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LINKAGES BETWEEN THE US AND AUSTRALIAN MARKETS: TIME SERIES EVIDENCE

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ABSTRACT

Globalisation and reduction of restrictions on international cross listings have led to significant growth in information linkages and cross-border equity flows among stock markets. In making financial decisions with regard to investment and risk management, it is important for corporate management to understand the behaviour of information linkages and correlations between markets. The aim of this paper is to examine the dynamic of price transmissions between the Australian shares and its American depository receipts (ADRs) for individual firm and the relationship between their share returns for all firms. Johasen maximum likelihood method is used to test for possible long-run cointegrating relationship between five pricing factors, namely, the price of the Australian ADRs and the underlying shares, the Australian and US market indices and the exchange rate, for individual firm. The seemingly unrelated regression is used to estimate the short run dynamics of the five pricing factors for all firms. In addition, the effect and persistence of a shock in one pricing factor to itself as well as to the other factors in the system are also analysed.

1 INTRODUCTION

Globalisation in capital markets and reduction of restrictions on international cross listings have led to greater flows of capital between economies, easier ownership and trading in securities from around the world. Advantages of international cross listing to a firm include lower cost of capital, greater global shareholder base, improved liquidity, and an effective diversification tools for investors because the risk from holding foreign equities can be diversified or hedged (see Bekaert and Harvey, 1997; Hargis, 2000; Hendry, 2000; and Karolyi, 1998). In making financial decisions with regard to investment and risk management, it is important for corporate management to understand the behaviour of information linkages and correlations between markets, and the net benefits of listing shares on overseas exchange.

When companies seek to list their shares in foreign exchanges, they must fulfil the listing standards requirement of those exchanges. An alternative form of overseas listing is the Depository Receipt which are negotiable certificates representing a specific multiple of underlying shares on deposit in the issuer's home market. Most companies list their shares in the United States in the form of an American Depository Receipt (ADR). ADRs are priced in US dollar and traded as any other stock in the US markets. One would expect the dollar price of the ADR will not differ from the price of the underlying share in its home market after incorporating the exchange rate factor. However, ADRs are not perfect substitute for their home market shares. The price differential between the ADRs and their underlying shares could be attributed to foreign exchange risk and limits to arbitrage such as transaction costs, different market locations and different trading hours.

Studies of return distribution of dually-listed stocks found that the price of stock listed in overseas markets is significantly affected by the price of their underlying shares in their home country. These studies also suggest that the exchange rate movements as well as innovation in the markets where the shares are listed contributed to changes in their prices. Hauser et al. (1998) use vector autoregressive (VAR) methodology and showed that information flow of internationally listed stocks is unidirectional from domestic to the foreign market. A number of studies (see Copeland and Copeland, 1998; Janakiramanan and Lamba, 1998; Jeong, 1999 and Wu and Su, 1998) report significant correlation between international stock markets and established leadership role of the US equity market on other markets. Patro (2000) indicates that both the world market and the home market returns are significant sources of risk for the ADRs. Using a VAR model with cointegration constraint and a seemingly-unrelated regression equations model, Kim et al (2000) found the price of the underlying shares as the most important factor with the exchange rate and the US market also have an impact on the ADR prices. Fang and Loo (2002) also found that ADR returns are significantly affected by their respective home market factors than by the US market and exchange rate movements. Alaganar and Bhar (2002) examined the information flows between dually listed stocks traded in Australia and the United States using a bivariate generalized autoregressive conditional heteroskedasticity model. Their results indicate one-way information flow from the US equity market to the Australian market both with the dually listed stock and the stock indices (both mean and volatility levels of stock returns).

