THE LINKAGES BETWEEN REAL ESTATE SECURITIES IN THE ASIA-PACIFIC

RYAN GARVEY, GARY SANTRY AND SIMON STEVENSON
University College Dublin, Ireland

ABSTRACT

This paper investigates the inter-relationships between real estate securities markets in Australia, Hong Kong, Japan, and Singapore. Two key issues are addressed, namely whether the markets are related in the short-term and secondly, whether short-run co-movement occurs between the markets on a weekly basis. The long-term analysis finds minimal evidence of cointegration between the markets, indicating that they do not share long-term trends. This implies long-term diversification opportunities. The short-term analysis of causal relationships and volatility spillovers also provides evidence of minimal co-movement. The primary piece of dissenting evidence is that consistent evidence of Granger Causality is found when contemporaneous observations are included.

Keywords: Real estate securities, market integration, diversification, Asia Pacific

INTRODUCTION

The issue of market integration between international markets has generated a wide body of research, due to factors such as the relaxation of exchange controls and increased international information flows. In addition, a growing body of empirical evidence points to increasing levels of integration following the stock market crash of October 1987[1]. This study aims to examine the inter-relationship between the real estate security markets in Australia, Hong Kong, Japan and Singapore. A long-term analysis of the four markets is undertaken using both cointegration methods and a mean-variance portfolio approach. Granger causality tests are then used to examine short-term causal relationships in the return series, while a Generalised Autoregressive Conditional Heteroscedasticity (GARCH) model is used to examine the impact of volatility spillovers.

Conventional time-series models assume that the variance of the error term is constant; however, in many financial time series, the assumption of homoscedasticity is unrealistic. A prime example refuting homoscedasticity is the clustering tendency during periods of high or low volatility. The variance of the disturbance term is therefore dependent on its own recent volatility. ARCH based models provide a more efficient means of modeling time-series. Such models allow for an examination of the relationship between different asset series. This effect, which can be referred to as volatility spillovers, allows us to examine whether volatility effects in one market influence the volatility of another market or asset.

[1] See for example Arshanapalli & Doukas (1993), Malliaris & Urrutia (1992) and Najand (1996).

While the analysis of market integration or segmentation does have implications for the relationship and linkages between different markets, there are also long-term implications that can be drawn from the use of cointegration methods. If markets are cointegrated, it implies that diversification opportunities between the markets are reduced in comparison to markets that are segmented. This study allows a comparison with other studies that have examined the diversification benefits available with an international portfolio of real estate securities. The literature that has examined the potential benefits has tended to find that substantial benefits can arise from diversifying a real estate security portfolio internationally. Studies such as Eichholtz (1996), Liu & Mei (1998) and Stevenson (2000) have all found that investors benefit from diversifying internationally.

A number of papers have examined the issue of co-movement and the related issue of volatility spillovers, including a number that have specifically examined Asian and Pacific markets. Much of this literature has concentrated on the issue of market integration and has examined co-movement between the first moments of return series. Koch & Koch (1991) used a simultaneous equations model to describe the relationship across eight major markets from 1972 to 1987, finding evidence that markets within the same geographic region have a tendency to become more interdependent over time. Kasa (1998) analysed five major world markets between 1974–1990 using monthly and quarterly data, finding a common trend driving all five markets. In contrast, Kwok (1995) looking at four Asian markets, Mathur & Subrahmanyam (1990) and Chan, Gup & Pan (1992) looking at Asian markets and the US, found little evidence of integration. In terms of real estate, few studies have examined causal relationships between real estate assets, with the majority examining the relationship between the direct sector and either indirect real estate or the general stock market[2]. With regard to the indirect sector, He (1998) finds evidence to support a causal relationship existing from Equity REITs to Mortgage REITs in the USA, with further evidence finding that the two sectors are cointegrated[3].

