Are Equity Markets Interdependent?
Evidence from Australia and the Three Little Dragons

Eduardo D. Roca and E. Antony Selvanathan*

Abstract

This paper provides further evidence on the issue of financial market integration. It analyses price linkages between the equity market of Australia and those of Hong Kong, Singapore and Taiwan using cointegration, Granger-causality, variance decomposition and impulse response analyses based on MSCI database covering the period 1975-1995. The results show that the Australian market is not significantly linked with any of these markets. The three little dragons therefore can serve as good avenues for portfolio diversification by Australian investors.

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Abstract

This paper provides further evidence on the issue of financial market integration. It analyses price linkages between the equity market of Australia and those of Hong Kong, Singapore and Taiwan using cointegration, Granger-causality, variance decomposition and impulse response analyses based on MSCI database covering the period 1975-1995. The results show that the Australian market is not significantly linked with any of these markets. The three little dragons therefore can serve as good avenues for portfolio diversification by Australian investors.
1. Introduction

This study examines the issue of financial market integration – an issue that has great theoretical, practical and policy significance, yet one that remains unresolved in the literature. Major models in economics, e.g. Mundell-Fleming (see Shepherd 1994), and finance, e.g. portfolio diversification (see Markowitz, 1959; Lintner, 1965; and Sharpe, 1964), depend on this issue. Based on portfolio diversification theory, it is important that investors are aware of the extent of financial integration between markets. If equity markets are less than fully integrated, the benefits of portfolio diversification exist. From a policy perspective, if equity market prices are found to be closely-linked, there is a danger that shocks in one market may spill-over to other markets (the so-called “contagion effect”- see King and Wadhwani, 1990). Hence, this may require closer co-operation between the prudential and monetary regulators in these markets if these effects are to be avoided or minimised.

Massive progress in information and communication processing technology and very substantial financial deregulation have occurred in financial markets over the last 30 years (Honeygold, 1989). Hence, it is claimed that financial markets have become integrated. The stock market crash of 1987 which was felt in markets worldwide is being cited as a clear evidence of this interdependence between national financial markets (see, for instance, Hamao, et. al., 1991, and King and Wadwhani, 1990). The Asian financial and economic crisis is often also cited in the popular press as another evidence of the financial integration between markets. The issue of financial market integration in general, and equity market integration in particular, is, however, far from being settled in the literature. Investigations done on the issue have failed to reach a
common conclusion. The results of previous studies vary according to the data, methodology, and theoretical models used. This research project aims to make a contribution to the resolution of this issue.

In particular, this paper investigates the extent and structure of price interdependence between the equity markets of Australia and that of Hong Kong, Singapore and Taiwan. The latter three countries, popularly referred to as the “three little dragons” are among those with the most dynamic economies not only in Asia but also in the whole world. Among Asian countries, these three little dragons have been the least affected by the on-going economic crisis in the region. As a group, they represent the third largest trading partner of Australia (DFAT, 1992). A significant amount of investment interaction also occur between Australia and these three little dragons as can be gleaned from the presence of Australian companies in these three countries and vice-versa (ibid). Thus, a significant amount of financial flow take place between Australia and these three countries. From the point of view of Australian investors who seek portfolio diversification in these economies, it is important therefore to find out the extent of interdependence between Australia and these three countries. It is well-established in modern portfolio theory that greater diversification benefits exist the less correlated the markets are.

There is a significant number of studies on equity market interdependence and/or integration. However, most of these studies focus on the developed markets. A few studies include in their investigation the markets of Australia, Hong Kong, Taiwan and Singapore (see for instance, Masih and Masih, 1997; Chowdhury, 1994; Kwan, et. al., 1995; Kwok, 1995), but to the best of our knowledge, no study focuses specifically on Australia’s equity market interaction with the three little dragons. The present study seeks to address this gap. It investigates price interdependence between the equity markets of Australia and that of Hong Kong, Singapore, and
Taiwan with the use of cointegration and error correction models (ECM), Granger-causality, variance decomposition (VDC) and impulse response (IR) analyses. These approaches represent recent developments in time series econometrics which allow the present study to simultaneously study both the long-run and short-run aspects of market linkages and to investigate the structure of these linkages, in terms of the speed and persistence of the interaction between markets. It is well-known that the cointegration approach avoids the loss of valuable long-term information as it allows the analyses to be done without the need to difference the variables for the purpose of achieving stationarity. Granger causality, VDC and IR enable us to investigate in detail the short-term interaction between the markets while the ECM enables us to trace the adjustment of markets from the short-term to the long-term. Thus, this study provides robust results which can further shed light on the issue of integration between financial markets.

