AN ECONOMETRIC ANALYSIS ON THE RELATIONSHIP BETWEEN BILATERAL TRADE LINKS AND GRANGER CAUSALITY: THE CASE OF AUSTRALIA AND KEY BILATERAL TRADE PARTNERS

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Abstract
The incidence of global and regional financial crisis has caused analysts to re-examine existing economic policies and tools. There is a growing need for adaptive policies and tools that help economists to anticipate or recognize the early signs of a crisis and the potential for contagion of financial crisis from other countries. An issue of concern is how trade and financial links could prove detrimental to a country's economic development –linkages seem to facilitate the transmission of crisis across borders. The negative impact of a crisis is often reflected in market indexes. This study explores the relationship between bilateral trade links and financial contagion in financial markets with particular emphasis on Australia. Monthly data from July 1997 to June 2013 was obtained from Yahoo Finance for the composite stock market indexes of Australia and six bilateral trade partners; China, United States, Korea, Japan, Singapore and United Kingdom. Using Eviews7 software, this study explored the relationship between stock indexes for the seven countries via co-integration and pairwise Granger Causality (GC) tests. Findings show that returns in the Australia are co-integrated with returns of the other six countries. Since GC tests are affected by the variation in lag-length, this study explained how it overcame shortcomings of commonly used lag selection criteria. Results indicate that, out of the six countries, only past values of returns on the Chinese stock index can be used to predict current values of the Australian stock index. Thus, Australian policy makers should consider the impact of the Chinese stock market on the Australian stock market. However, bilateral trade links are not the only factor responsible for the occurrence of financial contagion and more research is needed to understand the complex nature of how and why financial crisis spread as and in the manner they do.

Key words: Financial contagion, Australia, stock market, bilateral trade, financial crisis

1.0 Introduction
Understanding the factors that lead to contagion of a financial crisis from one country to another is a topic of considerable interest for financial researchers. There are diverging views as to why financial crisis spread in the manner they do and why some countries are vulnerable to financial crises while others appear immune to financial difficulties experienced by neighbouring countries despite having close association with the affected country. Academics disagree on whether cross border transmission of a crisis is caused by either financial links and/or trade links. On one hand, Kaminsky and Reinhart (2000) define contagion as the process by which "financial difficulties spread from one economy to another in the same region and beyond" via trade and financial linkages (p. 51). On the other hand, Caramazza *et al*. (2004) argue that it is difficult to determine if contagion experienced at the regional level is due mostly to financial links or trade links because countries tend to concurrently establish regional trade agreements and the interbank linkages needed to facilitate the associated trade. Nevertheless, these authors agree that linkages play a role in the transmission of financial crisis. Therefore, it is important for policy makers to consider the role that both linkages play in the development and spread of financial crises. By examining past episodes of financial crises policy makers would know how to prevent similar crises from recurring in future. Moreover, empirical studies on linkages could help develop early warning indicators that facilitate timely intervention to forestall or ameliorate future crises. This empirical study is motivated by this school of thought and seeks to examine the role that one type of inter-country linkages plays in the spread of financial crises.

My study focuses on the notion that trade linkages can be used to explain the manner in which financial crises spread from one country to another. In particular, I hypothesize that a country is more likely to experience contagion of a crisis from a country that it has more extensive trade links with. The empirical analysis shall focus on Australia and its top six bilateral trading partners. By examining the movements in the equity markets of Australia and the six key trading partners, I hope to shed some light on the extent to which Australia's trade relationships influence the movements in Australia's equity market.

2.0 Literature Review

2.1 The Role of Policy Makers during a Financial Crisis

In the aftermath of a financial crisis, researchers focus on understanding the cause of a crisis and the factors that led to the spread of a financial crisis from one country to another, with some studies blaming regulatory authorities for failure to act in a timely manner or creating an environment for a crisis to develop. A common view is that timely intervention would have minimized losses suffered by investors in financial markets during a crisis. There is some credence to this argument, especially in the case of the 2007-2009 Global Financial Crisis (GFC). Generally, some level of information asymmetry exists in a financial market especially since investors in the financial market have access to different sets of information that limits some investors' ability to properly differentiate between profitable and non-profitable securities (Mishkin, 1999). Nonetheless, the degree of information asymmetry is worse when sellers of securities are dishonest about the true riskness of a security and manage to sell a high-risk security at the same price as a low risk security (Akerlof, 1970). This makes it difficult for buyers of securities to establish the true worth of the security. For example, during the GFC credit rating agencies such as Moody's provided favourable ratings to high-risk Mortgage Backed Securities (MBS) implying that these were low-risk investments. Investors based investment decisions on these inaccurate assessments of risk and eventually suffered financial losses when it was discovered that the MBS's were actually 'toxic'. Edgar (2009) argues that a lack of accountability on the part of the regulatory authorities may have created a toxic environment where regulators could make decisions aimed at self-preservation as opposed to furthering the common good of society or the financial institutions. Nonetheless, the regulators are not entirely to blame. Investors' overreliance on the credit assessment by the rating authorities and extension of mortgage loans to individuals who were unable to pay off the debt also contributed to the development of the crisis.