Most studies examined only the unidirectional effects of three pricing factors namely, the underlying shares, exchange rate, and the foreign markets, on the overseas listed shares such as ADRs based on a value-weighted portfolio. This paper aims to provide an interesting avenue to further examine the behaviour of information linkages between markets using two time series methods. The primary focus is to examine the dynamic of price transmissions between the Australian shares and its ADRs for individual firm and the relationship between their share returns for all firms. Past studies have found that due to non-synchronous trading hours, price information may not be only unidirectional from the local Australian shares to the overseas listed Australian shares. Thus, Johasen maximum likelihood method is used to test for possible long-run cointegrating relationship between five pricing factors, namely, the price of the Australian ADRs and the underlying shares, the Australian and US market indices and the exchange rate, for individual firm. The seemingly unrelated regression is used to estimate the short run dynamics of the five pricing factors for all firms based on a value-weighted basis. In addition, the effect and persistence of a shock in one pricing factor to itself as well as to the other factors in the system are also analysed. Results from the analysis will provide not only an indication of the direction of information transmission but also an assessment on the degree of influence by individual variables on both the Australian shares and their ADRs.

The plan of this paper is as follows. Section 2 proposes the time series methods used to determine the information linkages between the US and the Australian stock markets. Section 3 outlines the types of Australian ADRs and the data used in the study. Section 4 presents the results of the study and some concluding remarks are given in Section 5.

2 METHODOLOGY

In this paper, two different time series methods are used to examine the information linkages between the US and the Australian markets. The first method applies unit root tests and cointegration analysis, which includes impulse response function and variance decomposition, and the second method uses a seemingly unrelated regression approach.

2.1 Cointegration Method

Time series modeling requires the data generating processes of the series and/or the structural relationships described by the model to be invariant with respect to time. Most economic variables are found to be non-stationary, and regressing one non-stationary variable against another can lead to spurious results and bias conventional significance tests. Econometric techniques of unit roots and cointegration are designed to overcome the problem of non-stationary data and dynamic adjustment. It also provides a way of analyzing the long-run relationship between economic variables, when they are separated from the short-run responses.

Empirically, testing for a long-run relationship between a set of variables in a cointegration framework requires each of the variables, namely the prices of Australian ADRs, their underlying prices, the exchange rates, the Australian market index and the US market index, to be integrated of order one or I(1) variable. The following augmented Dickey-Fuller (1981) (ADF) test is used to determine the order of integration for each variable:

$$\Delta y_t = a_0 + a_1 T + \beta y_{t-1} + \sum_{j=1}^{p} \delta_j \Delta y_{t-j} + u_t , \qquad (1)$$

where Δy_t denotes the logarithmic first-difference of a variable at time t, T is the deterministic trend, p is the order of the autoregressive process, Δy_{t-j} is included to accommodate (possible) serial correlation in the errors and u_t is the error term.

The rank of the cointegrating matrix in a multivariate framework can be estimated using the following VAR representation (Johansen, 1988, 1991):

$$\Delta Y_t = \mu + \Gamma(L)\Delta Y_{t-p+1} + \Pi Y_{t-p} + \varepsilon_t , \qquad (2)$$

where Y_t is a 5 x 1 vector of I(1) variables under study, Π is the long-run matrix of order 5x5 parameters, $\Gamma(L)$ is a polynomial of order $p - 1$ to capture the short-run dynamics of the system, and ε_t are independent Gaussian errors with zero mean and covariance matrix Ω. The reduced rank or r ($0 \le \text{rank}(\Pi) = r < n$) of the long-run impact matrix is formulated as follows:

$$\Pi = \alpha\beta' , \qquad (3)$$

where β is the 5 x r matrix of cointegrating vectors and α is the 5 x r matrix of adjustment coefficients.

After determining the cointegrating relationships among the variables, the impulse response function (IRF) and variance decomposition (VDC) of the forecast error of the VAR system for each firms will be computed. The IRF traces the impact of a shock in a variable onto the system over a time period which measures the time taken for information to be transmitted across different markets. On the other hand, the VDC of the forecast error is to measure the extent of shocks to a variable that can be explained by other variables considered in the system. Each firm's IRF and VDC are weighted equally to derive the average IRF and VDC, respectively.

