The Chinese Economy, vol. 38, no. 2, March–April 2005, pp. 88–107.

ISSN 1097–1475 / 2005 $9.50 + 0.00.

Billy S.C. Mak and Asta M.S. Ngai

Market Linkage for Dual-Listed Chinese Stocks

Abstract: *Only Chinese firms with the best financial integrity and corporate governance can be dually listed on the Hong Kong Exchange as H-shares or red chips and listed in the United States in the form of American Depository Receipts (ADRs). Dual listing for People's Republic of China (PRC) firms indicates their ability to attract international investors and to become international securities market participants. Using a bivariate generalized autoregressive conditional heteroscedasticity model, we examine patterns of information flows related to both pricing and volatility spillover across markets. Results indicate a significant mutual feedback of information between Hong Kong–listed stocks and ADRs. The Hong Kong market appears to play a more important role in influencing the pricing of corresponding companies in the U.S. market, whereas both markets are similarly influential to the volatility spillover. This finding is useful for foreign investment banking and financial services firms operating in China that need to understand the dual market performance of top PRC stocks.*

Two decades ago, almost all firms in China were owned by the state. These state-owned firms were financially weak. The standard of corporate governance was also very low. Through decades of changes imposed by the Chinese government, the performance of these state-owned firms improved. When they became better, they sought foreign listing for foreign capital. However, not all Chinese firms are eligible for overseas listing. Owing to the more stringent listing rules in the overseas markets such as the United States and Hong Kong, only those Chinese firms with financial integrity and corporate governance can be dually listed as H-shares or

Billy S.C. Mak is an assistant professor and Asta M.S. Ngai is a student in the Department of Finance and Decision Sciences at Hong Kong Baptist University, Kowloon Tong, Hong Kong (tel.: (852) 3411 7573; fax: (852) 3411 5585; e-mail: billy@net1.hkbu.edu.hk).
The authors thank Paul H.W. Yeung for his helpful research assistance. All errors remain those of the authors.

red chips on the Hong Kong Exchange and in the form of American Depository Receipts (ADRs) on the U.S. market. The ability to obtain dual listing in the overseas markets means that these People's Republic of China (PRC) firms are attractive for international investors.

The globalization of financial markets has been a rapid and continuing process over the past two decades. The trading of linked securities in domestic and foreign markets is a common phenomenon. There has been a dramatic increase in the trading of foreign stocks as investors recognize the need for international diversification and as foreign companies seek to broaden their shareholder base to raise capital. Foreign markets represent a source of new capital for the firms. Moreover, firms that are listed on the foreign markets can enhance the marketability of their securities and have better access to new funds at lower cost. However, this kind of cross-listing may have either beneficial or adverse consequences for the domestic equity market, depending on whether intermarket price information is freely available (Domowitz, Glen, and Madhavan 1998). As investors, it is important to understand the intermarket information linkages or volatility flows in order to effectively manage the investment portfolio.

In this study, we examine the market behavior of the ADRs listed on the New York Stock Exchange (NYSE). This choice is based on the significant growth of ADRs in recent years. For example, 465 ADRs were listed on the NYSE as of year-end 2003, as compared with just 288 in 1997.

An ADR is a negotiable certificate issued by a depositary bank for a number of non–U.S. securities that are held by the depositary's custodian in the home market of the non–U.S. company. Each ADR is backed by a fixed number of underlying shares in the custodian bank in the domestic market. ADRs can be listed on any of the U.S. exchanges, such as NYSE, NASDAQ, and AMEX. The issue of depository receipts facilitates cross-border trading and equity offering for U.S. and non–U.S. investors. Since the holder of an ADR has the right to redeem the receipt for the underlying share, the ADR and the underlying share are virtually perfect substitutes for each other, after adjusting for the transaction costs.

In this article, we focus on China-backed stocks, which are listed on both the Hong Kong Stock Exchange (HKSE) and the NYSE. There are two types of China-backed stocks listed in Hong Kong: H-shares and red chips. H-shares refer to the shares issued by companies that have been incorporated in mainland China but that have also obtained listing on the Hong Kong Exchange. Red chips are those shares issued by Chinese companies, which, although incorporated in Hong Kong, maintain their major business operations in mainland China. The numbers of H-shares and red chips that are cross-listed in the United States are growing. As of December 2003, there are more than 200 China-backed companies listed in Hong Kong, with fifteen of them also cross-listed on the NYSE as ADRs.

Dual-listed ADRs enable us to analyze the information flows across countries because ADRs represent the same company listed in different markets. The information flows across markets should reflect both forces—domestic and global factors. The ADRs dual-listed in Hong Kong and New York offer another dimension. Bae, Cha, and Cheung (1999) show that exchange rate movements affect the prices of ADRs. However, the H.K. dollar has been pegged to the U.S. dollar since 1983. The effects of the changes in the U.S. interest rate and other macroeconomic factors on equity returns are expected to transmit to the Hong Kong market immediately.

Since the common stocks that are listed in two different countries represent the same company, the information flows of the dual-listed stocks should be consistent with the home bias hypothesis. Firm-specific information, such as earnings, dividends, and corporate announcements, is likely to be dominated by home factors. Alternatively, the global center hypothesis, which is based on the presumption that the U.S. market is dominant in the global financial market, argues that the information flows from the global center to other financial markets. The objective of this study is to examine the information flows in terms of the pricing and volatility moments between the Hong Kong and the New York markets.

Literature Review

As there are increasing numbers of firms going to list their stocks in the foreign markets, a lot of empirical studies in the finance literature are conducted to examine the effects of dual listing. These studies usually focus on the impact of risk and returns by the introduction of dual listing and the relation of stock returns and volatility across markets.