Previous studies of volatility spillovers include Hamao et al. (1990), Bae & Karolyi (1994) and Koutmos & Booth (1995), who examined the linkages between the London, New York and Tokyo markets. Karolyi (1995) examines the US and Canadian markets, Ng et al. (1991) analyze major Pacific-Rim markets, while Theodossiou & Lee (1993) examine a number of major international markets. Kanas (1998) and Garvey &

[2] For example, Liu et al. (1990) assess the degree of integration between US real estate and equities, finding that the markets are segmented, while Lee (1998) finds similar evidence in terms of the UK market, with no evidence of any cointegrating relationships between direct real estate and either the equity or bond markets. Barkham & Geltner (1995) examine the relationship between the direct and indirect markets in both the United States and the UK in the context of price discovery, finding that the indirect sector, when adjusted for leverage, does have a leading role in the direct market. Ong (1995) finds no evidence of cointegration between indirect and direct property markets Singapore. Further studies to have examined the direct and indirect sectors include Wilson et al. (1996) who examine the Australian equity market and the Sydney apartment market, while Newell & Chau (1996) examine the direct and indirect sectors in Hong Kong. Wilson & Okunev (1996) examine the Australian, American and British indirect real estate and equity markets, finding in all three markets an absence of any cointegrating relationships.

[3] Previous studies of Asian and Pacific-Rim real estate security markets include Liow (1997, 2000)

Stevenson (2000) both examine major European markets on a daily and intra-daily basis respectively. In most cases, there is significant evidence of volatility spillover effects being present in the series analysed.

The remainder of the paper is laid out as follows. Initially, a brief description of the data is presented. The following three sections then present the empirical findings; the long-term issues concerning diversification are examined and the short-term co-movement in the first and second moments.

DATA

The data used in this study consists of weekly prices from January 1975 to March 2001 for real estate securities for Australia, Hong Kong, Japan and Singapore. Each data series was collected from Datastream. The returns were not converted into a common currency; rather, each is examined in their respective local currency. All tests were conducted on the overall sample and on three eight-year sub-samples. As the final period only contains data for the first quarter of 2001, it is slightly shorter than the rest of the sub-periods. The use of weekly data also overcomes potential problems in the use of higher frequency data. Daily data, for example, suffers both from issues concerning non-synchronous trading due to different market trading hours and also potential problems concerning thin trading. As many real estate securities in each of the markets are relatively illiquid, this may introduce a lagged effect into the index due to temporal aggregation.

Table 1 provides details of the summary statistics of the four series over all three periods analysed, while Table 2 reports the results of the unit root tests which examine the stationarity of the four series. Two alternative unit root tests are used; namely the Augmented Dickey-Fuller and the Phillips-Peron tests.

Table 1: Summary Statistics

	1975–2001		1975–1983		1984–1992		1993–2001	
	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
Australia	0.3380	2.5128	0.4554	2.7361	0.2838	2.7866	0.2693	1.8589
Hong Kong	0.4281	5.1816	0.4859	5.5019	0.5757	4.9890	0.2036	5.0303
Japan	0.1062	3.7755	0.1738	2.3693	0.1339	4.5246	0.0023	4.1151
Singapore	0.2178	4.6460	0.4386	4.1193	0.1410	4.6118	0.0611	5.1947

Note: Table 1 reports the daily summary statistics for the four real estate security markets over the entire period and the three sub-periods.

Table 2: Unit Root Tests

	Australia	Hong Kong	Japan	Singapore
Panel A: 1975–2001				
ADF: Levels	2.2182	1.2510	1.3979	1.8283
ADF: Differences	24.9440*	22.1560*	18.0600*	16.8510*
PP: Levels	1.8518	0.8797	1.4397	1.2803
PP: Differences	649.2200*	522.4500*	766.2600*	557.4400*
Panel B: 1975–1983				
ADF: Levels	2.7842	1.0717	1.4926	0.8333
ADF: Differences	15.0990*	13.1060*	18.4570*	9.4222*
PP: Levels	1.8904	1.0167	1.7928	1.2356
PP: Differences	233.4800*	192.3700*	244.0800*	196.3400*
Panel C: 1984–1992				
ADF: Levels	2.2002	1.8928	1.3150	1.1784
ADF: Differences	15.0840*	12.8670*	11.3960*	14.4400*
PP: Levels	1.8804	1.5850	1.1658	0.8518
PP: Differences	186.4200*	158.5600*	244.0900*	163.8400*
Panel D: 1993–2001				
ADF: Levels	3.7289	3.0483	1.5352	1.8004
ADF: Differences	10.3200*	12.3780*	14.8420*	8.8705*
PP: Levels	3.3709	2.8833	2.6147	1.5969
PP: Differences	279.8400*	168.5300*	269.8500*	195.5400*

Note: Table 2 reports the Augmented Dickey-Fuller and Philips-Peron unit root tests for each market in terms of both the level and first differenced series'. Both tests are conducted over the entire sample period and over each sub-period. * indicates significance at a 10% level.

