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Long-run Validity of Export-Led Growth: An Empirical Reinvestigation from Linear and Nonlinear Cointegration Test

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Abstract

This study is able to uncover long-run cointegration relationship for Singapore and South Korea, based on the Breitung (2001) rank test procedures. Breitung (2001) rank test can detect both linear and nonlinear cointegration relationships, added value to the literature with strong evidences of nonlinear cointegration on GDP growth and export.

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1. Introduction

Export-led growth (ELG) hypothesis postulates that the role of export is a key factor in promoting economic growth. Its empirical validity has important implications for the policy-makers who based their decision on export. For instance, exports expansion can be a mechanism for output growth directly as a component of aggregate output. Furthermore, an increase in foreign demand for domestic exportables can indirectly encourage the rapid expansion of employment and real wages of the economy (Awokuse, 2005a, b; Huang and Wang, 2007). Besides, export growth can also affect growth indirectly through efficient allocation of resources, greater capacity utilization, the best use of economies of scale, and provide greater incentives for technological advancement, thus raise the over-all comparative advantage (Ben-David & Lorwy, 1998; Awokuse, 2005a, b). Due to its importance, an extensive empirical literature has developed the topic of export-led growth hypothesis since past few decades.

Empirical support for the theory of export-led growth has been rather mixed. Previously, most of the studies conducted used data from a substantially large range of developed and developing countries. For example, Jung and Marshall (1985) found little support for the hypothesis even those New Industrialized Economies (NIEs) such as South Korea and Taiwan that have experienced both rapid growth and export expansion. Others, notably Bahmani-Oskooee and Alse (1993) and Doraisami (1996) showed that there is a stable long-run relationship between export and economic growth by using Engle-Granger two-step procedure in their study. Ghatak *et al.* (1997) also tested the relationship between export-led growth hypothesis by using annual data for Malaysia. The Johansen maximum likelihood procedure provided support for the hypothesis in their study.

Among the recent development on ELG studies, Awokuse (2005a) also found cointegration between real GDP and real export in South Korea by using Johansen and Juselius multivariate test. On the other hand, Awokuse (2005b) found ELG hypothesis is strongly rejected in Japan during 1960 to 1991. Siliverstovs and Herzer (2006) supported the export-led growth hypothesis for Chile in their study. Recently, Huang and Wang (2007) contributed an attractive discussion by examining the validity of export-led growth for the Newly Industrialized Economics (NIEs)[1]. Using the Johansen's maximum likelihood cointegration procedures, the authors found evidence of cointegration at the 10% level for all the four economies.

However, the above findings of export-led growth by the testing procedures formulated based on linear econometric[2] frameworks, may have two implications. First, export and GDP growth may not interrelated at all. Second, export and GDP growth may exhibit nonlinear relationship, ignoring the nonlinear of the cointegration relationship may lead to the misleading conclusion that no long-run relationship exists between this

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[1] Newly Industrialized Economies (NIEs) refer to Hong Kong, South Korea, Singapore and Taiwan.

[2] However, based on various well-accepted methodologies including the Engle and Granger (1987) test, as well as the Johansen (1988) cointegration test, the export-led growth (ELG) hypothesis still been hotly debated in the economic development literature over the past few decades.

two series. Therefore, instead of assuming a linear cointegrating relationship as in the previous literature, we test for nonlinear form of the cointegrating relation by using the rank tests advanced by Breitung (2001). One of the advantages of this approach over the linear one is that its monotonic transformation is a desirable property in the detection of cointegration. In many applications, logarithm transformation is used to achieve a linear cointegration relationship; however, it is not clear whether the variables need to be transformed. Moreover, if long-run relationship is indicated by the rank test procedure, it is interesting that the subsequent rank test for neglected non-linearity is able to distinguish linear or nonlinear cointegration relationship. Hence, our study complements previous studies by looking at a nonlinear adjustment to a linearly cointegrated long-run ELG relation. The remainder of this letter is organized as follows. Section 2 describes the Johansen cointegration test and rank tests for cointegration and for neglected nonlinearity. Section 3 presents the data and empirical results, while the final section concludes this paper.

2. Econometric Methodology

2.1 Linear Cointegration Analysis

Prior to testing for a long run cointegration relationship between the time series, it is necessary to test for their order of integration and establish that they are integrated of the same order. The unit root test performed here is Phillips and Perron (1988).

