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Price and Volatility Transmission between ADRs and Their Underlying Stocks: Evidence from the Korean Case*

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This study investigates the spillover effect of price returns and volatility between ADRs and their underlying Korean stocks, employing a Granger causality test and a bivariate GARCH model. First, the empirical results of Granger causality test suggest bi-directional transmission of price returns between the ADRs and their underlying stocks. Second, the empirical results from the estimations of bivariate GARCH model indicate that volatility spillover effect exists between the ADRs and underlying stocks. In addition, due to the small and illiquid Korean ADR market, it is evidenced that direction of volatility spillover effect from the home market to the ADR market, but the evidence is very weak.

JEL Classification: F3, G1
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1. INTRODUCTION

For theoretical and empirical reasons, the returns and volatility transmission amongst equity markets have drawn the attention of numerous academics and practitioners because they both play crucial roles in portfolio and risk management. Due to the increasing integration of international equity markets and recent global financial crisis, the information flows is more speedily spread around international equity markets and thus equity markets are integrated and interdependent each other. Thus, the market linkage amongst equity markets is an important ingredient for the portfolio diversification, arbitrate trading and risk management for both international as well as domestic investors.

Cross-listings of shares and issuance of American Depositary Receipts (ADRs) by foreign companies in the US have played a significant role in the market liquidity, international diversification, arbitrage opportunities and capital market integration (Gande, 1997; Karolyi, 2004). In particular, ADRs provide a unique opportunity to investigate price interaction channels between the US and non-US equity markets. The studies of ADRs have become an important ingredient of analyzing market integration among international equity markets. Numerous studies have already documented the price transmission with consistent results indicating that ADRs price returns have a bi-directional relationship with the underlying stock price returns (Choi and Kim, 2000; Kim, Szakmary, and Mathur, 2000; Ely and Salehizadeh, 2001; Faff, Hodgson, and Saudagaran, 2002; Rabinovitch, Silva and Susmel, 2003; Lim, 2008).

Another ongoing debate is to examine the volatility spillover between the ADRs and the underlying stocks. The evidence of volatility spillover indicates strong cross-market dependence in the volatility process. There are three different agreements in existing literature. The first group argues that the underlying markets affect the returns and volatility in the ADR markets. Choi and Kim (2000) found that price returns of underlying stocks are important determinants of the ADRs. Mak and Ngai (2005) reported a significant volatility spillover between Hong Kong stocks and their ADRs. Their result indicated that the home market influenced the pricing of ADRs. Kutan and Zhou (2006) also showed that conditional volatility of the Chinese ADRs is influenced by the innovations in the underlying stock markets.

The second group of these studies reported a uni-directional relationship from the ADRs to their underlying stocks. Alaganar and Bhar (2002) examined the information flow between dully listed stocks traded in Australia and US. They suggested that the ADR market dominates the Australian market. Jaiswal-Dale and Jithendranathan (2009) explored the effect of information shocks using cross-listing stocks in US and German markets. They found that returns and volatilities of domestic markets are affected by US shocks.

The final group supports bi-directional relationship between the ADRs and their underlying share markets. Park and Kim (2001), and Kim (2005) examined information flows between the ADRs and their Korean underlying stocks, taking into account the Asian currency crisis. They found that strong bi-directional spillover effect exists in both price returns and volatility after the Asian currency crisis, implying that the crisis has intensified the information transmission from the non-US market to the US market. Iwatsubo and Inagaki (2007) reported significant a bi-directional spillover effect in the return and return volatility of some Asian markets. Poshakwale and Aquino (2008) investigated volatility dynamics and information flow between 70 ADRs and their corresponding stocks. They reported a bi-directional volatility transmission and information flow between both markets.

The main objective of this study is to investigate the magnitude and direction of price returns and volatility spillovers between ADRs and their underlying stocks. For this purpose, we focus on the ADR market for the emerging ADR market, i.e., Korean ADRs. Although the ADRs from emerging markets bring diversification benefits to US investors and can serve as a proxy for the home markets, most emerging ADRs is less activated than their underlying stocks so that information flows of underlying stocks might be transmitted into ADR prices. In this context, we give rise to question on whether emerging underlying stocks in the home market affect ADRs in the US market or not. The use of ADRs provides a unique vehicle to measure the information flows form the non-US market to the US market.