Both the levels (log price series) and return series (first difference of the log indices) are tested for a unit root. The results show that in the case of each market, using both techniques and across the overall sample periods and the three sub-periods, each series was $I(1)$.

LONG-TERM DIVERSIFICATION BENEFITS

The empirical analysis is broken into three broad areas. First, an analysis is undertaken that examines whether long-term diversification benefits can be obtained with the four markets examined. This analysis is undertaken on the basis of cointegration tests and mean-variance based tests of performance improvement. The second and third sections of the empirical analysis examine more short-term issues by analysing linkages in the first and second moments of the return distributions.

Two alternative methods are used to tests for cointegration, the Engle & Granger (1987) methodology and the Johansen procedure. To test for cointegration using the Engle-Granger methodology, the residuals in the cointegration regression model are tested for a unit root using both of the techniques described previously. If the residuals are found to be stationary, then the series are cointegrated and have a common long-term equilibrium.

The lag length used is the highest significant lag order from either the autocorrelation or partial autocorrelation functions, up to a maximum of $\sqrt{N}$. The significance level used was 95%. The Johansen procedure provides a superior means of testing for cointegration, as it provides estimates of all the cointegrating vectors. Papers such as Hall (1991) have found evidence that the results from the Johansen procedure are sensitive to the lag length selected; therefore, the tests were run over four alternative lag lengths of 2, 4, 6 and 8.

Table 3 reports the findings using the two-step Engle-Granger method, while the Johansen results, over the alternative lag lengths, are displayed in Table 4. The results reveal limited evidence as to the four markets being cointegrated. The Engle-Granger results provide only two instances of cointegration between the four markets. The first of the significant results is Hong Kong and Japan over the entire sample period. However, this result is only significant when the ADF test incorporates a trend component. The second significant result is for Australia and Singapore for the third sub-period, 1993–2001. This finding is significant with both the Dickey-Fuller and Philips-Peron tests when the trend component is included. The Johansen results provide no evidence of cointegration between any of the markets, over any of the four sample periods and over any of the alternative lag lengths.

Table 3: Engle & Granger Cointegration Tests

	No Trend		With Trend	
	ADF	PP	ADF	PP
Panel A: 1975–2001				
Australia-Hong Kong	2.7802	1.4306	1.5645	0.8310
Australia-Japan	0.7864	1.7524	1.5985	1.7407
Australia-Singapore	1.3944	0.3699	0.8875	1.2811
Hong Kong-Japan	1.3391	0.8620	3.9454*	2.8562
Hong Kong-Singapore	1.4428	2.2858	1.9240	2.7355
Japan-Singapore	1.4904	1.6160	1.5487	1.4503
Panel B: 1975–1983				
Australia-Hong Kong	1.8292	1.9094	0.7216	0.3752
Australia-Japan	1.6420	2.1005	1.0887	0.3693
Australia-Singapore	0.8233	0.5105	1.2691	0.6744
Hong Kong-Japan	0.9964	1.0501	1.8014	1.5674
Hong Kong-Singapore	1.4740	1.3622	1.6436	1.2970
Japan-Singapore	1.0698	1.4235	2.5566	2.7766
Panel C: 1984–1992				
Australia-Hong Kong	2.2185	2.6614	2.4677	2.7324
Australia-Japan	0.3237	0.4459	2.5668	2.7177
Australia-Singapore	1.7134	1.7262	2.7274	2.5665
Hong Kong-Japan	0.0595	0.1406	2.7052	2.7873
Hong Kong-Singapore	1.6883	1.0116	2.3440	2.5593
Japan-Singapore	1.3441	1.3219	1.6353	1.6305
Panel D: 1993–2001				
Australia-Hong Kong	0.4515	0.2907	2.5783	2.9960
Australia-Japan	1.8460	2.3960	2.1567	2.7166
Australia-Singapore	1.7957	1.7956	3.7232*	3.6784*
Hong Kong-Japan	2.7244	2.3779	3.2568	3.1477
Hong Kong-Singapore	0.0001	1.9847	2.6224	2.7866
Japan-Singapore	2.7978	2.7584	2.8576	3.2690

Note: * indicates significance at a 10% level.