The most popular approach to linear cointegration analysis is the Johansen's framework (Johansen, 1988). In this study, consider a two-dimensional VAR (*p*) time series x_t with possible time trend and the model is defined by

$$x_t = \mu_t + \Phi_1 x_{t-1} + \cdots + \Phi_p x_{t-p} + a_t \tag{1}$$

where the error term, a_t is assumed to be Gaussian, μ_t is a two-dimensional vector of constants and x_t is an integrated process of order 1, *I*(1). Since x_t is nonstationary, an error-correction model (ECM) for the VAR (*p*) process is

$$\Delta x_t = \mu_t + \Pi x_{t-1} + \Phi_1^* \Delta x_{t-1} + \cdots + \Phi_{p-1}^* \Delta x_{t-p+1} + a_t \tag{2}$$

where $\Phi_j^* = -\sum_{i=j+1}^{p} \Phi_i$, j = 1, …, p – 1 and $\Pi = \Phi_p + \Phi_{p-1} + \cdots + \Phi_1 - I = -\Phi(1)$. The term Πx_{t-1} in Equation (2) is referred as the error-correction term, where the coefficient, Π contains information about long-run relationships between the variables. Three cases are of interest in considering the ECM in Equation (2). If rank (Π) = 2, the matrix Π has full rank and x_t is stationary. The ECM model is not informative and x_t can be studied directly. If rank (Π) = 0, this implies that the matrix Π is a null matrix and x_t is not cointegrated. Then Equation (2) corresponds to a traditional differenced vector time-series model. Finally, if rank (Π) = 1, there exist one cointegrating vectors; in this case, $\Pi = \alpha\beta'$, where α and β are 2×1 matrices. This means that x_t is cointegrated with one linearly independent cointegrating vectors and Equation (2) can be interpreted as an error-correction model.

The likelihood ratio (LR) test for the hypothesis of *r* cointegrating vectors is proposed by Johansen (1988). The cointegrating rank, *r*, can be tested with two statistics, namely trace and maximal eigenvalue. However, Cheung and Lai (1993) suggested that the trace test shows more robustness to both skewness and excess kurtosis in the residuals than the maximal eigenvalue test. Hence, we are guided by the trace statistic.

The limiting distributions of cointegration tests depend on the deterministic function μ_t in the dynamic model. The choice of the appropriate specification was based on the Pantula principle (Johansen, 1992, 1995). The Pantula principle[3] chooses both the correct rank order and the deterministic component. This principle can be summarized as follows. Three models are estimated and the results are presented from the most restrictive to the least restrictive alternative. The models employed are the Model 2 which includes intercept in the cointegration relation; Model 3 which allows deterministic trends in level; and Model 4 which allows for trend in the cointegration space. The test procedure then is to move through from the most restrictive model to less and at each stage compare the trace test statistic to its critical value. The selection process only stops at the first time where the null hypothesis is not rejected.

2.2 Rank tests for cointegration and neglected nonlinearity

Breitung (2001) proposed a rank test for cointegration, where the long-run relationship among GDP growth (y_t) and export (x_t) can be tested by using the following bivariate statistics:

$$K_T^* = T^{-1}\max_t |d_t| / \hat{\sigma}_{\Delta d} \quad \text{and} \quad \xi_T^* = T^{-3}\sum_{t=1}^{T} d_t^2 / \hat{\sigma}_{\Delta d}^2, \tag{3}$$

where $d_t = R_T(y_t) - R_T(x_t)$, for $R_T(y_t)$= Rank [of y_t among $y_1, \ldots, y_T$] and $R_T(x_t)$ Rank [of x_t among $x_1, \ldots, x_T$]. The $\max_t |d_t|$ is the maximum value of $|d_t|$ over *t* = 1, 2, . . . , *T* and $\hat{\sigma}_{\Delta d}^2 = T^{-2}\sum_{t=2}^{T}(d_t - d_{t-1})^2$ serves to adjust for possible correlation between the two series of interest.

[3] In testing ELG hypothesis, among others who employed the Pantula principle in selecting appropriate specification in cointegration test are Love and Chandra (2005) and Dawson (2006).

A multivariate version of Breitung (2001) rank test statistic of the following specification is also employed in this study:

$$\Xi_T^*[1] = T^{-3}\sum_{t=1}^{T}\left(\tilde{u}_t^R\right)^2 / \hat{\sigma}_{\Delta\tilde{u}}^2 \tag{4}$$

where $\tilde{u}_t^R = R_T(y_t) - \tilde{b}R_T(x_t)$, in which $\tilde{b}$ is the least squares estimates from the rank cointegration regression of $R_T(y_t)$ on $R_T(x_t)$, and $\tilde{u}_t^R$ are the estimated residuals of the regression. $\hat{\sigma}_{\Delta\tilde{u}}^2 = T^{-2}\sum_{t=2}^{T}\left(\tilde{u}_t^R - \tilde{u}_{t-1}^R\right)^2$ serves to circumvent the possible correlation among the variables.