2.2 Seemingly Unrelated Regression Model

In general, the existence of cointegrating relationship among a set of assets prices implies disequilibrium in the market due to some form of inefficiency within the market. However, this implication may not hold in this study. This is due to the fact that the price of the Australian underlying share is not observed simultaneously with the price of its ADR as well as the price of other underlying factors as a result of non-synchronous trading hours between the markets. Thus, the influences of the Australian ADRs, exchange rate, the Australian market and the US market on the Australian underlying shares are also examined by estimating the following regression model:

$$R_{A,t} = a_0 + \sum_{i=0}^{3} a_1 R_{U,t-i} + \sum_{i=0}^{3} a_2 R_{EX,t-i} + \sum_{i=0}^{3} a_3 R_{AM,t-i} + \sum_{i=0}^{3} a_4 R_{UM,t-i} + u_t , \quad (4)$$

$$R_{U,t} = b_0 + \sum_{i=0}^{3} b_1 R_{A,t-i} + \sum_{i=0}^{3} b_2 R_{EX,t-i} + \sum_{i=0}^{3} b_3 R_{AM,t-i} + \sum_{i=0}^{3} b_4 R_{UM,t-i} + \varepsilon_t , \quad (5)$$

where $R_{A,t}$ is the value-weighted return of Australian underlying shares listed in the US market on day *t*, $R_{U,t}$ is the value-weighted return of Australian ADRs, $R_{EX,t}$ is the exchange rate return (i.e. percentage change of the US dollar against the Australian dollar), $R_{AM,t}$ and $R_{UM,t}$ are the returns on the Australian and the US market indices, respectively, and u_t is the random disturbances with zero mean and constant variance.

As the error terms across firms are likely to be contemporaneously correlated, the regressions are estimated as a seemingly-unrelated system of equations. It also represent an estimation of the short run dynamics of the five pricing factors without feedback from the long-run relationship. The regressions are used mainly to provide additional evidence as to whether the prices of the Australian underlying shares and ADRs efficiently incorporate the innovations of the four pricing factors.

3 DATA

The Australian market and the US market are rather similar and harmonious in terms of information flow and technological advancement, financial reporting and regulations. In addition, the trading hours of the Australian market do not overlap with those of the US market. The non-synchronous trading hours between these markets allow us to test the lead-lag information flow between the US market and the Australian market.

The American Depository Receipts (ADRs) are classified into three levels, namely Level 1, Level 2 and Level 3. Level 1 ADRs trade over-the-counter as OTC Bulletin Board or Pink Sheet issues with limited liquidity and requires minimal Stock Exchange Commission (SEC) disclosure and the Generally Accepted Accounting Principles compliance. Level 2 ADRs are exchange listed securities, but without a capital-raising element. Level 3 ADRs are also exchange listed securities which require full SEC disclosure and compliance with an exchange's

Table 1: List of Australian ADRs

Name	Ratio (ADR:stock)	Exchange
Amcor Ltd (AMC)	1:4	NASDAQ
Alumina Ltd. (ALU)	1:4	NYSE
Ansell Ltd. (ANS)	1:4	NASDAQ
Atlas Pacific Ltd. (ATL)	1:20	NASDAQ
ANZ Banking Grp Ltd. (ANZ)	1:5	NYSE
BHP Billiton Ltd. (BHP)	1:2	NYSE
Coles Myer Ltd. CML)	1:8	NYSE
James Hardie Industries (HAR)	1:5	NYSE
Lihir Gold Ltd.	1:20	NASDAQ
Metal Storm Ltd. (MET)	1:20	NASDAQ
National Australia Bank Ltd (NAB)	1:5	NYSE
News Corporation Ltd. (NCP)	1:4	NYSE
Novogen Ltd. (NOV)	1:5	NASDAQ
Orbital Engine Corp Ltd. (ORB)	1:40	NYSE
Prana Biotechnology Ltd. (PRA)	1:10	NASDAQ
Santos Ltd. (SAN)	1:4	NASDAQ
Southern Pacific Petroleum (SPP)	1:40	NASDAQ
Telstra Corporation Ltd. (TLS)	1:5	NYSE
Westpac Banking Corp. (WBC)	1:5	NYSE
WMC Resources Ltd. (WMC)	1:4	NYSE

own listing rules. This paper examines 20 Australian ADRs (both Levels 2 and 3) that are traded on either the New York Stock Exchange or the NASDAQ. Level 1 ADRs with infrequent price movements are excluded from the sample.