Table 4: Johansen Cointegration Tests

	Null	1975–2001		1975–1983		1984–1992		1993–2001	
		Trace	Max	Trace	Max	Trace	Max	Trace	Max
Panel A: Lag Length = 2									
Australia-Hong Kong	r = 1	1.374	1.374	1,470	1.470	0.578	0.578	0.193	0.193
	r = 0	10.567	9.193	8.309	6.838	7.638	7.060	6.254	6.061
Australia-Japan	r = 1	1.082	1.082	2.432	2.432	0.537	0.537	0.216	0.216
	r = 0	7.609	6.527	10.904	8.472	5.277	4.741	11.415	11.199
Australia-Singapore	r = 1	0.315	0.315	1.691	1.691	1.105	1.105	0.006	0.006
	r = 0	9.125	8.901	8.334	6.643	4.849	3.745	7.882	7.876
Hong Kong-Japan	r = 1	1.321	1.321	0.339	0.339	0.181	0.181	4.775	4.775
	r = 0	4.147	2.826	2.445	2.106	5.662	5.481	11.005	6.230
Hong Kong-Singapore	r = 1	3.354	3.354	2,949	2.949	0.332	0.332	2.709	2.709
	r = 0	13.709	10.354	8.267	5.318	2.837	2.504	12.842	10.134
Japan-Singapore	r = 1	3.086	3.086	0.298	0.298	5.555	5.555	3.055	3.055
	r = 0	6.632	3.545	2.661	2.363	16.387	10.833	10.114	7.059
Panel B: Lag Length = 4									
Australia-Hong Kong	r = 1	1.549	1.549	2.222	2.222	0.570	0.570	0.195	0.195
	r = 0	12.896	11.347	7.738	5.516	8.556	7.987	7.544	7.350
Australia-Japan	r = 1	1.097	1.097	1.630	1.630	1.052	1.052	0.276	0.276
	r = 0	7.769	6.672	10.726	9.095	6.163	5.111	12.985	12.709
Australia-Singapore	r = 1	0.465	0.465	2.500	2.500	1.319	1.319	0.001	0.001
	r = 0	9.730	9.265	9.414	6.914	5.047	3.728	8.600	8.599
Hong Kong-Japan	r = 1	1.854	1.854	0.252	0.252	0.300	0.300	5.353	5.353
	r = 0	4.896	3.042	2.564	2.312	5.501	5.201	12.867	7.515
Hong Kong-Singapore	r = 1	3.468	3.468	2.878	2.878	0.453	0.453	2.894	2.894
	r = 0	13.806	10.337	8.735	5.857	3.478	3.025	13.495	10.600
Japan-Singapore	r = 1	3.282	3.282	0.322	0.322	6.524	6.524	4.106	4.106
	r = 0	6.873	3.591	2.918	2.596	16.311	9.787	11.546	7.440

