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Price Transmission Effect between GDRs and Their Underlying Stocks—Evidence from Taiwan

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Abstract. In this paper we examine the price transmission effect between ADRs or GDRs and their respective underlying stocks. This linkage is investigated for Granger causality using difference form and VECM. Results reveal unidirectional causality from Taiwan's capital market to the foreign market. This asymmetry suggests the domestic market plays a dominant role in price transmission relative to the foreign market. Besides, the prices of both markets will make adjustment to establish a long run cointegrated equilibrium. An additional finding is that both the premium and net buy have significant impacts on international price transmission for over twenty percent samples. Empirical outcomes also provide the evidence that our model is quite robust.

Key words: price transmission, ADRs, GDRs, premium, net buy

JEL Classification: G15, F21, F23, C22

1. Introduction

Among the emerging equity markets, Taiwan's capital market is an increasingly important one for global institutional investors due to the government's incessant revolution and liberalization policy in past decade. For example, in 1991, foreign institutional investors were allowed to directly invest in Taiwan stock market and from September 1996, Taiwan market was included in its indices by the Morgan Stanley Capital International Inc. (MSCI). As Taiwan capital market continuously deregulated, foreign investors are getting more active to this emerging market.

At the same time, as an important Original Equipment Manufacturer for worldwide famous enterprises in recent years, Taiwan companies, especially for high-tech industries, are attracting more attention from the global investors. Rapid growth in competitive ability has engendered the result that a large number of Taiwan firms have their stocks cross-listed

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on international exchanges successfully. The stock price linkage between Taiwan market and foreign market has become an important issue for local and foreign institutional investors because of the price interaction and arbitrage opportunities provided by dually listing.

The most commonly used vehicles of dual listing by Taiwan companies are American Depositary Receipts (ADRs) and Global Depositary Receipts (GDRs). The possible advantages for such cross listing are promoting a firm's reputation in large capital markets, the availability of capital, lower capital costs and elimination of investment barriers such as domestic accounting and tax practices (see Karolyi (1998) survey on why and how companies list abroad).

DRs can be created in one of the two ways: sponsored DR and unsponsored DR. In a sponsored DR, the underlying corporation pays a fee to the depositary institution to cover the cost of DR program. By regulation, the underlying corporation must provide periodic financial reports to the holders of DRs. A sponsored DR is often issued by a public company to seek to have its stock traded in foreign country and to raise capital from a foreign market. In contrast to sponsored DR, an unsponsored DR is issued by one or more banks or security brokerage firms that assemble a large block of the shares of a foreign corporation without the participation of the underlying corporation. Most DRs issued by Taiwanese listing companies are sponsored DRs.

The first issuance of DRs sponsored by a Taiwan company was the GDR of China Steel Corporation in May 1992. At the end of 1999, 36 Taiwanese listing companies have issued DRs and the total amount of issuance had reached to 6.243 billion US dollars. Among these DRs, high technology companies are the major sponsors, which record 22 or 61.11% of issuances. The capital raised by these high technology companies was 4.475 billion US dollars, or 71.68% of all issuances. Besides, the frequency of DRs issued by Taiwan companies dramatically increased from 1994 to 1999. The status of Taiwan-listed companies issuing DRs is summarized in Table 1.

In recent years, financial deregulation and international financial integration have resulted in a large amount of research on the dynamics of international transmission between GDRs or ADRs and their underlying securities. For example, Barclay et al. (1990) report that dual listing of sixteen New York Stock Exchange (NYSE) listed companies on the Tokyo Stock Exchange (TSE) has no impact on the variances of NYSE close-to-close returns on the stocks. Kato et al. (1991) and Wahab et al. (1992) try to find arbitrage opportunities between the prices of ADRs and underlying securities. They generally support the notation that, after transactions costs, few profitable opportunities exist in these markets, implying that both markets are efficient. Jayaraman, Shastri and Tandon (1993) suggest that the listing of ADRs are associated with permanent increases in the return volatilities of the underlying stocks. Kim, Szakmary and Mathur (2000) use both a vector autoregressive (VAR) model with a cointegration constraint and a seemingly unrelated regression (SUR) approach to examine the relative importance of, and the speed of adjustment of ADR prices to, these underlying factors. Their results show that the ADRs appear to initially overreact to the US market index but underreact to changes in underlying share prices and exchange rate.

Multiple listing offers a unique opportunity to study the transmission of pricing information across markets. Neumark, Tinsley and Tonsini (1991) find that the foreign market reacts to domestic price changes more quickly than the domestic market reacts to foreign

Table 1. Status of Taiwan listed company issuing sponsored DRs

Corporation Name	Common Stock Code	Industry	Listing Location	Issuing Date	Number of DRs (in thousand)	Unit Price (US dollar)	Total Amount (in thousand)	Leading Underwriter
China Steel	2002 TT	Steel	Global	05/28/92	18,000	18.20	327,600	Goldman Sachs
Asia Cement (1)	1102 TT	Cement	Global	06/23/92	2,400	27.50	66,003	Morgan Stanley
President Enterprises	1216 TT	Food	LX	11/24/92	4,993	16.51	82,426	CS First Boston
Chia Hsin Cement	1103 TT	Cement	LI	05/25/93	2,100	16.90	35,490	Jarding Fleming
Tuntex Distinct	1462 TT	Textile	Global	05/04/94	7,000	12.12	84,840	Baring Brothers
Microelectronics Technology	2314 TT	Electronic	Global/LX	05/24/94	3,900	12.70	48,260	CS First Boston
Hocheng	1810 TT	Glass and Ceramic	LX	06/29/94	2,800	31.50	85,400	BZW
Tung Ho Steel	2006 TT	Steel	LX	08/09/94	6,000	17.20	103,200	Jarding Fleming
Yageo	2327 TT	Electronic	Global/LX	09/28/94	4,000	22.90	114,500	Schroder
Aurora	2373 TT	Electronic	LX	01/27/95	1,875	16.00	30,000	NA
GVC	2322 TT	Electronic	LI	04/03/95	5,000	15.30	76,500	Goldman Sachs
ASE	2311 TT	Electronic	Global/LX	07/13/95	8,600	15.25	131,150	Morgan Stanley
A.D.I.	2304 TT	Electronic	LX	09/28/95	2,500	16.96	42,400	Bankers Trust
Walsin Lihwa	1605 TT	Elec. Cable and Wire	Global/LX	10/03/95	10,000	12.18	121,800	Daiwa, Bankers Trust
Siliconware Precision	2325 TT	Electronic	Global/LI	10/04/95	6,000	15.20	91,200	BZW
Acer (1)	2306 TT	Electronic	Global/LI	11/01/95	17,000	12.99	220,830	Nomura Int'l
Macronix Int'l	2337 TT	Electronic	NASDAQ	05/14/96	10,000	17.76	176,700	CS First Boston
Evergreen Marine	2603TT	Marine	Global/LI	07/30/96	10,800	18.05	194,940	Goldman Sachs
Asia Cement (2)	1102 TT	Cement	Global/LI	09/12/96	3,750	20.00	60,000	SBC Warburg

(continued)

Table 1. (*Continued*)

Corporation Name	Common Stock Code	Industry	Listing Location	Issuing Date	Number of DRs (in thousand)	Unit Price (US dollar)	Total Amount (in thousand)	Leading Underwriter
Lite-on Technology	2346 TT	Electronic	LI	09/25/96	4,900	14.55	71,295	BZW
Yung Ming Marine	2609 TT	Marine	LI	11/14/96	10,000	11.64	116,392	UBS
Accton Technology	2345 TT	Electronic	Europe/LI	02/01/97	12,000	7.51	90,120	Jarding Fleming
Teco Elec. & Mach.	1504 TT	Engineer	Global/LI	03/27/97	5,540	20.08	111,241	SBC Warburg
Asustek Computer	2357 TT	Electronic	Global/LI	05/30/97	21,000	11.23	235,830	Nomura Int'l
Standard Foods	1227 TT	Food	Global/LX	06/19/97	3,000	9.69	29,070	Schroder
Synnex Technology (1)	2347 TT	Electronic	Global/LX	07/03/97	431	9.81	4,225	Baring Brothers
Synnex Technology (1)	2347 TT	Electronic	Global/LX	07/03/97	6,270	22.23	139,382	Baring Brothers
Acer (2)	2306 TT	Electronic	Global/LI	07/23/97	10,000	16.06	160,600	Goldman Sachs
TSMC (1)	2330 TT	Electronic	NYSE	10/08/97	24,000	24.78	594,720	Goldman Sachs
Fubon Insurance	2817 TT	Insurance	Global/LI	04/17/98	8,000	20.07	160,560	CS First Boston
D-Link	2332 TT	Electronic	Global/LX	09/18/98	5,000	10.13	50,650	Salomon Smith Barney
Winbond (1)	2344 TT	Electronic	LX	02/05/99	14,600	11.45	167,170	ABN Amro
Acer Peripherals	2352 TT	Electronic	LI	06/29/99	2,700	23.22	62,694	Nomura Int'l
TSMC (2)	2330 TT	Electronic	NYSE	07/15/99	12,094	24.00	296,500	Goldman Sachs
Synnex Technology (2)	2347 TT	Electronic	Global/LX	08/12/99	5,463	18.93	103,415	Jarding Fleming
TSMC (3)	2330 TT	Electronic	NYSE	09/09/99	5,486	28.96	158,897	Goldman Sachs
Mosel Vitelic	2342 TT	Electronic	LX	09/16/99	9,980	8.70	86,867	Nomura Int'l
Hou Hai Precision	2317 TT	Electronic	LI	10/07/99	30,000	13.89	416,700	Warburg Dillion Read
Ritek	2349 TT	Electronic	LX	10/15/99	27,500	11.86	326,150	ABN Amro
Powerchip Semicond	5346 TT	Electronic	LX	10/21/99	27,000	10.70	288,900	Nomura Int'l
Far East Textile	1402 TT	Textile	LX	10/25/99	13,500	14.00	189,000	Goldman Sachs
Campal	2324 TT	Electronic	LX	11/09/99	8,000	15.27	122,160	Nomura Int'l
Winbond (2)	2344 TT	Electronic	LX	11/12/99	10,000	16.70	167,000	Warburg Dillion Read
Total							6,242,778	

Data source: Securities and Futures Commission Ministry of Finance, R.O.C.; LX: Luxembourg; LI: London.

price changes. This asymmetry, confirmed for price indices by Eun and Shim (1989) and Hamao, Masulis and Ng (1990), is interpreted by Garbade and Silber (1979) as evidence that the foreign market acts as a satellite to the domestic market. Hauser, Tanchuma and Yaari (1998) investigate five companies based in Israel whose stocks are listed on both the Tel Aviv Stock Exchange and NASDAQ. Their empirical tests of causality in price changes use the side-by-side Box-Jenkins ARIMA models and the Sims VAR model. Overall, the results show that price causality in dually listed stocks is unidirection from the domestic market to the foreign market. Jithendranathan, Nirmalanandan and Tandon (2000) evaluate market segmentation and its effect on the pricing of cross-listed securities using Indian Global Depositary Receipts (GDRs). They report that capital flow barriers existing in India lead to the GDRs being priced at a premium over the exchange rate adjusted prices of the underlying Indian securities. And GDR index returns are affected by both domestic and international factors, while the underlying Indian securities are affected only by domestic variables.