Inspite of the significant trade and investment linkages between Australia and these three little dragons, the study finds no significant linkage, both in the short-term and in the long-term, between the equity market prices of Australia and these three countries. Thus, these three markets can serve as good avenues for portfolio diversification by Australian investors.

2. Methodology

The econometric analyses are conducted in the following sequence: (a) unit root test, (b) test of lag length, (c) test for cointegration, (d) error correction model construction, (e) Granger-causality test, and (f) VDC and IR analyses. A cointegration test is conducted first since the results from cointegration serve as inputs to the conduct of the Granger-causality test. The cointegration test, therefore, also serves as a diagnostic test for the Granger-causality test. If cointegration is found, the Granger-causality, variance decomposition and impulse response analyses must be done based on error-correction models. If no cointegration is found, then the analyses will be based on the regression of the first differences of the variables using a standard
VAR model. However, before cointegration can be done, the variables have to be tested for stationarity and optimum lags have to be determined. The IR analyses are conducted on the markets which are found from the Granger-causality test to be significantly linked.

3. Data

Data on the markets being investigated are obtained from Morgan Stanley Capital International (MSCI) as this is highly-regarded in the finance literature for its comparability and avoidance of dual-listing. The MSCI indices for different markets are computed using the same formula which is value weighted and are therefore comparable. The study uses weekly data. The use of weekly data avoids some of the problems associated with daily and monthly data. Daily data is deemed to contain “too much noise” (Bailey and Stulz, 1990) and is affected by the day-of-the-week effect while monthly data is also affected by the month-of-the-year effect. Weekly data from January 2, 1988 to December 8, 1995 are collected for Australia, Hong Kong, Singapore, Taiwan and the US. Although this study focuses on Australia and the three little dragons, the US is included as this market is well-recognised as an international factor that drives world stock markets (Eun and Shim, 1989; Cheung and Mak, 1992). Not including the US would result in spurious results, as found by Espitia and Santamaria (1994).

Calculations for the unit root test were done in SHAZAM (1993). All other calculations were conducted in RATS (Doan, 1992 and 1995).

4. Empirical Results

This section applies the techniques of cointegration, Granger causality, forecast variance decomposition and impulse response analyses to test the degree and structure of relationship
between the equity market prices of Australia and the three little dragons. Given the close economic linkages between Australia and these three countries, and the fact that their equity markets are quite similar in size, it is expected that the equity market prices between the former and latter markets will be significantly linked.

Unit Root Test Results

Both the Augmented Dickey-Fuller or ADF (Dickey and Fuller, 1981; Said and Dickey, 1984) and Phillips and Perron (1988) or PP tests were performed using the SHAZAM software. The results are given in Table 1. As can be seen for each market, the null hypothesis of the existence of unit roots was not rejected at the level form of the data but was accepted at the first-difference form, by both the ADF and PP tests. Each data series in the first difference is stationary and hence are integrated of order 1 or I(1).

Determining the Optimum Lag Length Results

The optimum number of lags to be used in the VAR models is determined using the likelihood ratio test (Sims, 1980). We test the null hypothesis of the number of lags being equal to k-1 against the alternative hypothesis that the number of lags is k (= 2, 3, ...). Some studies (Eun and Shim, 1989; Espitia and Santamaria, 1994) have found that information from one national market spill-over to other national markets within a period of one week. Hence, lags of 1 vs. 2 are first tested (H₀ : k = 1 vs. H₁ : k = 2). If the null hypothesis is rejected, the test continues by testing the next higher lags. The estimation is done using the RATS econometric program (Doan, 1992 & 1995). For the test pertaining to lags of 1 vs. 2 (H₀ : k = 1 vs. H₁ : k = 2), a chi-square value
of 23.41 with a p-value of 0.55 was obtained. Thus, the null hypothesis cannot be rejected which means that the optimum lag length is 1.