Panel C: Lag Length = 6									
Australia-Hong Kong	r = 1	1.780	1.780	1.985	1.985	0.606	0.606	0.220	0.220
	r = 0	13.560	11.780	6.312	4.327	7.068	6.461	7.534	7.314
Australia-Japan	r = 1	1.216	1.216	1.414	1.414	0.696	0.696	0.252	0.252
	r = 0	8.156	6.940	8.778	7.363	5.622	4.926	12.013	11.760
Australia-Singapore	r = 1	0.285	0.285	3.012	3.012	1.193	1.193	0.010	0.010
	r = 0	10.280	9.995	10.695	7.683	5.778	4.585	7.778	7.768
Hong Kong-Japan	r = 1	1.774	1.774	0.076	0.076	0.162	0.162	4.653	4.653
	r = 0	4.689	2.914	2.128	2.052	4.887	4.725	13.308	8.655
Hong Kong-Singapore	r = 1	3.726	3.726	2.797	2.797	0.171	0.171	2.079	2.079
	r = 0	12.899	9.173	7.695	4.898	4.157	3.986	13.657	11.578
Japan-Singapore	r = 1	3.150	3.150	0.128	0.128	5.180	5.180	3.009	3.009
	r = 0	6.742	3.592	2.976	2.848	15.281	10.101	11.262	8.253
Panel D: Lag Length = 8									
Australia-Hong Kong	r = 1	2.387	2.387	2.114	2.144	0.525	0.525	0.148	0.148
	r = 0	13.630	11.243	7.205	5.091	8.351	7.826	7.330	7.182
Australia-Japan	r = 1	1.586	1.586	2.629	2.629	0.361	0.361	0.139	0.139
	r = 0	9.138	7.552	7.397	4.769	5.858	5.497	11.740	11.601
Australia-Singapore	r = 1	0.655	0.655	2.610	2.610	1.755	1.755	0.019	0.019
	r = 0	10.482	9.828	12.003	9.393	6.735	4.979	8.364	8.344
Hong Kong-Japan	r = 1	1.779	1.779	0.010	0.010	0.017	0.017	4.511	4.511
	r = 0	4.697	2.918	2.238	2.227	4.732	4.715	14.586	10.075
Hong Kong-Singapore	r = 1	3.522	3.522	3.814	3.814	0.067	0.067	2..534	2.534
	r = 0	13.331	9.809	12.629	8.815	5.052	4.985	14.293	11.759
Japan-Singapore	r = 1	3.030	3.030	0.009	0.009	4.185	4.185	3.140	3.140
	r = 0	6.572	3.542	2.932	2.923	15.093	10.908	13.666	10.526

Note: * indicates significance at a 10% level and ** at a 5% level.

Significant results can also be interpreted in terms of the potential diversification opportunities. Evidence of cointegration can mean the reduction of diversification opportunities. In this study, cointegration implies that diversification opportunities do generally occur within Pacific-Rim real estate security markets. Few studies have specifically examined the diversification opportunities available in such markets in a mean-variance framework.

Stevenson (2000) examines the improvement in performance that results from the extension of a domestic real estate security portfolio in an international context. Ten countries were examined, including all of the Pacific-Rim markets analysed in the current study, with the exception of Hong Kong. In the case of Australia, no significant improvement occurred; however, for Japan and Singapore, significant results were obtained. It should be noted that as the overall sample in that study included North American and European markets, it can not stated that the improvement occurred due to investment in other Asian Pacific-Rim markets. In order to formally compare the results, we undertake a similar mean-variance portfolio analysis, using the Gibbons, Ross & Shanken (1989) F-test for performance improvement. Using each market as a base home market, we estimate optimal tangency portfolios for each period for the four markets. The Sharpe ratios of the tangency portfolio is then compared to that of the respective 'home' market.

The results are reported in Table 5 and support the cointegration findings. With the exception of Australia, and for one sub-period in Hong Kong, each market in each sub-period sees a statistically significant improvement in performance from extending their real estate security portfolio into other Pacific-Rim markets. The results are also consistent with Stevenson (2000), in that no significant findings were found in relation to Australia. The combination of these findings indicate that over longer horizons, significant diversification gains can be obtained by an investor diversifying a real estate security portfolio throughout the Asia Pacific-Rim region.

Table 5: Gibbons, Ross & Shanken Performance Improvement Tests

	1975–2001	1975–1983	1984–1992	1993–2001
Australia	1.2199	3.6794	3.3646	0.0822
Hong Kong	6.3283*	12.7368**	2.0341	8.8761*
Japan	9.1093*	13.8626**	7.7140*	9.6361*
Singapore	8.4579*	11.1016**	7.6868*	9.5720*

Note: Table 5 reports the results of Gibbons, Ross & Shanken (1989) performance improvement test.
* indicates statistical significance at a 10% and ** at a 5% level.