It is important to note that regulation and policy implementation may prove inadequate in combating pre-existing systemic problems. Dabrowski (2010) points out that, during the GFC, even though policy response was delayed and poorly co-ordinated, systemic weaknesses were prevalent in European banks that were overleveraged. Regulators could address future vulnerability of the European financial sector to contagion of a financial crisis by not only improving regulation of financial institutions but also undertaking timely policy implementation.

In the absence of systemic weaknesses, adaptive policies could help to minimise the effects of a crisis on an economy. For example, strict regulation and supervisory practices by the Australian Prudential Regulation Authority's (APRA) is a major reason why Australian banks fared well compared to banks in other developed countries during the GFC (Pais and Stork, 2011). Edwards (2010) argues that unlike the United States and the United Kingdom, Australian financial institutions had not exposed themselves to the similar levels of risk. Specifically, there only existed non-conforming loans in the Australian market that were less risky than subprime mortgages, and even if lenders had riskier loans, they bore the risk of default instead of passing it on to investors. Besides, it would appear that Australia was lucky in that since 2003 it had been enjoying an mining boom mainly driven by China's increased demand for coal and iron ore (Sykes, 2010). This boom may have reduced the impact of the GFC on the Australian economy, but it did not make Australia immune to the contagion of the crisis. While this mining boom continues to date, there is speculation that it will soon end and that Australia may not recover as quickly from future episodes of crises. In light of this, it would be prudent for Australia to consider the potential for future contagion of financial difficulties experienced by its key trading partners.

2.2 Australia and Bilateral Trade

Australia is an open economy that engages in trade agreements based on shared political and economic interests. According to the Department of Foreign Affairs and Trade, Australia's top six bilateral trading partners in 2011 were China, Japan, the United States (US), Korea, Singapore and the United Kingdom (UK), in that particular order(DFAT, 2012). Mining plays an important role in Australia's economy with minerals being Australia's key export. In 2012 Australia's leading bilateral trader China imported 53,459 million dollars' worth of minerals mainly consisting of iron ores (approximately 72% of all minerals imported), coal, gold and petroleum. Imports from China included electronics, clothing and furniture which accounted for 15,073 million dollars (DFAT, 2013a). China and Australia's also share common interests that extend beyond the trade an collaborate on matters such as regional security, climate change and political concerns (ABS, 2012). Australia's second bilateral trader in 2012 was Japan, which imported coal, iron and copper worth 25,534 million dollars' and exported vehicles, engineering equipment and petrol worth 10,332 million dollars (DFAT, 2013b). Collaborations on security matters include in the 2007 Joint Declaration on Security Co-operation (ABS, 2012). Unlike other countries that mainly import minerals, US imports agricultural products such as beef and alcoholic beverages. The US, ranks third as a bilateral trading partner, has had a free trade agreement with Australia since 2005-the Australia-United States Free Trade Agreement (AUSFTA). In 2012 exports and imports to the US amounted to 39,947 million dollars (DFAT, 2013c). In 2011, the republic of Korea and United Kingdom were ranked as Australia's fourth and sixth with bilateral trade in goods and services amounting to approximately 32.7 billion dollars and 23 billion dollars respectively. Data that is more recently available shows that Korea maintained this ranking in 2012 while the UK slipped to the 10th position as bilateral trader. Singapore, the fifth bilateral trader is also Australia's "largest trade and investment partner in Association of South East Asian Nations"… and has the second oldest free trade arrangement in effect- the Singapore-Australia Free Trade Agreement (SAFTA) DFAT (2012: 196).

3.0 Data and Methods

3.1 Data

Monthly data for closing prices of the All Ordinaries (Australia), Hang Seng (China), S&P500 (United States), Kospi (Korea), Nikkei 225 (Japan), Straits Time (Singapore) and FTSE 100 (United Kingdom) stock indexes were obtained from the Yahoo finance website. The dataset for each stock index ranges from July 2007 to June 2013 and consists of 192 observations. All stock time series are transformed to the natural logarithmic form and the summary statistics of the transformed indexes are contained in table 1. Statistical analysis is performed using the Eviews7 econometric package.

Table 1: Descriptive statistics for stock and trade weighted indexes

	Australia	China	Japan	Korea	Singapore	United Kingdom	United States
Mean	8.263	9.645	9.414	6.951	7.685	8.590	7.084
Median	8.280	9.642	9.367	6.952	7.675	8.630	7.106
Maximum	8.822	10.353	9.920	7.693	8.244	8.844	7.397
Minimum	7.810	8.892	8.932	5.697	6.753	8.180	6.600
Std. Dev.	0.253	0.318	0.257	0.515	0.316	0.151	0.164

3.2 Methodology

The main objective of this study was to explore causality relationships between stock indexes of Australia and its key trading partners. This section discusses the Granger causality procedure used in this study and briefly highlights the empirical tests required prior to conducting Granger causality tests.

The concept of Granger causality was first introduced by Granger (1969) who argued that Granger Causality occurs when past values of one series (A_t) can be used to predict the current value of another series (B_t). A_t is said to Granger cause B_t if it contains information that can be used to predict series B_t and vice versa. The nature of causality may be unidirectional or bidirectional. Unidirectional causality occurs when A_t Granger causes B_t but B_t does not Granger cause A_t. Bi-directional causality occurs when A_t Granger causes B_t and B_t Granger causes A_t; in other words the two variables are interdependent. Investigation of Granger causality relationships between economic or financial variables can form the basis for risk management. For instance, a study on causal relationships between world oil and agricultural commodity prices could reveal that causal relationships exist. If this is the case, importers and exporters of either commodity could hedge against anticipated fluctuation in prices of either commodity by using forward or future contracts.