The contribution of this paper is twofold. First, regarding the price returns and volatility transmission in the ADRs, a little attention has been given to Korean ADRs. Analyzing whether the transmission of price returns and volatility exist between the ADRs and the underlying stocks leads to a better understanding of the linkages between the two markets and the nature of risks that the participants in both markets have to cope with.

Second, we identify how the price returns and volatility in one market is transmitted to the other market, employing two approaches: a Ganger-causality test and a bivariate GARCH model. In particular, employing bivariate GARCH model is a useful technique to capture information causality between the ADRs and the underlying stocks. Our empirical results contribute to the ongoing debate about information flows and volatility transmission between the ADRs and the underlying stocks.

The rest of this paper is organized as follows. Section 2 discusses econometric methodology. Section 3 provides descriptive statistics of the sample data. Section 4 discusses the empirical results. Section 5 concludes.

2. MODEL FRAMEWORK

2.1. Granger Causality Test

The Granger (1969) causality test provides the statistical causation between returns and variances. The following bivariate regressions are used to test for causality between the returns and variances:

$$x_t = a_0 + a_1 x_{t-1} + \cdots + a_k x_{t-k} + b_1 y_{t-1} + \cdots + b_n y_{t-n} + \varepsilon_{xt}, \qquad (1)$$

$$y_t = a'_0 + a'_1 y_{t-1} + \cdots + a'_n y_{t-n} + b'_1 x_{t-1} + \cdots + b'_k x_{t-k} + \varepsilon_{yt}, \quad (2)$$

where n and k are lag orders, and x_t and y_t are the returns of ADRs and their underlying stocks, respectively. The regression residuals, ε_{xt} and ε_{yt}, are assumed to be mutually independent and individually distributed with zero mean and constant variance. To test for strict Granger causality for all possible pairs of $\{x_t, y_t\}$ in this linear framework, a standard joint test (*F*-statistic) is used to determine whether lagged information on a variable (y_{t-i}) provides any statistically significant information about a variable (x_t) in the presence of lagged x_t. If not, then "y_t does not Granger-cause x_t".

The null hypothesis, that y_t does not strictly Granger-cause x_t, is rejected if the coefficient on the lag values of y_t in equation (1) are jointly significantly different from zero, i.e., $b_1 \neq b_2 \neq \cdots \neq b_n \neq 0$. Bidirectional causality exists if the null hypothesis, that x_t does not strictly Granger-cause y_t, is also rejected.

2.2. Bivariate GARCH Model

Substantial attention has been focused on how news from one market affects the volatility process of another market. In this study, we further analyze the volatility transmission between ADRs and their underlying stocks by using a bivariate framework of the BEKK parameterization (Engle and Kroner, 1995). In this model the variance-covariance matrix of equations depends on the squares and cross products of innovation (ε_t) which is derived from the following mean equation:

$$R_{i,t} = \mu_i + \varepsilon_{i,t}, \quad (3)$$

where $R_{i,t}$ is the continuously compounded percentage return series on index i between $t-1$ and t, μ_i is a long-term drift coefficient, and $\varepsilon_{i,t}$ is the error term (shock) for the return on index i at time. The standard BEKK parameterization for the multivariate GARCH model is written as:

$$H_t = C'C + A'\varepsilon_{t-1}\varepsilon'_{t-1}A + B'H_{t-1}B, \tag{4}$$

$$\begin{aligned} H_t = \begin{bmatrix} h_{11,t} & h_{12,t} \\ h_{21,t} & h_{22,t} \end{bmatrix} &= \begin{bmatrix} c_{11} & \\ c_{21} & c_{22} \end{bmatrix}' \begin{bmatrix} c_{11} & \\ c_{21} & c_{22} \end{bmatrix} \\ &+ \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix}' \begin{bmatrix} \varepsilon^2_{1,t-1} & \varepsilon_{1,t-1}\varepsilon_{2,t-1} \\ \varepsilon_{2,t-1}\varepsilon_{1,t-1} & \varepsilon^2_{2,t-1} \end{bmatrix} \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} \\ &+ \begin{bmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{bmatrix}' \begin{bmatrix} h_{11,t-1} & h_{12,t-1} \\ h_{21,t-1} & h_{22,t-1} \end{bmatrix} \begin{bmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{bmatrix}, \end{aligned} \tag{5}$$