Cointegration Test Results

Since the unit root test results show that each of the data series is I(1), the cointegration test based on the Johansen (1988) procedure is conducted using the RATS econometric software. The trace statistics are calculated to test the null hypothesis of \( r = 0 \) (no cointegration), versus the alternative hypothesis of \( r > 0 \) (cointegration) where \( r \) is the number of cointegrating vectors which can be more than 1 and can go up to \( n - 1 \). The computed trace statistic corresponding to \( r = 0 \) is 2.22. Since, the critical value of the trace statistic is 71.47, as shown in Table A.3, p. 209 of Johansen and Juselius (1990), the null hypothesis cannot be rejected. Thus, Australia and the three little dragon markets are not cointegrated. This means that there is no significant long-term price linkage between the equity markets of Australia and that of Hong Kong, Singapore, and Taiwan.

Granger Causality Test Results

Since no cointegration exists between the different time series, the Granger causality test was performed with variables in first difference form. For a particular market, the equation used is:

\[
\Delta Y_t = \sum_{j=1}^{3} b_j \Delta X_{jt-1} + c\Delta Y_{t-1} + u_{t-1}
\]

For example, for \( Y = \) Australia; \( X_1 = \) Hong Kong; \( X_2 = \) Singapore; and \( X_3 = \) Taiwan, with the use of the RATS software (Doan, 1992 & 1995), F-statistic is calculated to test the null hypothesis that a specific \( X_j \) does not affect \( Y \) (\( H_0 : b_j = 0 \)), against the alternative hypothesis that \( X_j \) does affect \( Y \) (\( H_0 : b_j \neq 0 \)). The test is conducted for each market within a VAR
framework. The results for Australia against the other 3 countries are presented in column 2 of Table 2. The results showing the impact of Australia on the other 3 countries are shown in Column 3 of the same Table. None of the numbers is significant, hence, there is no significant short-term relationship between Australia and the three little dragons in the Granger-sense.

[INSERT TABLE 2 HERE]

Forecast Variance Decomposition and Impulse Response Analyses Results

The forecast variance decomposition analysis (see Eun and Shim, 1989) was also performed using RATS and the results of the analyses are presented in Table 3. Since the VDC is sensitive to the ordering of variables in the VAR equation, the analyses was conducted based on three different ordering of variables in order to determine whether the results obtained are robust. A particular result is accepted only if this result is consistently obtained from the different ordering of the variables. The results presented in columns 2 to 7 of Table 3 corresponds to a certain ordering of variables indicated in the footnote of the Table.

[INSERT TABLE 3 HERE]

The forecast variance decomposition (VDC) analysis shows the proportion of the changes in price in a particular equity market arising out of random shocks that can be attributed to random shocks coming from each market. This can therefore show how influential other markets are on Australia and vice versa. Australia’s influence on each market can be seen by the numbers in Column 1 (when the ordering of variables is Australia, Hong Kong, Singapore, Taiwan, and US); in Column 2 (US, Australia, Hong Kong, Singapore, and Taiwan); and in Column 3 (US, Hong Kong, Singapore, Taiwan, and Australia). For example, according to entries in Column 1 (when the ordering of the variables is Australia, Hong Kong, Singapore, and Taiwan, and the US), Australia accounts for 97.47% of its own forecast variance, 9.11% of the Hong Kong forecast variance,
6.96% of the Singapore forecast variance, and 0.83% of the Taiwan forecast variance. Comparing these with the entries in Columns 2 and 3, we can see that Australia's influence on each market varies considerably when the ordering of the variables are changed.

The influence of each market on Australia is indicated by the VDC results shown in the last three columns. The entries in these 3 columns are for different ordering of the variables mentioned above. For example, the entries in Column 5 indicate that 97.47% of the forecast variance of Australia is due to itself, 0.09% is due to Hong Kong, 0.002% is due to Singapore, and 0.08% is due to Taiwan when the ordering of the variables is Australia, Hong Kong, Singapore, Taiwan and the US. However, when the ordering of variables is changed, the percentages change considerably, as seen in Columns 6 and 7.