Granger causality tests check for existence of short-run causal relationships between two series using bivariate vector autoregressive (VAR) models. The structure of bivariate VAR models is formulated based on the properties of the individual series and the co-integrative relationship between the two series of interest. A condition of the standard Granger causality tests is that the series must be stationary. Hence, the first step in any Granger causality testing procedure is to check whether a stock index series is stationary. A stationary series has mean reverting tendencies and contains no unit root while a non-stationary series follows a random walk and contains a unit root. I shall use the standard Augmented Dickey Fuller (ADF) tests developed by

Dickey and Fuller (1979) to check for the presence of a unit root. If a unit root exists, it is common practice to transform non-stationary series into a stationary form by differencing a series a certain number of times until a stationary series is achieved. A series that is stationary after getting the dth difference it is said to be integrated of order d (I(d)) (Engle and Granger, 1987).

The second step of Granger causality testing involves checking whether variables are co-integrated. I consider the use of two widely accepted co-integration tests, the Engle and Granger (1987) technique and the Johansen framework (Johansen, 1988; Johansen, 1991) and present the arguments in support of the use of one test over another. It important to consider whether a co-integration relationship exists since Granger causality tests are performed using regression models. The use of non-stationary variables that are integrated of the same order and yet are not co-integrated could result in spurious causality regressions (Dakurah and Sampath, 2001). Granger and Newbold (1974) state that such spurious relationships are characterized by high R-squared statistics and low Durbin Watson values.

The Granger Causality tests are set up based on the results of the unit root and co-integration tests. Granger (1969) recommends that when two series are level stationary (meaning they are integrated of order zero I(0), the Granger causality relationship can be tested using the bivariate vector autoregressive (VAR) model in equation (1) and (2).

$A_t = \alpha_0 + \sum_{i=1}^{k} \alpha_{1i} A_{t-i} + \sum_{i=1}^{k} \alpha_{2i} B_{t-i} + \varepsilon_{1t}$……………………………………………………………Eqn (1)
$B_t = \beta_0 + \sum_{i=1}^{k} \beta_{1i} A_{t-i} + \sum_{i=1}^{k} \beta_{2i} B_{t-i} + \varepsilon_{2t}$……………………………………………………………Eqn (2)

Where A_t and B_t represent logged stock indexes at the level, A_{t-i} and B_{t-i} are the i-th lagged coefficients of stock index A_t and B_t respectively, α_0 and β_0 are the constant terms and ε_{1t} and ε_{2t} are the error terms of the estimated VAR models. I can conclude that B_t Granger causes A_t if any α_{2i} is not equal to zero and A_t Granger causes B_t if any β_{1i} is not equal to zero. Thus, if all α_{2i} and β_{1i} are equal to zero no causal relationship exists between A_t and B_t.

According to Granger et al. (2000), if two series are not stationary and are not co-integrated, the bivariate VAR model for Granger causality test should be specified using the differenced form of the series as shown in equations (3) and (4), where Δ is the first difference operator for the logged time series.
$\Delta A_t = \alpha_0 + \sum_{i=1}^{k} \alpha_{1i} \Delta A_{t-i} + \sum_{i=1}^{k} \alpha_{2i} \Delta B_{t-i} + \varepsilon_{1t}$…………………………………………………Eqn (3)
$\Delta B_t = \beta_0 + \sum_{i=1}^{k} \beta_{1i} \Delta A_{1t-i} + \sum_{i=1}^{k} \beta_{2i} \Delta B_{t-i} + \varepsilon_{2t}$ …………………………………………………Eqn (4)
Furthermore, if two variables are non-stationary at the level yet co-integrated, Engle and Granger (1987) recommend the inclusion of an error correction term (ECT) to equation (3) and (4) to avoid model misspecification. The resultant error correction model (ECM) is as shown in equation (5) and (6), where α_{3i} and β_{3i} are the coefficients for the error correction term for series A_t and B_t respectively. $ECT_{A,t-1}$ and $ECT_{B,t-1}$ are the lagged error correction terms for equation (5) and (6) respectively.
$\Delta A_t = \alpha_0 + \sum_{i=1}^{k} \alpha_{1i} \Delta A_{t-i} + \sum_{i=1}^{k} \alpha_{2i} \Delta B_{t-i} + \alpha_{3i} ECT_{A,t-1} + \varepsilon_{1t}$………………………………………Eqn (5)
$\Delta B_t = \beta_0 + \sum_{i=1}^{k} \beta_{1i} \Delta A_{t-i} + \sum_{i=1}^{k} \beta_{2i} \Delta B_{t-i} + \beta_{3i} ECT_{B,t-1} + \varepsilon_{2t}$………………………………………Eqn (6)

3.0 Results

3.1 Unit Root Tests

A starting point of econometric analysis is to inspect the univariate characteristics of the stock indexes. Graphical representations of the logged stock indexes in Figure 1 indicate that the series are non-stationary.