where H_t is a 2×2 matrix of conditional variance-covariance at time t, and C is a 2×2 lower triangular matrix with three parameters. A is a 2×2 square matrix of parameters and measures the extent to which conditional variances are correlated past squared errors. B is a 2×2 squared matrix of parameters and shows the extent to which current levels of conditional variances are related to past conditional variances.

The conditional variance of the bivariate GARCH (1, 1) model can be expressed as:

$$\begin{aligned} h_{11,\,t} = {} & c^2_{11} + c^2_{21} + a^2_{11}\varepsilon^2_{1,t-1} + 2a_{11}a_{21}\varepsilon_{1,t-1}\varepsilon_{2,t-1} + a^2_{21}\varepsilon^2_{2,t-1} + b^2_{11}h_{11,t-1} \\ & + 2b_{11}b_{21}h_{12,t-1} + b^2_{21}h_{22,t-1}, \end{aligned} \tag{6}$$

$$\begin{aligned} h_{22,\,t} = {} & c^2_{22} + a^2_{12}\varepsilon^2_{1,t-1} + 2a_{12}a_{22}\varepsilon_{1,t-1}\varepsilon_{2,t-1} + a^2_{22}\varepsilon^2_{2,t-1} + b^2_{12}h_{11,t-1} \\ & + 2b_{12}b_{22}h_{12,t-1} + b^2_{22}h_{22,t-1}. \end{aligned} \tag{7}$$

Equations (6) and (7) reveal how volatility is transmitted over time and across the ADRs and underlying stocks. Significant lagged variance $b_{11}(b_{22})$ would suggest that current conditional variance of the ADRs (underlying stocks) is affected by its own past conditional volatility, whereas a significant squared error term represented by $a_{11}(a_{22})$ would indicate that conditional variance of the ADRs (underlying stocks) is correlated with its past squared errors.

The off-diagonal elements of matrices A and B capture cross-market effects. The significance of covariance term $b_{12}(b_{21})$ indicates that indirect volatility transmission from the ADRs (underlying stocks) to the underlying stocks (ADRs). In addition, a significant cross-product of error term $a_{12}(a_{21})$ would indicate presence of shock transmission and direct volatility transmission between ADRs and underlying stocks.

The parameters of bivariate GARCH model can be estimated by the maximum likelihood estimation method optimized with the Berndt, Hall, Hall and Hausman (BHHH) algorithm. The conditional log likelihood function $L(\theta)$ is expressed as:

$$L(\theta) = -T\log 2\pi - 0.5\sum_{t=1}^{T}\log\left|H_t(\theta)\right| - 0.5\sum_{t=1}^{T}\varepsilon_t(\theta)' H_t^{-1}\varepsilon_t(\theta), \tag{8}$$

where T is number of observations and θ denotes the vector of all the unknown parameters.

3. DATA

This study considers five Korean ADRs traded in the New York Stock Exchange, namely Kookmin Bank (KB), KT Corporation (KT), POSCO (PO), Shinhan Financial Group (SFG) and SK Telecom (SKT).[1)] Table 1 summarizes the descriptive information of five Korean ADRs with the lists of ADRs, ADR to stock ratio, the names of respective industries and sample period.

1) Despite the fact that 10 Korean ADRs are listed in the NYSE, trading activities are very low. We select five ADRs which are relatively more activated in the market.

