.1776	(-3.77)***
c_1	-.0061	(-.11)	-.2092	(-2.61)**
a_2	-.0088	(-.26)	-.0541	(-2.65)**
b_2	.9244	(42.77)***	.9381	(52.40)***
c_2	.0642	(.33)	.3661	(2.74)**
d_2	.0766	(4.31)***	.0114	(1.27)
e_2	-		.0796	(3.64)***
(d'_2)	-		.0114	(1.23)
(e'_2)	-		.0912	(4.28)***
Skewness	.1163*		-.0553	
Kurtosis	2.5392***		2.7219	
$Q_6 LB$	7.7890*		2.1429	
$Q_{12} LB$	18.3087**		7.5319	
$Q_6^2 LB$	2.1267		1.0446	
$Q_{12}^2 LB$	3.8098		3.4468	

et al.'s (1994) contention that the true sensitivity seems to be underestimated without considering the asymmetric effect. However, unlike Bae, et al., we further find that only the negative news from U.S. significantly influence return volatility in Japan. Overall, we find that both mean and volatility spillovers from U.S. to Japan, but the volatility spillover occurs only with negative news from U.S. while the mean spillover occurs regardless of the nature of news.

2. Price and Volatility Spillover from Japan to U.S.

We present the first-stage estimation of Nikkei 225 daytime returns in Table 5. The results here are almost the same as in Table 3, which report the estimation of S&P daytime returns. As in the S&P index futures, significant negative b_1 coefficients confirms the price reversal effect in the Nikkei futures. The asymmetric coefficient, e_2 is also positive and significant (e_2=0.796 with robust t-value of 3.64) implying that the negative past innovations in the Nikkei 225 futures produce a higher volatility that do positive innovations of an equal magnitude. The models fit the data reasonably well despite some linear dependence in the standardized residuals in the symmetric model.

Table 6 reports the second-stage estimation of S&P overnight returns which is conditioned on the unexpected Nikkei daytime returns to measure the mean and volatility spillovers from Japan to U.S. In contrast to Hamao, et al. (1990) and King and Wadhwani (1990), but consistent with Lin, et al. (1994), we find significant spillover from the Nikkei daytime returns to the S&P 500 overnight returns. We further document that the asymmetry in mean spillover exists (e_3=0.0245 with robust t-value of 2.72), and this asymmetric effect occurs only with the negative new from Japan (e'_3=0.202 with robust t-value of 2.33). Like the mean spillover, we find the asymmetry in volatility spillover (g_4=0.0015 with robust t-value of 2.06), and only the negative news from Japan significant increase the volatility in U.S. (g'_4=0.016 with the robust t-value of 2.28). Again, this finding support the Bae, et al's (1994) argument that the influence of foreign news on the domestic return volatility is understated if asymmetric effect is ignored. But we further document that only the negative news from Japan significantly influence the return volatility in U.S. In sum,f

Table 6. Maximum Likelihood Estimation of Symmetric GARCH and Asymmetric GJR-GARCH Models for the S&P Overnight Returns (Second-Stage Estimation)

The estimation is based on the following second-stage model of overnight S&P 500 returns.

$$SP_t^n = a_3 + b_3 SP_{t-1}^d + c_3 M_t + d_3 \varepsilon_t + e_3 \varepsilon_t N_t + \nu_t$$

$$h_t^n = a_4 + b_4 h_{t-1}^n + c_4 M_t + d_4 \nu_{t-1}^2 + e_4 \nu_{t-1}^2 N_{t-1}^{\sim} + f_4 \varepsilon_t^2 + g_4 \varepsilon_t^2 N_t$$

where SP_t is the S&P 500 index futures returns with the superscripts d and n represent daytime (open-to-close) and overnight (close-to-open) returns, respectively. The dummy variables M_t equals 1 if t is a Monday or a day following a holiday, and zero otherwise. N_t ($N_t^{\sim}$) equals 1 if ε_t (ν_t) is negative, and zero, otherwise. ε_t (ν_t) is the residual which is assumed to follow normal distribution with zero-mean, and a time varying variance, h_t^d (h_t^n). Robust t-values are reported in parentheses. ***, **, * indicates significance at 1%, 5%, and 10% level, respectively.

