Is There an ASEAN Convergence Club?

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Abstract: Most countries in the world, particularly those in East Asia, have experienced substantial economic growth, with the pace of growth having varied substantially across both countries and regions. The increasing diversity of average growth rates and income levels across countries has generated a large literature on testing the hypothesis of income convergence. Recent empirical studies have found evidence of several convergence clubs, in which per capita incomes have converged for selected groupings of countries and regions. This paper applies three different time series tests of convergence, namely the cointegration method, the Kalman filter method and the cluster algorithm, to determine if there is a convergence club for the five founding ASEAN member countries (ASEAN-5), as well as ASEAN-5 and the USA. The three different methods yield contrasting results, but empirical evidence supports convergence for pairs of countries within ASEAN-5, and between ASEAN-5 and the USA.

1. INTRODUCTION

Despite a strong world growth performance in the post-world war period, the extent of income disparities across countries and regions has continued to worsen. However, there has been an obvious catching up in the East Asian economies, which grew faster (on average) than all the other regions in the world over the 1965-90 period. Four founding member countries of the Association of South-East Asian Nations (ASEAN) have been identified by the World Bank [1993] as among the eight high-performing Asian economies that grew more than twice as fast as the rest of East Asia since 1960. As there has been limited research on the countries in the South-East Asian region, this paper focuses on the five founding member countries of ASEAN, namely Indonesia, Malaysia, the Philippines, Thailand and Singapore (hereafter referred to as ASEAN-5).

With the empirical evidence indicating the existence of different convergence clubs and regional convergence for different nations, it would be interesting to determine if there is a convergence club in the South-East Asian region. As the cross-section tests for the convergence hypothesis for five ASEAN countries are unlikely to be robust due to degrees of freedom, it would be more appropriate to perform tests of convergence in a time series framework.

The plan of the paper is as follows. Section 2 outlines the time series methods used to test the convergence hypothesis. Section 3 presents the test results for ASEAN-5. Some concluding remarks are given in Section 4.

2. METHODOLOGY

Testing for convergence among the ASEAN-5 economies, and among ASEAN-5 and the world leader, USA, in a time series framework requires comparative income data for these countries over extended periods. Comparative real GDP per capita data for ASEAN-5 and the USA are only available from the Penn World Table 5.6 of Summers and Heston [1994], which are limited to the post-war period from 1960 to 1992. As Singapore separated from Malaysia and became independent in 1965, this paper will focus on the output series of ASEAN-5 from 1965 onward, using three different methods of testing for convergence, namely the cointegration method, the Kalman filter method and the cluster algorithm.

2.1 Cointegration Method

The neoclassical implication of the convergence hypothesis is that countries with low initial per capita output grow faster than those with high initial per capita output, under the assumption of diminishing marginal returns. In a time series context, this can be interpreted to mean that differences in per capita incomes among a cross-section of economies will be transitory. Thus, a stochastic definition of income convergence requires per capita income disparities across countries to follow a stationary process. Bernard and Durlauf [1995] have proposed a time series test for convergence and common trends. The notion of convergence in multivariate output is defined such that the long-term forecasts of output for all countries, $i = 1, \ldots\ldots, n$, are equal at a fixed time t [Bernard and Durlauf, 1995, p. 99]:

$$\lim_{k \to \infty} E(y_{1,t+k} - y_{i,t+k} | I_t) = 0, \qquad \forall i \neq 1, \qquad (1)$$

where $y_{i,t+k}$, is the logarithm of real per capita output for country i at time $t+k$, and I_t is publicly available information at time t. Applying the concepts of unit roots and cointegration, their convergence test determines whether $y_{1,t+k} - y_{i,t+k}$ in equation (1) is a zero mean stationary process in a cointegration framework. Convergence in output for two countries, p and q, implies that output must be cointegrated, with cointegrating vector [1, -1].

Empirically, testing for convergence and common trends in a cointegration framework requires the individual output series to be integrated of order one. The following augmented Dickey-Fuller (ADF) test will be used to determine the order of integration for real GDP per capita of the ASEAN-5/USA countries:

$$\Delta y_{i,t} = a_0 + a_1 t + \beta y_{i,t-1} + \sum_{j=1}^{p} \delta_j \Delta y_{i,t-j} + \varepsilon_{i,t}, (2)$$

where $y_{i,t}$ is the logarithm of per capita output for country i, $\Delta y_{i,t}$ approximates the growth rate in $y_{i,t}$, t is the deterministic trend, p is the order of the autoregressive process, and $\Delta y_{i,t-j}$ is included to accommodate an autoregressive process in the errors.