The sequences of $R_T(y_t)$ on $R_T(x_t)$ tend to diverge if there is no cointegration between y_t and x_t, whereas under cointegration the sequences of ranks evolve similarly. The null hypothesis of no cointegration between y_t and x_t is rejected if these tests statistics are smaller than their respective critical values, available in Table 1 of Breitung (2001).

If y_t and x_t are cointegrated, the linearity nature of the cointegration relationship may then be determined. The following two regressions are run consecutively:

$$y_t = \tilde{\gamma}_0 + \sum_{j=1}^{p}\tilde{\alpha}_j y_{t-j} + \tilde{\gamma}_1 x_t + \sum_{j=-p}^{p}\tilde{\pi}_j \Delta x_{t-j} + \tilde{u}_t \tag{5}$$

$$\tilde{u}_t = \tilde{a}_0 + \sum_{j=1}^{p}\tilde{b}_j y_{t-j} + \tilde{a}_1 x_t + \sum_{j=-p}^{p}\tilde{c}_j \Delta x_{t-j} + \tilde{\theta}_j R(x_t) + \tilde{\varepsilon}_t \tag{6}$$

where $\tilde{a}_0 + \sum_{j=1}^{p}\tilde{b}_j y_{t-j} + \tilde{a}_1 x_t + \sum_{j=-p}^{p}\tilde{c}_j \Delta x_{t-j}$ is the linear part of the relationship. Under the null hypothesis, it is assumed that $\tilde{\theta}_j R(x_t) = 0$ for all *t*. The appropriate value of *p* is selected based on Akaike's information criterion, such that serial correlation in $\tilde{u}_t$ is removed and possible endogeneity of x_t is allowed for. The computed score statistic $T \cdot R^2$, as the number of observations T multiplied by R^2, the coefficient of determination of Equation (6), is distributed asymptotically as a χ^2 distribution. A significant $T \cdot R^2$ indicates that $\tilde{\theta}_j$ is nonzero, which can be taken as evidence of nonlinearity in cointegration. The null hypothesis of linear relationship may be rejected in favor of the alternative hypothesis of nonlinear relationship if the computed statistic value exceeds the χ^2 critical values with one degree of freedom.

3. Data and Empirical Results

This study employs yearly data of South Korea[4] (1954-2008), Singapore[5] (1966-2008) and Hong Kong[6] (1971-2008). The required export and GDP growth are taken from International Financial Statistics of the International Monetary Fund.

3.1 Result of Linear Cointegration Analysis

As the first step, the result of the unit root test is presented in Table 1. The results reveal that the stationarity property is found in the first-differencing level of the variables for Singapore and Hong Kong, while South Korea is in the second-differencing level.

Table 1 Phillips-Perron Unit Root Test

	Test Statistic			5% Critical Value		
Variables	**Level**	**1st Differences**	**2nd Differences**	**Level**	**1st Differences**	**2nd Differences**
South Korea						
GDP Growth	-2.125 (0)	-20.687 (20)*	-71.768 (51)*	-2.917	-2.918	-2.919
Export	10.207 (7)	-2.136 (3)	-13.729 (22)*			
Singapore						
GDP Growth	-4.172 (3)*	-12.079 (5)*		-2.933	-2.935	
Export	12.581 (24)	-3.610 (5)*				
Hong Kong						
GDP Growth	-3.169 (3)*	-7.583 (3)*		-2.943	-2.946	
Export	3.062 (3)	-3.258 (3)*				

Note: (1) terms in the parenthesis show the number of augmentations or lags (k); (2) k is chosen with the help of an automatic model selection criterion (Newey-West Bandwidth).

Table 2 presents the results of the linear cointegration test. The testing strategy begins with moving from the most restrictive model (rank 0 Model 2) and comparing the trace test statistic with the critical value given in parenthesis. If the model is rejected, we continue to Model 3 with the rank being kept fixed. This procedure is continued till the null is accepted for the first time. For Singapore and Hong Kong, the trace test statistics suggests that model 2 with rank equal to 0 is the most appropriate model, which indicates

[4] South Korea experienced rapid growth of industrialization in the early 1960s after the adoption of an outward-looking strategy. This strategy promoted economic growth through labor-intensive manufactured exports, in which South Korea could develop a competitive advantage.

[5] Singapore gained its independence and became a republic on 9 August 1965, this small island nation was filled with uncertainties and unemployment was one of the pressing problems. Industrial estates were set up consequently on promoting manufacturing sector, especially in Jurong. These progresses helped to lighten the unemployment crisis, at the same time, promoting export strategy to achieve greater revenue.