Hauser, Tanchuma, and Yaari (1998) investigate five companies which are dually listed on both the Tel Aviv Stock Exchange (TASE) and NASDAQ. Their results of the ARIMA and VAR models show the price change on the TASE causes the price change on the NASDAQ, whereas a reversed causality does not exist.

A similar study by Kadapakkam and Misra (2003), which examines the return linkages between Indian stocks and their London global depositary receipts (GDRs), reports a feedback effect in information flows between the Mumbai (formerly Bombay) and London markets. The impact of the Mumbai (home) returns on the subsequent London (offshore) returns is significant both economically and statistically, whereas the impact from London returns to Mumbai returns is relatively small.

Karolyi (1995) shows that the generalized autogressive conditional heteroscedasticity (GARCH) model can explain the cross-markets linkage better than the VAR model. Alaganar and Bhar (2002) examine the information flows between the dually listed stocks traded in Australia and the United States as ADRs. The results of the bivariate GARCH model show that the asymmetric information flow is subjected to external shocks from the world market as well as from the original market. Xu and Fung (2002) use a bivariate ARIMA-GARCH model to investigate the information flow for ten China-backed stocks that are dually listed in Hong Kong and New York as of February 1998. They find that the home market plays a more important role in the pricing process, whereas the offshore market plays a more influential role in the volatility spillover.

Data

We selected our samples from a record of the China-backed firms listed on the HKSE and traded as ADRs on the NYSE and obtained the data from DataStream. Fifteen firms were chosen. Our sample period covered almost ten years between June 9, 1994, and December 31, 2003. Table 1 provides information about the fifteen firms in our sample, such as the conversion ratio (the number of shares for the firms listed in Hong Kong that corresponds to one ADR traded in New York) and industry classification.

Why is there a conversion ratio between the Hong Kong–listed stocks and the U.S. ADRs? The major reason is to fit the tradition of the U.S. markets. The stocks traded in Hong Kong are denominated in H.K. dollars, while the ADR counterparts are denominated in U.S. dollars when they are traded in the U.S. market. Since there is an exchange rate difference when H.K. dollars are translated into U.S. dollars, one H.K. dollar is worth much less than one U.S. dollar. Therefore, many of these stocks and ADRs are regarded as penny stocks in the U.S. markets. From the perspective of the U.S. investor, a penny stock is a risky investment. Besides, there is also a delisting rule for the stock which does not meet the minimum share price requirement imposed by the exchanges. For instance, NASDAQ requires the stock prices of all listed stocks to be more than one U.S. dollar; otherwise, the stock would be delisted after the grace period. To reduce the chance of being delisted and to give confidence to the investors, the price of an ADR is always greater than US$10. That makes the conversion ratio greater than ten for most of the cases.

The daily return series is computed as the log difference of the adjusted prices over the entire period. The daily returns, therefore, correspond to close-to-close prices. Since the stocks traded on the HKSE are denominated in H.K. dollars, whereas the ADRs traded in the United States are denominated in U.S. dollars, the exchange rate and the conversion ratio must be adjusted. Therefore, we obtained the exchange rate (daily middle rate) between the U.S. dollar and the H.K. dollar from DataStream.

Methodology

We used a bivariate GARCH model to examine the price and volatility spillovers of cross-market information transmission of China-backed stocks that are dual-listed on the HKSE and the NYSE. Bollerslev (1986) develops the GARCH model by allowing the conditional variance to depend on past conditional variances. That is, the autoregressive component captures the persistence in the conditional variance of returns, whereas the past squared residual component captures the infor-

Table 1

China-Backed Stocks Listed on Both the Hong Kong Stock Exchange (HKSE) and the New York Stock Exchange (NYSE) in 2003

Company name	Industry	Beginning date in data stream[a]	No. of obser-vations	HKSE stock code	NYSE ticker	Con-version ratio[b]
Aluminium Corp. of China, Ltd.	Mining & metals	12/12/2001	534	2600	ACH	1:100
Brilliance China Automotive Holdings, Ltd.	Auto manufacturers	04/18/2000	965	1114	CBA	1:100
China Eastern Airlines Corp., Ltd.	Airlines	02/05/1997	1,799	670	CEA	1:100
China Mobile (Hong Kong), Ltd.	Wireless communication	10/23/1997	1,613	941	CHL	1:5
China Petroleum & Chemical Corp.	Energy	10/19/2000	833	386	SNP	1:100
China Southern Airlines Corp., Ltd.	Airlines	07/31/1997	1,672	1055	ZNH	1:50
China Unicom, Ltd.	Wireless communication	06/22/2000	918	762	CHU	1:10
CNOOC–China National Offshore Oil Corp.	Energy	02/28/2001	739	883	CEO	1:20
Guangshen Railway Co., Ltd.	Industrial transport	05/14/1996	1,990	525	GSH	1:50
Huaneng Power International, Inc.	Electric utilities	02/07/1998	1,550	902	HNP	1:40
Jilin Chemical Industrial, Co. Ltd.	Chemicals	05/24/2001	678	368	JCC	1:100
Petrochina Co., Ltd.	Energy	04/07/2000	972	857	PTR	1:100
Sinopec Beijing Yanhua Petro-chemical Co., Ltd.	Chemicals	06/26/1997	1,697	325	BYH	1:50
Sinopec Shanghai Petrochemical Co., Ltd.	Energy	06/09/1994	2,493	338	SHI	1:100
Yanzhou Coal Mining Co., Ltd.	Energy	04/08/1998	1,494	1171	YZC	1:50

Notes:
a. The beginning date is not necessarily the same as the listing date.
b. The conversion ratio indicates the number of underlying shares traded in Hong Kong that corresponds to one ADR share traded in New York. For example, 1 share of ACH traded in NYSE is equivalent to 100 shares of HK ID 2,600 traded in Hong Kong.

mation shocks to stock returns. This model has been empirically shown to capture reasonably well the time variation in the volatility of daily and monthly stock returns (Bollerslev, Chou, and Kroner 1992). Ross (1989) mentions that the volatility is directly reflective of information flow. The bivariate GARCH process can provide information on properties such as first (pricing)- and second (volatility)-order spillover between markets, autoregressive tendency, volatility persistence, and volatility clustering.