The rank of the cointegrating matrix in a multivariate framework can be estimated using the following vector autoregressive (VAR) representation [Johansen, 1991]:

$$\Delta Y_t = \Gamma(L)\Delta Y_t + \Pi Y_{t-k} + \mu + \varepsilon_t, \qquad (3)$$

where Y_t is a vector of the logarithms of real GDP per capita for the ASEAN-5/USA countries, Π represents the long-run relationships of the cointegrating vectors, $\Gamma(L)$ is a polynomial of order $k-1$ and captures the short-run dynamics of the system, and ε_t are independent Gaussian errors with zero mean and covariance matrix Ω. The reduced rank $(0 < \text{rank}(\Pi) = r < n)$ of the long run impact matrix is formulated as follows:

$$\Pi = \alpha\beta', \qquad (4)$$

where β is the matrix of cointegrating vectors and α is the matrix of adjustment coefficients. Applying the Johansen maximum likelihood (ML) estimation method, convergence in multivariate output, as defined in equation (1), would require $r = n - 1$ (or four) cointegrating vectors for five ASEAN countries of the form [1, -1] (i.e. one common long-run trend for the individual output series in Y_t).

2.2 Kalman Filter Method

Another time series approach to test the convergence hypothesis is the Kalman filter method, as proposed by St. Aubyn [1996]. Output per capita for a pair of countries, y_p and y_q, is said to converge if their difference $y_{p,t} - y_{q,t}$ converges in probability to a random variable as t tends to infinity. The Kalman filter tests are derived from the following state space model [St. Aubyn, 1996, p. 9]:

$$y_{p,t} - y_{q,t} = \gamma_t + \varepsilon_t, \quad \varepsilon_t \sim N(0, \sigma^2), \qquad (5)$$

$$\gamma_t = \gamma_{t-1} + \mu_t, \quad \mu_t \sim N(0, \Omega_t), \qquad (6)$$

$$\Omega_t = \phi^2 \Omega_{t-1}, \qquad (7)$$

$$\Omega_0 = \Psi^2. \qquad (8)$$

Equation (5) is known as the measurement equation and (6) as the state equation. It is assumed that the variance of μ given by Ω_t in (7) is potentially time varying, but this variance will tend to zero in the long run if $|\phi| < 1$, which implies that the two output series are converging and their difference becomes an I(0) variable. The likelihood function can be constructed using the Kalman filter algorithm and the test for convergence is H_0: $\phi = 1$ against H_a: $\phi < 1$, based on the following test statistic:

$$T(\phi_{ML}) = \frac{\phi_{ML} - 1}{\sqrt{(h^{-1})_{22}}}, \qquad (9)$$

where ϕ_{ML} is the ML estimator and $(h^{-1})_{22}$ is the corresponding element of the inverse of the information matrix. It is important to note that the critical values for the test statistic do not follow a standard t-distribution, and St. Aubyn [1996] provides a simulated distribution for testing the null hypothesis of no convergence.

2.3 Cluster Algorithm

The cluster algorithm proposed by Hobijn and Franses [1999] is also applied in this paper, as it provides inferences about convergence clubs for a small group of countries such as ASEAN-5. This cluster procedure is based on the asymptotic properties of the log per capita income (y_t) disparities between n countries for T years, and the multivariate process is given by [Hobijn and Franses, 1999, p. 5]:

$$y_t = a + bt + D^* \sum_{s=0}^{t-1} v_s^* + u_t^* , \qquad (10)$$

where $y_t = [y_{1t}, \ldots, y_{nt}]' \in \Re^n$, t is a deterministic trend, v_t^* is the first difference of the $m^* \in \{0,\ldots,n\}$ common trends in y_t, and u_t^* is a zero mean vector stationary process.

For a sub-sample of n countries (or n^*), x_t is assumed to have the same representation as y_t in (10) (i.e. $x_t \equiv M_{n^*} y_t^* \in \Re^{n^*-1}$), with stationary covariance, $\eta_t = [u_t' \, v_t']'$, having the following moving average (∞) representation [Hobijn and Franses, 1999, pp. 8-10]:

$$\eta_t = \sum_{s=0}^{\infty} \Psi_s \varepsilon_{t-s} = \Psi(L)\varepsilon_s , \qquad (11)$$

where ε_t is an iid zero mean process, $E[\varepsilon_t \varepsilon_t'] = \Omega = PP'$ (using the Choleski factorisation), $\Lambda = \Psi(1)P$ and $G = \Lambda\Lambda'$. Two types of convergence, namely asymptotically perfect and asymptotically relative convergence, are defined as follows:

i) n^* countries are converging *asymptotically perfectly* if x_t is *zero mean stationary*;
ii) n^* countries are converging *asymptotically relatively* if x_t is *level stationary*.