Earlier studies on international capital asset theory assume that international dually listed securities should sell at the same price in the absence of transaction costs and restriction to capital flows. Garbade and Silber (1979) reported that prices may differ between market centers for short intervals of time in imperfectly integrated market. The adjustment between prices in market A and market B can be characterized in one of two ways: (1) the adjustment may be symmetrical; (2) the adjustment may be one-sided. Hence, this paper uses Granger tests to examine causal relations between the returns on GDRs or ADRs and their respective underlying Taiwanese securities. We use error-correction model to analyze the long run causal relations where the stock returns data is nonstationary. In addition, this paper further discusses the impact of premium or discount in overseas-listed stocks on the price transmission effect.[1] The net buy by QFIIs[2] in Taiwan is also one of important factors to be measured in price transmission effect because QFIIs play an increasingly important role in Taiwan market since the MSCI indices including this emerging market. So we also examine the effect of the net buy variable on causal relations.

Similar to the most existing research, our empirical results show the return causality is mostly unidirection from the domestic market to foreign market for dually listed Taiwan stocks. Besides, the prices of both markets will make adjustment to establish a long run cointegrated equilibrium. Unlike prior studies, this paper finds that both the premium or discount and QFII's net buy have significant impacts on international price transmission for over twenty percent samples. Empirical tests show that our model is robust.

The remainder of this article is organized as follows: the next section presents the data description and the related empirical methodology. Our empirical results are described in section three. The final section concludes the paper.

2. Data and methodology

2.1. Data description

Thirty-six listed companies issued GDRs or ADRs by the end of 1999 in Taiwan; ninety-five GDRs or ADRs were issued and listed on exchange or over-the-counter (see Table 2). This

Table 2. List of Taiwan listed companies issuing GDRs or ADRs

Corporation Code	Bloomberg Code: High Liquid	Bloomberg Code: Low Liquid	Bloomberg Code: No Quotation	Issuing Date	Shares of QFIIs' Holding (in thousand)	Ratio of QFIIs' Holding (%)	Ratio of QFIIs' & Non-QFIIs' Holding (%)
2002 TT	CSGDS LI CNS GR (EUR$)	CHCG LX CIS XF US	CISEY US	05/28/92	547,186	6.39	6.82
1102 TT	ACGDS LI	AIA GR (EUR$)		06/23/92	69,589	3.72	11.88
1216 TT		PENT LX	UPEZY US	11/24/92	190,148	6.50	13.62
1103 TT	CHCDS LI		CHSNF US	05/25/93	7,436	1.06	11.43
1462 TT	TTXS LI		TUNG LX	05/04/94	23,887	1.07	12.01
2314 TT			METG LX	05/24/94	56,630	17.15	46.38
1810 TT	HCDR LI	HCDG LX		06/29/94	8,589	2.05	2.57
2006 TT		THSGG LX		08/09/94	1,082	2.28	2.94
2327 TT		YAGG LX	YAG SP; YGEQY US	09/28/94	79,407	6.67	16.43
2373 TT	AURD LI	AURG LX	AUR SP	01/27/95	38,810	6.24	9.43
2322 TT			GVCD LI; 2552Q US	04/03/95	17,030	2.27	11.78
2311 TT	ASED LI	ASEG LX	ASE SP	07/13/95	256,888	12.97	39.28
2304 TT	ADOD LI	ADIC LX		09/28/95	22,839	3.38	15.37
1605 TT	WLWD LI		WLWD LX	10/03/95	25,812	0.82	13.53
2325 TT	SILD LI		SLCZF US; SPIAF US; SLCWY US	10/04/95	110,158	9.77	16.34
2306 TT	ACID LI ACIG GR (EUR$)	ACEHF US	ACERY US 1280Q US	11/01/95	320,816	10.32	25.69
2337 TT	MXICY US	MSID LI MXIC GR (EUR$)	MXITY US MXIA LI	05/14/96	201,890	9.49	19.91
2603 TT	EGMD LI EMA GR (EUR$)			07/30/96	119,344	6.43	33.14
2346 TT	LTTD LI			09/25/96	32,403	6.57	7.04
2609 TT	YMTD LI		1848Q US	11/14/96	175,538	10.45	11.52
2345 TT	ATOD LI		ACTG LX; ACTVF US; ATHYYP US	02/01/97	26,491	11.29	13.69

1504 TT	TECD LI			03/27/97	35,806	2.05	4.99
2357 TT	ASKD LI			05/30/97	200,007	17.45	17.73
1227 TT	SFTD LI			06/19/97	21,007	6.95	12.31
2347 TT	SYXD LI		SYXTY LX; SYXTY US; 2678Q US	07/03/97	36,112	10.32	37.87
2330 TT	TSM US TMSD LI TSFA GR (EUR$)			10/08/97	1,777,349	17.79	34.69
2817 TT	FBND LI		FUIZF US; FUISY US; 2030Q US	04/17/98	86,170	5.00	9.57
2332 TT	DLKD LI	DLNKG LX		09/18/98	90,727	29.63	31.99
2344 TT	WBDD LI		WBDA LX; WBEKY US	02/05/99	272,733	7.73	12.20
2352 TT		ACER LX; ACED LI		06/29/99	137,787	15.41	15.81
2342 TT	MSVD LI		2671Q US	09/16/99	57,125	2.25	14.26
2317 TT	HHPD LI		HNHPF US; 1092Z LX; 2685Q US	10/07/99	326,998	29.73	34.53
2349 TT	RKCD LI	RTK GR (EUR$)	RITK LX	10/15/99	12,776	2.01	3.42
5346 TT	POSD LI		POSD LX	10/21/99	303,432	17.84	39.16
1402 TT	FETD LI		FARE LX; 2699Q US	10/25/99	460,977	16.76	23.76
2324 TT	CPED LI	CPED LX		11/09/99	152,969	9.83	10.06
Average					175,110	9.10	17.87

Data sources: Bloomberg Information System; Securities and Futures Commission Ministry of Finance, R.O.C.; EnTrust Securities Company.

Table 3. List of selected samples

Bloomberg Code						
Corporation Code	GDRs or ADRs Code	Issuing Date	Shares of QFIIs' Holding (in thousand)	Ratio of QFIIs' Holding (%)	Ratio of QFIIs' & Non-QFIIs' Holding (%)	Sample Days
2317 TT	HHPD LI	10/07/99	326,998	29.73	34.53	151
5346 TT	POSD LI	10/21/99	303,432	17.84	39.16	141
2330 TT	TSM US	10/08/97	1,777,349	17.79	34.69	623
2357 TT	ASKD LI	05/30/97	200,007	17.45	17.73	626
1402 TT	FETD LI	10/25/99	460,977	16.76	23.76	139
2311 TT	ASED LI	07/13/95	256,888	12.97	39.28	626
2345 TT	ATOD LI	02/01/97	26,491	11.29	13.69	626
2609 TT	YMTD LI	11/14/96	175,538	10.45	11.52	626
2306 TT	ACID LI	11/01/95	320,816	10.32	25.69	626
2347 TT	SYXD LI	07/03/97	36,112	10.32	37.87	626
2324 TT	CPED LI	11/09/99	152,969	9.83	10.06	128
2325 TT	SILD LI	10/04/95	110,158	9.77	16.34	626
2337 TT	MXICY US	05/14/96	201,890	9.49	19.91	539
2344 TT	WBDD LI	02/05/99	272,733	7.73	12.20	307
1227 TT	SFTD LI	06/19/97	21,007	6.95	12.31	626
2346 TT	LTTD LI	09/25/96	32,403	6.57	7.04	626
2603 TT	EGMD LI	07/30/96	119,344	6.43	33.14	626
2002 TT	CSGDS LI	05/28/92	547,186	6.39	6.82	626
1102 TT	ACGDS LI	06/23/92	69,589	3.72	11.88	626
2342 TT	MSVD LI	09/16/99	57,125	2.25	14.26	162
1605 TT	WLWD LI	10/03/95	25,812	0.82	13.53	626
		Average:	261,658	10.71	20.73	Sum: 10,328

paper chooses twenty-one GDRs or ADRs from the ninety-five, representing twenty-one listed companies, for total data of 10,328 sample days (see Table 3). The principal of making selections is as below:

1. Forty-two GDRs or ADRs which have no quotations and no trading are eliminated. Eighteen GDRs or ADRs which have quotations but traded light are also excluded.
2. We deleted some listed company samples because their shares held by QFII are less than or equal to 6.3%. Exceptions are Asia Cement, Mosel Vitelic, and Walsin Lihwa, because these stocks are included in MSCI Taiwan Index.
3. We chose GDRs or ADRs on exchange for some companies issuing more than one and being liquid, for example, Taiwan Semiconductor Manufacturing (TSM US). GDRs or ADRs in dollar quotation are selected if they have dollar and eurdollar quotations, for example, ACID LI, EGMD LI, and CSGDS LI.
4. Finally D-Link is also deleted because of late issuance and there only being forty-seven collected days.

The data for this paper are taken from three sources: the daily close price for GDRs or ADRs and NT exchange rate are collected from the Bloomberg information system; the underlying stock close price and adjusted price for ex-dividend are provided by Taiwan Economic Journal (TEJ); the volume of net buy by foreign institutions is offered by the EnTrust Securities Company.

The period of selected samples is from October 8, 1997 to May 31, 2000 on the basis of the three points below:

1. In September 1997, Taiwan stocks were first included in the MSCI indices as a result of increasing foreign institution investment in the Taiwan equity market. It happened that the Asian Financial crisis began at the same time, which sharply increased systematic risk in Taiwan stock market. This event didn't end until the fourth quarter of 1997.
2. Taiwan Semiconductor Manufacturing (TSM) ADR made an epochal entry for Taiwan companies issuing GDRs or ADRs because TSM is at the head of Taiwan's high-tech industry, the first Taiwan company listed in NYSE, and the issuing amount being the largest among all GDRs or ADRs.
3. These two years and seven months of selected samples cover a bearish market in 1998 and bullish market in 1999 and 2000. So this period represents a complete business cycle in the Taiwan stock market.

