第三期 100.09 page15-22
ISSN：2076-9474

# The Cointegration Relationship between Mergers Variables and Stock Market-Evidence from 10 Developed Countries

# 併購變數與股票市場之共整合－10 個已開發國家之實證

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## ABSTRACT

This study applies a more powerful rank test for nonlinear cointegration, proposed by Brietung (2001) to test the long-run cointegration relationships between the M&A variables (the numbers and values of M&A transactions) and stock indices for a sample of 10 developed countries over January 1980 to September 2010. The empirical results indicate that the cointegration relationships hold true for all the 10 developed countries studied. Our results have important policy implications for these countries studied.

**Keywords:** Rank Test for Nonlinear Cointegration, M&A, Developed Countries

## 摘 要

本研究利用更具檢定力之秩檢定(Rank Test)—為 Brietung 於 2001 提出之非線性共積等級檢定，來對 10 個已開發國家驗證併購變數(併購交易數量與規模)與股票指數間之共整合關係，研究期間為 1980 年 1 月至 2010 年 9 月。研究結果發現這些國家之併購變數與股票指數間是存在共整合關係，並且我們對此研究結論說明政策上之意涵。

**關鍵字：**非線性共積等級檢定、併購、已開發國家

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## 1. Introduction

Previous studies of mergers and acquisitions (hereafter, M&A) primarily focused on synergy creation, such as Weston, Chung and Sui, 1998, Fluck and Lynch, 1999, Walker, 2000, and examined the performance changes in acquiring and acquired companies, such as Loughran and Vijh, 1997, Conn et al., 2005, Moeller, Schlingemann and Stulz, 2005, all of the papers emphasized on the microeconomic analyses.

However, analyzing the influences coming from macroeconomic environments also is a very important issue before enterprises deciding to carry out M&A investments. Post (1994) stated that the activities of M&As can be thought as a kind of investing behavior and managers should prudently consider outside economic status while making a takeover decision. Yagil (1996) also mentioned that whatever the motives and purposes of M&A are taken by participants, the first consideration is to examine the macroeconomic conditions before undertaking takeover activities.

Owing to the variations of macroeconomic variables substantially correlating to mergers activities, many studies examined their impacts to these activities. Haque et al. (1995) used trivariate system, takeover variables, stock prices and interests, to test their causality and found the positive relationship between stock prices and takeover activities. Shughart and Tollison (1984) analyzed the yearly data on mergers in the US during the period of 1895-1979 and found M&A activities are consistent with first-order autoregressive (AR(1)) property. Melicher et al. (1983) employed 1947-1977 quarterly data on mergers in the US and pointed out stock prices and yield rates of bonds can precisely forecast the changes of mergers activities in advance. Maule (1968) and Eis (1970) both found that stock prices have a higher correlation with mergers activities than industrial production do. Yet, Guerard (1989), using time series methodology of Box and Jenkins, found that stock prices and industrial production have not power of explanation to mergers activities significantly.

Among all of the macroeconomic variables, stock market was thought to be most correlated with M&A activities. Tilly (1982) found that the performance of stock markets does not influence significantly in mergers activities in German data. Granger (1969) found that, using Granger causality tests with monthly and quarterly data of US and UK, there are not mutual causality between mergers activities and stock prices. However, Clark et al. (1988) obtained totally different results from the yearly data with longer periods. Haque et al. (1995) engaged Canadian data to revisit the same question and acquired there are positive correlation between mergers activities and stock prices. Crook (1995) found in the long run there are very close relationships among mergers numbers, GDP growth rate, Tobin's q, unemployment rate and stock prices by using the cointegration method. Nieh (2004) explored out that five macroeconomic variables, including GDP, stock prices, interest rate, inflation rate and unemployment rate, profoundly influence in mergers activities with US quarterly data and his research illustrated there exists cointegration relationships among these variables, especially stock prices and inflation rate having greater effects on mergers.

From above discussions, the variable of stock market is very important to mergers activities and its impacts may result in different outcomes from a variety of researches, even mutual contradiction. Therefore we would like to explore its 'real' impacts to mergers activities. In our research we choose a sample of ten developed countries over January 1980 to September 2010 and apply a more powerful rank test for nonlinear cointegration, proposed by Brietung (2001) to determine whether the long-run cointegration relationships between the M&A variables (the numbers and values of M&A transactions) and stock indices exist in our sample. Precisely what we find is that the long-run cointegration relationships exist in these countries studied.