[6] Hong Kong is a well known international financial center after the dominating textiles manufacturing ended at year 1970s. Although the textiles manufacturing was the largest share of the economy, this only hold for a short period of time. The dominating sectors turned to services since 1980s until now.

that there is no cointegrating vector. For South Korea, model 2 with rank equal to 1 is chosen, which suggests that GDP growth and export are cointegrated.

Table 2 Cointegration Rank and Model Selection: Trace Statistic

	Model 2	Model 3	Model 4
South Korea	VAR Lag Order Selection Criteria : SIC (Lag 8)		
r			
0	30.84 (19.96)	29.49 (15.41)	70.09 (25.32)
1	3.90 (9.24)	2.96 (3.76)	4.69 (12.25)
Singapore	VAR Lag Order Selection Criteria : SIC (Lag 7)		
r			
0	18.24 (19.96)	13.48 (15.41)	14.50 (25.32)
1	7.97 (9.24)	5.25 (3.76)	5.72 (12.25)
Hong Kong	VAR Lag Order Selection Criteria : SIC (Lag 3)		
r			
0	19.75 (19.96)	18.30 (15.41)	36.90 (25.32)
1	3.40 (9.24)	2.53 (3.76)	13.26 (12.25)

Note: Figures in the parenthesis are the 5% critical values of the respective test statistics

3.2 Result of Rank tests for cointegration and neglected nonlinearity

Table 3 summarized the results of the Breitung (2001) rank cointegration test. One of the bivariate test (ξ_T^*) reveals that GDP growth and export are cointegrated in Singapore (10% level of significance) and South Korea (1% level of significance). The multivariate test ($\Xi_T^*[1]$) which provides additional supportive evidence, again shows higher results of cointegration at 5% level of significance for Singapore and 1% level of significant for South Korea. However, we failed to reject the null hypothesis of cointegration relationship between GDP growth and export in the case of Hong Kong, for both the bivariate and multivariate tests.

Table 3 Rank Test for Cointegration

Country	Bivariate		Multivariate
	K_T^*	ξ_T^*	$\Xi_T^*[1]$
South Korea	0.6597	0.0110*	0.0104*
Singapore	0.4763	0.0198***	0.0160**
Hong Kong	0.6018	0.0534	0.0342
Critical Values			
10%	0.3941	0.0232	0.0248
5%	0.3635	0.0188	0.0197
1%	0.3165	0.0130	0.0136

Notes: Reject the null hypothesis when test statistic is less than critical values given in Table 1 of Breitung (2001). ***, ** and * indicate the rejection of null hypothesis of no cointegration at 10, 5 and 1% significance level.

The results of nonlinearity test are shown in Table 4. Notice that the rank tests for neglected nonlinearity are meaningful only in the cases where cointegration is detected. In this study, since GDP growth and export are not cointegrated in the case of Hong

Kong, the nonlinearity test is not applicable for this sample. For Singapore and South Korea, there is evidence indicates that the existing cointegration relationships is nonlinear in nature. The computed score statistics $T \cdot R^2$ are significant at 5% for both countries.

Table 4 Rank Test for Neglected Nonlinearity

Country	Linearity Test Statistic (lag)
South Korea	6.562**(3)
Singapore	4.655** (3)
Hong Kong	n.a.
Critical Values	
10%	2.706
5%	3.841
1%	6.635

Notes: Reject the null hypothesis if computed $T{\cdot}R^2$ value exceeds the critical value. ** indicate the rejection of null hypothesis of linear relationship exists between GDP growth and export at 5% significance level.

4. Conclusion

In conclusion, this present study re-examines the long run validity between GDP growth and export by Johansen test and Breitung rank test. Since Johansen method is based on the assumption of linear cointegration while the rank test is invariant to a monotonic transformation of the original data series, the results of rank test should be able to lend additional support to Johansen test. Li (2006) also mentioned that the linear and nonlinear test techniques are better treated as supplements to, rather than substitutes for, each other.

Based on the Breitung rank test procedures, which can detect both linear and nonlinear cointegration relationships, this study contributed to the literature with some evidences of nonlinear cointegration on GDP growth and export. For Singapore, cointegration on GDP growth and export is not supported by the Johansen test, but evidence emerges from the rank tests. For South Korea, the long run relationship between these variables fits in both linear and nonlinear form. On the other hand, in the case of Hong Kong, cointegration relationship is not found either linearly or nonlinearly.

Another related issue emerging from this study, since it is not clear whether the variables must be transformed to logarithms to achieve a linear cointegrating relationship, the robustness of the rank test with monotonic transformation is a desirable property of a cointegration test. The result of this study shown that financial time series could be cointegrated in nonlinear form without any transformation. Consequently, further investigations into other possible nonlinear forms should be carried out in the case of no cointegration among log-transformed data.

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