2.2. Methodology

The methodology employed in this study is based on Granger (1969). Other causality testing methods reported in the literature include the test proposed by Sims (1972) and the procedure suggested by Pierce and Haugh (1977). However, Granger's tests are employed because they are superior to Sims' (see Geweke, Meese and Dext (1983), and according to Hardouvelis (1988)), they perform well for small samples. However, it is necessary to test if the variables are stationary or not before Granger tests. If they are nonstationary, it is appropriate to specify by means of the vector error-correction models (Engle and Granger, 1987) to explore Granger causality relationship between GDRs or ADRs and the prices of underlying shares.

2.2.1 Unit root test. The assumptions of the classical regression model necessitate that the time series be stationary and the errors have a zero mean and finite variance. In the presence of nonstationary variables, there might be what Granger and Newbold (1974) call a spurious regression.[3] Thus, the first step in the analysis is to check if the structure of the returns series is stationary by the augmented Dickey-Fuller test (ADF).

The augmented Dickey-Fuller test can be applied both in the case of a lower and a higher autoregressive (AR) process. The following equation presents a higher AR process version (with a constant and a time trend) of the Dickey Fuller test:

$$\Delta y_t = a_0 + a_1 t + \gamma y_{t-1} + \sum_{i=2}^{P} \beta_i \cdot \Delta y_{t-i+1} + e_t, \quad e_t \sim \text{iid}(0, \sigma^2)$$

where y_t represents a time series, Δ implies first difference, and t is the time trend. According to Said and Dickey (1984) the ADF test procedure is valid for a general ARMA process in the errors. The null hypothesis in the ADF test is unit root ($\gamma = 0$). For y_t to be stationary, γ should be negative and significantly different from zero.

2.2.2 Cointegration tests. A system of nonstationary individual stock price in levels can, however, share common stochastic trends. Put simply, two nonstationary time series are cointegrated if a linear combination of two variables is stationary, that is, converges to an equilibrium over time. The main idea behind cointegration is a specification of models that includes beliefs about the movements of variables relative to each other in the long-run, such as the price of Taiwan's stock and GDRs or ADRs. Thus a common stochastic trend in a system of stock prices can be interpreted to mean that the stochastic trend in Taiwan's stock price is related to the GDRs or ADRs trend. There exists more than one method of conducting cointegration tests. The long-run relationship tests in this paper are conducted by means of the method developed by Johansen (1988) and Johansen and Juselius (1990). The Johansen maximum likelihood approach sets up the nonstationary time series as a vector autoregressive (VAR). The model is also called vector error-correction model (VECM):

$$\Delta X_t = c + \sum_{i=1}^{N} \Gamma_i \Delta X_{t-i} + \prod X_{t-1} + \eta_t, \quad \eta_t \sim \text{niid}(0, \delta)$$

where X_t is a vector of nonstationary (in levels) variables, Δ implies first difference and c is the constant term. The information on the coefficient matrix between the levels of the series $\prod$ is decomposed as $\prod = \alpha\beta'$ where the relevant elements of the α matrix are the adjustment coefficients and the β matrix contains the cointegrating vectors. α and β are $p \times r$ matrices of full rank. If $r = 0$, then $\prod = 0$, and there exists no linear combination of the elements of X_t that is stationary. At the other extreme, if rank $(\prod) = p$, X_t is itself a stationary process. In the intermediate case, when $0 < r < p$, there exist r stationary linear combinations of the elements of X_t. The constant term is included to capture the trending characteristic of the time series involved. The Johansen method provides the trace test and to determine the number of cointegrating vector. It is defined as:

$$\text{trace statistic} = -T \sum_{i=r+1}^{p} \ln(1 - \lambda_i)$$

for $r = 0, 1, 2, \ldots, p - 1$ where λ_i is the ith largest eigenvalue. The critical values for the trace statistic are reported by Osterwald-Lenum (1992), not those tabulated in Johansen and Juselius (1990). The trace statistic generally has greater power when the $\lambda_{i\,s}$ are evenly distributed.

2.2.3 Granger causality test. The objective of this section is to investigate causal relations between the returns on GDRs or ADRs and their respective underlying Taiwan securities. The methodology employed in this study is based on Granger (1969). The Granger Causality tests with difference form involve the estimation of the following equation:

$$R^f_{i,t} = \lambda^f_0 + \lambda^f_1 R^f_{i,t-1} + \lambda^f_2 R^d_{i,t} + \varepsilon^f_{i,t} \tag{1}$$

$$R^d_{i,t} = \lambda^d_0 + \lambda^d_1 R^d_{i,t-1} + \lambda^d_2 R^f_{i,t-1} + \varepsilon^d_{i,t} \tag{2}$$

where

$R_{i,t} = \log(p^{f(d)}_{i,t}) - \log(p^{f(d)}_{i,t})$

$p^{f(d)}_{i,t}$: $p^f_{i,t}$ denotes the close price of GDRs or ADRs in day t;
$p^d_{i,t}$ denotes the close price of the underlying security in day t.

Within the same calendar day, Taiwan market closes earlier than US and European markets, so foreign investors can observe the returns of both markets on the same day. On the other hand, the domestic investors observe the returns of the preceding day overseas. The regression model is set up so that R^f_t regresses on R^f_{t-1} and R^d_t, but R^d_t regresses on R^d_{t-1} and R^f_{t-1}. The Granger causality tests with the VECM involve the estimation of the following equation while the data exist cointegration relationship:

$$R^f_{i,t} = k^f_0 + k^f_1 R^f_{i,t-1} + k^f_2 R^d_{i,t} + k^f_3 \left(\log p^f_{i,t-1} - c_0 - c_1 \log p^d_{i,t-1}\right) + \varepsilon^f_{i,t} \tag{3}$$

$$R^d_{i,t} = k^d_0 + k^d_1 R^d_{i,t-1} + k^d_2 R^f_{i,t-1} + k^d_3 \left(\log p^d_{i,t-1} - d_0 - d_1 \log p^f_{i,t-1}\right) + \varepsilon^d_{i,t} \tag{4}$$

The lambdas and kappas are the parameters to be estimated. In the above estimation of equation (1) to equation (4), if the estimated coefficients λ^f_2 and k^f_2 of equations (1) and (3) are statistically significant while the estimated coefficients λ^d_2 and k^d_2 of equations (2) and (4) are not statistically significant, then the results suggest a uni-directional causality, in the Granger sense, from the Taiwan stock returns to change GDR stock returns. In terms coined by Garbade and Silber (1979), the underlying security market is dominant and the overseas security market is a satellite. If, on the other hand, the estimated coefficients λ^d_2 and k^d_2 of equations (2) and (4) are statistically significant while the estimated coefficients λ^f_2 and k^f_2 of equations (1) and (3) are not statistically significant, then uni-directional causality exists from changes in GDRs or ADRs to Taiwan's stock returns. If the four coefficients are statistically significant in equations (1) and (4), then the data provide evidence of bi-directional causality. Absence of directional causality is indicated when the set of parameters λ^d_2, k^d_2, λ^f_2 and k^f_2 are statistically insignificant. Finally, both k^d_3 and k^f_3 represent the speed of adjustment coefficient for reflecting the long-run disequilibrium in the prices between the underlying stock and the GDRs or ADRs. c_0, d_0, c_1, d_1 are cointegrating coefficients.

2.2.4 The impact of premium and net buy on Granger causality

The premium effect. Several studies on the pricing behavior of dual listed international securities do not find any significant difference between the domestic price and exchange rate adjusted price of the same security listed in an overseas market.[4] Park and Tavakkol

(1994) examine the exchange rate adjusted returns of Japanese ADRs and the underlying stocks and find no significant differences between the two. On the other hand, Miller and Morey (1996) find intra-day pricing differences between the British ADRs and the underlying securities. This paper examines whether the price transmission effect is significantly amplified while the magnitude of the premium or discounts in overseas-listed stocks increases. We set up the estimation of the following equations:

$$R^f_{i,t} = \lambda^f_0 + \lambda^f_1 R^f_{i,t-1} + \left(\beta^f_0 + \beta^f_1 * \text{prem}^f_t\right) R^d_{i,t} + \varepsilon^f_{i,t} \tag{5}$$

$$R^d_{i,t} = \lambda^d_0 + \lambda^d_1 R^d_{i,t-1} + \left(\beta^d_0 + \beta^d_1 * \text{prem}^d_{t-1}\right) R^f_{i,t-1} + \varepsilon^d_{i,t} \tag{6}$$

$$R^f_{i,t} = k^f_0 + k^f_1 R^f_{i,t-1} + \left(\phi^f_0 + \phi^f_1 \cdot \text{prem}^f_t\right) R^d_{i,t} + k^f_3\left(\log p^f_{i,t-1} - c_0 - c_1 \log p^d_{i,t-1}\right) + \varepsilon^f_{i,t} \tag{7}$$

$$R^d_{i,t} = k^d_0 + k^d_1 R^d_{i,t-1} + \left(\phi^d_0 + \phi^d_1 \cdot \text{prem}^d_t\right) R^f_{i,t-1} + k^d_3\left(\log p^d_{i,t-1} - d_0 - d_1 \log p^f_{i,t-1}\right) + \varepsilon^d_{i,t} \tag{8}$$

where

$$\text{prem}^f_t = \frac{p^f_{i,t-1} \cdot EX_t - p^d_{i,t}}{p^d_{i,t}} \tag{9}$$

$$\text{prem}^d_t = \frac{p^f_{i,t-1} \cdot EX_{t-1} - p^d_{i,t-1}}{p^d_{i,t-1}} \tag{10}$$

EX_t : exchange rate in day t

We further discuss the above equations in two cases: one, both the premium and R^d_t have the same sign. For example, if foreign investors observe that there exists positive premium and the underlying stock price rises, then through the market mechanism of arbitrary transactions, the prices of ADRs or GDRs will not change or even go down in order to shrink the price gap between the underlying stock and ADRs or GDRs. Therefore, both β^f_1 and ϕ^f_1 will be expected to be equal to or less than zero. Second, the premium and R^d_t have the opposite sign. In this case, if foreign investors find that there exists positive premium but the underlying stock price is down, then the prices of ADRs or GDRs will decline. Thus, both β^f_1 and ϕ^f_1 will be expected to be greater than or equal to zero. According to the above, if both the premium and R^f_{t-1} are the same sign, for example, domestic investors observe that there exists positive premium and ADRs or GDRs price is also up, then the underlying stock price will go up and both β^d_1 and ϕ^d_1 will be expected to be greater than or equal to zero. On the contrary, when both the premium and R^f_{t-1} are the opposite sign, for example, domestic investors observe that there exists positive premium but ADRs or GDRs price is down, the underlying stock price will not change or even go up in order to shrink the price gap. Therefore, both β^d_1 and ϕ^d_1 will be expected to be equal to or less than zero.