The plan of this paper is organized as follows. Section II briefly describes the nonlinear rank test for cointegration. Section III presents the data used in our study and Section IV explains our empirical results. Section V concludes the paper.

## 2. Brietung (2001) Rank Tests and Score Test

### 2.1. Rank Test for Nonlinear Cointegration

In order to test for cointegration between two time series, $y_t$ and $x_t$. Consider $y_t$ as a function of $x_t$, which may be represented by:

$$y_t = f(x_t) + u_t \qquad [1]$$

where $y_t$ and $f(x_t)$ are both integrated or order one, that is, $y_t$ ~ I(1) and $f(x_t)$ ~

I(1), and $u_t$ stands for the stochastic disturbances. The cointegration tests in the past have been developed on the assumption that $f(x_t)$ is a linear function of $x_t$.

Brietung (2001) showed that residual-based linear cointegration tests are inconsistent for some class of nonlinear functions (see Sargan and Bhargava, 1983; Phillips and Oularis, 1990)). To overcome this problem, he thus proposed cointegration test based on rank transformation of the time series. The rank test exploits the property that a sequence of ranks is invariant to monotonic transformation of the data. In other words, if $x_t$ is a random walk then the ranked series of $x_t$ behaves like a random walk as well. Similarly, if two series are cointegrated, possibly nonlinearly, then the ranked series are cointegrated as well. The rank transformation therefore allows getting away from specific functional forms of the cointegrating relation. An advantage of rank tests is that one does not have to be explicit about the exact functional form of the nonlinear cointegrating relationship.

The rank test is based on a measure of the squared distance between the ranked series. When the test statistic takes on a value smaller than the appropriate critical value, this is evidence against the null hypothesis of no cointegration in favor of the alternative hypothesis of cointegration because in this case the variables move closely together over time and do not drift too far apart. Such a test checks whether the ranked series move together over time towards a long-run cointegrating equilibrium that may be linear or nonlinear.

Following the Brietung (2001), we can define a ranked series as $R(w_t)$ = Rank of $w_t$ among $(w_1, w_2, ..., w_T)$, where w={y, x}. Two consistent rank-test statistics based on the difference between the sequences of ranks are as follows:

$$B_1 = T^{-1} \sup_{1<t<T} |d_t| \quad , \qquad [2]$$

and

$$B_2 = T^{-3} \sum_{t=1}^{T} d_t^2 \quad , \qquad [3]$$

where $d_t = R(y_t) - R(x_t)$, with the assumption that $R(y_t)$ and $R(x_t)$ are both monotonically increasing or monotonically decreasing. The basic idea of these rank tests is that the sequences of ranks tend to evolve similarly if there is cointegration between the two series $y_t$ and $x_t$, otherwise the sequences of ranks tend to diverge. The null hypothesis of no (nonlinear) cointegration between $y_t$ and $x_t$ is rejected if these tests statistics are smaller than their respective critical values.

Note that the above test statistics are developed under the assumption that two time series $y_t$ and $x_t$ are mutually serially uncorrelated random walks. To relax this somewhat unrealistic assumption, Breitung (2001) suggests that monotonic functions of $x_t$ and $y_t$ are converged with correlation coefficient $\rho$. If the value of $|\rho|$ is small, the test statistics following corrections:

$$B_1^* = \frac{\sup_{1<t<T} |d_t|}{T\hat{\sigma}_{\Delta d}^2} \qquad [4]$$

and

$$B_2^* = \frac{\sum_{t=1}^{T} d_t^2}{T^3 \hat{\sigma}_{\Delta d}} \qquad [5]$$

where $\hat{\sigma}_{\Delta d}^2 = T^{-2} \sum_{t=1}^{T} (d_t - d_{t-1})^2$ are used to adjust for possible correlation between the two series of interest. If $|\rho|$ is close to 1, the test statistics $B_1^*$ and $B_2^*$ should be obtained as:

$$B_1^{**} = \frac{B_1^*}{1 - 0.174(\rho_T^R)^2} \qquad [6]$$

and

$$B_2^{**} = \frac{B_2^*}{1 - 0.462(\rho_T^R)} \qquad [7]$$

where $\rho_T^R$ is the correlation coefficient for differences of ranks as follows:

$$\rho_T^R = \frac{\sum_{t=2}^{T} \Delta R_T(x_t) \Delta R_T(y_t)}{\sqrt{(\sum_{t=2}^{T} \Delta R_T(x_t)^2)(\sum_{t=2}^{T} \Delta R_T(y_t)^2)}} \qquad [8]$$

The asymptotic distribution of the test statistics $B_1^{**}$ and $B_2^{**}$ are the same as $B_1^*$ and $B_2^*$, respectively. The null hypothesis of no cointegration is rejected if the critical value exceeds the test statistics.