Daily closing prices of the dually-listed Australian shares, exchange rate of US dollar per Australian dollar, and the Australian and the US total market return indices are obtained from Datastream International. The study period covers from 1st January 1996 to 31st August 2003. The daily returns for each company are computed as logarithmic differences of daily share prices over the entire sample period. Due to differences of public holidays among markets, the non-trading day in a market is assumed to have the same closing price as the previous trading day. Daily returns for the portfolios of both ADRs and their underlying shares for 20 Australian companies are value-weighted using the corresponding daily Australian market value of each share against the daily Australian total market value of the portfolio.

4 EMPIRICAL RESULTS

Both the cointegration and seemingly unrelated regression methods are used to determine the factors affecting the prices of Australian ADRs and their underlying shares, and their share returns, respectively. All estimation and test results are derived for the period 1st January 1996 to 31st August 2003 using the Microfit 4.0 econometric software program (Pesaran and Pesaran, 1997).

4.1 Cointegration Results

Before testing for the cointegration of the five pricing factors, namely the prices of Australian ADRs and their underlying shares for the 20 Australian firms, the market indices for the Australian and the US markets, and the US exchange rates against the Australian dollar, it is essential to determine the order of integration for each of the variable in logarithmic form using the ADF test. For each variable, an initial lag length of twelve is used to test the presence of a unit root. If the t-statistic for the largest lag is insignificant, the lag length is reduced successively until a significant lag length is obtained. Although detailed results are not reported to save space, the ADF t-statistics do not reject the null hypothesis of a unit root for all the variables, implying that each variable is non-stationary. Upon taking first differences of all the series, which indicate stationarity of the transformed series, the test results indicate that all the series are integrated of order one. Thus, the Johansen maximum likelihood (ML) method can be used to test for the presence of cointegrating long-run relationship among the five variables.

An unrestricted VAR model of order 10 for each company is first estimated and the Schwartz Bayesian criterion is used to determine the optimal order of the VAR model. The test statistics and choice criteria indicating a VAR model of order three. Using unrestricted intercepts and no trends in the VAR, Table 2 reports the trace and maximal eigenvalue statistics of the stochastic matrix for 20 Australian firms to determine the number of cointegrating vectors (r) that are significant at the 5% and 10% levels.

Table 2: Johansen ML Cointegration Tests, January 1996 to August 2003

	Trace Test		Maximal Eigenvalue Test	
Firms	$H_0: r = 0$ $H_a: r \geq 1$	$H_0: r = 1$ $H_a: r \geq 2$	$H_0: r = 0$ $H_a: r = 1$	$H_0: r \leq 1$ $H_a: r = 2$
AMC	86.8715*	52.6248**	34.2467**	20.4946
ALU	425.3308*	37.7728	387.5581*	13.7343
ANS	280.8260*	41.6576	239.1684*	19.9234
ATL	262.0815*	42.0384	220.0403*	16.5683
ANZ	468.3348*	37.3061	431.0287*	16.5743
BHP	146.1013*	43.8760	102.2253*	15.4467
CML	397.6096*	38.5283	359.0813*	13.5897
HAR	68.2869	41.7582	26.5287	17.5580
LIH	385.4034*	41.7068	343.6966*	17.1622
MET	126.7998*	40.0441	86.7557*	18.9537
NAB	495.4871*	36.3207	459.1664*	13.1330
NCP	521.9225*	37.2301	484.6924*	13.4554
NOV	213.4820*	35.6498	177.8321*	14.9878
ORB	261.0722*	53.1635**	207.9087*	24.4025
PRA	112.1318*	50.5295**	61.6023*	21.5383
SAN	180.3630*	32.0448	148.3182*	14.7623
SPP	63.1259	41.5552	21.5707	14.1090
TLS	349.5145*	59.8203*	289.6942*	31.6352
WBC	399.1213*	36.5672	362.5541*	14.7825
WMC	98.4091*	46.8323	51.5768*	23.5424

* indicate significance at the 5% level.
** indicates significance at the 10% level.