GRANGER CAUSALITY

The next section of the empirical analysis tests for causal relationships between the four markets in the first moment using Granger causality tests. The models used to test for causality are shown in Equations (1) and (2).

$$Y_t = \delta_0 + \sum_{i=1}^{m} \alpha_i X_{t-1} + \sum_{j=1}^{m} \beta_j Y_{t-j} + \gamma\varepsilon_{t-1} + \mu_t \quad (1)$$

$$X_t = c_0 + \sum_{i=1}^{m} a_i Y_{t-1} + \sum_{j=1}^{m} b_i X_{t-j} + d\varepsilon_{t-1} + e_t \quad (2)$$

The number of lags was determined as that which provides the minimum value of Akaike's Final Prediction Error. The results were run over the entire sample period and over each sub-period.

The results from the causality tests are reported in Table 6 and reveal marked differences between the results incorporating and excluding contemporaneous observations. When the same weeks returns are excluded from the analysis, only limited evidence of Granger causality is evident. A significant bi-directional relationship is found between Australia and Hong Kong for both the entire period, 1975–2001, and from 1984–1992. The only other significant finding is that Singapore Granger causes Hong Kong at a statistically significant level over the period 1984–1992. These results would also indicate that minimal linkages are present between the four markets, supporting the long-term analysis previously undertaken.

Table 6: Granger Causality Tests

	1975–2001	1975–1983	1984–1992	1993–2001
Panel A: Excluding Contemporaneous Observations				
Australia → Hong Kong	6.8065*	2.7279	8.0207*	0.9535
Hong Kong → Australia	7.4847*	1.5634	5.9537*	1.8712
Australia → Japan	1.9959	3.8336	2.7521	2.0051
Japan → Australia	1.0574	2.5422	0.7089	2.1697
Australia → Singapore	4.3116	3.5186	3.4312	0.6944
Singapore → Australia	2.9916	1.6329	0.5998	3.1938
Hong Kong → Japan	0.0935	1.3269	0.1180	0.4638
Japan → Hong Kong	0.9145	0.9325	0.6356	0.6836
Hong Kong → Singapore	2.7487	1.4981	0.8018	4.5343
Singapore → Hong Kong	3.2557	1.5453	6.1091*	0.2138
Japan → Singapore	1.4176	3.5628	0.7083	1.7490
Singapore → Japan	2.7045	2.4757	0.9703	3.7628

	1975–2001	1975–1983	1984–1992	1993–2001
Panel B: Including Contemporaneous Observations				
Australia → Hong Kong	33.1822***	8.2999*	24.3685**	6.0379*
Hong Kong → Australia	33.9009***	7.0899*	22.1054**	6.9927*
Australia → Japan	11.8017**	7.8317*	6.8211*	4.8429
Japan → Australia	10.8400**	6.5008*	4.7255	5.0063
Australia → Singapore	39.3171***	8.4199*	39.9759***	4.8374
Singapore → Australia	37.8864***	6.4712*	36.4905***	7.4094*
Hong Kong → Japan	10.9419**	3.0504	4.5548	5.7729*
Japan → Hong Kong	11.7968**	2.6469	5.0893	5.9944*
Hong Kong → Singapore	133.5558***	27.8372***	33.6184***	94.2173***
Singapore → Hong Kong	134.1961***	27.8830***	40.0519***	87.2224***
Japan → Singapore	14.8211**	4.4604	7.5366*	7.2942*
Singapore → Japan	16.1492**	3.3701	7.8101*	9.3883**

Note: * indicates significance at a 10% level, ** at a 5% level and *** at a 1% level.

The results displayed in Panel B, when contemporaneous observations are included in the analysis, see a considerable increase in the number of significant F-statistics. For the entire sample period, significant bi-directional relationships are observed for each market pairing. When the analysis is conducted on the sub-samples, two pairings show significant bi-directional causal relationships for each sub-period; namely, Australia & Hong Kong and Hong Kong & Singapore. In addition, for Australia & Singapore, significant results are reported in each case with the exception of Australia influencing Singapore in the final sub-period. Australia and Japan, see a bi-directional relationship for 1973–1983, while Australia significantly influences Japan for the following eight year period, 1984–1992. In the case of Hong Kong and Japan, no significant findings are observed in the first two sub-periods, as a significant bi-directional relationship is found for the period 1993–2001. While no significant findings are observed for the period 1975–1983 for Japan and Singapore, significant bi-directional results are obtained for the second and third time periods.