As indicated by the Brietung (2001) that his rank test can also be generalized to test cointegration among k+1 variables $y_t, x_{1t}, ..., x_{kt}$, where it is assumed that $R(y_t)$ and $R(x_{jt})$ for j=1,..., k are monotonic functions. As such, one may compute the following multivariate rank statistic:

$$B_3[k] = T^{-3} \sum_{t=1}^{T} (\tilde{u}_t^R)^2 \qquad [9]$$

where

$$\tilde{u}_t^R = R(y_t) - \sum_{j=1}^{k} \tilde{b}_j R(x_{jt}) \qquad [10]$$

in which $\tilde{b}_1, ..., \tilde{b}_k$ are the least squares estimates from a regression of $R(y_t)$ on $R(x_{1t}), ..., R(x_{kt})$, and $\tilde{u}_t^R$ are the estimated residuals.

Whilst the bilateral rank tests are one-sided tests which are applicable for functions that are known to be either monotonically increasing or decreasing, such multivariate rank test is a two-sided test and it is useful when it is unknown whether the functions are monotonically increasing or decreasing. Again, to circumvent the possible correlation between the series, the statistics can be modified as:

$$B_3^*[k] = B_3[k] / \tilde{\sigma}_{\Delta u}^2 \qquad [11]$$

where

$$\tilde{\sigma}_{\Delta u}^2 = T^{-2} \sum (\tilde{u}_t^R - \tilde{u}_{t-1}^R)^2 \qquad [12]$$

The null hypothesis of no (nonlinear) cointegration between $y_t$ and $x_t$ is rejected if these tests statistics are smaller than their respective critical values. Critical values obtained from Monte Carlo simulations of $B_1, B_2, B_1^*, B_2^*, B_1^{**}, B_2^{**}$ and $B_3^*[k]$ are given in Table 1 of Breitung (2001).

### 2.2. Score Tests for Neglected Nonlinearity

To assess whether the cointegration is linear or nonlinear found by the rank test,

Breitung (2001) suggests the score test statistic $T \cdot R^2$ as:

$$\tilde{u}_t = c_0 + c_1 x_t + c_2 R(x_t) + e_t \qquad [13]$$

where T is the sample size, $R^2$ is the coefficient of determination of regression [13], and $\tilde{u}_t = y_t - (\tilde{a}_0 + \tilde{a}_1 x_t)$, where $\tilde{a}_0$ and $\tilde{a}_1$ in turn, are the least squares estimates from a regression of $y_t$ on a constant and $x_t$. Under the assumptions of $\tilde{u}_t$ is a zero-mean white noise and that $x_t$ is exogenous, the score test statistic $T \cdot R^2$ is asymptotically Chi-squared $(\chi^2)$ distributed with one degree of freedom. The null hypothesis of linear cointegration, $c_2 = 0$, may be rejected in favor of nonlinear cointegration when $T \cdot R^2$ exceeds the $\chi^2$ critical value. However, Brietung (2001) points out that in many cases, $x_t$ is endogenous. Brietung (2001) proposes to adopt the cointegration regression due to Stock and Watson (1993) for adjustment, by truncating the infinite sums in the following specification appropriately:

$$y_t = \alpha_0 + \sum_{j=1}^{\infty} \alpha_j y_{t-j} + \beta_1 x_t + \sum_{j=-\infty}^{\infty} \gamma_j \Delta x_{t-j} + \varepsilon_t \qquad [14]$$

The least squares estimated residual $\tilde{\varepsilon}_t$ is then regressed on the regressors of Equation [14] and $R(x_t)$. Under the null hypothesis of a linear cointegration relationship, the resulting $T \cdot R^2$, where $R^2$ is the coefficient of determination of regression [14], is also asymptotically Chi-squared $(\chi^2)$ distributed. The Monte Carlo simulations by Brietung (2001) show that for a wide range of nonlinear models the rank tests perform better than their parametric competitors.

## 3. Data

The quarterly end-of-period stock indices in the empirical analysis are obtained from Taiwan Economic Journal (TEJ). The data of M&A variables (the numbers and values of M&A transactions) are collected from Securities Data Company (SDC platinum). Among a sample of these 10 developed countries includes USA, Japan, Canada, UK, Australia, Germany, Hong Kong, Singapore, Taiwan and Korea. The sample period is from January 1980 to September 2010.