Parameters	Symmetric Model		Asymmetric Model	
	Coefficient	t-value	Coefficient	t-value
a_3	-.0097	(-1.56)	-.0031	(-1.70)*
b_3	.0063	(.04)	.0042	(.69)
c_3	.0022	(.09)	-.0055	(.64)
d_3	.0439	(6.37)***	-.0041	(-1.26)
e_3	-		.0245	(2.72)**
(d'_3)	-		-.0034	(-.94)
(e'_3)	-		.0202	(2.33)**
a_4	.0038	(.57)	-.0005	(-4.19)***
b_4	.7932	(4.13)***	.3768	(5.02)***
c_4	.0085	(.66)	.0236	(2.87)**
d_4	.1515	(1.21)	.6392	(4.19)***
e_4	-		.8383	(1.94)*
f_4	.0008	(.47)	.0001	(1.43)
g_4	-		.0015	(2.06)**
(f'_4)	-		.0001	(1.20)
(g'_4)	-		.0016	(2.28)**
Skewness	-1.028***		-.9020***	
Kurtosis	13.5525***		15.4068***	
$Q_6 LB$	3.8014		3.9952	
$Q_{12} LB$	5.7280		6.4170	
$Q_6^2 LB$	1.2772		3.8869	
$Q_{12}^2 LB$	3.7238		4.6218	

we find the mean and volatility spillovers from Japan to U.S., but both spillovers occur only with negative news from Japan.

V. Conclusions

This paper contributes to the ongoing controversy over mean and volatility spillovers across countries by providing new evidence on the asymmetry in spillovers with the futures data of the S&P 500 and Nikkei 225 index futures contracts from January 3, 1990 to April 16, 1996. Previous studies have used the stock index cash returns to measure the cross-market interdependence in returns and volatilities. The opening prices of the stock index contain the nonsynchronous trading problem. Although Lin, et al. (1994) have used prices for some time after the market officially opens, the problem still remains since the information from one market might be quickly dissipated to other markets. In fact, with high-frequency data Becker, Finnerty and Tucker (1992) and Susmel and Engle (1994) find that the transmission across national markets occurs within the first hour of trading. We find that our data set is free from stale quote problem in that both the S&P500 and the Nikkei 225 futures prices used in this study show clear price reversal and no sign of price continuation (Stole and Whaley (1990b)) in contrast to the studies with spot indexes.

Based on the two-stage estimations in Lin, Engle, and Ito (1994) we specify asymmetric GARCH models similar to Bae and Karolyi, in which foreign daytime return is a function of the preceding overnight return to account for the price reversal effect and to use the residual as a 'foreign shock' in the first stage, and the domestic overnight return is conditioned on the foreign shock to figure out the influence of unexpected foreign daytime shock to the domestic overnight return in the second stage. The estimation results show that both U.S. and Japanese daytime returns significantly influence the subsequent overnight returns of other market. Contrary to Hamao, Masulis, and Lin (1990), we find no signs of volatility spillovers between two international markets with the symmetric model. However, with the asymmetric models, as in Bae and Karolyi (1994), we find that the negative foreign shocks have larger influence on the domestic return volatility. We further document that only the negative shock is statistically significant while Bae, et al. find both negative and positive shocks are significant.

The findings here generally suggest that the two markets are more sensitive to the bad news originating in other markets. This nature of transmission between two markets would have important implications to the arbitragers who are trying to exploit the short-term dynamics of price and volatility movements across two security markets. It would be interesting to examine whether these asymmetric relationships exist between the U.S. and the Korean (or between the Japanese and the Korean) stock markets despite the differences in market capitalization and regulations. Our future research effort will be made to pursue this topic.

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