The results appear to suggest that Japan in some respects is the odd market out with considerably less evidence of co-movement with the other markets. While relatively consistent evidence of bi-directional relationships are observed for Australia, Hong Kong and Singapore, the results in relation to Japan would appear to indicate that the circumstances underlying the Japanese market is evident in the results. The period under study has seen a dramatic boom and bust cycle in the Japanese real estate market, together with considerable long-term financial and economic problems. In addition, the relative performance of the general Japanese equity markets should also be considered. Whilst this study is examining real estate securities, general stock market sentiment will be incorporated into property stock returns, thereby influencing the findings.

VOLATILITY SPILLOVERS

The final empirical section of the paper extends the analysis of Granger causality to examine short-term linkages in the second moment of the returns series. The analysis of volatility spillovers is assessed through the use of Autoregressive Conditional Heteroscedasticity (ARCH) based models, the principles of which were developed by Engle (1982). The basic ARCH model can be used to generate a series of changing volatility, essentially suggesting that large and small forecast errors have a tendency to occur in clusters. The Generalized (GARCH) form, proposed by Bollerslev (1986), allows for lagged variances and the further lagging of the error term. The GARCH form that is examined in this study is GARCH (1,1).

Due to many real estate securities being relatively small capitalization issues and often suffering from thin trading, we adapt the models using an Autoregressive Moving Average (ARMA) (1,1) model. Table 7 reports the base GARCH (1,1) model for each index over each of the four time periods. In general, the findings are in line with expectations. The constant in the mean equation is not significantly different from zero in the majority of cases. The only exceptions are for Australia for 1993–2001, Hong Kong for 1983–1992 and for both of these markets over the entire sample period.

Table 7: GARCH (1,1) Model

	A1	A2	MA1	C	Q	P
Panel A: 1975–2001						
Australia	0.0074***	-0.9923***	-0.9956***	0.0001***	0.0602***	0.8698***
Hong Kong	0.0030**	0.5065**	0.4192*	0.0001***	0.1676***	0.7886***
Japan	0.0001	-0.3671	-0.3198	0.0000*	0.0527***	0.9451***
Singapore	0.0001	0.8529***	0.7896***	0.0001***	0.1087***	0.8551***
Panel B: 1975–1983						
Australia	0.0016	0.6135	0.5993	0.0006**	0.1298	0.0000
Hong Kong	0.0014	0.6367***	0.5333**	0.0001*	0.2217***	0.7771***
Japan	0.0004	-0.9942***	-0.9873***	0.0002	0.1122	0.4922
Singapore	0.0007	-0.6356*	-0.6965**	0.0001*	0.1513***	0.8150***
Panel C: 1983–1992						
Australia	0.0023	0.3819	0.3133	0.0001**	0.0835*	0.8060***
Hong Kong	0.0150***	-0.6875**	-0.7425***	0.0003**	0.1452***	0.7116***
Japan	0.0023	-0.7885**	-0.8185***	0.0001*	0.1489***	0.7968***
Singapore	-0.0001	0.8180***	0.7451***	0.0002	0.0518	0.8463***
Panel D: 1993–2001						
Australia	0.0023*	0.0768	0.2012	0.0000	0.0296*	0.9576***
Hong Kong	0.0020	0.5601*	0.4703	0.0001	0.1082***	0.8608***
Japan	-0.0020	-0.3975	-0.2697	0.0000	0.0452*	-0.9557***
Singapore	0.0008	0.6667**	0.5831*	0.0001*	0.1440***	0.8412***

Note: Table 7 reports the results of the GARCH (1,1) model for each of the individual markets. A1 refers to the constant in the mean equation, A2 refers to the AR term, MA is the moving average term, C is the constant in the conditional variance equation, Q is the coefficient for the lagged squared residuals and P is the conditional variance coefficient.