Hence, the results in Table 3 show that the forecast variance decomposition for each market is not consistent. The percentage of forecast variance varies depending on the ordering of the variable. This confirms the results from the Granger causality test – that there is no significant short-term interaction between the equity markets of Australia and the three little dragons inspite of the significant economic interaction between the former and the latter. As there is no significant interaction between Australia and any of the three markets, the impulse response analysis is no longer conducted.

5. Conclusion

The empirical results of our analysis show that there is no significant short-term and long-term linkage between the equity markets of Australia and that of Hong Kong, Singapore, and Taiwan.
Thus, from the point of view of Australian investors, the three little dragons can serve as good avenues for portfolio diversification. The lack of cointegration and the absence of Granger-causality between the Australian market and those of the three little dragons can also imply market efficiency as prices in the three little dragons markets cannot be predicted using past prices in Australia, and vice-versa.
Endnotes

1 For studies that claim that markets are integrated, see for instance, Agmon, 1972; Ripley, 1973; Hillard, 1979; Ibbotson, et. al., 1982; Jaffe and Westerfield, 1985; Schollhammer and Sand, 1987; Wheatley, 1988; Hamao, et. al., 1990; Espitia and Santamaria, 1994, among others; for those that claim the opposite, see, Grubel, 1968; Makridakis and Wheelwright, 1974; Adler and Dumas, 1983; Jorion and Schwartz, 1986; Levy and Lerman, 1988; Dwyer and Hafer, 1988; Jorion, 1989; Smith, et. al., 1995, among others.
References


Table 1
Unit Root Test Results
(\( H_0 \): unit root \ vs. \( H_A \): no unit root)

<table>
<thead>
<tr>
<th>Market</th>
<th>ADF Test Results*</th>
<th>PP Test Results*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Level</td>
<td>First Difference</td>
</tr>
<tr>
<td>Australia</td>
<td>-2.5992</td>
<td>-4.7480</td>
</tr>
<tr>
<td>Hong Kong</td>
<td>-2.3782</td>
<td>-5.4428</td>
</tr>
<tr>
<td>Singapore</td>
<td>-1.7603</td>
<td>-4.5578</td>
</tr>
<tr>
<td>Taiwan</td>
<td>-2.7261</td>
<td>-4.9093</td>
</tr>
<tr>
<td>US</td>
<td>-1.4220</td>
<td>-4.8324</td>
</tr>
</tbody>
</table>

*critical value (5% level): -3.13

Table 2
Granger Causality: F-Test Results
(p value in parenthesis)

<table>
<thead>
<tr>
<th>Market</th>
<th>As Dependent Variable</th>
<th>As Explanatory Variable</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1) As Dependent Variable (2) As Explanatory Variable</td>
<td></td>
</tr>
<tr>
<td>Hong Kong</td>
<td>0.26 (0.61)</td>
<td>0.24 (0.63)</td>
</tr>
<tr>
<td>Singapore</td>
<td>0.32 (0.57)</td>
<td>0.93 (0.33)</td>
</tr>
<tr>
<td>Taiwan</td>
<td>0.12 (0.73)</td>
<td>0.59 (0.44)</td>
</tr>
</tbody>
</table>

Table 3
Forecast Variance Decomposition Analyses
(4-week time horizon)

<table>
<thead>
<tr>
<th>Market</th>
<th>% of Forecast Variance of Each Market Due to Australia</th>
<th>% of Forecast Variance of Australia Due to Each Market</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(2)**</td>
<td>(3)**</td>
</tr>
<tr>
<td>Australia</td>
<td>97.47</td>
<td>91.56</td>
</tr>
<tr>
<td>Hong Kong</td>
<td>9.11</td>
<td>6.99</td>
</tr>
<tr>
<td>Singapore</td>
<td>6.96</td>
<td>4.08</td>
</tr>
<tr>
<td>Taiwan</td>
<td>0.83</td>
<td>0.93</td>
</tr>
</tbody>
</table>

* order of variables: Australia, Hong Kong, Singapore, Taiwan, US
** order of variables: US, Australia, Hong Kong, Singapore, Taiwan
*** order of variables: US, Hong Kong, Singapore, Taiwan, Australia