At the 5% level of significance, both the trace and maximal eigenvalue test statistics indicate that 18 of the 20 firms have at least one long-run cointegrating relationship among the prices of the Australian ADRs and their underlying shares, the exchange rate, the Australian and the US market indices. The two Australian companies that do not reject the null hypothesis of no cointergrating relationship are James Hardie Industries and Southern Pacific Petroleum. Of the 18 cointegrating firms, one firm (Telstra Corporation Ltd) and three firms (Amcor Ltd, Orbital

Engine Corporation Ltd and Prana Biotechnology Ltd) are found to have at least two cointegrating relationships at the 5% and 10% level of significance, respectively, based on the trace test statistic.

4.1.1 Generalised Variance Decomposition

Given the existence of a cointegrating relationship among the five variables, the variance decomposition (VDC) of the forecast error of a VAR system of order 3 with cointegratin constraint for each firms are computed. It is an attempt to gauge the extent of shocks to a variable that can by explained by other variables considered in the system. Generally, the results based on orthogonalized variance decomposition and impulse response functions are found to be sensitive to the number of lag lengths used and the ordering of the variables in the equation. The errors in any equation in a VAR are normally serially uncorrelated by construction, however, there may have contemporaneous correlations across errors of different equations. To overcome this problem, the generalised variance decomposition of forecast error is applied (see Pesaran and Pesaran, 1997).

Table 3 shows the average generalized VDCs from one-standard deviation shocks to each variable over the horizon of 0 to 5 days, 10 days and 20 days in the five-variable VAR system, namely the prices of Australian underlying shares (P_A) and ADRs (P_U), the total market indices for Australia (P_{AM}) and the United States (P_{UM}), and the exchange rate (P_{EX}). Each number reported in Table 3 denotes the percentage of average forecast error variance of the 20 Australian firms (based on an equal-weighted basis) for the variables shown on the left-hand side that are explained by innovations in the variables listed on the top.

Among the five variables in the VAR system, the US market and exchange rate seem to be the most exogenous as most of the shocks are explained by their own innovations over the horizon of 20 days. The next most exogenous variables are the prices of Australian ADRs and their underlying shares. Innovation from the Australian ADRs explained a substantial portion of innovations in their underlying shares (about 50%), followed by the Australian and the US markets (about 10% and 5%, respectively), while the impact of the exchange rate on the Australian underlying shares is only about 1%.

In line with the findings of past studies, innovations from Australian underlying shares explains substantial portion of innovations in the Australian ADRs (about 51%). Innovations from the US market, the Australian market and exchange rate (i.e. about 7%, 7% and 8%, respectively) are less significant than the underlying shares. Nonetheless, their influences on the price of Australian ADRs are still important.