The conditional mean equations in the bivariate GARCH model are:

$$R_{h,t} = \alpha_0^h + \sum_{r=1}^{HR} \alpha_r^h R_{h,t-r} + \sum_{s=1}^{HS} \beta_s^h R_{n,t-s} + \varepsilon_{h,t} \tag{1}$$

$$R_{n,t} = \alpha_0^n + \sum_{r=1}^{NR} \alpha_r^n R_{n,t-1} + \sum_{s=1}^{NS} \beta_s^n R_{h,t+1-s} + \varepsilon_{n,t} \tag{2}$$

where the error terms have the distribution

$$\varepsilon_t = \begin{bmatrix} \varepsilon_{h,t} \\ \varepsilon_{n,t} \end{bmatrix}, \varepsilon_t \middle| \Omega_{t-1} \sim N(0, H_t).$$

The residual ε_t is represented as a column vector of forecast errors of the best linear predictor of R_t conditional on past information, denoted by Ω_{t-1}, and including the r and s lagged values of R_t.

The conditional variance equations are:

$$H_{hh,t} = \phi_0^h + \phi_1^h H_{hh,t-1} + \sum_{q=1}^{HQ} \eta_q^h \varepsilon_{h,t-q}^2 + \sum_{u=1}^{HU} \lambda_u^h \varepsilon_{n,t-u}^2 \tag{3}$$

$$H_{nn,t} = \phi_0^n + \phi_1^n H_{nn,t-1} + \sum_{q=1}^{NQ} \eta_q^n \varepsilon_{n,t-q}^2 + \sum_{u=1}^{NU} \lambda_u^n \varepsilon_{h,t+1-u}^2 \tag{4}$$

where $R_{h,t}$ and $R_{n,t}$ are returns for a cross-listed stock on the HKSE and the NYSE on day t; ε_t is a vector of residuals that has a conditional bivariate normal distribution, with zero mean and a conditional variance-covariance matrix H_t. In the conditional mean equations (1) and (2), *HR* (*HS*) and *NR* (*NS*) are the number of own-market (cross-market) returns lag for Hong Kong and New York. In the conditional equations (3) and (4), *HQ* (*HU*) and *NQ* (*NU*) are the number of own-market (cross-market) volatility lags for Hong Kong and New York. The specification is interpreted as follows: the constant term is the weighted average of long-term average; the GARCH term is the forecasted variance from the last period, and the ARCH term is the information about volatility observed in the previous period.

The multivariate structure allows us to measure the effects of a pricing in the stock returns of one market on its own lagged returns and that of the other market. Equations (3) and (4) model the dynamic process of H_t as a linear function of its own past value H_{t-1}, as well as q and u past values of squared residuals, both of which allow for own-market and cross-market influences in the conditional variances.

In the selection of the appropriate GARCH model, a number of criteria are used. Special care must be taken when testing for the conditional mean equations (1) and (2) on nonsynchronous data. The VAR equations and tests of lead-lag relations between the two markets require stationarity of the time series. If a time series is stationary, its mean, variance, and autocovariance (at various lags) remain the same, no matter at what point of time we measure them; that is, they are time invariant. Therefore, a stationarity test must be employed. We use the Augmented Dickey-Fuller test to check for the existence of unit root in the returns and the residuals series. The results of the unit root test are shown in Table 2.

For each Hong Kong and New York pair, we use the Schwarz Information Criterion (SIC) to specify the optimal lag-length for the conditional mean returns and conditional volatility equations, which is defined as:

$$SIC = n^{k/n} \frac{\sum \hat{u}^2}{n} = n^{k/n} \frac{RSS}{n} \tag{6}$$

or in log-form:

$$\ln SIC = \frac{k}{n} \ln n + \ln\left(\frac{RSS}{n} \right) \tag{7}$$

where k is the number of regressors (including the intercept) and n is the number of observations. [(k/n) ln n] is the penalty factor and RSS is the residual sum of square of the regression models. In the above formula, SIC imposes a harsher penalty than R^2 for adding more regressors. In comparing two or more models, the model with the lowest value of SIC is preferred. As GARCH is typically appropriate for time series of 200 observations or more, the stocks in our sample fit this requirement.