## 4. Empirical Results

### 4.1. Unit Root Test

Several traditional unit root tests are first employed to examine the null of a unit root for the M&A variables (the numbers and values of M&A transactions) and stock indices in these 10 developed countries that we study. ADF and PP tests both fail to reject the null of a unit root for the M&A variables and stock indices of these 10 developed countries. The KPSS test also yields the same results. Our results signify that the M&A variables and stock indices of these 10 developed countries are all random process. Unit root test are suppressed here for space consideration but are available upon request.

### 4.2. Results from the Rank Tests

Table 1 reports the bivariate case of the rank test, and we compute the autocorrelation adjusted test statistics, $B_3^*[K]$, where K=1 for the bivariate case. As shown by the $B_3^*[K]$ statistic in Table 1, the null hypothesis is rejected for all these 10 developed countries examined in the study, since the test statistics are smaller than the critical values at the 5% level of significance. As such, we can observe cointegrating relationships between the numbers of M&A and stock indices for all 10 developed countries. The results indicate that the rank test employed in the study provides evidence of cointegration relationships between M&A activities and stock market in the long term.

Similarly, we use the values of M&A transactions as the dependant variable to investigate cointegrating relationships with stock induces. From Table 2, we find just 6 out of 10 countries their autocorrelation adjusted test statistics, $B_3^*[1]$, are smaller than the critical values, meaning that these countries have cointegration relationships between M&A activities and stock market in the long term. But observing the other 4 countries' bivariate rank test statistics, $B_1^*, B_1^{**}, B_2^* \textit{ and } B_2^{**}$ their values are smaller than the critical values at the 1% level of significance, also meaning the existence of cointegration relationships.

Hence, the rank tests employed in the study provide strong evidence favoring the long-run cointegration relationships between M&A activities and stock market. Our results are not consistent with those of Tilly (1982) and Guerard (1989) that both studies found stock market performance does not influence in M&A activities significantly. We believe our results are more reliable due to the use of a more powerful nonparametric rank test of cointegration, proposed by Brietung (2001).

### 4.3. Results from the Score Test

Based upon the cointegration relationships identified above, we go on to distinguish between linear and non-linear cointegration using the score test of Breitung (2001). It is clearly shown from Table 1 that the null hypothesis of linear cointegration in bivariate case is not rejected for most of the ten countries. The score test results clearly indicate that the linear cointegration relationship exists between the numbers of M&A and stock indices for 9 out of the 10 countries, except for Korea. However, observing the linear cointegration relationship between the values of M&A transactions and stock indices from Table 2, the null hypothesis of the nonlinear cointegration is also rejected for only 2 countries, Australia and Korea. The findings of the nonlinearly interrelated between the M&A variables and stock indices for these 2 countries may be due to regulations and constraints with government related laws in M&A activities during this sample period.

The major implications that emerge from our study are that from government viewpoint, if governments encourage enterprises to undertake mergers and enhance international competition, they should watch the trends of stock market and select a proper timing; and from the viewpoint of enterprise investment, if enterprises choose M&A as the way of enterprise growth, they should not be against the stock market.

## 5. Conclusions

This study applies the rank test for nonlinear cointegration, proposed by Brietung (2001) to test the long-run cointegration relationships between the M&A variables (the numbers and values of M&A transactions) and stock indices for a sample of 10 developed countries over January 1980 to September 2010. The empirical results indicate that the cointegration relationships hold true for all the 10 developed countries studied and the M&A variables and stock indices are nonlinear interrelated for only 2 of these countries. Our results have important policy implications for these 10 developed countries.

## Acknowledgement

We thank Professor Tsangyao Chang for giving some helpful suggestions to related program that implements the tests described in this study.

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Table1 Results of rank tests for cointegration—M&As numbers vs. stock indices