For each of the markets, and over each time period, each of the remaining market's volatility is added to the conditional variance equation in order to examine for the presence of volatility spillovers. Table 8 reports the result for each market, with the results reported on both a contemporaneous and lagged basis. Unlike the analysis of linkages in the first moment, the volatility spillover tests provide little consistent evidence of spillovers. For the entire sample period, only three significant results are observed, with all three in relation to their influence on the Singapore market; these being contemporaneous Australian volatility and both contemporaneous and lagged Japanese volatility. In none of the three cases are the respective coefficients statistically significant in any of the sub-periods. The only other significant findings are in relation to Singapore's influence on Japan in the period 1993–2001 and for Japan's effect on Hong Kong in the first sub-period. This final coefficient does differ from the other significant results, in that the coefficient is significantly negative. This indicates that an increase in volatility in the securitised real estate market in Japan has a negative impact on the volatility in Hong Kong. The small number of significant findings is in contrast to much empirical work on volatility spillovers which have tended to find evidence of significant spillover effects. However, most of the existing work has primarily examined daily data. The use of weekly data in this study may aid in explaining the differences in the findings obtained[3].

[3] A earlier draft of the current study did examine daily data for the same four markets over the time period 1986-2000. While the majority of the spillover coefficients were statistically significant, there was evidence of mis-specification in the GARCH models.

Table 8: Volatility Spillover Tests with GARCH (1,1) Model

	1975–2001	1975–1983	1984–1992	1993–2001
Panel A: Australia				
Hong Kong	0.0012			
Contemporaneous		0.0026	0.0009	-0.0005
Hong Kong Lagged	0.0013	-0.0026	-0.0001	-0.0004
Japan Contemporaneous	0.0057	-0.0615	0.0067	0.0193
Japan Lagged	0.0014	0.0538	0.0068	0.0187
Singapore	0.0038			
Contemporaneous		0.1002	0.1286	0.0047
Singapore Lagged	0.0042	0.0770	0.1985	0.0050
Panel B: Hong Kong				
Australia	-0.1132			
Contemporaneous		0.2628	0.2144	1.2432
Australia Lagged	0.6609	0.7410	0.6445	0.8423
Japan Contemporaneous	0.0014	-0.2956**	0.0077	0.0384
Japan Lagged	0.0012	-0.1306	0.0036	0.0369
Singapore	0.0521			
Contemporaneous		0.1553	0.0931	0.0620
Singapore Lagged	0.0466	0.1527	0.0764	0.0628
Panel C: Japan				
Australia	-0.0027			
Contemporaneous		0.0071	-0.0096	0.4921
Australia Lagged	0.2984	0.6405	0.2981	1.0072
Hong Kong	-0.0029			
Contemporaneous		0.0055	-0.0100	0.5730
Hong Kong Lagged	-0.0033	0.0031	-0.0109	0.4946
Singapore	-0.0006			
Contemporaneous		0.0065	0.0611	0.4015*
Singapore Lagged	-0.0011	0.0127	0.0572	0.3859
Panel D: Singapore				
Australia	0.0284*			
Contemporaneous		-0.1184	0.0375	1.9615
Australia Lagged	0.4981	0.7207	0.4247	0.4450
Hong Kong	0.0053			
Contemporaneous		0.0232	-0.0045	0.0312
Hong Kong Lagged	0.0004	0.0116	-0.0079	0.0056
Japan Contemporaneous	0.0291*	-0.1325	0.0362	0.0472
Japan Lagged	0.0311*	-0.1276	0.0373	0.0573

Note: Table 8 reports the results of the GARCH (1,1) with volatility spillovers. The coefficient reported is that for the appropriate exogenous variable.

CONCLUSION

This study has examined the linkages between the four largest securitised real estate markets in the Asia Pacific-Rim region. The analysis examines the relationships on both a short and long term basis. The long-term analysis, based on cointegration and portfolio benefits, finds little evidence of common long-term trends, indicating the potential for diversification benefits. These results are supported by the portfolio analysis, which finds with the exception of Australia, significant improvements in portfolio performance can be obtained by an investor diversifying out of an all-domestic portfolio into an internationally diversified portfolio in the Asia Pacific-Rim region. The short-term analysis examines linkages in both the first and second moment of the return series using Granger Causality and GARCH models respectively. The results generally concur with the long-term tests, finding little evidence of co-movement or influence between the markets on a bivariate basis. The primary exception occurs when contemporaneous observations are incorporated into the causality tests. In this case, with the exception of Japan, consistent evidence is found of bilateral causal relationships between Australia, Hong Kong and Singapore. The results therefore provide evidence that investors would benefit from diversifying real estate security portfolios internationally within the Pacific-Rim on both a short and long term basis.

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