Net buy effect. During these years QFIIs are more aggressive to increase their investment positions in Taiwan. In consequence of the substantial growth of QFIIs' portfolio holding in Taiwan's equities, the net buy or net sell of QFIIs' daily trading has become an important investment signal for all investors participating in the Taiwan market. Stock with positive net buy by QFIIs is often followed by an increase in share price on next trading day, in particular, for those stocks underlying ADRs or GDRs. Thus, we also add the variable of QFIIs' daily net buy into our empirical models to further examine the impact of net buy on Granger causality relationship between the underlying stock and the ADRs or GDRs. The models are as follows:

$$R^f_{i,t} = \lambda^f_0 + \lambda^f_1 R^f_{i,t-1} + \left(\delta^f_0 + \delta^f_1 \cdot BS^f_t\right) R^d_{i,t} + \varepsilon^f_{i,t} \tag{11}$$

$$R^d_{i,t} = \lambda^d_0 + \lambda^d_1 R^d_{i,t-1} + \left(\delta^d_0 + \delta^d_1 \cdot BS^d_{t-1}\right) R^f_{i,t-1} + \varepsilon^d_{i,t} \tag{12}$$

$$\begin{aligned} R^f_{i,t} &= k^f_0 + k^f_1 R^f_{i,t-1} + \left(\omega^f_0 + \omega^f_1 \cdot BS^f_t\right) R^d_{i,t} \\ &\quad + k^f_3\left(\log p^f_{i,t-1} - c_0 - c_1 \log p^d_{i,t-1}\right) + \varepsilon^f_{i,t} \end{aligned} \tag{13}$$

$$\begin{aligned} R^d_{i,t} &= k^d_0 + k^d_1 R^d_{i,t-1} + \left(\omega^d_0 + \omega^d_1 \cdot BS^d_{t-1}\right) R^f_{i,t-1} \\ &\quad + k^d_3\left(\log p^d_{i,t-1} - d_0 - d_1 \log p^f_{i,t-1}\right) + \varepsilon^d_{i,t} \end{aligned} \tag{14}$$

where

BS^f_t: the volume of net buy for underlying stock by QFIIs in Taiwan observed by foreigners in day t; i.e., the net shares of total bought minus total sold for underlying stock by all QFIIs in day t

BS^d_{t-1}: the volume of net buy for underlying stock by QFII in Taiwan observed by the domestic investors in day t

In the above estimation of equations (11) and (13), if QFIIs buy net shares for the underlying stock in Taiwan's market and at the same time the return of the underlying stocks rises, the prices of GDRs or ADRs will rise, fall or hold steady, so the signs of δ^f_1 and w^f_1 can't be determined. There are two reasons to explain the above phenomenon. One is that the prices of the underlying stocks are relatively undervalued as a consequence of QFIIs' net buy in order to get arbitrage profit. Of course the gap between both prices can be shrunk by arbitrage trading. The other reason is that the prospect of the underlying company demonstrates such potential that QFIIs purchase these underlying stocks, and as a result the prices of the underlying stocks and ADRs or GDRs simultaneously rise. On the other side, in equations (12) and (14), if the return of GDRs or ADRs is negative and QFIIs buy net shares of the underlying stock, the return of the underlying stock will be positive, negative or zero, so the signs of δ^d_1 and w^d_1 are also uncertain. The reason for the uncertainty is that the prices of the underlying stocks are undervalued and QFIIs buying net shares will lead to the price of the underlying stocks rising. However, the underlying stock prices may also drop to reflect the falling price of GDRs or ADRs.

Robust test. Finally, our model simultaneously includes the premium and net buy factors to examine if the model is robust. This is reflected in the estimation of equations (15) to (18):

$$R_{i,t}^f = \lambda_0^f + \lambda_1^f R_{i,t-1}^f + \left(\theta_0^f + \theta_1^f \cdot \text{prem}_t^f + \theta_2^f \cdot BS_t^f\right) R_{i,t}^d + \varepsilon_{i,t}^f \tag{15}$$

$$R_{i,t}^d = \lambda_0^d + \lambda_1^d R_{i,t-1}^d + \left(\theta_0^d + \theta_1^d \cdot \text{prem}_t^d + \theta_2^d \cdot BS_{t-1}^d\right) R_{i,t-1}^f + \varepsilon_{i,t}^d \tag{16}$$

$$R_{i,t}^f = k_0^f + k_1^f R_{i,t-1}^f + \left(\gamma_0^f + \gamma_1^f \cdot \text{prem}_t^f + \gamma_2^f \cdot BS_t^f\right) R_{i,t}^d + k_3^f \left(\log p_{i,t-1}^f - c_0 - c_1 \log p_{i,t-1}^d\right) + \varepsilon_{i,t}^f \tag{17}$$

$$R_{i,t}^d = k_0^d + k_1^d R_{i,t-1}^d + \left(\gamma_0^d + \gamma_1^d \cdot \text{prem}_t^d + \gamma_2^d \cdot BS_{t-1}^d\right) R_{i,t-1}^f + k_3^d \left(\log p_{i,t-1}^d - d_0 - d_1 \log p_{i,t-1}^f\right) + \varepsilon_{i,t}^d \tag{18}$$

3. Empirical results

3.1. Unit root and cointegration tests results

As stated earlier, all series are applied in logarithmic form. As required of all cointegration tests, the series of stock price must first be inspected for the presence of unit roots. Table 4

Table 4. Augmented Dickey-Fuller tests for a unit root[a]

Corporation Code	Taiwan	GDRs or ADRs
1102	−2.721650	−2.885068
1227	−2.532691	−2.382961
1402	−1.494700	−1.252938
1605	−1.586543	−1.845639
2002	−2.816041	−2.404293
2306	−1.864972	−2.064231
2311	−1.910316	−2.050046
2317	−1.981890	−1.352853
2324	−1.791862	−1.935491
2325	−3.505806**	−3.729858**
2330	−1.978247	−2.587620
2337	−1.401737	−1.530777
2342	−2.154823	−2.252726
2344	−3.093396	−3.008204
2345	−2.522986	−2.494403
2346	−1.172046	−1.113604
2347	−3.763689**	−3.686703**
2357	−2.081670	−2.191681
2603	−2.337686	−1.714761
2609	−3.341800**	−3.717536**
5346	−2.465527	−2.501067

[a]The entry in each cell is the ADF statistic.
**Implies rejection of the null at 5% level.

Table 5. Cointegration test results (Lags in the VAR = 1)

	$r^{a} = 0$		$r \leqq 1$	
Corporation Code	Eigenvalue	Trace Statistic	Eigenvalue	Trace Statistic
1102	0.028652	26.32853***	0.013037	8.188700***
1227	0.018837	12.46983	0.000966	0.603329
1402	0.071200	12.34016	0.016081	2.221029
1605	0.034779	23.29036***	0.001924	1.202012
2002	0.031511	24.74242***	0.007604	4.763040**
2306	0.199605	14.02069***	0.002038	1.273044
2311	0.033467	24.49023***	0.005194	3.249319
2317	0.090624	16.04527**	0.020229	2.840711
2324	0.083378	14.61861	0.028546	3.649078
2330	0.044065	28.63125***	0.001040	0.645971
2337	0.215139	13.00895***	0.000003	0.001861
2342	0.114581	20.31530***	0.005262	0.844201
2344	0.065481	20.70226***	0.000153	0.046571
2345	0.011082	8.226734	0.002038	1.272949
2346	0.013422	11.19552	0.004419	2.763638
2357	0.047425	32.22369***	0.003050	1.906004
2603	0.022752	18.79700**	0.007083	4.435474**
5346	0.060651	10.65297	0.013973	1.955989

[a] r is hypothesized number of cointegrating relationships.
*** and **imply rejection of the null at 1% and 5% level, respectively.

presents the results from ADF tests. We employed Akaike's information criterion to select the appropriate lag lengths. For most of the series, we are unable to reject the unit root hypothesis, but there are some exceptions. In other words, most of time series data are I (1), but some series data are I (0). When the series are stable, they don't need the cointegration test.

Table 5 presents the results from the cointegration tests. In this paper, we used trace test to determine the number of cointegrating vectors. Results show a cointegration relationship existing between most Taiwan stock prices and their GDR's or ADR's prices. In other words, we are able to find a stationary long run relationship between both. So, we should employ VECM to test Granger causality relationship for existing cointegration time series. It is appropriate to simultaneously consider long- and short-term effects. For time series without cointegration, they directly take the first difference form to test Granger causality relationship. As reported in Table 5, trace tests indicate that at least one cointegration relationship exists for twelve of the firms. Each firm's cointegrating vector is calculated and incorporated in the VAR model estimation to capture the long run equilibrium relationship.

3.2. Granger causality tests results

Table 6 shows the results from Granger Causality with difference form. Only seven samples have bi-directional causality but fourteen samples among twenty-one total show

Table 6. Granger causality tests results—difference form

$$R_{i,t}^{f} = \lambda_0^{f} + \lambda_1^{f} R_{i,t-1}^{f} + \lambda_2^{f} R_{i,t}^{d} + \varepsilon_{i,t}^{f}$$

$$R_{i,t}^{d} = \lambda_0^{d} + \lambda_1^{d} R_{i,t-1}^{d} + \lambda_2^{d} R_{i,t-1}^{f} + \varepsilon_{i,t}^{d}$$

		λ_0^f	λ_1^f	λ_2^f	
Corporation Code	D. V.[a]	λ_0^d	λ_2^d		λ_1^d
1102	R_t^f	−0.0002	−0.0381	0.8993	
		(0.7954)	(0.1667)	(0.0000)***	
	R_t^d	−0.0005	0.1077		−0.0446
		(0.6563)	(0.0241)**		(0.4457)
1227	R_t^f	−0.0002	0.0844	0.7185	
		(0.8390)	(0.0073)***	(0.0000)***	
	R_t^d	−0.0006	0.1447		0.0154
		(0.5680)	(0.0010)***		(0.7632)
1402	R_t^f	0.0001	0.0508	0.7535	
		(0.9609)	(0.4282)	(0.0000)***	
	R_t^d	0.0008	0.1383		−0.0683
		(0.8085)	(0.1808)		(0.5582)
1605	R_t^f	0.0001	−0.0282	0.9315	
		(0.9272)	(0.1644)	(0.0000)***	
	R_t^d	0.0005	0.0931		−0.1169
		(0.6575)	(0.2052)		(0.1407)
2002	R_t^f	−0.0000	0.0164	1.0482	
		(0.9792)	(0.5628)	(0.0000)***	
	R_t^d	0.0002	0.1391		0.1770
		(0.8430)	(0.0003)***		(0.0018)***
2306	R_t^f	0.0000	−0.1074	0.9934	
		(0.9536)	(0.0000)***	(0.0000)***	
	R_t^d	0.0009	0.1744		−0.1645
		(0.5259)	(0.0146)		(0.0422)**
2311	R_t^f	0.0001	0.0156	0.9501	
		(0.9152)	(0.5719)	(0.0000)***	
	R_t^d	0.0004	0.1021		−0.1039
		(0.7498)	(0.0216)		(0.0742)*
2317	R_t^f	−0.0003	0.1373	0.8626	
		(0.8942)	(0.0305)**	(0.0000)***	
	R_t^d	0.0021	0.1098		0.0003
		(0.4069)	(0.1669)		(0.9975)
2324	R_t^f	0.0002	0.0530	1.0029	
		(0.9188)	(0.2725)	(0.0000)***	
	R_t^d	−0.0006	0.0938		−0.1403
		(0.8474)	(0.5136)		(0.4079)
2325	R_t^f	0.0000	−0.0440	0.9086	
		(0.9892)	(0.1629)	(0.0000)***	
	R_t^d	0.0003	0.0594		−0.0370
		(0.8375)	(0.0896)*		(0.4684)
2330	R_t^f	0.0009	−0.1244	0.7192	
		(0.5526)	(0.0008)***	(0.0000)***	
	R_t^d	0.0011	0.2096		−0.0637
		(0.3371)	(0.0000)***		(0.1398)