Table 1 Summary of Korean ADR Samples

Name	Ratio (ADR: stock)	Industry	Sample Period
Kookmin Bank (KB)	1:1	Banks	09/11/2001 ~22/2/2010
KT Corporation (KT)	2:1	Fixed line telecom	02/01/2000 ~22/2/2010
POSCO (PO)	4:1	Industrial metal & mining	06/01/2003 ~22/2/2010
Shinhan Financial Group (SFG)	1:2	Banks	17/09/2003 ~22/2/2010
SK Telecom	9:1	Mobile telecom	13/01/2003 ~22/2/2010

Source: The Bank of New York.[2)]

We employ the weekly price of the five ADRs and their underlying stocks obtained from DataStream International. Weekly returns are used in order to avoid the problem of non-sychronous trading and the day-of-weeks effects (see Ramchand and Susmel, 1998; Ng, 2000; Skintzi and Refenes, 2006 amongst other studies that use weekly data in estimating the GARCH model). Moreover, weekly data on equity returns in different national markets, computed for Friday-to-Friday periods, largely overlap and thus information is shared among markets. As a result, with daily data, markets in the KRX and NYSE may not share the same information. The ADRs and underlying stock prices are then converted into the nominal logarithmic return series for all sample indices, i.e., $R_{i,t} = \ln\left(P_{i,t}/P_{i,t-1}\right) \times 100$, where $R_{i,t}$ denotes the continuously compounded percentage return for index i at time t, and $P_{i,t}$ denotes the price level of index i at time t.

2) The Bank of New York website on Depository Receipts Directory, http://www.adrbnymellon.com/dr_directory.jsp

Table 2 Descriptive Statistics and Unit Root Tests

	ADRs					Underlying Stocks				
	KB	KT	PO	SFG	SKT	KB	KT	PO	SFG	SKT
Panel A: Descriptive Statistics										
Obs.	432	530	373	337	372	432	530	373	337	372
Mean (%)	0.042	–0.221	0.388	0.274	–0.062	0.014	–0.206	0.387	0.267	–0.065
S.D. (%)	6.489	5.281	6.499	6.041	4.477	5.786	4.482	5.622	5.327	4.159
Max.	0.213	0.193	0.449	0.170	0.121	0.189	0.199	0.403	0.171	0.146
Min.	–0.261	–0.309	–0.324	–0.231	–0.235	–0.251	–0.219	–0.221	–0.197	–0.239
Skew.	–0.254	–0.246	0.155	0.060	-0.790	–0.203	–0.241	0.562	–0.271	–0.656
Kurt.	4.148	6.862	10.49	4.391	6.430	4.406	6.047	9.761	4.084	6.284
J-B	28.40***	334.0***	872.6***	43.11***	221.0***	38.53***	210.0***	729.9***	20.63***	193.9***
$Q^2(20)$	173.5***	305.6***	129.1***	132.8***	91.46***	145.2***	173.8***	65.47***	90.27***	52.93***
Panel B: Unit Root Tests										
ADF	–22.15***	–26.70***	–20.01***	–18.21***	–22.53***	–24.92***	–25.53***	–16.00***	–20.72***	–23.19***
PP	–22.12***	–26.63***	–20.15***	–18.21***	–22.39***	–24.67***	–25.54***	–20.98***	–20.69***	–23.16***

Notes: The Jarque and Bera (J-B) is a test statistic for the null hypothesis of normality in the sample return distribution. The Ljung-Box test statistic, $Q_S(n)$, checks for the serial correlation of the squared return residuals for up to the nth order. Mackinnon's 1% critical value is –3.435 for the ADF and PP tests. *** indicates a rejection of the null hypothesis at the 1% significance level.

Table 2 shows the descriptive statistics and the results of the unit root test for all of the sample returns. As shown in Panel A of table 2, underlying stocks offer lower returns and standard deviation (S.D.) relative to their corresponding ADRs. Based on the values of skewness (Skew.), excess kurtosis (Kurt.), and the Jarque-Bera (J-B) statistics, we can conclude that all of the return series tend to follow a leptokurtic distribution, which has a higher peak and fatter tail than a normal distribution. The calculated values of the Ljung-Box *Q*-statistic, $Q^2(20)$, for the squared return series are extremely high, indicating the rejection of the null hypothesis of no serial correlation. Thus, the returns follow ARCH-type dependencies confirming the appropriateness of the GARCH model in analyzing volatility.

Additionally, Panel B of table 2 provides the results of two types of unit root test: the augmented Dickey-Fuller (ADF) and Phillips-Peron (PP). Large negative values for the ADF and PP test statistics in this table reject the null hypothesis of a unit root at a significance level of 1%. Thus, all return series are a stationary process.