Empirical Results

The chronological sequence of trading activities for stocks cross-listed in Hong Kong and New York is illustrated in Figure 1 and Table 3. The HKSE and NYSE markets have nonoverlapping trading hours with a trading sequence as follows:

Table 2

Unit–Root Test: Augmented Dickey Fuller

Company name	Return–Hong Kong	Return–New York	Residuals–Hong Kong	Residuals–New York
Aluminium Corp. of China, Ltd.	–20.6660	–19.6942	–22.7930	–18.1125
Brilliance China Automotive Holdings, Ltd.	–30.4840	29.6537	–30.9349	–17.8733
China Eastern Airlines Corp., Ltd.	–42.5588	–40.1524	–32.1540	–23.9556
China Mobile (Hong Kong), Ltd.	–29.5690	–40.3104	–26.3935	–25.7550
China Petroleum & Chemical Corp.	–25.4528	–29.9475	–28.5930	–18.4189
China Southern Airlines Corp., Ltd.	–38.2483	–38.9286	–41.0932	–23.5706
China Unicom, Ltd.	–27.4019	–30.6617	–30.8839	–18.1601
CNOOC–China National Offshore Oil Corp.	–19.0349	–18.3112	–19.5995	–13.6447
Guangshen Railway Co., Ltd.,	–43.9272	–43.9061	–44.5532	–26.3727
Huaneng Power Int., Inc.	–25.8414	–36.8725	–39.7922	–28.9390
Jilin Chemical Industrial Co., Ltd.	–26.6265	–23.7875	–26.0351	–16.9701
Petrochina Co., Ltd.	–20.6075	–31.3275	–21.0886	–21.1376
Sinopec Beijing Yanhua Petrochemical Co., Ltd.	–38.8549	–40.1187	–41.3234	–25.3985
Sinopec Shanghai Co., Petrochemical Co., Ltd.	–48.1798	–47.9888	–50.1167	–28.0367
Yanzhou Coal Mining Co., Ltd.	–28.6253	–37.4699	–29.2048	–24.2808

Notes: The test critical values: 1 percent level –3.4373; 5 percent level –2.8645; 10 percent level –2.5684; the null hypothesis is that there is a unit root. If the value is greater than the critical value, that means the series is stationary. The results reject the null hypothesis, indicating that all the data series are stationary.

trading *day t-1* on the HKSE, trading *day t-1* on the NYSE, trading *day t* on the HKSE, trading *day t* on the NYSE. The mean and variance equations are specified to capture the proper information flows for the trading days for the Hong Kong and New York markets.

The Hong Kong market is expected to take its cues from the New York market, if the Hong Kong traders believe that the transactions in New York capture addi-

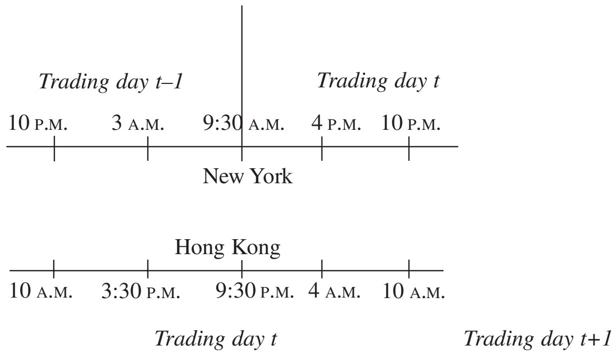
Figure 1 Relative Timing of Trading Days on the Hong Kong Stock Exchange (HKSE) and the New York Stock Exchange (NYSE)

The sequence:

Trading day *t–1* $\rightarrow$ Trading day *t* $\rightarrow$ Trading day *t+1*

HK_{t-1} NY_{t-1} $\quad$ HK_t NY_t $\quad$ HK_{t+1} NY_{t+1}

The time line diagram:



Notes: The New York market lags twelve hours behind the Hong Kong market. Time correspondence is based on daylight saving time. In any season, the trading hours of the HKE and the NYSE do not overlap.

tional information after the close of trading in Hong Kong. If the New York market provides a more complete response to the news on *day t,* then we expect the returns in New York on *day t* to predict Hong Kong returns on *day t+1*.

Table 4 reports the results on the conditional mean equations and conditional variance equations for the fifteen China-backed ADRs. We find that the returns of both the underlying stocks and the ADRs follow a negative autoregressive process. With this model, we can test how the stock returns in the Hong Kong and New York markets transmit to each other and how the volatility transmits to the other markets. In the bivariate GARCH model, a longer lag length reflects the delay of adjustment to market information on previous days.

The response to the information flows is quite fast for both the Hong Kong and New York markets, where the numbers of lag range from one to a maximum of five. It implies that the markets take one to five days to fully adjust to the returns and volatility.

The strong interaction across markets can be demonstrated by the significant cross-market coefficients (β and λ) in both the conditional mean and conditional variance equations. We examine the mean spillover by looking at the cross-market

Table 3

Chronological Sequence of Trading Activities on the Hong Kong and the New York Markets

Hong Kong hours	New York hours	Hong Kong market status	New York market status
10:00 A.M.–3:30 P.M.	10:00 P.M.–3:00 A.M.	open	closed
3:30 P.M.–9:30 P.M.	3:00 A.M.–9:30 A.M.	closed	closed
9:30 P.M.–4:00 A.M.	9:30 A.M.–4:00 P.M.	closed	open
4:00 A.M.–10:00 A.M.	4:00 P.M.–10:00 P.M.	closed	closed

coefficients of the mean equations (namely, the β coefficients). As the β coefficients are higher for the New York market than for the Hong Kong market, the pricing transmission of China-backed ADRs from the Hong Kong market to the New York market is stronger. These results are indicative of a strong influence from the underlying stocks to ADRs at the level of mean returns. Our results also show the interdependence of the pricing transmission between the two markets. However, the values of the coefficients are less than one, indicating that the New York returns do not move in perfect harmony with the Hong Kong returns. In addition, we observe that part of the response of the ADRs to the Hong Kong returns on the earlier day is deferred to the next trading session. Our finding is similar to that of Kadapakkam and Misra (2003) who report a delayed reaction of GDRs to the underlying stocks. Kadapakkam and Misra attribute it to the impediments to arbitrage, such as transaction costs and nonsynchronous trading time.