| | Bivariate Rank Test | | | | | Multivariate Rank Test | Rank Sum Linearity Test |
|---|---|---|---|---|---|---|---|
| Country | $B_1^{*}$ | $B_1^{**}$ | $B_2^{*}$ | $B_2^{**}$ | $\rho_T^R$ | $B_3^{*}[1]$ | $T \cdot R^2$ |
| USA | 0.6108 | 0.6139 | 0.0594 | 0.0646 | 0.1720 | 0.0089*** | 1.4769 |
| Japan | 0.7249 | 0.7258 | 0.0931 | 0.0968 | 0.0829 | 0.0087*** | 0.2657 |
| Canada | 0.3282** | 0.3317** | 0.0078*** | 0.0088*** | 0.2440 | 0.017** | 2.2963 |
| UK | 0.6293 | 0.6362 | 0.0384 | 0.0434 | 0.2495 | 0.0093*** | 0.5455 |
| Australia | 0.2958*** | 0.296*** | 0.0079*** | 0.0082*** | 0.0728 | 0.018** | 0.1962 |
| Germany | 0.2713*** | 0.2715*** | 0.0075*** | 0.0077*** | 0.0642 | 0.0178** | 0.9860 |
| Honk Hong | 0.4407 | 0.4459 | 0.0131** | 0.0148** | 0.2585 | 0.0164** | 0.4971 |
| Singapore | 0.3419** | 0.3438** | 0.0141** | 0.0154** | 0.1787 | 0.0159** | 2.1977 |
| Taiwan | 0.3775* | 0.3783* | 0.0189* | 0.0179** | -0.1123 | 0.0137** | 0.0055 |
| Korea | 0.5307 | 0.5341 | 0.0441 | 0.0484 | 0.1921 | 0.0117*** | 5.5114** |

| Critical Value(%) | $B_1^{*}$ / $B_1^{**}$ | $B_2^{*}$ / $B_2^{**}$ | $B_3^{*}[1]$ | $T \cdot R^2$ |
|---|---|---|---|---|
| 10 | 0.3941 | 0.0232 | 0.0248 | 2.71 |
| 5 | 0.3635 | 0.0188 | 0.0197 | 3.84 |
| 1 | 0.3165 | 0.013 | 0.0136 | 6.63 |

Notes:

a. The null hypothesis of the rank test is that no cointegration exists between the numbers of M&As transactions and stock indices; the alternative hypothesis is otherwise. The null hypothesis is rejected when the critical value exceeds the test statistic. The multivariate rank test is adjusted for autocorrelation. The critical values are tabulated at Table 1 of Breitung (2001).

b. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Table2 Results of rank tests for cointegration—values of M&As transactions vs. stock indices

| | Bivariate Rank Test | | | | | Multivariate Rank Test | Rank Sum Linearity Test |
|---|---|---|---|---|---|---|---|
| Country | $B_1^*$ | $B_1^{**}$ | $B_2^*$ | $B_2^{**}$ | $\rho_T^R$ | $B_3^*[1]$ | $T \cdot R^2$ |
| USA | 0.2761*** | 0.2793*** | 0.0131** | 0.0149** | 0.2528 | 0.0120*** | 0.0614 |
| Japan | 0.3350** | 0.3350** | 0.0238 | 0.0241 | 0.0246 | 0.0103*** | 0.2934 |
| Canada | 0.2640*** | 0.2645*** | 0.0043*** | 0.0045*** | 0.1017 | 0.2595 | 1.6657 |
| UK | 0.2506*** | 0.2520*** | 0.0071*** | 0.0077*** | 0.1805 | 0.0198* | 1.8925 |
| Australia | 0.2431*** | 0.2453*** | 0.0054*** | 0.0060*** | 0.2283 | 0.0358 | 20.2003*** |
| Germany | 0.2152*** | 0.2157*** | 0.0048*** | 0.0050*** | 0.1135 | 0.0670 | 2.4496 |
| Honk Hong | 0.2359*** | 0.2364*** | 0.007*** | 0.0074*** | 0.1053 | 0.0380 | 0.0057 |
| Singapore | 0.2864*** | 0.2889*** | 0.0111*** | 0.0124*** | 0.2233 | 0.0188** | 1.0355 |
| Taiwan | 0.2755*** | 0.2756*** | 0.0118*** | 0.0115*** | -0.0540 | 0.0173** | 0.0453 |
| Korea | 0.3459** | 0.3459** | 0.0202* | 0.0200* | -0.0241 | 0.0137** | 19.1188*** |
| Critical Value(%) | | | | | | | |
| 10 | 0.3941 | | 0.0232 | | | 0.0248 | 2.71 |
| 5 | 0.3635 | | 0.0188 | | | 0.0197 | 3.84 |
| 1 | 0.3165 | | 0.0130 | | | 0.0136 | 6.63 |

Notes:

a. The null hypothesis of the rank test is that no cointegration exists between the values of M&As transactions and stock indices; the alternative hypothesis is otherwise. The null hypothesis is rejected when the critical value exceeds the test statistic. The multivariate rank test is adjusted for autocorrelation. The critical values are tabulated at Table 1 of Breitung (2001).

b. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.