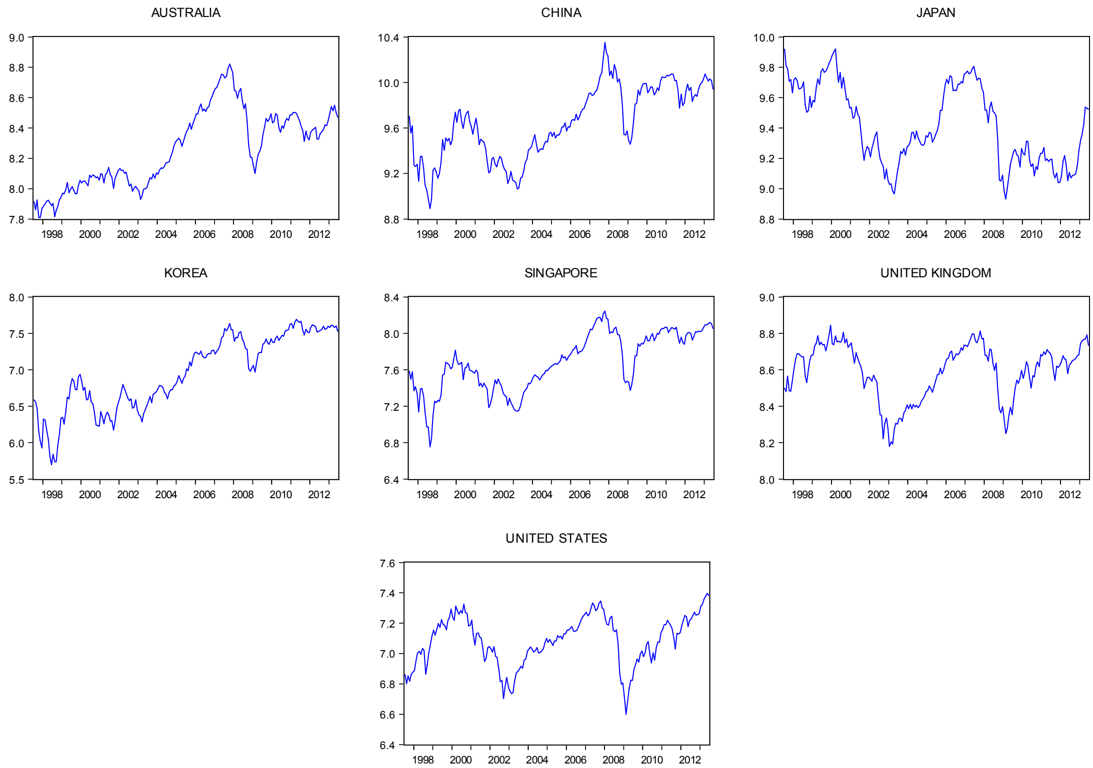

Figure 1: The logged stock indexes for all countries from 1997 to 2013

I checked each series stationary properties using the standard Augmented Dickey Fuller (ADF) tests developed by Dickey and Fuller (1979). As mentioned earlier non-stationary series can be differenced a certain number of times in order to achieve stationary series.

The ADF tests the null hypothesis that a series contains a unit root. The mathematical expressions for testing the null hypothesis as show in equation (7) and (8). Equation (7) has a constant and no trend while equation (8) has a constant and a trend term.

$\Delta y_t = \alpha + \rho y_{t-1} + \gamma_1 \Delta y_{t-1} + \cdots + \gamma_p \Delta y_{t-p} + e_t$..........Eqn (7)

$\Delta y_t = \alpha + \beta t + \rho y_{t-1} + \gamma_1 \Delta y_{t-1} + \cdots + \gamma_p \Delta y_{t-p} + e_t$..........Eqn (8)

Where Δy_t is the first difference of the stock index, α is a constant term, β is the coefficient of the trend term, t is the trend term and ρ is the correlation coefficient of the lagged stock index. γ_1 is coefficient of the first difference of the first lag of the stock index, γ_p is the coefficient of the 1st difference of the pth lag of the stock index and e_t is the error term.

Ng and Perron (2001) recommend the used of the Modified Akaike Criterion (MAC) to select the number of lags (p) to include in equations (7) and (8). The null hypothesis of a unit root is rejected if $\rho = 0$, and I conclude that a series is stationary. Conversely, if $\rho < 0$, I fail to reject the null hypothesis of existence of a unit root and conclude that the series is non-stationary. Table 2 shows the results of ADF unit root tests. As expected, the tests confirm that all stock indexes contain a unit root and all series are non-stationary at all levels of significance.

Table 2: Augmented Dickey-Fuller Unit Root Test Results of Stock Indexes

Country	Variable	Intercept	Intercept and Trend
Australia	LOG(Aus)	-1.613	-1.815
China	LOG(China)	-1.691	-3.113
United Kingdom	LOG(UK)	-1.913	-1.916
Singapore	LOG(Singapore)	-1.681	-2.801
United States	LOG(US)	-1.804	-1.903
Japan	LOG(Japan)	-2.126	-1.919
Korea	LOG(Korea)	-1.052	-3.178

Note: *** statistically significant at 1% , ** statistically significant at 5%, *statistically significant at 10%

In order to determine the order of integration I take the first difference of all series. There is no evidence of a deterministic trend component in the differenced series as shown in Figure 2. Consequently, the ADF test for a unit root is performed using the first equation, which excludes the trend component. The results in table 3 show that the first difference of the stock indexes (the stock returns) is stationary since the null hypothesis for no unit root is rejected at all levels of significance. Consequently, the stock returns of the indexes are used for the subsequent analysis of Granger Causality.