In contrast, the cross-market coefficients in the conditional variance equations (the λ coefficients) show a different phenomenon. Eight of the China-backed ADRs (Aluminium Corporation of China, China Mobile, China Petroleum and Chemical, China Unicom, Guangshen Railway, Jilin Chemical Industrial, Petrochina, and Sinopec Shanghai Petrochemical) exhibit a stronger volatility transmission from the Hong Kong market to the New York market, whilst the remaining seven stocks show the opposite results. This finding is quite different from the previous work done by Xu and Fung (2002), which shows that the major volatility transmission is from New York to Hong Kong.

We used the trading volume of the stocks in the Hong Kong market and the ADRs in the New York market to explain these results. Karpoff (1987) documents a strong positive empirical relation between volume and return volatility; that is, public information is associated with increases in trading volume. Thus, return is more volatile when trading is active. The comparison of average monthly volume (in shares) of the China-backed stocks trading on the HKSE and the NYSE during the sample period is shown in Table 5. The volume ratios between the Hong Kong trading turnover and the New York trading turnover of ADRs, after adjusting for the conversion ratios, are computed. The results show that all the stocks trade

Table 4

Results for Conditional Mean Equations and Conditional Variance Equations

$$R_{h,t} = \alpha_0^h + \sum_{r=1}^{HR} \alpha_r^h R_{h,t-r} + \sum_{s=1}^{HS} \beta_s^h R_{n,t-s} + \varepsilon_{h,t} \tag{1}$$

$$R_{n,t} = \alpha_0^n + \sum_{r=1}^{NR} \alpha_r^n R_{n,t-1} + \sum_{s=1}^{NS} \beta_s^n R_{h,t+1-s} + \varepsilon_{n,t} \tag{2}$$

$$H_{hh,t} = \phi_0^h + \phi_1^h H_{hh,t-1} + \sum_{q=1}^{HQ} \eta_q^h \varepsilon_{h,t-q}^2 + \sum_{u=1}^{HU} \lambda_u^h \varepsilon_{n,t-u}^2 \tag{3}$$

$$H_{nn,t} = \phi_0^n + \phi_1^n H_{nn,t-1} + \sum_{q=1}^{NQ} \eta_q^n \varepsilon_{n,t-q}^2 + \sum_{u=1}^{NU} \lambda_u^n \varepsilon_{h,t+1-u}^2 \tag{4}$$

Coefficient	Aluminum Corp. of China	Brilliance China Automotive	China Eastern Airlines	China Mobile	China Petroleum & Chemical	China Southern Airlines	China Unicom	CNOOC
Conditional mean equation (pricing transmission parameters) – Hong Kong market								
α_0 Constant term	0.0002	0.0009	0.0003	–0.0000	0.0010	–0.0003	–0.0006	0.0012*
	(1.37)	(0.78)	(0.32)	(–0.14)	(1.41)	(–0.35)	(–0.72)	(1.75)
α_1 Own-market return lag 1	–0.1802**	–0.9696*	–0.1433***	–0.3371***	–0.0661	–0.1046***	–0.1933***	–0.2545***
	(–2.31)	(–1.86)	(–3.69)	(–8.11)	(–1.39)	(–2.43)	(–4.88)	(–4.96)

α_2 Own-market return lag 2		–0.0392 (–1.06)		–0.2486*** (–6.09)				
β_1 Cross-market return lag 1	0.3752*** (4.57)	0.1972*** (3.84)	0.2237*** (5.19)	0.5235*** (15.09)	0.2025*** (4.51)	0.2161*** (5.09)	0.4152*** (12.08)	0.3153 (6.33)
β_2 Cross-market return lag 2				0.2234*** (5.89)				
β_3 Cross-market return lag 3				0.1035*** (3.93)				
Conditional variance equation (volatility spillover parameters) – Hong Kong market								
ϕ_o Constant term	0.0000 (1.23)	0.0001*** (3.93)	0.0002*** (7.11)	0.0000*** (4.89)	0.0000* (2.26)	0.0002*** (5.80)	0.0000*** (3.33)	0.0000 (1.04)
ϕ_1 GARCH lag 1	0.9209*** (14.33)	0.8589*** (41.62)	0.6939*** (23.85)	0.8175*** (34.43)	0.9661*** (87.83)	0.7056*** (19.07)	0.8687*** (38.43)	0.9541*** (53.79)
Conditional variance equation (volatility spillover parameters) – Hong Kong market								
η_1 ARCH lag 1	0.0067 (0.41)	0.0596*** (4.63)	0.1617*** (8.65)	0.0036 (0.19)	0.0263*** (3.03)	0.1184*** (7.21)	0.0697*** (5.03)	0.1498*** (3.33)
η_2 ARCH lag 2				0.0891*** (3.41)				–0.1144*** (–2.57)
λ_1 Volatility spillover lag 1	0.0144 (0.50)	0.1277*** (5.39)	0.1532*** (4.18)	0.0622*** (3.41)	0.0062** (2.38)	0.1171*** (4.81)	0.0288*** (2.82)	0.0053 (0.31)

(*continued*)

Table 4 (*continued*)