4. EMPIRICAL RESULTS

4.1. Results of Granger Causality Test

In this section, we examine the tranmission of price returns between ADRs and their underlying stocks. Table 3 reports the results of the Granger causality test between the ADRs and their underlying stocks. Note that we consider the lags 2 selected in all sample return series. Except for the case of SKT, the results rejects the null hypothesis that ADRs returns do not cause their underlying stock returns, and in reverse direction. This means that there is bidirectional returns causality between the ADRs and their underlying stocks.

Table 3 Pairwise Granger Causality Tests

Series	Null Hypothesis	Test Values	
		F-value	*P*-value
KB	$(ADR) \neq> (Original)$	5.578***	0.000
	$(Original) \neq> (ADR)$	3.263***	0.001
KT	$(ADR) \neq> (Original)$	2.429**	0.014
	$(Original) \neq> (ADR)$	3.436***	0.001
PO	$(ADR) \neq> (Original)$	3.997***	0.000
	$(Original) \neq> (ADR)$	2.569***	0.009
SFG	$(ADR) \neq> (Original)$	4.024***	0.000
	$(Original) \neq> (ADR)$	1.843*	0.068
SKT	$(ADR) \neq> (Original)$	0.983	0.449
	$(Original) \neq> (ADR)$	0.723	0.670

Notes: The symbol " $\neq>$ " means "does not Granger-cause". *, **, *** indicate rejection of the null hypothesis at 10, 5, and 1% significance levels, respectively.

4.2. Volatility Spillover Effect

In order to examine volatility spillover effect, we employ the bivariate GARCH model for five ADRs and their underlying stocks. The estimation results of the bivariate GARCH model with BEKK parameterization are reported in table 4. The important coefficients in the bivariate GARCH(1, 1) model are $a_{i,i}$ and $b_{i,i}$ elements of matrices A and B, respectively where $i = 1$ stands for the ADRs and $i = 2$ for the underlying stocks. The Ljung-Box *Q*-statistics for both standardized, $Q_i(20)$, and squared standardized residuals, $Q_i^2(20)$, are reported below table 4, respectively. We find that there is no serial correlation in the standardized and squared standardized residuals, indicating the appropriateness of the GARCH-BEKK model.

Table 4 Results of Bivariate GARCH on ADRs and Their Underlying Stocks using BEKK Parameterization

Firms	KB		KT		PO		SFG		SKT	
	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.
Panel A: GARCH(1, 1)-BEKK Estimations										
c_{11}	0.002	(0.003)	0.009***	(0.002)	0.014	(0.010)	–0.003	(0.004)	0.005	(0.004)
c_{21}	–0.008***	(0.002)	0.005***	(0.001)	0.013	(0.009)	0.009***	(0.004)	–0.001	(0.007)
c_{22}	0.000	(0.027)	0.000	(0.001)	0.008***	(0.001)	0.000	(0.022)	–0.004	(0.004)
a_{11}	0.202**	(0.100)	0.497***	(0.058)	0.767***	(0.123)	0.261*	(0.141)	0.426***	(0.070)
a_{12}	–0.283***	(0.091)	0.106**	(0.048)	0.354***	(0.107)	–0.254**	(0.117)	0.055	(0.053)
a_{21}	–0.085	(0.115)	–0.252***	(0.065)	–0.420***	(0.152)	0.028	(0.167)	–0.259***	(0.078)
a_{22}	0.417***	(0.081)	0.093**	(0.045)	0.026	(0.133)	0.516***	(0.130)	0.090	(0.060)
b_{11}	0.647***	(0.049)	0.891***	(0.027)	0.540***	(0.137)	0.722***	(0.079)	0.862***	(0.049)
b_{12}	–0.123***	(0.002)	–0.018	(0.019)	–0.277**	(0.116)	0.015	(0.191)	–0.020	(0.023)
b_{21}	0.404***	(0.052)	0.047**	(0.020)	0.397**	(0.173)	0.285***	(0.106)	0.115***	(0.054)
b_{22}	1.096***	(0.006)	0.989***	(0.012)	1.139***	(0.151)	0.928***	(0.095)	0.999***	(0.024)