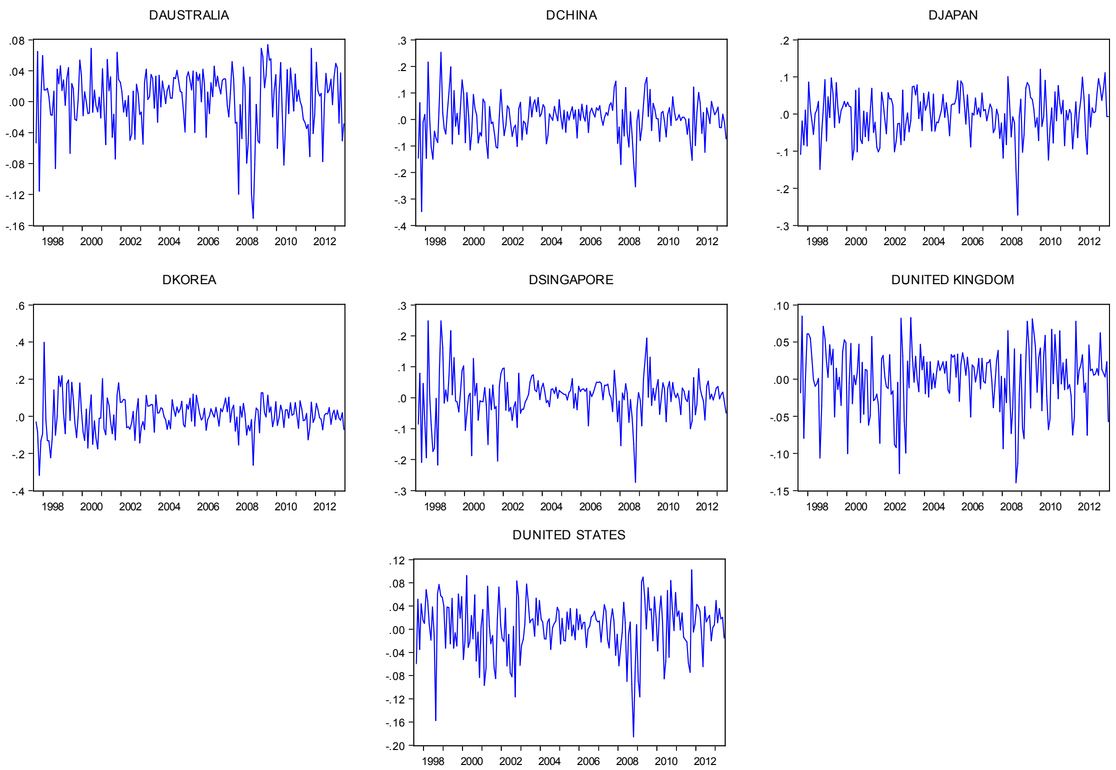

Figure 2: The first difference of stock indexes for all countries from 1997 to 2013

Table 3: Augmented Dickey-Fuller Unit Root Test Results of Stock Indexes

Variable	Intercept
ΔLOG(Australia)	-5.600***
ΔLOG(China)	-12.856***
ΔLOG(UK)	-4.529***
ΔLOG(Singapore)	-8.499***
ΔLOG(US)	-3.324**
ΔLOG(Japan)	-5.699***
ΔLOG(Korea)	-7.867***

Note: *** statistically significant at 1% , ** statistically significant at 5%, *statistically significant at 10%

3.2 Co-integration Tests

The results of the unit root tests show that all stock index series are integrated of order one (I(1)) and are stationary after taking the first difference. I consider two widely accepted methods of testing for co-integration, namely the Engle and Granger (1987) technique and the Johansen framework (Johansen, 1988; Johansen, 1991). Although both techniques vary, the ultimate goal of either method is to check whether a long-run relationship exists between variables that can be expressed in the form of an equation.

The Engle and Granger (1987) technique involves a two-step testing process that tests for a co-integrating relationship between two variables by estimating an ordinary least squares regression between the variables. Thereafter the residuals of the regression are examined in order to establish whether the two series are co-integrated. Two variables are co-integrated if a linear combination of the variables has residuals (e_t) that are stationary ($e_t \sim I(0)$). Co-integrated series tend to have stationary residuals, while non-stationary series residuals indicate that the series are not co-integrated. One limitation of this method is that it can only identify whether one co-integrated relationship exists or not. However, it fails to identify the number of co-integrating relationships that exist between variables especially when dealing with more than two variables. It is possible for more than one co-integrated relationship to exist especially when dealing with more than two variables. A group of **M** variables can have up to **M-1** co-integrating relationships (Koop, 2006). Thus, we can have up to six co-integrating relationships among the seven stock indexes considered in this study. The Johansen framework can be used to identify the number of co-integrating relationships that exist among the seven countries (Johansen, 1988; Johansen, 1991).