Based on a multivariate generalisation of the KPSS stationarity test, Hobjin and Franses provide the following two statistics for testing whether x_t is zero mean stationary (for asymptotically perfect convergence) or level stationary (for asymptotically relative convergence):

Zero mean stationarity:

$$\varpi_0 = T^{-2} \sum_{t=1}^{T} S_t' \left[\hat{G}_l\right]^{-1} S_t , \qquad (12)$$

Level stationarity:

$$\varpi_\mu = T^{-2} \sum_{t=1}^{T} \tilde{S}_t' \left[\hat{G}_l\right]^{-1} \tilde{S}_t , \qquad (13)$$

where $S_t \equiv \sum_{s=1}^{t} x_s$, $\tilde{S}_t \equiv \sum_{s=1}^{t} \left(x_t - \frac{1}{T} \sum_{s=1}^{T} x_s \right)$,

and $\hat{G}_l$ is a consistent Newey-West estimator of the first k $(= n^* - 1)$ rows and columns of G. Tests for asymptotically perfect and asymptotically relative convergence of clusters i and j are applied to $x_t^{(i,j)} \equiv M_{k_i+k_j} \left[y_t^{(i)'} \; y_t^{(j)'} \right]' \in \Re^{k_i+k_j-1}$, where $y_t^{(i)}$ and $y_t^{(j)}$ are vectors of (log) real GDP per capita for countries in clusters i and j, respectively, and k_i and k_j are the numbers of countries in clusters i and j, respectively. The p-values or excess probabilities of $\varpi_0^{(i,j)}$ and $\varpi_\mu^{(i,j)}$ are denoted by $p_0^{(i,j)}$ and $p_\mu^{(i,j)}$, respectively, and the critical p-value or significance level is denoted by $p_{\min} \in (0,1)$. According to Hobijn and Franses [1999, p. 13], asymptotically perfect convergence is rejected for all pairs of clusters if no combination of i and j has $p_0^{(i,j)} > p_{\min}$. Clusters of countries that converge asymptotically perfectly will then be tested for level stationarity using the $p_\mu^{(i,j)}$ value.

3. EMPIRICAL RESULTS

This paper applies time series tests of the convergence hypothesis to real GDP per capita (adjusted for changes in the terms of trade) in natural logarithms for two groups of countries, namely ASEAN-5 and ASEAN-5/USA, over the 1965-92 period. All estimation and test results are derived using the Microfit 4.0 econometric software program, except for the Kalman filter convergence test and the cluster algorithm results, which are obtained from the Gauss 3.2 program.

Before testing for convergence based on the method of Bernard and Durlauf [1995], it is essential to determine the order of integration for each of the output series. ADF tests are used to test for the presence of unit roots in the logarithms of real GDP per capita (LGDP) for ASEAN-5 and the USA. Tests for possible breaks in the output series, as suggested by Perron [1989], are not considered because of the small sample size and the lack of any distinct breaks in the level of per capita GDP. For annual data, an initial lag length of two is used for the ADF test. If the t-statistic is insignificant, the lag length is reduced successively until a significant lag length is obtained. The t-statistics for the ADF tests did not reject the null hypothesis of a unit root for the six LGDP series, implying that they are non-stationary. By taking first difference of the series, the test results indicate all six LGDP series are integrated of order one. Thus, the Johansen method can be used to test for the presence of cointegrating vectors or common trends.

The six LGDP series are tested for convergence between each country of ASEAN-5 and USA, and Singapore and the other four founding member countries of ASEAN-5 (hereafter ASEAN-4), based on the definition in Bernard and Durlauf [1995]. Both the Akaike Information Criterion (AIC) and Schwarz Bayesian Criterion (SBC) are used to determine the order of the VAR model. Overall, the test statistics and choice criteria indicate a VAR model of order one. If LGDP for two countries are cointegrated, the restriction [1, -1] is imposed on the cointegrating vector. Table 1 reports the trace and maximal eigenvalue statistics of the stochastic matrix (with unrestricted intercepts and no trends in the VAR) that determine the number of cointegrating vectors (r).