Panel B : Diagnostic Tests

$\log(L)$	1634.57	2132.05	1450.22	1297.59	1538.96
$Q_1^2(20)$	22.53	8.26	11.50	15.22	20.74
$Q_2^2(20)$	20.77	15.20	20.94	17.64	15.73

Notes: The diagonal elements C in matrix represents the mean equation. While matrix A captures own and cross-market ARCH effects, the diagonal elements in matrix B measure own and cross-market GARCH effects. $Q_i^2(20)$ presents the Ljung-Box Q-statistic for standardized squared residuals. In every pair, $(i=1)$ represents the ADRs and $(i=2)$ refers to the underlying stock. *, **, and *** indicate the rejection of t-statistics in the 10%, 5% and 1% significance levels, respectively.

As mentioned earlier, the diagonal elements in matrix A capture the own past shock effect, while the diagonal elements in matrix B measure the own past volatility effect. From table 4, the diagonal parameters (b_{11} and b_{22}) in matrix B are statistically significant, indicating the presence of strong GARCH effects, i.e., own past volatility affect the conditional variance of both markets. Furthermore, the diagonal parameters (a_{11} and a_{22}) are significant, implying an ARCH effect in both markets, except for PO and SKT underlying stocks.

The off-diagonal elements of matrices A and B capture cross-market effects, such as direct and indirect volatility spillover effects between ADRs and underlying stocks. We find evidence of bi-directional direct volatility spillover between the ADRs and underlying stocks of both KT and PO cases, because of the significance of off-diagnostic coefficients a_{12} and a_{21}. However, other cases show evidence of uni-directional direct spillover. For example, due to the significance of cross-product coefficient a_{12}, the post shocks of ADR market in the banking industry (KB and SFG) affect the present volatility of underlying stocks, while the mobile telecom industry (SKT) shows shock volatility spillover from the underlying stocks to ADRs, owing to the significance of cross-product coefficient a_{21}. As a result, we find mixed results on shock volatility spillover between ADRs and underlying stocks.

Additionally, we identify a bi-directional indirect volatility spillover effect between the ADRs and underlying stocks of both KB and PO cases, due to the significance of both off-diagonal elements b_{12} and b_{21}. However, other cases (KT, SFG, and SKT) report evidence of uni-directional indirect spillover from the underlying stocks to ADRs. Thus, we find evidence of volatility spillover effect from underlying stocks to ADRs, but this evidence of volatility spillover direction is very weak.

In conclusion, our empirical results are inconsistent with those reported in earlier studies by Poshakwale and Aquino (2008) and Iwatsubo and Inagaki (2007) where there is bi-directional volatility spillover effect between the ADR and underlying stock markets. One possible reason could be attributed to information asymmetry between two markets. As the Korean ADRs market in the NYSE is relatively small and a less liquidity market than the home market, the uninformed investors of Korean ADRs do not react to market news, but confirm information flows from the home market.

5. CONCLUSIONS

The integration of financial market has provoked greater interest in the dynamics of price return and volatility transmission among international equity markets. In particular, the studies of ADRs have become an important ingredient of analyzing market linkages between US and non-US markets for markets participants, regulators, and academic researchers.

This study has examined the spillover effect of price returns and volatility between ADRs and their Korean underlying stocks using the Granger causality test and the bivariate GARCH model. First, the empirical results of Granger causality test suggest bi-directional transmission of price returns between the ADRs and their underlying stocks. Second, the empirical results from the estimations of bivariate GARCH model indicate that volatility spillover effect exists between the ADRs and underlying stocks. In addition, due to the small and illiquid Korean ADR market, it is evidenced that direction of volatility spillover effect from the home market to the ADR market, but the evidence is very weak.

In conclusion, current research found the evidence of transmission of price returns and volatility between ADRs and their Korean underlying stocks. As for the return transmission, strong bi-direction relationship exists between two markets. Unlike previous studies, there is no general agreement on the direction of volatility spillover between two markets. Following the studies of Park and Kim (2001) and Kim (2005), future research takes into account the recent global financial crisis to examine the direction changes of spillover effect in the pre-and post crisis.