Johansen (1988) developed a framework that employs the maximum likelihood technique to estimate long-run co-integration vectors using a vector autoregressive (VAR) model. The VAR of order p is expressed in matrix notation as shown in equation (9) (Johansen, 1995; Johansen, 1991). As the Johansen technique is sensitive to the variation of lags, the Akaike Information Criterion (AIC) is used to specify the appropriate lag length (p) for performing a Johansen tests. The AIC recommends the use of VAR model with two lags.

$$\Delta y_t = \Pi y_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta y_{t-i} + Bx_t + \epsilon_t \quad \text{.......Eqn (9)}$$

Π and Γ_i are *n* x *n* matrices of unknown parameters where $\Pi = \sum_{i=1}^{p} \mathrm{A}_i - I$, and $\Gamma_i = -\sum_{j=i+1}^{p} \mathrm{A}_j$. $\Delta y_t$is the first difference of a k-vector of I(1) variables, x_t is a d-vector of deterministic variables and ϵ_t is the vector of innovations.

If the coefficient matrix Π has reduced rank r < p, then there exist p × r matrices α and β such that Π = $\alpha\, \beta'$ and $\beta' y_t$ is stationary, even if y_t is nonstationary (Johansen, 1988: 170). The rank r shows the number of cointegrating relations, α indicates the speeds of adjustment and each column of β contains the long-run co-integrating vectors. The estimated co-integration vectors are subjected to likelihood ratio tests in order to ascertain the number of co-integrating relationships that exist among a set of variables. Two likelihood ratio tests are recommended for successive hypothesis tests; namely the trace test and the maximum eigenvalue test. The trace test statistic and the maximum eigenvalue test statistic are calculated as shown in equation (10) and (11). Where T is the sample size, λ_i is the i-th largest eigenvalue of the Π matrix and k is the total number of endogenous variables under consideration.

$LR_{trace} = -T\ \sum_{i=r+1}^{k} \log(1-\lambda_i)$ ……………………………………………………………………………………………………Eqn (10)
$LR_{max} = -T\ \log(1-\lambda_{r+1})$ ………Eqn (11)
I set up the null hypothesis for the trace tests as $H_0: r \leq k$ versus the alternative hypothesis of $H_1: r > k$. The maximum eigenvalue tests $H_0: r = k$ against $H_1: r > k$ where k = 0, 1, 2, 3, 4, 5 and 6. The sequential hypothesis testing starts with the test for zero or no co-integrating relationships versus the hypothesis of one or more co-integrating relationships. Subsequent hypothesis tests are performed by successively increasing the value of k by one unit. Table 4 shows the results for the two tests for co-integration.

Table 4: Seven-country Johansen co-integration test results

Trace Rank test

Number of co-integrating relationships	**Eigenvalue**	**Trace Statistic**	**5% critical value**
None *	0.206	129.979	125.615
At most 1	0.161	86.309	95.754
At most 2	0.138	53.075	69.819
At most 3	0.0571	24.910	47.856
At most 4	0.0311	13.801	29.797
At most 5	0.0269	7.833	15.495
At most 6	0.0141	2.684	3.841

Maximum Eigenvalue Rank test

Number of co-integrating relationships	**Eigenvalue**	**Max-Eigen Statistic**	**5% critical value**
None	0.206	43.670	46.231
At most 1	0.161	33.234	40.078
At most 2	0.138	28.165	33.877
At most 3	0.0571	11.109	27.584
At most 4	0.0311	5.968	21.132
At most 5	0.0269	5.149	14.265
At most 6	0.0141	2.684	3.841

* denotes rejection of the hypothesis at the 5% level

The null of no co-integrations is rejected by the trace test, at a 5% level of significance, since the trace test statistic of 129.979 is greater than the critical value of 125.615. I fail to reject the null hypothesis of the subsequent hypothesis tests since the calculated trace statistics of subsequent tests are less than the corresponding critical values. Consequently, the trace test shows that one co-integrating relationship exists among seven variables.

Turning to the maximum eigenvalue test results in table 4, the maximum eigenvalue test statistic for the null of no co-integration of 43.670 is smaller than the critical value of 46.231. Thus, I fail to reject the null of no co-integrating relationships, at a 5% level of significance. Similar results are obtained from subsequent tests where I fail to reject the null hypotheses because the calculated maximum eigenvalue test statistics are smaller than the critical values. Based on maximum eigenvalue test results I conclude that there is no co-integration relationship between the seven stock indexes.

As the two likelihood ratio tests yield conflicting results, we turn to literature for clues on how to resolve this conflict. Theoretically, Enders (1995) prefers the use of the maximum eigenvalue test due to the "sharper alternative hypothesis" for trying to establish the number of co-integrating relationships that exist (p. 393). Similarly, Kennedy (2008) considers the maximum eigenvalue test a superior test for co-integration compared to the trace test Conversely, in practice, Lüütkepohl et al. (2001) performed simulations on small samples of 100 and found that the trace test performs better compared to the maximum eigenvalue test especially if there exist two more co-integrating relations than defined by the null. In the same study, the authors recommend the use of the trace test if one has to choose between the two test. Indeed, they point out that it is common for researchers to choose to use the trace test alone. Gómez-Puig and Sosvilla-Rivero (2013) adopt this approach by opting to perform Johansen trace tests on daily bond yields of five European countries; maximum eigenvalue tests were not conducted in this study. Given that literature fails to provide a definitive argument for the selection of either test, I decide to use the trace test results for further analysis in this study and conclude that the seven stock indexes are co-integrated. Consequently, the co-integration equation can be expressed as shown in equation (12) and the long-run coefficients of the resultant co-integrated equation are shown in Table 5.