TABLE 1
Maximal Eigenvalue and Trace Statistics for VAR(1) model, 1966-92

Country	Maximal Eigenvalue H_0: r=0, H_a: r=1	Trace H_0: r=0, H_a: r≥1
USA		
Indonesia	7.6026	8.7530
Malaysia	5.6239	6.9563
Philippines	8.2443	8.7108
Singapore	10.5775	14.0611
Thailand	6.7216	6.7245
Singapore		
Indonesia	11.8628	20.8608*
Malaysia	11.5185	19.0884*
Philippines	9.8365	11.1033
Thailand	10.5157	10.7544

Note: * denotes significance at the 5% level.

Both the trace and maximal eigenvalue statistics reject the existence of a long-run cointegrating relationship between the USA and each of the ASEAN-5 countries. In the case of Singapore and each ASEAN-4 country, the trace statistics indicate a long-run cointegrating relationship exists between Singapore and each of Indonesia and Malaysia. On the other hand, the maximal eigenvalue statistics do not reject the null of no cointegrating relationship between Singapore and each ASEAN-4 country. If the trace statistics yield the correct inferences, the likelihood ratio test of a unit restriction on each cointegrating vector is not rejected for Singapore and Indonesia (with $\chi^2(1) = 2.3181$ and probability value = 0.128), and for Singapore and Malaysia (with $\chi^2(1) = 2.5904$ and probability value = 0.108). These results imply income convergence between Singapore and each of Indonesia and Malaysia. However, Cheung and Lai [1993] stress that the Johansen method tends to underestimate the cointegration space in small samples, which often leads to the rejection of no cointegration under the null. In addition, the significance of the trace statistics for both Indonesia and Malaysia are not robust to the sample period used. Thus, the cointegration tests are based on the maximal eigenvalue statistics, which reject income convergence between Singapore and each of Indonesia and Malaysia.

For the two groups of countries reported in Table 1, tests for the presence of a common trend are also undertaken. Both the trace and maximal eigenvalue statistics suggest the presence of at least one cointegrating vector, which indicate non-convergence of income for these two groups of countries.

As the time series tests for convergence developed by Bernard and Durlauf [1995] are rather stringent, the Kalman filter approach proposed by St. Aubyn [1996] is also applied to the per capita output series for ASEAN-5 and the USA. Following the specifications of the state space model, equations (5) and (6) are estimated using the Gauss program provided by St. Aubyn. There are 15 pairwise combinations for these six countries, and the test statistics are shown in Table 2. The non-standard critical values for $T(\phi_{ML})$ at the 5% and 1% levels of significance are -2.479 and -3.479, respectively.

In testing convergence between the USA and individual ASEAN-5 countries (the first five pairs of countries shown in Table 2), Singapore is the only country that rejects the null hypothesis of non-convergence at the 5% significance level. This suggests that the per capita incomes of the USA and Singapore have converged over time. As for the ten pairwise ASEAN-5 countries, only Indonesia, Malaysia and Thailand (hereafter ASEAN-3) are found to have converged with Singapore, while the null hypothesis of non-convergence is not rejected for the remaining seven pairs of ASEAN-5 countries

The empirical evidence for income convergence between Singapore and the USA lends support to the observed high growth performance of Singapore, which has reduced substantially the income gap with the USA. On the other hand, the convergence between Singapore and individual ASEAN-3 countries does not necessarily suggest the existence of an ASEAN-5 club since the null hypothesis of non-convergence is not rejected for the three pairwise ASEAN-3 countries. St. Aubyn [1996] classified this type of convergence as "limited convergence", where only a subset of a country's per capita income converges to that of a leading country.

TABLE 2
Kalman Filter Test Statistics for ASEAN-5 and the USA, 1965-92

Paired Countries	Convergence Coefficient	$T(\phi_{ML})$ Statistic H_0: ϕ=1, H_a: ϕ<1
USA		
Indonesia	0.9809	-1.116
Malaysia	0.9999	0.010
Philippines	1.0500	1.050
Singapore	0.9654	-2.924*
Thailand	1.0180	1.329
Singapore		
Indonesia	0.9607	-2.607*
Malaysia	0.9444	-4.097**
Philippines	0.9801	-1.532
Thailand	0.9175	-5.670**
Malaysia		
Indonesia	1.0050	0.269
Philippines	1.0070	0.479
Thailand	0.9977	-0.140
Thailand		
Indonesia	0.9934	-0.346
Philippines	1.0540	2.225
Indonesia		
Philippines	1.0260	1.360

Notes: * indicates significance at the 5% level.
** indicates significance at the 1% level.