Table 6. (*Continued*)

Corporation Code	D. V.[a]	λ_0^f / λ_0^d	λ_1^f / λ_2^d	λ_2^f	λ_1^d
2337	R_t^f	0.0005	−0.1373	0.7759	
		(0.7222)	(0.0000)***	(0.000)***	
	R_t^d	0.0011	0.1300		−0.0548
		(0.5018)	(0.0080)**		(0.3338)
2342	R_t^f	0.0007	−0.0334	0.9720	
		(0.6420)	(0.3512)	(0.0000)***	
	R_t^d	0.0056	0.0230		0.0473
		(0.0815)*	(0.8873)		(0.7873)
2344	R_t^f	0.0004	−0.0840	1.0020	
		(0.7229)	(0.0074)	(0.0000)***	
	R_t^d	0.0033	0.1238		−0.1679
		(0.0767)	(0.1577)		(0.1094)
2345	R_t^f	−0.0006	−0.0753	1.0214	
		(0.4457)	(0.0001)***	(0.0000)***	
	R_t^d	0.0004	0.0116		0.0874
		(0.7739)	(0.8720)		(0.2932)
2346	R_t^f	−0.0004	−0.0876	0.9839	
		(0.6363)	(0.0000)***	(0.0000)***	
	R_t^d	−0.0000	0.0091		0.1163
		(0.9796)	(0.9094)		(0.1848)
2347	R_t^f	0.0000	−0.1148	0.9800	
		(0.9753)	(0.0000)***	(0.0000)***	
	R_t^d	0.0004	0.0769		0.0748
		(0.7415)	(0.2383)		(0.3125)
2357	R_t^f	0.0003	−0.0628	1.0568	
		(0.7993)	(0.0355)**	(0.0000)***	
	R_t^d	0.0010	0.1374		−0.0739
		(0.3419)	(0.0001)***		(0.1711)
2603	R_t^f	−0.0000	0.0439	0.8715	
		(0.9898)	(0.1034)	(0.0000)***	
	R_t^d	−0.0002	0.0722		0.0435
		(0.8058)	(0.1542)		(0.4660)
2609	R_t^f	0.0006	−0.0094	0.8723	
		(0.4126)	(0.7111)	(0.0000)***	
	R_t^d	−0.0001	0.0642		−0.0199
		(0.9626)	(0.2578)		(0.7549)
5346	R_t^f	0.0021	−0.0297	0.9594	
		(0.2426)	(0.4854)	(0.0000)***	
	R_t^d	0.0033	0.0259		0.0199
		(0.3150)	(0.8617)		(0.9020)

[a]D. V. represents dependent variable.
*Significant at the 10% level.
**Significant at the 5% level.
***Significant at the 1% level.
(.) represents p-value.

uni-directional causality. This demonstrates that most of the time the Taiwan stock returns change GDRs or ADRs returns. In addition, the estimated coefficient λ_2^d approaches 100 percent, despite the estimated coefficient λ_2^f being near to zero. So our empirical results mostly support Garbade and Silber's (1979) idea that the underlying security market is dominant and the overseas security market is a satellite.

To continue, the cointegration relationship data employ the Granger causality test with VECM which simultaneously considers long run and short run effects between the returns of Taiwan stock and GDRs or ADRs. Table 7 presents the empirical results with VECM. In the short run, it shows similar results that Taiwan stock returns significantly influence GDRs or ADRs returns but not the reverse. In the long run, all the coefficients for the speed of

Table 7. Granger causality tests results—VECM

$$R_{i,t}^f = k_0^f + k_1^f R_{i,t-1}^f + k_2^f R_{i,t}^d + k_3^f (\log p_{i,t-1}^f - c_0 - c_1 \log p_{i,t-1}^d) + \varepsilon_{i,t}^f$$
$$R_{i,t}^d = k_0^d + k_1^d R_{i,t-1}^d + k_2^d R_{i,t-1}^f + k_3^d (\log p_{i,t-1}^d - d_0 - d_1 \log p_{i,t-1}^f) + \varepsilon_{i,t}^d$$

Corporation Code	D.V[a]	κ_0^f / κ_0^d	κ_1^f / κ_2^d	κ_2^f	κ_3^f	κ_1^d	κ_3^d
1102	R_t^f	−0.0002	−0.0240	0.9088	−0.0545		
		(0.8056)	(0.3817)	(0.0000)***	(0.0000)***		
	R_t^d		0.0927			−0.0324	−0.0302
			(0.0558)*			(0.5812)	(0.0857)*
1605	R_t^f	0.0038	−0.0274	0.9311	−0.0007		
		(0.6412)	(0.1784)	(0.0000)***	(0.6455)		
	R_t^d	0.0187	0.0925			−0.1125	−0.0064
		(0.2620)	(0.2078)			(0.1565)	(0.2749)
2202	R_t^f	−0.0000	0.0277	1.0570	−0.0551		
		(0.9763)	(0.3236)	(0.0000)***	(0.0000)***		
	R_t^d	0.0002	0.1333			−0.1699	−0.0146
		(0.8434)	(0.0007)***			(0.0031)***	(0.3940)
2306	R_t^f	−0.0001	−0.0062	1.0453	−0.5855		
		(0.8883)	(0.7336)	(0.0000)***	(0.0000)***		
	R_t^d	0.0009	−0.0207			0.0012	−0.3905
		(0.5105)	(0.8064)			(0.9889)	(0.0000)***
2311	R_t^f	−0.0001	0.0318	0.9659	−0.0425		
		(0.9250)	(0.2527)	(0.0000)***	(0.0004)***		
	R_t^d	0.0004	0.0803			−0.0930	−0.0437
		(0.7441)	(0.0724)*			(0.1084)	(0.0008)***
2317	R_t^f	−0.0005	0.1613	0.8939	−0.0467		
		(0.8620)	(0.0134)**	(0.0000)***	(0.1231)		
	R_t^d	0.0021	0.0461			0.0350	−0.1167
		(0.3888)	(0.5669)			(0.7434)	(0.0047)***
2330	R_t^f	0.0009	−0.1134	0.7351	−0.0191		
		(0.5712)	(0.0028)***	(0.0000)***	(0.1663)		
	R_t^d	0.0012	0.1740			−0.0648	−0.0607
		(0.2966)	(0.0000)***			(0.1255)	(0.0000)***

Table 7. (*Continued*)

		κ_0^f	κ_1^f	κ_2^f	κ_3^f		
Corporation Code	D.V[a]	κ_0^d	κ_2^d			κ_1^d	κ_3^d
2337	R_t^f	0.0003	−0.0133	0.8312	−0.5796		
		(0.8124)	(0.6487)	(0.0000)***	(0.0000)***		
	R_t^d	−0.0048	0.0454			0.0288	−0.1681
		(0.0790)*	(0.4330)			(0.6542)	(0.0073)***
2342	R_t^f	0.0004	−0.0023	0.9973	−0.2655		
		(0.7952)	(0.9475)	(0.0000)***	(0.0000)***		
	R_t^d	0.0057	−0.1091			0.1679	−0.2772
		(0.0712)*	(0.5285)			(0.3598)	(0.0418)**
2344	R_t^f	0.0003	−0.0490	1.0169	−0.1630		
		(0.8205)	(0.1131)	(0.0000)***	(0.0000)***		
	R_t^d	0.0006	0.0931			−0.1434	−0.0629
		(0.8471)	(0.3081)			(0.1794)	(0.2395)
2357	R_t^f	0.0003	−0.0396	1.0849	−0.0663		
		(0.8356)	(0.1880)	(0.0000)***	(0.0001)***		
	R_t^d	0.0010	0.1030			−0.0470	−0.0799
		(0.3304)	(0.0045)***			(0.3828)	(0.0001)***
2603	R_t^f	−0.0000	0.0362	0.8796	−0.0200		
		(0.9899)	(0.1782)	(0.0000)***	(0.0018)***		
	R_t^d	−0.0003	0.0691			0.0580	−0.0329
		(0.8078)	(0.1720)			(0.3332)	(0.0338)

[a]D. V. represents dependent variable.
*Significant at the 10% level.
**Significant at the 5% level.
***Significant at the 1% level.
(.) represents p-value.

adjustment, k_3^d's and k_3^f's, are negative and most of them are significant. This result indicates that once the return relationship of the underlying stock and the GDRs or ADRs deviates from the long run cointegrated equilibrium, both markets will make opposite adjustment to reestablish the equilibrium in next period. In a word, Table 7 shows that price causality in dually listed stocks is mostly unidirectional from the domestic market to the foreign market and the prices of both markets will adjust to a long run cointegrated equilibrium.