$Australia = \beta_1 China + \beta_2 Japan + \beta_3 Korea - \beta_4 Singapore - \beta_5 UK + \beta_6 US$.................................. Eqn (12)

Table 5: Co-integrating equation for the seven countries (Dependent variable: Australia)

Independent variables	Normalized co-integrating coefficients	Standard error
China	0.275	(0.304)
Japan	0.761	(0.147)
Korea	0.686	(0.187)
Singapore	-0.24	(0.456)
United Kingdom	-0.934	(0.381)
United states	0.066	(0.342)

Given that the series are non-stationary and are co-integrated an error correction term must be estimated included in the Granger causality tests. The error correction model (ECM) applicable in this instance is specified in equations (5) and (6). Much like the Johansen tests, Granger causality tests are sensitive to the variation in the lag-length. By varying the lag-length of the Vector Error Correction Model (VECM), it is possible to obtain different results for causality. In order to determine a suitable lag-length for the VECM, I estimate an unrestricted VAR model for the seven series and apply lag selection tests to the estimated model. Table 6 shows the VECM's for all countries.

Table 6: Vector Error Correction Models for Australia and Top Six Bilateral Traders

	Δ AUSTRALIA	Δ CHINA	Δ JAPAN	ΔKOREA	Δ SINGAPORE	Δ UK	Δ US
Error Correction Term	-0.0184	0.0402	0.0326	0.0679	0.0380	-0.029	-0.017
	(0.013)	(0.026)	(0.021)	(0.031)	(0.024)	(0.015)	(0.016)
	[-1.367]	[1.526]	[1.586]	[2.177]	[1.559]	[-1.932]	[-1.032]
ΔAUS(t-1)	-0.131	-0.105	-0.192	0.120	-0.385	0.0452	-0.025
	(0.129)	(0.251)	(0.196)	(0.297)	(0.233)	(0.144)	(0.156)
	[-1.016]	[-0.419]	[-0.978]	[0.403]	[-1.653]	[0.313]	[-0.159]
ΔCHINA(t-1)	0.146	0.120	0.143	0.245	0.269	0.054	0.127
	(0.066)	(0.129)	(0.100)	(0.152)	(0.119)	(0.074)	(0.080)
	[2.228]	[0.939]	[1.426]	[1.616]	[2.262]	[0.728]	[1.587]
Δ JAPAN(t-1)	0.0837	0.179	0.089	-0.099	0.177	0.071	0.119
	(0.065)	(0.127)	(0.099)	(0.151)	(0.118)	(0.073)	(0.079)
	[1.286]	[1.406]	[0.897]	[-0.659]	[1.497]	[0.968]	[1.511]
Δ KOREA(t-1)	0.006	0.138	-0.077	0.0170	0.191	0.010	-0.04
	(0.044)	(0.086)	(0.066)	(0.102)	(0.080)	(0.050)	(0.054)
	[0.132]	[1.595]	[-1.145]	[0.166]	[2.382]	[0.195]	[-0.751]
Δ SINGAPORE(t-1)	-0.123	-0.098	-0.0721	-0.107	-0.185	-0.058	-0.097

	(0.070)	(0.136)	(0.106)	(0.161)	(0.126)	(0.078)	(0.084)
	[-1.770]	[-0.720]	[-0.680]	[-0.667]	[-1.466]	[-0.743]	[-1.152]
Δ UK(t-1)	-0.041	-0.327	0.286	0.238	-0.265	-0.182	0.062
	(0.132)	(0.258)	(0.201)	(0.305)	(0.240)	(0.148)	(0.160)
	[-0.31]	[-1.265]	[1.420]	[0.780]	[-1.105]	[-1.230]	[0.389]
Δ US(t-1)	0.151	0.0377	0.007	-0.149	0.238	0.137	-0.009
	(0.124)	(0.242)	(0.189)	(0.286)	(0.224)	(0.139)	(0.150)
	[1.222]	[0.156]	[0.039]	[-0.522]	[1.062]	[0.980]	[-0.062]
Constant	0.003	0.002	-0.001	0.004	0.003	0.001	0.004
	(0.003)	(0.006)	(0.004)	(0.007)	(0.005)	(0.003)	(0.003)
	[1.231]	[0.443]	[-0.191]	[0.671]	[0.635]	[0.397]	[1.042]

Note: Standard errors are shown in ( ) and t-statistics in [ ]

Four lag selection tests are used to determine the appropriate lag length, namely the modified Likelihood Ratio (LR) test, the final prediction error (FPE), the Akaike Information Criterion (AIC), Schwarz Information Criterion (SIC) and the Hannan-Quinn Information Criterion (HQIC). All tests were conducted at a 5% level of significance and the results of the tests are included in Table 7.