Table 3: Generalized Variance Decompositions of Forecast Error

Days relative variance in	Percentage of forecast variance explained by innovations in				
	P_A	P_{AM}	P_{UM}	P_{EX}	P_U
$\boldsymbol{P_A}$					
0	100.00	12.295	0.364	0.371	35.517
1	94.195	10.491	3.822	0.673	45.144
2	92.055	10.315	4.880	0.850	48.959
3	90.826	10.182	5.393	0.989	50.905
4	89.886	10.065	5.705	1.083	52.223
5	89.167	9.970	5.909	1.146	53.170
10	87.130	9.664	6.368	1.309	55.568
20	85.462	9.366	6.662	1.449	57.142
$\boldsymbol{P_{AM}}$					
0	12.295	100.00	1.262	0.266	6.537
1	10.021	81.404	24.722	0.410	9.368
2	9.335	76.800	30.612	0.456	10.110
3	8.915	74.703	33.185	0.546	10.490
4	8.671	73.486	34.653	0.601	10.684
5	8.510	72.664	35.624	0.635	10.799
10	8.118	70.760	37.786	0.709	11.008
20	7.779	69.502	39.091	0.751	11.020
$\boldsymbol{P_{UM}}$					
0	0.364	1.262	100.00	0.073	5.433
1.	0.435	1.540	99.744	0.088	5.464
2	0.461	1.674	99.618	0.144	5.542
3	0.500	1.760	99.508	0.175	5.529
4	0.535	1.814	99.424	0.193	5.508
5	0.563	1.855	99.354	0.206	5.490
10	0.638	1.956	99.121	0.242	5.407
20	0.703	2.031	98.827	0.275	5.302
$\boldsymbol{P_{EX}}$					
0	0.371	0.266	0.073	100.00	6.088
1	0.411	0.478	0.934	99.061	7.169
2	0.415	0.596	1.708	98.263	7.453
3	0.422	0.657	2.007	97.923	7.450
4	0.433	0.695	2.160	97.721	7.443
5	0.447	0.722	2.269	97.566	7.436
10	0.500	0.791	2.536	97.141	7.392
20	0.545	0.831	2.698	96.822	7.370
$\boldsymbol{P_U}$					
0	35.517	6.537	5.433	6.088	100.00
1	44.484	6.910	6.437	7.533	95.553
2	48.546	7.165	6.921	8.468	92.456
3	51.128	7.379	7.234	8.906	90.227
4	53.141	7.537	7.449	9.181	88.287
5	54.690	7.650	7.599	9.387	86.654
10	58.999	7.914	7.988	9.940	81.695
20	62.060	7.982	8.212	10.381	77.739

4.1.2 Generalised Impulse Response Functions

The impulse response function (IRF) traces the effect and persistence of a shock in one variable to itself as well as to the other variables in the system. It tells us how fast information transmits from one market to another market. As discussed in Section 4.1.1, the generalized IRF is used to overcome the dependence on the ordering of the variables in the equation. Estimation of average generalised IRFs for the prices of underlying shares and ADRs for 20 Australian firms based on an equal-weighted basis are provided in Table 4. The numbers reported in Panel A of Table 4 are the average generalised impulse responses of the prices of Australian underlying firms on the *i*th day to a unit innovation in its own prices, the Australian and the US market indices, exchange rate and the ADRs prices. Similarly, Panel B of Table 4 presents the average generalised impulse responses of the prices of Australian ADRs on the *i*th day to a unit innovation in its own prices and the other four pricing factors.

Table 4: Generalized Impulse Responses of the Prices of Australian Underlying Shares (Panel A) and Australian ADRs (Panel B) to a Unit Shock in Each Variable

Panel A – Price of Underlying Share					
Days after shock	P_A	P_{AM}	P_{UM}	P_{EX}	P_U
0	0.02512	0.00561	0.00055	0.00075	0.01350
1	0.02414	0.00554	0.00480	0.00092	0.01755
2	0.02316	0.00570	0.00478	0.00105	0.01778
3	0.02295	0.00547	0.00484	0.00090	0.01754
4	0.02276	0.00539	0.00486	0.00084	0.01763
5	0.02261	0.00534	0.00485	0.00081	0.01763
10	0.02221	0.00519	0.00487	0.00081	0.01760
20	0.02182	0.00501	0.00486	0.00091	0.01742

Panel B – Price of ADR					
Days after shock	P_A	P_{AM}	P_{UM}	P_{EX}	P_U
0	0.01586	0.00434	0.00440	0.00471	0.03089
1	0.01915	0.00457	0.00554	0.00584	0.02736
2	0.01952	0.00497	0.00568	0.00637	0.02635
3	0.02008	0.00516	0.00595	0.00638	0.02582
4	0.02045	0.00529	0.00608	0.00646	0.02511
5	0.02067	0.00539	0.00614	0.00656	0.02467
10	0.02104	0.00552	0.00628	0.00675	0.02389
20	0.02109	0.00550	0.00633	0.00697	0.02330

On average, the price of Australian shares is found to respond more to its own shocks and shocks in the price of Australian ADRs. In addition, the results also indicate that its responses to a unit shock in the Australian market, the US market, and exchange rate are positive but relatively small, and decline gradually over time (see Panel A of Table 4). For the price of the Australian ADRs, the responses are mainly from its own shocks and that of the underlying shares (see Panel B of Table 4). Similar to the Australian underlying shares, its responses to a unit shock in the other three factors are small and positive, and tend to decline gradually over time.