These findings of income convergence between Singapore and each ASEAN-3 country contradict the results of the Johansen test. St. Aubyn [1996] argued that the economic definition of income convergence does not necessarily imply that the output difference between two countries is stationary. It is possible for the per capita incomes of two countries to become equal or to converge, but their difference might not exhibit stationarity. These contrasting results could be explained by the definition of convergence of St. Aubyn [1996], which only requires the output difference of two countries to converge in probability to a random variable rather than to zero, as proposed in Bernard and Durlauf [1995].

For comparison, the cluster algorithm for testing asymptotically perfect and asymptotically relative convergence is also applied to ASEAN-5/USA and ASEAN-5. The cluster algorithm is provided by Hobijn and Franses [1999] as a Gauss program. Before applying the cluster procedure, it is necessary to choose the critical p-value (p_{min}) and the bandwidth parameter (l). According to Hobijn and Franses [1999, p. 14], a smaller p_{min} implies that a rejection of convergence under the null hypothesis is less likely, while the choice of l does not seem to have a significant effect on the number of convergence clubs found. However, based on the Monte Carlo results for the univariate version of the KPSS test, the choice of l is found to have a significant effect on the size of the test in small samples [Hobijn et al., 1998]. Following Hobijn and Franses [1999], p_{min} is set at the 1% significance level and the bandwidth for the Bartlett window (l) is set at 4. The test results are presented in Table 3.

TABLE 3
Cluster Algorithm Results for ASEAN-5/USA and ASEAN-5

Asymptotically Perfect Convergence (p_{min} = 0.01, l = 4)	**Asymptotically Relative Convergence** (p_{min} = 0.01, l = 4)
ASEAN-5/USA: *6 clusters*	ASEAN-5/USA: *3 clusters*
1. Indonesia	1. Malaysia and Thailand
2. Malaysia	2. Philippines and USA
3. Philippines	3. Singapore and Indonesia
4. Singapore	
5. Thailand	
6. USA	
ASEAN-5: *5 clusters*	ASEAN-5: *3 clusters*
1. Indonesia	1. Malaysia and Thailand
2. Malaysia	2. Singapore and Indonesia
3. Philippines	3. Philippines
4. Singapore	
5. Thailand	

For ASEAN-5/USA, there are six asymptotically perfect convergence clubs with a single country in each club, and three asymptotically relative convergence clubs with two countries in each club (see Table 3). The results of asymptotically perfect and asymptotically relative convergence are the same for ASEAN-5, except for a single country (i.e. the Philippines) in an asymptotically relative convergence club when the USA is excluded. Based on the definition of asymptotically perfect convergence, there is no evidence to support the equalisation of per capita income in the long run, implying that none of the ASEAN-5 countries and the USA converges to each other. However, the results indicate the existence of three asymptotically relative convergence clubs of two countries, namely Malaysia and Thailand, Singapore and Indonesia, and the Philippines and the USA. Given the low growth performance of the Philippine economy, it is surprising to find asymptotically relative convergence between the Philippines and the USA. This could be explained by the definition of asymptotically relative convergence, which requires the income gap between two countries to be level stationary, or simply remaining stable (i.e. no catching up) over time, as in the case of the Philippines and the USA.

As the samples are relatively small, the tests are also conducted with $p_{min} = 0.05$ and the bandwidth parameter ranging from 1 to 6 to examine the robustness of the results. For both ASEAN-5 and ASEAN-5/USA, an increase in the critical p-value to 0.05 does not significantly affect the results of Table 3. However, when the bandwidth parameter is reduced to 2 and below, it increases the number of asymptotically relative convergence clubs to four for both ASEAN-5 and ASEAN-5/USA. In both cases, Singapore and Indonesia do not converge to the same asymptotically relative convergence club, but each of them converges to a single country club. Based on the cluster procedure, there is evidence to support asymptotically relative convergence between Malaysia and Thailand, and the Philippines and the USA.

4. CONCLUSION

This paper finds no evidence of convergence within the ASEAN-5 countries, and between ASEAN-5 and the USA, for time series data using the cointegration method. It has been argued that the economic definition of income convergence would require more than the output difference between two series to be stationary. In terms of limited convergence, however, the Kalman filter test results support convergence between the USA and Singapore, and between Singapore and individual ASEAN-3 countries. The cluster analysis also provides support for asymptotically relative convergence between Malaysia and Thailand, and between the Philippines and the USA.

It is important to stress that the contrasting results from the three different methods could be affected by the size of the sample. In addition, the time series methods available to test the convergence hypothesis are limited to testing the time series properties of income differences, without considering the factors that determine economic growth. Thus, further research on the existing time series methods for testing the convergence hypothesis, examining the sample size, and considering other relevant variables that determine economic growth, would be invaluable.

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