Coefficient	Aluminum Corp. of China	Brilliance China Automotive	China Eastern Airlines	China Mobile	China Petroleum & Chemical	China Southern Airlines	China Unicom	CNOOC
Conditional mean equation – New York market								
α_0 Constant term	0.0002 (0.47)	0.0001 (0.25)	0.0002 (–0.58)	0.0000 (0.17)	0.0002 (0.53)	0.0000 (0.06)	–0.0002 (–0.34)	0.0003 (0.67)
α_1 Own-market return lag 1	–0.3169*** (–6.90)	–0.2699*** (–7.41)	–0.2539*** (–10.14)	–0.5983*** (20.78)	–0.4394*** (–13.29)	–0.3050*** (–11.94)	–0.4490*** (13.21)	–0.3366*** (–8.02)
α_2 Own-market return lag 2				–0.4410*** (–14.38)				
α_3 Own-market return lag 3				–0.2178*** (–8.01)				
β_1 Cross-market return lag 1	0.7571*** (33.84)	0.7927*** (41.42)	0.6690*** (41.66)	0.8974*** (43.17)	0.8676*** (38.35)	0.7537*** (45.44)	0.8634*** (27.21)	0.7855*** (32.87)
β_2 Cross-market return lag 2		0.2676*** (7.54)	0.2742*** (13.73)	0.5568*** (16.97)	0.3969*** (11.92)	0.3155*** (13.83)	0.2988*** (8.74)	0.3343*** (9.29)
β_3 Cross-market return lag 3		0.0585*** (2.85)	0.0714 (5.62)	0.3743*** (11.35)		0.0775*** (5.08)		0.0662*** (3.26)
β_4 Cross-market return lag 4		0.0386** (2.06)		0.1995*** (7.67)				
β_5 Cross-market return lag 5				–0.0182 (–1.03)				
Conditional variance equation – New York market								
ϕ_0 Constant term	0.0001 (4.25)	0.0000*** (4.02)	0.0000*** (6.15)	0.0000*** (3.75)	0.0001*** (4.51)	0.0000*** (4.92)	0.0000 (0.23)	0.0000*** (2.76)

η_1 ARCH lag 1	0.1894*** (4.12)	0.1665*** (4.92)	0.0938*** (6.24)	0.1234*** (5.38)	0.1139*** (3.49)	0.1667*** (9.60)	0.0549*** (5.37)	0.1563*** (3.54)
η_2 ARCH lag 2	0.4176*** (5.97)				0.2905*** (5.49)			
Conditional variance equation – New York market								
λ_1 Volatility spillover lag 1	0.0635*** (4.74)	0.0497*** (8.76)	0.1056*** (11.54)	0.1189*** (8.94)	0.0786*** (4.28)	0.0806*** (7.38)	0.1436*** (4.39)	0.0471*** (3.64)
λ_2 Volatility spillover lag 2			–0.0675*** (–8.01)			–0.0417*** (–4.48)	–0.0887*** (–3.06)	–0.3040*** (–2.76)
Coefficient	Guangshen Railway	Huaneng Power	Jilin Chemical	Petrochina	Sinopec Beijing Yanhua Petrochemical	Sinopec Shanghai Petrochemical	Yanzhou Coal Mining	
Conditional mean equation (pricing transmission parameters) – Hong Kong market								
α_0 Constant term	0.0000 (0.13)	0.0006 (0.90)	0.0016 (1.24)	0.0011** (1.98)	–0.0003 (–0.31)	–0.0001 (–0.21)	0.0007 (0.76)	
α_1 Own-market return lag 1	–0.1473*** (–4.70)	–0.3105*** (–7.57)	–0.0666 (–1.12)	–0.2118*** (–4.71)	–0.0188 (–0.54)	–0.1131*** (–3.84)	0.0722* (1.76)	
α_2 Own-market return lag 2		–0.3689*** (10.63)						
α_3 Own-market return lag		–0.2046*** (–6.98)						
β_1 Cross-market return lag 1	0.2189*** (6.05)	0.4957*** (12.29)	0.0890 (1.44)	0.2823*** (6.15)	0.1432*** (4.07)	0.2891*** (10.19)	0.0289 (0.72)	
β_2 Cross-market return lag 2		0.3205*** (8.52)						
β_3 Cross-market return lag 3		0.1712*** (5.23)						
Conditional variance equation (volatility spillover parameters) – Hong Kong market								

(*continued*)

Table 4 (*continued*)

Coefficient	Aluminum Corp. of China	Brilliance China Automotive	China Eastern Airlines	China Mobile	China Petroleum & Chemical	China Southern Airlines	China Unicom	CNOOC
ϕ_0 Constant term	0.0000*** (6.35)	0.0000*** (3.10)	0.0000*** (3.06)	0.0000*** (2.99)	0.0001*** (6.25)	0.0000*** (3.98)	0.0000** (2.33)	
ϕ_1 GARCH lag 1	0.9709*** (290.83)	1.0005*** (883.51)	0.9264*** (52.33)	0.9571*** (151.28)	0.7319*** (34.16)	0.9485*** (186.60)	0.9708*** (133.03)	
η_1 ARCH lag 1	0.1673*** (7.27)	0.0791*** (89.38)	0.1873*** (3.75)	0.0358*** (5.16)	0.1324*** (8.23)	0.2436*** (9.41)	0.1118*** (3.67)	
η_2 ARCH lag 2	–0.0811*** (–2.56)	–0.0846*** (–178.23)	–0.1427*** (–3.08)			–0.1995*** (–7.62)	–0.0078 (–0.18)	
η_3 ARCH lag 3	–0.0592*** (–3.17)						–0.0895*** (–3.67)	
Coefficient	Guangshen Railway	Huaneng Power	Jilin Chemical		Petrochina Sinopec Beijing Yanhua Petrochemical	Sinopec Shanghai Petrochemical	Yanzhou Coal Mining	
Conditional variance equation (volatility spillover parameters) – Hong Kong market								
λ_1 Volatility spillover lag 1	0.2154*** (4.79)	0.2272*** (5.33)	0.0067 (0.43)	0.1110 (1.73)	0.1977*** (6.89)	0.0092 (1.48)	0.0316*** (3.23)	
λ_2 Volatility spillover lag 2	–0.0536 (–0.95)	–0.2202*** (–5.18)		0.1318 (1.36)				
λ_3 Volatility spillover lag 3	–0.1612*** (–4.83)			–0.2492*** (–3.54)				
Conditional mean equation – New York market								