4.2 Regression Results

The short run dynamics of the five pricing factors for a value-weighted portfolio of 20 Australian firms are estimated using the seemingly unrelated regression (SURE) approach (see Equations (4) and (5) in Section 2.2). Table 5 reports the coefficient estimates of regressing the returns on the Australian ADRs, exchange rate, the Australian and the US markets on the Australian underlying shares return based on a lag length of three. Estimation results for longer lag length are insignificant, and hence are not reported here. As shown in Table 5, the Australian underlying shares return is highly sensitive to return on

Table 5: SURE Estimation for Australian Underlying Share Returns (R_A), January 1996 to August 2003

Regressor	Coefficient	t-Ratio[Prob]
a_0	-.2453E-5	-.03280[.974]
R_{AM}	1.03270	75.3981[.000]
$R_{AM(-1)}$	-0.04190	-2.9927[.003]
$R_{AM(-2)}$	-0.03300	-2.3649[.018]
$R_{AM(-3)}$	-0.01310	-1.1959[.232]
R_{UM}	-0.06947	-9.2215[.000]
$R_{UM(-1)}$	-0.00641	-.7677[.443]
$R_{UM(-2)}$	0.00526	.6298[.529]
$R_{UM(-3)}$	0.01357	1.6297[.103]
R_{EX}	-0.13799	-9.7603[.000]
$R_{EX(-1)}$	-0.07585	-5.2678[.000]
$R_{EX(-2)}$	-0.00082	-.0573[.954]
$R_{EX(-3)}$	-0.02517	-1.8179[.069]
R_U	0.17942	16.2229[.000]
$R_{U(-1)}$	0.04484	3.9252[.000]
$R_{U(-2)}$	0.00116	.1019[.919]
$R_{U(-3)}$	-0.00258	-.2463[.806]
R-Squared	0.89617	
F-stat. F(16,1979)		1067.6[.000]

the Australian market, followed by the ADRs return, exchange rate changes and the US market return. The coefficients for the exchange rate and the US market returns are negative and highly significant for day 0. It is rather surprising to find that the US market return has a negative effect on the Australian underlying shares return. This negative influence may be attributed to the composition of the underlying shares having opposite movements with the US market. The coefficients of the returns on the Australian market, exchange rate and the Australian ADRs may be smaller in magnitude for day (-1), they remain significant, indicating that not all of the adjustments to the Australian underlying shares return take place within the same day.

As in the case of the Australian ADRs return, estimation of Equation (5) identify the returns on the US market, exchange rate and the Australian underlying shares have significant influence on the Australian ADRs. The test results for the regression model on the Australian ADRs are given in Table 6. The coefficients for the returns on the US market, exchange rate and Australian underlying shares are all positive and highly significant for day 0. The results suggest that adjustment of the Australian ADRs return to these variables occur contemporaneously. However, some effect of the Australian ADRs return to exchange rate changes is deferred until the next day. In terms of Australian ADRs reactions to innovations in the US market, the day 0 response is positive and highly significant, followed by a significant negative return response on day (-1) and continue to day (-2) and day (-3) with insignificant negative return responses. This pattern indicates a correction process to the over-reaction of responses on day 0.