Table 7: Vector Autoregressive Lag selection tests

Lag	LR	AIC	SIC	HQIC
0	NA	-9.752	-9.628	-9.702
1	2,924.130	**-26.209***	**-25.215***	**-25.806***
2	77.814	-26.136	-24.273	-25.381
3	82.135	-26.111	-23.380	-25.004
4	64.097	-25.991	-22.390	-24.531
5	63.447	-25.887	-21.417	-24.075
6	73.891	-25.882	-20.543	-23.717
7	43.618	-25.673	-19.465	-23.156
8	66.877	-25.673	-18.595	-22.803
9	67.434	-25.710	-17.763	-22.487
10	72.437	-25.830	-17.014	-22.255
11	**68.670***	-25.958	-16.273	-22.032
12	55.956	-26.003	-15.449	-21.724

*Note: * indicates the lag length selected by the test criterion*

With the exception of the Likelihood Ratio test, which indicates that 11 lags should be used, the other three tests recommend the use of one lag in the Granger causality tests. Accordingly, pairwise Granger causality tests were performed using a VECM with one lag. The results of the Granger causality tests are contained in table 8. I only fail to reject the null hypothesis of non-causation in three instances where the probability of the chi-squared statistic is less than a chosen level of significance. At a 5% level of significance, I find unidirectional causality from China to Australia, China to Singapore and Korea to Singapore. Bidirectional causality also exists at a 10% level of significance between Singapore and Australia. No other Granger causality relationships are identified.

Table 8: Granger Causality tests for seven countries

Null hypothesis	Chi-squared statistic	Probability
ΔChina —/→ΔAustralia	4.966**	0.026
ΔJapan —/→ΔAustralia	1.653	0.199
ΔKorea —/→ΔAustralia	0.017	0.895
ΔSingapore —/→ΔAustralia	3.132*	0.077
ΔUK —/→ΔAustralia	0.096	0.756
ΔUS —/→ΔAustralia	1.495	0.221
ΔAustralia —/→ΔChina	0.176	0.675
ΔJapan —/→ΔChina	1.978	0.160
ΔKorea —/→ΔChina	2.545	0.111
ΔSingapore —/→ΔChina	0.518	0.472
ΔUK —/→ΔChina	1.601	0.206
ΔUS —/→ΔChina	0.024	0.876
ΔAustralia —/→ΔJapan	0.957	0.328
ΔChina —/→ΔJapan	2.032	0.154
ΔKorea —/→ΔJapan	1.310	0.252
ΔSingapore —/→ΔJapan	0.462	0.497
ΔUK —/→ΔJapan	2.016	0.156
ΔUS —/→ΔJapan	0.002	0.969
ΔAustralia —/→ΔKorea	0.163	0.687
ΔChina —/→ΔKorea	2.612	0.106
ΔJapan —/→ΔKorea	0.434	0.510
ΔSingapore —/→ΔKorea	0.445	0.505
ΔUK—/→ΔKorea	0.608	0.436
ΔUS —/→ΔKorea	0.272	0.602
ΔAustralia —/→ΔSingapore	2.731*	0.098
ΔChina —/→ΔSingapore	5.119**	0.024
ΔJapan —/→ΔSingapore	2.241	0.134
ΔKorea —/→ΔSingapore	5.675**	0.017
ΔUK —/→ΔSingapore	1.220	0.269
ΔUS —/→ΔSingapore	1.127	0.289
ΔAustralia —/→ΔUK	0.098	0.754
ΔChina —/→ΔUK	0.529	0.467
ΔJapan —/→ΔUK	0.938	0.333
ΔKorea —/→ΔUK	0.038	0.845
ΔSingapore —/→ΔUK	0.553	0.457
ΔUS —/→ΔUK	0.961	0.327
ΔAustralia —/→ΔUS	0.025	0.874
ΔChina —/→ΔUS	2.519	0.113
ΔJapan —/→ΔUS	2.283	0.131
ΔKorea —/→ΔUS	0.564	0.453
ΔSingapore —/→ΔUS	1.329	0.249

ΔUK −/→ΔUS	0.151	0.697
Note: the null hypothesis for Granger causality tests for non-causation and is stated in the form $\mathrm{H_0}$: $\mathrm{Country\ A}\ -/\rightarrow \mathrm{Country\ B}$, where "−/→" stands for "does not Granger cause". *** statistically significant at 1% , ** statistically significant at 5%, *statistically significant at 10%		

4.0 Discussion and Conclusions

The objective of this study was to examine whether movements in the stock markets of Australia's key trading partners can explain movements in Australia's equity markets. Using the Johansen co-integration test, I found that one long-run equilibrium relationship exists among the seven stock markets and presented the co-integrating equation for the seven markets. In the short-run, I found that past values of the Chinese stock index could help explain the current value of the Australia Stock index. However, I did not find a reverse causal relationship from Australia to China's stock market. Surprisingly, no short-run relationships existed between Australia and the other bilateral partners, despite the presence of extensive trade links and economic partnerships. This suggests that certain trade links play a more significant role in the health of the Australian economy than others. In some aspects, these results are as expected; given the fact China's residential construction industry is the leading driver of the Australian mining industry. Accordingly, Australian policy makers should consider the degree of the impact of the Chinese stock market on the Australian stock market. Nonetheless, bilateral trade links are not the only factor responsible for the occurrence of financial contagion and more research is needed to understand the complex nature of how and why financial crises spread as and in the manner they do.

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