	Guangshen	Huaneng	Jilin	Petrochina Sinopec Beijing Yanhua		Sinopec Shanghai	Yanzhou Coal
α_0 Constant term	0.0000 (0.06)	0.0003 (0.86)	−0.0002 (−0.34)	0.0002 (0.48)	−0.0004 (−0.79)	−0.0004 (−1.23)	−0.0002 (−0.37)
α_1 Own-market return lag 1	−0.2412** (−9.91)	−0.2894***−0.2201*** (−10.26)	−0.4817*** (−5.61)	−0.2801*** (−13.54)	−0.2869*** (−10.84)	−0.3066*** (−13.71)	(11.70)
α_2 Own-market return lag 2				−0.2875*** (−8.59)			
α_3 Own-market return lag 3							
β_1 Cross-market return lag 1	0.6611*** (38.74)	0.7412*** (43.73)	0.6564*** (23.87)	0.7801*** (36.44)	0.6889*** (36.23)	0.7177*** (55.17)	0.6940*** (40.51)
β_2 Cross-market return lag 2	0.2445*** (11.25)	0.2663*** (10.91)	0.3077*** (9.58)	0.4603*** (12.72)	0.3209*** (13.52)	0.2945*** (16.28)	0.3691*** (16.77)
β_3 Cross-market return lag 3			0.0946*** (3.87)	0.2175*** (6.56)	0.0452** (2.52)	0.0395*** (3.61)	0.0739*** (4.98)
β_4 Cross-market return lag 4			0.0376 (1.59)				0.0429*** (2.97)
Conditional variance equation – New York market							
ϕ_4 Constant term	0.0000*** (9.17)	0.0000 (0.58)	0.0001*** (5.86)	0.0000*** (4.19)	0.0001*** (5.19)	0.0000*** (7.25)	0.0000 (1.07)
ϕ_4 GARCH lag 1	0.5500*** (19.51)	0.9457*** (135.99)	0.2222*** (4.15)	0.7542*** (14.64)	0.7107*** (23.88)	0.5965*** (17.85)	0.9159*** (64.54)
η_1 ARCH lag 1	0.1893*** (11.10)	0.1849*** (6.20)	0.0575 (1.74)	0.0708*** (3.05)	0.1352*** (7.27)	0.1412*** (7.16)	0.0576** (2.43)
η_2 ARCH lag 2		−0.1454*** (−5.00)	0.1694*** (4.16)				0.0857** (2.33)
η_3 ARCH lag 3							−0.0319 (−0.86)
η_4 ARCH lag 4							−0.0597** (−2.25)

(*continued*)

Table 4 (*continued*)

Coefficient	Aluminum Corp. of China	Brilliance China Automotive	China Eastern Airlines	China Mobile	China Petroleum & Chemical	China Southern Airlines	China Unicom	CNOOC
Coefficient	Railway	Power	Chemical		Petrochemical	Petrochemical	Mining	
				Conditional variance equation – New York market				
λ_1 Volatility spillover lag 1	0.0853*** (9.18)	0.0638*** (5.19)	0.1472*** (7.45)	0.0264*** (3.68)	0.1288*** (8.52)	0.0994*** (12.51)	0.1089*** (7.31)	
λ_2 Volatility spillover lag 2		–0.0574*** (–4.86)			–0.0787*** (–5.62)	–0.0156*** (–6.06)	–0.0967*** (–6.95)	

Table 5

Comparison of Average Monthly Volume Between Hong Kong Stock Exchange (HKSE) and New York Stock Exchange (NYSE)

Company name	Turnover on HKE	Conversion ratio	Turnover on NYSE	HKSE/NYSE turnover ratio
Aluminium Corp. of China, Ltd.	539,805	100	94,880	5.69
Brilliance China Automotive Holdings, Ltd.	424,129	100	70,823	5.99
China Eastern Airlines Corp., Ltd.	307,171	100	89,704	3.42
China Mobile (Hong Kong), Ltd.	441,330	5	67,809	6.51
China Petroleum & Chemical Corp.	1,213,149	100	204,181	5.94
China Southern Airlines Co., Ltd.	147,209	50	64,463	2.28
China Unicom, Ltd.	445,637	10	113,768	3.92
CNOOC–China National Offshore Oil Corp.	243,140	20	38,328	6.34
Guangshen Railway Co., Ltd.	167,201	50	35,220	4.75
Huaneng Power International, Inc.	147,155	40	85,126	1.73
Jilin Chemical Industrial Co., Ltd.	376,792	100	10,081	37.38
Petrochina Co., Ltd.	1,939,069	100	336,815	5.76
Sinopec Beijing Yanhua Petrochemical Co., Ltd.	357,404	50	24,170	14.79
Sinopec Shanghai Petrochemical Co., Ltd.	404,772	100	65,468	6.18
Yanzhou Coal Mining Co., Ltd.	175,423	50	N/A	N/A

Notes: Due to the unavailability of data from DataStream, we used Xu and Fung's data as a reference here. The turnover by volume for Yanzhou Coal Mining Co. is unavailable on the NYSE.

more actively in the Hong Kong market than in the New York market, implying that the Hong Kong market plays a more important role in the trading of dual-listed stocks. This may explain why the pricing transmissions of the fifteen stocks are from Hong Kong to New York.