3.3. Results of the premium and net buy effect

Table 8 reveals the results from Granger Causality involving the premium in overseas-listed stocks. The estimated coefficient β_0^f or ϕ_0^f is significant and approaches to 1, but the estimated coefficient β_0^d or ϕ_0^d is mostly not significant and near to zero. So the price transmission effect is still unidirectional from the domestic market to the foreign market. The transmission effect of seven samples is influenced by the premium in overseas-listed

Table 8. Change in Granger causality results—Premium

$$R^f_{i,t} = \lambda^f_0 + \lambda^f_1 R^f_{i,t-1} + \left(\beta^f_0 + \beta^f_1 * \text{prem}^f_t\right) R^d_{i,t} + \varepsilon^f_{i,t} \tag{5}$$

$$R^d_{i,t} = \lambda^d_0 + \lambda^d_1 R^d_{i,t-1} + \left(\beta^d_0 + \beta^d_1 * \text{prem}^d_{t-1}\right) R^f_{i,t-1} + \varepsilon^d_{i,t} \tag{6}$$

$$R^f_{i,t} = k^f_0 + k^f_1 R^f_{i,t-1} + \left(\phi^f_0 + \phi^f_1 \cdot \text{prem}^f_t\right) R^d_{i,t} + k^f_3 \left(\log p^f_{i,t-1} - c_0 - c_1 \log p^d_{i,t-1}\right) + \varepsilon^f_{i,t} \tag{7}$$

$$R^d_{i,t} = k^d_0 + k^d_1 R^d_{i,t-1} + \left(\phi^d_0 + \phi^d_1 \cdot \text{prem}^d_t\right) R^f_{i,t-1} + k^d_3 \left(\log p^d_{i,t-1} - d_0 - d_1 \log p^f_{i,t-1}\right) + \varepsilon^d_{i,t} \tag{8}$$

Corporation Code	D.V.[a]	$\lambda^f_0(\kappa^f_0)$ $\lambda^d_0(\kappa^d_0)$	$\lambda^f_1(\kappa^f_1)$ $\beta^d_0(\phi^d_0)$	$\beta^f_0(\phi^f_0)$	$\beta^f_1(\phi^f_1)$	κ^f_3	$\lambda^d_1(\kappa^d_1)$	$\beta^d_1(\phi^d_1)$	κ^d_3
1102	R^f_t	−0.0009	−0.0133	0.9580	−1.2071	−0.0572			
		(0.2970)	(0.6279)	(0.0000)***	(0.0003)***	(0.0000)***			
	R^d_t	−0.0007	0.0347				−0.0107	0.6373	−0.0292
		(0.5149)	(0.5408)				(0.8581)	(0.0525)*	(0.0961)*
1227	R^f_t	−0.0007	0.0811	0.8006	−0.5703				
		(0.5076)	(0.0098)***	(0.0000)***	(0.0187)**				
	R^d_t	−0.0006	0.1650				0.0157	−0.1647	
		(0.5884)	(0.0017)***				(0.7584)	(0.4745)	
1402	R^f_t	−0.0000	0.0522	0.7713	−0.1063				
		(0.9902)	(0.4231)	(0.0000)***	(0.8913)				
	R^d_t	0.0003	−0.2416				−0.0094	1.5740	
		(0.9375)	(0.1719)				(0.9352)	(0.0095)***	
1605	R^f_t	0.0038	−0.0274	0.9315	−0.0000	−0.0007			
		(0.6419)	(0.1798)	(0.0000)***	(0.9608)	(0.6462)			
	R^d_t	0.0188	0.1359				−0.1383	−0.7969	−0.0064
		(0.2596)	(0.1022)				(0.0946)*	(0.2653)	(0.2750)
2002	R^f_t	−0.0000	0.0294	1.0946	−0.0000	−0.0551			
		(0.9902)	(0.2967)	(0.0000)***	(0.4570)	(0.0000)***			
	R^d_t	0.0001	0.0863				−0.1410	0.3727	−0.0105
		(0.9458)	(0.0770)*				(0.0189)**	(0.1098)	(0.5458)

2306	R_t^f	−0.0001 (0.8656)	−0.0064 (0.7223)	1.0349 (0.0000)***	0.0000 (0.5064)	−0.5845 (0.0000)***			
	R_t^d	0.0001 (0.9620)	−0.0315 (0.7080)				1.0241 (0.7873)	2.9732 (0.0118)**	−0.3836 (0.0000)***
2311	R_t^f	0.0004 (0.7520)	−0.0927 (0.1106)	0.0783 (0.1973)	0.0101 (0.9601)	−0.0437 (0.0029)***			
	R_t^d	0.0004 (0.7520)	0.0783 (0.1973)*				−0.0927 (0.1106)	0.0101 (0.9601)	−0.0437 (0.0028)***
2317	R_t^f	−0.0005 (0.8467)	0.1583 (0.0162)**	0.8665 (0.0000)***	0.0001 (0.6891)	−0.0460 (0.1305)			
	R_t^d	0.0023 (0.3696)	0.0889 (0.6091)				0.0365 (0.7340)	−0.1182 (0.7808)	−0.1148 (0.0062)***
2324	R_t^f	0.0002 (0.9002)	0.0665 (0.1722)	0.9532 (0.0000)***	0.0004 (0.0948)*				
	R_t^d	−0.0005 (0.8618)	0.1294 (0.4380)				−0.1587 (0.3661)	−0.7208 (0.6715)	
2325	R_t^f	0.0000 (0.9947)	−0.0375 (0.2338)	0.9880 (0.0000)***	−0.0004 (0.0080)***				
	R_t^d	0.0004 (0.7754)	0.0814 (0.1392)				−0.0418 (0.4199)	−0.0969 (0.6033)	
2330	R_t^f	0.0007 (0.6663)	−0.1210 (0.0016)***	0.6540 (0.0000)***	0.0002 (0.1832)	−0.0192 (0.1633)			
	R_t^d	0.0012 (0.2822)	0.1850 (0.0002)***				−0.0653 (0.1230)	−0.0288 (0.7821)	−0.0607 (0.0000)***
2337	R_t^f	0.0001 (0.9389)	−0.0159 (0.5870)	0.7948 (0.0000)***	0.0002 (0.0697)*	−0.5748 (0.0000)***			
	R_t^d	−0.0055 (0.0450)**	0.0428 (0.4587)				0.0331 (0.6071)	1.3587 (0.0902)*	−0.1723 (0.0059)***

(*continued*)

Table 8. (*Continued*)

Corporation Code	D.V.[a]	$\lambda_0^f(\kappa_0^f)$ / $\lambda_0^d(\kappa_0^d)$	$\lambda_1^f(\kappa_1^f)$ / $\beta_0^d(\phi_0^d)$	$\beta_0^f(\phi_0^f)$	$\beta_1^f(\phi_1^f)$	κ_3^f	$\lambda_1^d(\kappa_1^d)$	$\beta_1^d(\phi_1^d)$	κ_3^d
2342	R_t^f	0.0004	0.0011	1.0185	−0.0002	−0.2645			
		(0.7845)	(0.9739)	(0.0000)***	(0.2407)	(0.0000)***			
	R_t^d	0.0054	−0.0751				0.1661	1.5598	−0.2759
		(0.0936)*	(0.6732)				(0.3657)	(0.4087)	(0.0431)**
2344	R_t^f	0.0003	−0.0491	1.0055	0.0000	−0.1631			
		(0.8121)	(0.1126)	(0.0000)***	(0.7325)	(0.0000)***			
	R_t^d	0.0006	0.1234				−0.1593	−0.9562	−0.0694
		(0.8447)	(0.2073)				(0.1418)	(0.3852)	(0.1991)
2345	R_t^f	−0.0006	−0.0753	1.0178	0.0165				
		(0.4784)	(0.0001)***	(0.0000)***	(0.8725)				
	R_t^d	0.0005	0.0364				0.0835	−0.0992	
		(0.7587)	(0.6630)				(0.3166)	(0.5583)	
2346	R_t^f	−0.0004	−0.0875	0.9915	−0.0002				
		(0.5862)	(0.0000)***	(0.0000)***	(0.1940)				
	R_t^d	−0.0000	0.0073				0.1172	0.0202	
		(0.9794)	(0.9331)				(0.1893)	(0.9564)	
2347	R_t^f	0.0000	−0.1141	0.9831	−0.0001				
		(0.9570)	(0.0000)***	(0.0000)***	(0.5909)				
	R_t^d	0.0003	0.0632				0.0826	0.3805	
		(0.8264)	(0.3601)				(0.2725)	(0.5483)	

2357	R_t^f	0.0002 (0.8685)	−0.0413 (0.1715)	1.0726 (0.0000)***	0.0002 (0.4507)	−0.0663 (0.0001)***			
	R_t^d	0.0011 (0.2956)	0.1219 (0.0065)***				−0.0555 (0.3145)	−0.1019 (0.4723)	−0.0808 (0.0001)***
2603	R_t^f	−0.0000 (0.9859)	0.0401 (0.1361)	0.9174 (0.0000)***	−0.0002 (0.0522)*	−0.0210 (0.0010)***			
	R_t^d	−0.0003 (0.7938)	0.0267 (0.6683)				0.0798 (0.2038)	0.2721 (0.2457)	−0.0330 (0.0329)**
2609	R_t^f	0.0004 (0.5884)	−0.0133 (0.5980)	0.8217 (0.0000)***	0.0003 (0.0026)***				
	R_t^d	−0.0001 (0.9444)	−0.0067 (0.9237)				−0.0011 (0.9863)	0.3824 (0.0823)*	
5346	R_t^f	0.0020 (0.2608)	−0.0269 (0.5358)	0.9496 (0.0000)***	0.0001 (0.7024)				
	R_t^d	0.0036 (0.2806)	0.0507 (0.7361)				0.0435 (0.7897)	1.1538 (0.2902)	

[a]D. V. represents dependent variable.
*Significant at the 10% level.
**Significant at the 5% level.
***Significant at the 1% level.
(.) represents p-value.

Table 9. Change in Granger causality results—net buy

$$R_{i,t}^{f} = \lambda_0^{f} + \lambda_1^{f} R_{i,t-1}^{f} + \left(\delta_0^{f} + \delta_1^{f} \cdot BS_t^{f}\right) R_{i,t}^{d} + \varepsilon_{i,t}^{f} \quad (11)$$

$$R_{i,t}^{d} = \lambda_0^{d} + \lambda_1^{d} R_{i,t-1}^{d} + \left(\delta_0^{d} + \delta_1^{d} \cdot BS_{t-1}^{d}\right) R_{i,t-1}^{f} + \varepsilon_{i,t}^{d} \quad (12)$$

$$R_{i,t}^{f} = k_0^{f} + k_1^{f} R_{i,t-1}^{f} + \left(\omega_0^{f} + \omega_1^{f} \cdot BS_t^{f}\right) R_{i,t}^{d} + k_3^{f}\left(\log p_{i,t-1}^{f} - c_0 - c_1 \log p_{i,t-1}^{d}\right) + \varepsilon_{i,t}^{f} \quad (13)$$

$$R_{i,t}^{d} = k_0^{d} + k_1^{d} R_{i,t-1}^{d} + \left(\omega_0^{d} + \omega_1^{d} \cdot BS_{t-1}^{d}\right) R_{i,t-1}^{f} + k_3^{d}\left(\log p_{i,t-1}^{d} - d_0 - d_1 \log p_{i,t-1}^{f}\right) + \varepsilon_{i,t}^{d} \quad (14)$$