Table 6: SURE Estimation for Australian ADRs returns (R_U), January 1996 to August 2003

Regressor	Coefficient	t-Ratio[Prob]
b_0	-0.00001	-.0977[.922]
R_A	0.65551	15.6498[.000]
$R_{A(-1)}$	0.07315	1.7520[.080]
$R_{A(-2)}$	-0.10071	-2.4129[.016]
$R_{A(-3)}$	0.01934	.4650[.642]
R_{AM}	-0.01846	-.3451[.730]
$R_{AM(-1)}$	-0.05081	-.95336[.341]
$R_{AM(-2)}$	0.16316	3.0646[.002]
$R_{AM(-3)}$	0.01521	.29872[.765]
R_{UM}	0.40871	34.3054[.000]
$R_{UM(-1)}$	-0.19563	-13.7794[.000]
$R_{UM(-2)}$	-0.00297	-.2095[.834]
$R_{UM(-3)}$	-0.01676	-1.1806[.238]
R_{EX}	0.71479	31.1475[.000]
$R_{EX(-1)}$	0.08133	3.5369[.000]
$R_{EX(-2)}$	0.03975	1.7290[.084]
$R_{EX(-3)}$	-0.01576	-.6842[.494]
R-Squared	0.68253	
F-stat. F(16,1979)		265.9171[.000]

5 CONCLUSION

This paper examines the inter-market information flow of the dually-listed Australian shares traded in the US market. Fundamentally, the Australian ADRs should be priced based on the underlying shares. As Australian ADRs are traded in US dollar, their cash flows are generated from their underlying stocks in Australia. One would expect the Australian ADRs to be sensitive to Australian home market conditions and exchange rate movements. With the convertibility of the Australian ADRs and their underlying shares, however, changes in the value of the exchange rate is most likely to have been incorporated in the price of Australian ADRs. In addition, price movements in the US market may also have been reflected in the price of Australian ADRs.

Analysis of the inter-relationship between the prices of Australian ADRs and underlying shares, the Australian and the US markets and the exchange rate is conducted using a VAR model with cointegration constraints. The generalized forecast error variance decompositions indicate that the price of Australian underlying shares is highly sensitive to price movement in the Australian ADRs, followed by the changes in the Australian and the US markets. While the influence of the exchange rate is found to be insignificant. Consistent with the dominant market theory, this study found that the US market is not affected by the Australian market, but rather by its own market conditions. The results for the Australian ADRs concur with the results of past studies, whereby the Australian underlying shares has the most significant influence on the Australian ADRs, with the Australian market, the US market and exchange rate also playing an important part on its prices. The generalised impulse response functions of the VAR model show that the price of Australian underlying shares is more responsive to its own shock and shock in the price of Australian ADRs. Similarly, for the Australian ADRs, the responses are mainly coming from their own shocks and that of the underlying shares.

Overall, the regression results of the Australian underlying shares and ADRs are quite in line with the VAR findings. However, the order of influence on individual variables differed. The regression results show that for the Australian underlying share return, the Australian market return overtook Australian ADR return as the most dominant variable. This may be true because the regression results represented the short-run dynamics without the error correction term or feedback from the long-run equilibrium of the VAR model. Based on the t-ratio results, the Australian market conditions had the most significant influence on the underlying shares traded in the Australian market.

On the other hand, return for the Australian ADRs is more sensitive to the US market return than the Australian underlying shares return. This phenomena can be attributed to the different trading hours between the Australian and the US market. As the Australian market closes ahead of the US market, any new information will be adjusted in these markets before the Australian market on the following day. Thus, the influence of the US market seems to be more dominant than the Australian underlying shares and the Australian market. In terms of information transmission, the results of the regression show a greater lag in the adjustment of the Australian underlying shares and Australian ADRs returns to their underlying factors. Most of the effects on both shares returns occur on the same day, however, their responses to exchange rate are generally corrected over a 2-day period due to under-reaction of the market to its effect on day 0.

The findings of inter-market information flow of dually-listed Australian shares in this paper are rather restrictive as the sample only include the US market. For more conclusive inferences on inter-market linkages of dually-listed Australian shares, it is recommended that this research be extended to include Australian shares listed in the international stock markets of other regions such as the Asia Pacific Basin and Europe.

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