REFERENCES

Alaganar, V. T. and R. Bhar, "Information and Volatility Linkage under External Shocks — Evidence from Dually Listed Australian Stocks," *International Review of Financial Analysis*, 11(1), 2002, pp. 59-71.

Choi, Y. K. and D. -S. Kim, "Determinants of American Depositary Receipts and their Underlying Stock Returns — Implications for International Diversification," *International Review of Financial Analysis*, 9(4), 2000, pp. 351-368.

Ely, D. and M. Salehizadeh, "American Depository Receipts: An Analysis of International Stock Price Movements," *International Review of Financial Analysis*, 10(4), 2001, pp. 343-363.

Engle, R. F. and K. F. Kroner, "Multivariate Simultaneous Generalized ARCH," *Econometric Theory*, 11, 1995, pp. 122-150.

Faff, R. W., A. Hodgson, and S. Saudagaran, "International Cross-listings towards More Liquid Markets: The Impact on Domestic Firms," *Journal of Multinational Financial Management*, 12(4-5), 2002, pp. 365-390.

Gande, A., "American Depositary Receipts: Overview and Literature Survey," *Financial Markets, Institutions & Instruments*, 6(5), 1997, pp. 61-83.

Granger, C. W. J., "Investigating Casual Relations by Econometric Models and Cross-Spectral Methods," *Econometrica*, 37(3), 1969, pp. 424-438.

Iwatsubo, K. and K. Inagaki, "Measuring Financial Market Contagion using Dually-Traded Stocks of Asian Firms," *Journal of Asian Economics*, 18(1), 2007, pp. 217-236.

Jaiswal-Dale, A. and T. Jithendranathan, "Transmission of Shocks from Cross-listed Markets to the Return and Volatility of Domestic Stocks," *Journal of Multinational Financial Management*, 19(5), 2009, pp. 395-408.

Karolyi, G. A., "The Role of American Depositary Receipts in the

Development of Emerging Equity Markets," *Review of Economics and Statistics*, 86(3), 2004, pp. 670-690.

Kim, D. S., "Information Transmission between Cross-listed Stocks: The Case of U.S. Market-listed Foreign Firms," *Korea Trade Review*, 30(1), 2005, pp. 169-194.

Kim, M., A. C. Szakmary, and I. Mathur, "Price Transmission Dynamics between ADRs and Their Underlying Foreign Securities," *Journal of Banking & Finance*, 24(8), 2000, pp. 1359-1382.

Kutan, A. M. and H. Zhou, "Determinants of Returns and Volatility of Chinese ADRs at NYSE," *Journal of Multinational Financial Management*, 16(1), 2006, pp. 1-15.

Lim, L. K., "A Cointegration Analysis of Price Transmission between ADRs and Dually Listed South Korean Stocks," *Mathematics and Computers in Simulation*, 78(2-3), 2008, pp. 200-208.

Mak, B. S. C. and A. M. S. Ngai, "Market Linkage for Dual-listed Chinese Stocks," *The Chinese Economy*, 38(2), 2005, pp. 88-107.

Ng, A., "Volatility Spillover Effects from Japan and the US to the Pacific-Basin," *Journal of International Money and Finance*, 19(2), 2000, pp. 207-233.

Park, J. W. and J. H. Kim, "Empirical Evidence on the Information Flows between Korean ADRs and their Underlying Shares," *International Business Journal*, 12(1), 2001, pp. 247-270.

Poshakwale, S. S. and K. P. Aquino, "The Dynamics of Volatility Transmission and Information Flow between ADRs and their Underlying Stocks," *Global Financial Journal*, 19(2), 2008, pp. 187-201.

Rabinovitch, R., A. C. Silva, and R. Susmel, "Returns on ADRs and Arbitrage in Emerging Markets," *Emerging Markets Review*, 4(3), 2003, pp. 225-247.

Ramchand, L. and R. Susmel, "Volatility and Cross Correlation across Major Stock Markets," *Journal of Empirical Finance*, 5(4), 1998, pp. 397-416.

Skintzi, V. and A. N. Refenes, “Volatility Spillovers and Dynamic Correlation in European Bond Markets,” *Journal of International Financial Markets, Institutions and Money*, 16(1), 2006, pp. 23-40.