Corporation Code	D.V.[a]	$\lambda_0^f(\kappa_0^f)$ $\lambda_0^d(\kappa_0^d)$	$\lambda_1^f(\kappa_1^f)$ $\delta_0^d(\omega_0^d)$	$\delta_0^f(\omega_0^f)$	$\delta_1^f(\omega_1^f)$	κ_3^f	$\lambda_1^d(\kappa_1^d)$	$\delta_1^d(\omega_1^d)$	κ_3^d
1102	R_t^f	−0.0003	−0.0232	0.9114	0.0000	−0.0544			
		(0.7715)	(0.3999)	(0.0000)***	(0.6190)	(0.0000)***			
	R_t^d	−0.0007	0.0993				−0.0276	0.0000	−0.0321
		(0.5349)	(0.0403)**				(0.6376)	(0.0281)**	(0.0671)*
1227	R_t^f	−0.0002	0.0844	0.7185	−0.0000				
		(0.8445)	(0.0075)***	(0.0000)***	(0.9931)				
	R_t^d	−0.0005	0.1395				0.0188	−0.0000	
		(0.6787)	(0.0017)***				(0.7130)	(0.3648)	
1402	R_t^f	0.0010	0.0603	0.7471	−0.0000				
		(0.7254)	(0.3541)	(0.0000)***	(0.3768)				
	R_t^d	0.0019	0.1136				−0.0581	−0.0000	
		(0.5792)	(0.2830)				(0.6192)	(0.2884)	
1605	R_t^f	0.0040	−0.0285	0.9311	−0.0001	−0.0007			
		(0.6288)	(0.1618)	(0.0000)***	(0.1673)	(0.6381)			
	R_t^d	0.0187	0.0934				−0.1131	0.0000	−0.0064
		(0.2622)	(0.2051)				(0.1551)	(0.8671)	(0.2750)

2002	R_t^f	−0.0000	0.0287	1.0557	0.0002	−0.0545			
		(0.9375)	(0.3058)	(0.0000)***	(0.2859)	(0.0000)***			
	R_t^d	0.0001	0.1260				−0.1600	−0.0001	−0.0126
		(0.8751)	(0.0014)***				(0.0056)***	(0.1506)	(0.4643)
2306	R_t^f	−0.0002	−0.0062	1.0470	0.0001	−0.5870			
		(0.8095)	(0.7317)	(0.0000)***	(0.1820)	(0.0000)***			
	R_t^d	1.0010	−0.0255				2.0044	−0.0001	−0.3961
		(0.4729)	(0.7628)				(0.9609)	(0.4134)	(0.0000)***
2311	R_t^f	0.0003	0.0315	0.9717	−0.0001	−0.0429			
		(0.8138)	(0.2575)	(0.0000)***	(0.3295)	(0.0004)***			
	R_t^d	0.0001	0.9502				0.0307	0.0001	−0.0425
		(0.9524)	(0.0000)***				(0.2709)	(0.5249)	(0.0004)***
2317	R_t^f	0.0005	0.1742	0.9476	−0.0005	−0.0506			
		(0.8558)	(0.0068)***	(0.0000)***	(0.0104)**	(0.0894)*			
	R_t^d	0.0016	0.0297				0.0466	0.0002	−0.1176
		(0.5108)	(0.7112)				(0.6613)	(0.0746)*	(0.0041)***
2324	R_t^f	0.0000	0.0649	1.0129	0.0004				
		(0.9906)	(0.1700)	(0.0000)***	(0.0059)***				
	R_t^d	−0.0006	0.1539				−0.1924	−0.0002	
		(0.8449)	(0.3160)				(0.2739)	(0.2659)	
2325	R_t^f	0.0004	−0.0462	0.9171	−0.0003				
		(0.8030)	(0.1420)	(0.0000)***	(0.0377)**				
	R_t^d	0.0002	0.0590				−0.0365	0.0000	
		(0.8526)	(0.0923)*				(0.4746)	(0.8057)	

(*continued*)

Table 9. (*Continued*)

Corporation Code	D.V.[a]	$\lambda_0^f(\kappa_0^f)$ $\lambda_0^d(\kappa_0^d)$	$\lambda_1^f(\kappa_1^f)$ $\delta_0^d(\omega_0^d)$	$\delta_0^f(\omega_0^f)$	$\delta_1^f(\omega_1^f)$	κ_3^f	$\lambda_1^d(\kappa_1^d)$	$\delta_1^d(\omega_1^d)$	κ_3^d
2330	R_t^f	0.0010	−0.1158	0.7581	−0.0005	−0.0198			
		(0.5326)	(0.0023)***	(0.0000)***	(0.0426)**	(0.1499)			
	R_t^d	0.0013	0.2031				−0.0812	−0.0004	−0.0595
		(0.2348)	(0.0000)***				(0.0521)*	(0.0000)***	(0.0000)***
2337	R_t^f	0.0002	−0.0127	0.8331	−0.0001	−0.5776			
		(0.8766)	(0.6630)	(0.0000)***	(0.4058)	(0.0000)***			
	R_t^d	−0.0048	0.0457				0.0286	0.0000	−0.1679
		(0.0818)*	(0.4318)				(0.6582)	(0.9477)	(0.0075)***
2342	R_t^f	0.0004	−0.0012	0.9929	0.0001	−0.2653			
		(0.7908)	(0.9712)	(0.0000)***	(0.4930)	(0.0000)***			
	R_t^d	0.0056	−0.1101				0.1627	0.0001	−0.2724
		(0.0758)*	(0.5257)				(0.3768)	(0.5927)	(0.0464)**
2344	R_t^f	0.0003	−0.0473	1.0162	0.0001	−0.1641			
		(0.8308)	(0.1275)	(0.0000)***	(0.4369)	(0.0000)***			
	R_t^d	0.0008	0.0704				−0.1237	0.0002	−0.0598
		(0.7932)	(0.4528)				(0.2538)	(0.2943)	(0.2638)
2345	R_t^f	−0.0008	−0.0756	1.0191	0.0000				
		(0.3488)	(0.0001)***	(0.0000)***	(0.2919)				
	R_t^d	−0.0001	−0.0117				0.1013	0.0001	
		(0.9473)	(0.8719)				(0.2227)	(0.0196)**	

2346	R_t^f	−0.0003	−0.0892	0.9828	0.0001				
		(0.6558)	(0.0000)***	(0.0000)***	(0.4070)				
	R_t^d	−0.0000	0.0113				0.1124	0.0001	
		(0.9950)	(0.8885)				(0.2013)	(0.5693)	
2347	R_t^f	0.0000	−0.1147	0.9797	0.0000				
		(0.9976)	(0.0000)***	(0.0000)***	(0.8637)				
	R_t^d	0.0004	0.0762				0.0751	0.0000	
		(0.7611)	(0.2439)				(0.3113)	(0.8317)	
2357	R_t^f	0.0006	−0.0389	1.0834	−0.0002	−0.0643			
		(0.6252)	(0.1950)	(0.0000)***	(0.0858)*	(0.0002)***			
	R_t^d	0.0009	0.1038				−0.0441	0.0001	−0.0770
		(0.4311)	(0.0042)***				(0.4128)	(0.1710)	(0.0003)***
2603	R_t^f	−0.0000	0.0354	0.8802	0.0001	−0.0199			
		(0.9576)	(0.1882)	(0.0000)***	(0.5779)	(0.0019)***			
	R_t^d	−0.0002	0.0673				0.0594	−0.0000	−0.0325
		(0.8204)	(0.1866)				(0.3233)	(0.7620)	(0.0363)**
2609	R_t^f	0.0007	−0.0130	0.8748	−0.0002				
		(0.3496)	(0.6081)	(0.0000)***	(0.1131)				
	R_t^d	−0.0001	0.0670				−0.0226	0.0001	
		(0.9247)	(0.2381)				(0.7226)	(0.2796)	
5346	R_t^f	0.0022	−0.0298	0.9597	0.0000				
		(0.2350)	(0.4860)	(0.0000)***	(0.8140)				
	R_t^d	0.0028	0.0205				0.0237	−0.0002	
		(0.4082)	(0.8904)				(0.8837)	(0.3851)	

[a]D. V. represents dependent variable.
*Significant at the 10% level.
**Significant at the 5% level.
***Significant at the 1% level.
(.) represents p-value.

Table 10. Change in Granger causality results—premium and net buy

$$R^f_{i,t} = \lambda^f_0 + \lambda^f_1 R^f_{i,t-1} + \left(\theta^f_0 + \theta^f_1 \cdot \text{prem}^f_t + \theta^f_2 \cdot BS^f_t\right) R^d_{i,t} + \varepsilon^f_{i,t} \quad (15)$$
$$R^d_{i,t} = \lambda^d_0 + \lambda^d_1 R^d_{i,t-1} + \left(\theta^d_0 + \theta^d_1 \cdot \text{prem}^d_t + \theta^d_2 \cdot BS^d_{t-1}\right) R^f_{i,t-1} + \varepsilon^d_{i,t} \quad (16)$$
$$R^f_{i,t} = k^f_0 + k^f_1 R^f_{i,t-1} + \left(\gamma^f_0 + \gamma^f_1 \cdot \text{prem}^f_t + \gamma^f_2 \cdot BS^f_t\right) R^d_{i,t} + k^f_3 \left(\log p^f_{i,t-1} - c_0 - c_1 \log p^d_{i,t-1}\right) + \varepsilon^f_{i,t} \quad (17)$$
$$R^d_{i,t} = k^d_0 + k^d_1 R^d_{i,t-1} + \left(\gamma^d_0 + \gamma^d_1 \cdot \text{prem}^d_t + \gamma^d_2 \cdot BS^d_{t-1}\right) R^f_{i,t-1} + k^d_3 \left(\log p^d_{i,t-1} - d_0 - d_1 \log p^f_{i,t-1}\right) + \varepsilon^d_{i,t} \quad (18)$$

Cor. Code	D.V.[a]	$\lambda^f_0(\kappa^f_0)$ $\lambda^d_0(\kappa^d_0)$	$\lambda^f_1(\kappa^f_1)$ $\theta^d_0(\gamma^d_0)$	$\theta^f_0(\gamma^f_0)$	$\theta^f_1(\gamma^f_1)$	$\theta^f_2(\gamma^f_2)$	κ^f_3	$\lambda^d_1(\kappa^d_1)$	$\theta^d_1(\gamma^d_1)$	$\theta^d_2(\gamma^d_2)$	κ^d_3
1102	R^f_t	−0.0010	−0.0127	0.9597	−1.2026	0.0000	−0.0572				
		(0.2850)	(0.6440)	(0.0000)***	(0.0003)***	(0.7092)	(0.0000)***				
	R^d_t	−0.0009	0.0434					−0.0069	0.6120	0.0000	−0.0311
		(0.4186)	(0.4444)					(0.9079)	(0.0620)*	(0.0331)**	(0.0759)*
1227	R^f_t	−0.0007	0.0812	0.8007	−0.5711	0.0000					
		(0.5067)	(0.0098)***	(0.0000)***	(0.0187)**	(0.9338)					
	R^d_t	−0.0005	0.1538					0.0185	−0.1088	−0.0000	
		(0.6745)	(0.0050)***					(0.7185)	(0.6547)	(0.4754)	
1402	R^f_t	0.0007	0.0646	0.7902	−0.2604	−0.0000					
		(0.8282)	(0.3322)	(0.0000)***	(0.7436)	(0.3527)					
	R^d_t	0.0015	−0.2796					0.0036	1.6147	−0.0000	
		(0.6548)	(0.1191)					(0.9751)	(0.0078)***	(0.2178)	
1605	R^f_t	0.0040	−0.0284	0.9316	−0.0000	−0.0001	−0.0007				
		(0.6294)	(0.1631)	(0.0000)***	(0.9572)	(0.1677)	(0.6388)				
	R^d_t	0.0188	0.1373					−0.1393	−0.8032	0.0000	−0.0064
		(0.2598)	(0.1000)					(0.0930)*	(0.2623)	(0.8310)	(0.2751)