However, for the volatility transmissions, eight of the stocks show a pattern of flowing from Hong Kong to New York, whereas the other seven stocks display the reverse. It indicates that the volatility transmission flows from New York to Hong Kong. We cannot use the trading turnover to explain this result because seven of the stocks (Brilliance China Automotive Holdings Ltd., CNOOC, China Eastern Airlines Co., China Southern Airlines Co., Huaneng Power International INC, Sinopec Beijing Yanhua Co. and Yanzhou Coal Mining Co.) do not trade heavily on the NYSE.

We used the different market structures to explain the results. Chowdhury and Nanda (1991) show that informed traders have greater opportunities to exploit private information when a share is traded in several markets. The expected return of informed traders is diminished by a timely transmission of pricing information to satellite markets. Therefore, one of the possible explanations for the greater return volatility of shares traded on the NYSE is the greater exposure of the NYSE to the U.S. market and the greater influence of noise traders. Since the ADRs offer the informed traders longer trading time for trading (as the trading hours are nonsynchronous in the Hong Kong and New York markets), more information can be revealed through the trading process. As a consequence, the volatility of the underlying stocks on their home exchange increases. Hauser, Tanchuma, and Yaari (1998) find that the volatility is greater in the foreign market than the domestic one.

Similarly, the dual-listed stocks in our sample are listed on two markets with different trading mechanisms. The NYSE is a fragmented market with a market-maker system, whereas the HKSE is a centralized market with an order-driven system. The volatility is usually higher as the traders prefer to trade in a more transparent market than a less transparent one (see O'Hara 1999). On the NYSE, the level of pretrade transparency is reduced as the bilateral telephone negotiations between the dealers and buyers are not observable. Unlike the NYSE, the market dealers on the HKSE can observe the quotes and transactions of competitors. It increases the transparency of the market and thus accounts for the higher volatility in the Hong Kong market.

Conclusion

We made use of the bivariate GARCH model to examine the market behavior of fifteen China-backed stocks which are dually listed in Hong Kong and New York. In particular, we investigated the information flow of the stocks in terms of pricing and volatility transmission. We found that the home market (Hong Kong) plays a more significant role in the pricing transmission, whereas for the volatility spillover, the domestic market is slightly more influential than the offshore market. Our pricing results of information flows were consistent with the home-bias hypothesis.

The speed of the information transmission ranged from one to five days—mostly within three days. It implies that the information flow across markets is quite efficient. Our finding is different from the previous works of Alaganar and Bhar (2002), which finds that the U.S. market dominates both the mean pricing and volatility spillover, and of Xu and Fung (2002), which reports that pricing and volatility are influenced by the home market and the overseas market, respectively.

The empirical evidence of the effects of international listings on their underlying stocks is mixed. This may be attributed to the different trading mechanisms in different markets, and thus the impact of information flows and volatility spillover on dual listing is diverse. Moreover, the spans of different samples exhibit different results. In this study, we find a faster information transmission between markets, which may be explained by the higher degree of integration in global markets. Our sample consists of Chinese firms with the best financial integrity and corporate governance as they are dually listed on the Hong Kong Stock Exchange as H-shares or red-chips and listed in the United States in the form of ADRs. Dually listed PRC firms attract international investors' attention due to their presence in the international markets. This finding is useful for foreign investment banking and financial services firms operating in China and seeking investment opportunities in PRC stocks.

References

Alaganar, Vaira T., and R. Bhar. 2002. "Information and Volatility Linkage Under External Shock: Evidence from Dually Listed Australian Stocks." *International Review of Financial Analysis* 11: 59–71.

Bae, K.H., B. Cha, and Y.L. Cheung. 1999. "The Transmission of Pricing Information of Dually Listed Stocks." *Journal of Business Finance and Accounting* 27: 451–65.

Bollerslev, T. 1986. "Generalized Autoregressive Conditional Heteroscedasticity." *Journal of Econometrics* 31: 307–27.

Bollerslev, T., R. Chou, and K. Kroner. 1992. "ARCH Modeling in Finance Theory and Empirical Evidence." *Journal of Econometrics* 37: 231–356.

Chowdhury, B., and V. Nanda. 1991. "Multimarket Trading and Market Liquidity." *Review of Financial Studies* 4: 483–511.

Domowitz, I., J. Glen, and A. Madhavan. 1998. "International Cross-Listing and Order Flow Migration: Evidence from an Emerging Market." *Journal of Finance* 53: 2001–27.

Hauser, S., Y. Tanchuma, and U. Yaari. 1998. "International Transfer of Pricing Information Between Dually Listed Stocks." *Journal of Financial Research* 21: 139–56.

Kadapakkam, P.R., and L. Misra. 2003. "Return Linkages Between Dual Listings Under Arbitrage Restrictions: A Study of Indian Stocks and Their London Global Depositary Receipts." *Financial Review* 38: 611–33.

Karolyi, G.A. 1995. "A Multivariate GARCH Model of International Transmissions of Stock Returns and Volatility: The Case of the United States and Canada." *Journal of Business and Economic Statistics* 13, no. 1: 11–25.

Karpoff, J.M. 1987. "The Relation Between Price Changes and Trading Volume: A Survey." *Journal of Quantitative Financial Analysis* 22: 109–26.

O'Hara, M. 1999. "Making Market Microstructure Matter." *Financial Management* 28, no. 2 (Summer): 83–90.

Ross, S.A. 1989. "Information and Volatility: The No-Arbitrage Martingale Approach to Timing and Resolution Irrelevancy." *Journal of Finance* 44: 1–17.

Xu, X.E., and H.G. Fung. 2002. "Information Flows Across Markets: Evidence from China-Backed Stocks Dual-Listed in Hong Kong and New York." *Financial Review* 37: 563–88.