2002	R_t^f	−0.0000	0.0303	1.0918	−0.0001	0.0002	−0.0546				
		(0.9515)	(0.2814)	(0.0000)***	(0.4759)	(0.2958)	(0.0000)***				
	R_t^d	0.0000	0.0895					−0.1388	0.3041	−0.0000	−0.0097
		(0.9511)	(0.0673)*					(0.0209)**	(0.2092)	(0.2970)	(0.5761)
2306	R_t^f	−0.0002	−0.0065	1.0376	0.0000	0.0001	−0.5860				
		(0.7911)	(0.7214)	(0.0000)***	(0.5461)	(0.1920)	(0.0000)***				
	R_t^d	0.0001	−0.0385					0.0293	3.1092	−0.0001	−0.3908
		(0.9193)	(0.6481)					(0.7429)	(0.0088)***	(0.2745)	(0.0000)**
2311	R_t^f	0.0002	0.0306	0.9584	0.0001	−0.0001	−0.0429				
		(0.8434)	(0.2725)	(0.0000)***	(0.6022)	(0.3659)	(0.0004)***				
	R_t^d	0.0004	0.0818					−0.0944	−0.0053	0.0000	−0.0437
		(0.7681)	(0.1888)					(0.1068)	(0.9800)	(0.7948)	(0.0029)**
2317	R_t^f	0.0005	0.1759	0.9618	−0.0000	−0.0005	−0.0510				
		(0.8442)	(0.0069)***	(0.0000)***	(0.8481)	(0.0115)**	(0.0887)*				
	R_t^d	0.0018	0.0943					0.0491	−0.1790	0.0002	−0.1148
		(0.4687)	(0.5845)					(0.6458)	(0.6719)	(0.0711)*	(0.0058)***
2324	R_t^f	0.0001	0.0778	0.9645	0.0004	0.0004					
		(0.9716)	(0.1024)	(0.0000)***	(0.0955)*	(0.0061)***					
	R_t^d	−0.0005	0.2481					−0.2472	−1.5602	−0.0003	
		(0.8745)	(0.1888)					(0.1871)	(0.3881)	(0.1804)	
2325	R_t^f	0.0004	−0.0396	1.0009	−0.0004	−0.0003					
		(0.7704)	(0.2079)	(0.0000)***	(0.0054)***	(0.0249)**					
	R_t^d	0.0004	0.0845					−0.0419	−0.1129	0.0000	
		(0.7871)	(0.1294)					(0.4192)	(0.5554)	(0.7097)	

(*continued*)

Table 10. (*Continued*)

Cor. Code	D.V.[a]	$\lambda_0^f(\kappa_0^f)$ $\lambda_0^d(\kappa_0^d)$	$\lambda_1^f(\kappa_1^f)$ $\theta_0^d(\gamma_0^d)$	$\theta_0^f(\gamma_0^f)$	$\theta_1^f(\gamma_1^f)$	$\theta_2^f(\gamma_2^f)$	κ_3^f	$\lambda_1^d(\kappa_1^d)$	$\theta_1^d(\gamma_1^d)$	$\theta_2^d(\gamma_2^d)$	κ_3^d
2330	R_t^f	0.0008	−0.1209	0.6981	0.0002	−0.0004	−0.0198				
		(0.6028)	(0.0016)***	(0.0000)***	(0.3534)	(0.0738)*	(0.1496)				
	R_t^d	0.0015	0.2390					−0.0834	−0.0916	−0.0004	−0.0595
		(0.1838)	(0.0000)***					(0.0465)**	(0.3759)	(0.0000)***	(0.0000)***
2337	R_t^f	0.0000	−0.0153	0.7971	0.0002	−0.0001	−0.5730				
		(0.9963)	(0.6006)	(0.0000)***	(0.0745)*	(0.4442)	(0.0000)***				
	R_t^d	−0.0055	0.0428					0.0331	1.3586	−0.0000	−0.1723
		(0.0463)**	(0.4607)					(0.6081)	(0.0908)*	(0.9997)	(0.0060)***
2342	R_t^f	0.0004	0.0019	1.0138	−0.0002	0.0001	−0.2643				
		(0.7814)	(0.9568)	(0.0000)***	(0.2635)	(0.5541)	(0.0000)***				
	R_t^d	0.0053	−0.0792					0.1627	1.4015	0.0001	−0.2728
		(0.0954)*	(0.6580)					(0.3775)	(0.4712)	(0.7234)	(0.0465)**
2344	R_t^f	0.0003	−0.0474	1.0042	0.0000	0.0001	−0.1642				
		(0.8220)	(0.1271)	(0.0000)***	(0.7198)	(0.4330)	(0.0000)***				
	R_t^d	0.0008	0.0957					−0.1383	−0.6757	0.0002	−0.0649
		(0.8010)	(0.3544)					(0.2142)	(0.5575)	(0.4066)	(0.2318)
2345	R_t^f	−0.0008	−0.0755	1.0117	0.0332	0.0000					
		(0.3911)	(0.0001)***	(0.0000)***	(0.7490)	(0.2762)					
	R_t^d	−0.0001	0.0023					0.0989	−0.0543	0.0001	
		(0.9606)	(0.9783)					(0.2355)	(0.7492)	(0.0226)**	

2346	R_t^f	−0.0004	−0.0891	0.9904	−0.0002	0.0001					
		(0.6051)	(0.0000)***	(0.0000)***	(0.2012)	(0.4252)					
	R_t^d	−0.0000	0.0084					0.1138	0.0315	0.0001	
		(0.9949)	(0.9228)					(0.2036)	(0.9322)	(0.5671)	
2347	R_t^f	0.0000	−0.1141	0.9829	−0.0001	0.0000					
		(0.9781)	(0.0000)***	(0.0000)***	(0.5935)	(0.8726)					
	R_t^d	0.0003	0.0627					0.0827	0.3761	0.0000	
		(0.8428)	(0.3647)					(0.2720)	(0.5535)	(0.8488)	
2357	R_t^f	0.0006	−0.0406	1.0715	0.0002	−0.0002	−0.0643				
		(0.6554)	(0.1784)	(0.0000)***	(0.4629)	(0.0876)*	(0.0002)***				
	R_t^d	0.0010	0.1357					−0.0576	−0.1711	0.0001	−0.0777
		(0.3828)	(0.0029)***					(0.2957)	(0.2469)	(0.1006)	(0.0002)***
2603	R_t^f	−0.0001	0.0393	0.9181	−0.0002	0.0001	−0.0209				
		(0.9521)	(0.1445)	(0.0000)***	(0.0514)*	(0.5598)	(0.0011)***				
	R_t^d	−0.0003	0.0261					0.0805	0.2682	−0.0000	−0.0328
		(0.8030)	(0.6763)					(0.2009)	(0.2545)	(0.8325)	(0.0349)**
2609	R_t^f	0.0005	−0.0167	0.8248	0.0003	−0.0002					
		(0.5123)	(0.5095)	(0.0000)***	(0.0030)***	(0.1325)					
	R_t^d	−0.0001	−0.0104					−0.0026	0.4211	0.0002	
		(0.8959)	(0.8815)					(0.9680)	(0.0578)*	(0.1854)	
5346	R_t^f	0.0021	−0.0270	0.9501	0.0001	0.0000					
		(0.2537)	(0.5353)	(0.0000)***	(0.7105)	(0.8270)					
	R_t^d	0.0031	0.0445					0.0458	1.0927	−0.0002	
		(0.3639)	(0.7683)					(0.7796)	(0.3183)	(0.4257)	

[a]D. V. represents dependent variable.
*Significant at the 10% level.
**Significant at the 5% level.
***Significant at the 1% level.
(.) represents p-value.

stocks in equations (5) and (7). On the other side, four samples report that the transmission effects have been changed in equations (6) and (8) when the premium is considered. That is, the premium has significant impact on international price transmission for one fifth to one third of samples. However the impact may amplify or reduce the transmission effect since the signs of β_1^f (ϕ_1^f) are ambiguous.

The results from Granger Causality involving QFII's net buy are shown in Table 9. Taiwan stock market is still dominant and the foreign market is a satellite. The result is similar to the stated outcomes above. In addition, QFII's net buy significantly influences the price transmission effect of twenty percent samples and the direction of net buy effect is also obscured.

Finally, Table 10 illustrates the results from Granger Causality, including both the premium and QFII's net buy factors. The outcomes are quite consistent with the Table 8 and Table 9. The premium and QFII's net buy still have significant impact on international price transmission for the same samples. These results prove the robustness of our models.

4. Conclusion

This paper studies the price transmission effect between ADRs or GDRs and their respective underlying stock. The selected samples cover twenty-one sponsored DRs issued by Taiwan listing companies from October 8, 1997 to May 31, 2000. We use Granger tests to examine causal relations between the returns of both capital markets. Error-correction model is employed to analyze the long run causal relations when the stock returns data is nonstationary.

Results reveal unidirectional causality from Taiwan's capital market to foreign markets. This asymmetry suggests the domestic market plays a dominant role relative to the foreign market. At the same time, the prices of both markets will make opposite adjustment to establish the long run cointegrated equilibrium. An additional finding is that both the premium and QFII's net buy have significant impacts on international price movement for over twenty percent samples. Empirical outcomes provide the evidence that the models presented in this paper are quite robust.

Notes

1. One anonymous reviewer indicates that the premium or discount is an important variable for closed-end funds. However, there are a few differences in premium concept between ADRs and closed-end funds. ADRs and underlying securities are two separately traded assets and their prices may exist lead-lag relation in both directions, thus causes the possible price premium or discount across different markets. The net asset value (NAV) of a closed-end fund is not marketable. NAV may affect the market price of a closed-end but not the reverse.
2. QFIIs (Qualified Foreign Institutional Investors) refer to foreign banks, insurance companies, securities firms, fund management institutions and other investment institutions who meet the qualifications set by the Securities and Futures Commission, Taiwan, R.O.C.
3. A spurious regression has a high R^2, t-statistics that appear to be significant, but the results are without any economic meaning. The regression output "looks good" because the least-squares estimates are not consistent and the customary tests of statistical inference do not hold.
4. For a review of arbitrage and market efficiency of ADR markets, see Karolyi (1998).

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