Developing and Developed ASEAN-10 Economies: Converge or Diverge?

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ABSTRACT

The governments of the ten ASEAN economies recognised substantial disparity in income level among the more developed and the less developed ASEAN economies. We seek to examine whether there is any tendency for such income disparity among ASEAN countries to narrow over the years. In order to fill the existing gap in literature, the present paper aims to examine income convergence and/or divergence in ASEAN incorporated for the possible nonlinearity in economic growth among countries. The KSS-CHLL nonlinear unit root test proposed by Chong *et al*. (CHLL, 2008) being an extension of the work by Kapetanios *et al*. (KSS, 2003), allow us to examine nonlinear long-run convergence and nonlinear catching-up hypotheses. This test is applied on the ASEAN-10 countries with respect to ASEAN average covering the period from 1970 to 2015. Nonlinear convergence was detected in Indonesia, Malaysia, Singapore and Thailand during the period from 1980 to 2015, depending on whether a linear or nonlinear trend was included in the test. Similarly, nonlinear convergence was observed in Indonesia, Singapore, and Thailand during the period from 1985 to 2015. However, only Thailand was found to show nonlinear convergence in the period from 1990 to 2015. Overall, Laos exhibited nonlinear catching-up throughout the sub-periods except for the period from 1990 to 2015. Similarly, Cambodia and Vietnam also showed nonlinear catching-up in some of the sub-periods. On the other hand, Brunei, the Philippines and Myanmar had shown divergence consistently in all sub-periods. These results imply that the government of the ASEAN economies have to work harder in order to achieve the aspiration of the ASEAN Economic Community in the long-term future.

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INTRODUCTION

To date, the ASEAN member countries consist of Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand, and Vietnam. The ASEAN Economic Community (AEC) was established at the end of December 2015. Earlier, in October 2003, the leaders of the said ASEAN member countries agreed to endorse the ASEAN Economic Community towards the aspiration of "Many Countries, One Economy" via expanding the regional economic integration. The primary objective of the AEC was to increase the efforts taken by ASEAN Free Trade Agreements (AFTA) to broaden and deepen trade liberalisation. It started with the introduction of "Preferential Trading Arrangement" which promoted intra-regional trade and expanded the economic space. In addition, it serves to strengthen economic ties with ASEAN's neighbours such as China, Japan, South Korea, and India through bilateral and collective free trade arrangements.

The AEC is envisaged to be a single market and a production base in a highly competitive region with equitable economic development. At the same time, it was also intended to promote full integration into the global economy (Hew, 2008). The idea of a single market is understood as a market with no geographic segmentation, absent of discrimination, and having the ability to source in the regional markets for goods, services or factors of production such as capital and labour (Lloyd, 2005). Accordingly, there will be free flow of goods, services, investments, capital, and skilled labour within AEC.

Nevertheless, one of the challenges to overcome was the limited resources among the CLMV (Cambodia, Laos, Myanmar and Vietnam) countries as compared to the ASEAN-6 countries. In this regard, the ASEAN leaders were committed to reduce the development gap and to accelerate the economic integration between the CLMV countries and ASEAN-6 countries. The Initiative for ASEAN Integration (IAI) was launched in year 2000 as the mechanism for ASEAN-6 to help the CLMV countries. Projects were formulated to specifically respond to the needs of the CLMV countries in terms of provision of external assistance, long-term continuity and sustainability, and building their capacity for participation in ASEAN programmes. However, the CLMV countries had to overcome the challenges posed by globalisation and rapid technological developments. Continuing efforts by ASEAN also involved the development of frameworks to support the small and medium-sized enterprises (SMEs) within ASEAN, in particular the CLMV countries, to integrate them into the international production network and global value chain. Such supports include access to financing, facilitation in addition to technology and human resource development. Despite the efforts and initiatives carried out by ASEAN, the income gap among the ASEAN member countries still persist. For example, Menon (2013) asserts that the income differences between the CLV countries and the more developed ASEAN countries have been reduced since the 1990s, but more needs to be done in terms of labour migration, education, health, and land reforms in order to further narrow the gaps.

Plummer (2006: p.438) made clear his concerns when he stated that, "…the divergence within ASEAN is far greater than that of the EU, and the countries are far poorer. This suggests that matters related to the speed of implementation of AEC, and even the ability of ASEAN to be completely inclusive for all member-states, will be complicated and difficult." Furthermore, according to Vo (2008), unless the development gap between the less developed CLMV countries and the more developed ASEAN member countries narrows, ASEAN integration cannot succeed. To date, the income disparity still exists within ASEAN, with member countries falling into three groups. According to the latest classification by the World Bank, both Brunei and Singapore are categorised as high-income countries followed by upper-middle income countries consisting of Malaysia and Thailand, while lower-middle income countries include Cambodia, Indonesia, Laos, Myanmar, the Philippines and Vietnam. It is noted that Malaysia has been "trapped" in the upper-income category for more than two decades.

In Table 1, we present the real GDP per capita relative to the ASEAN average. The output of both Brunei and Singapore are clearly above the ASEAN average. Malaysia is converging while Thailand is quickly catching-up to reach the ASEAN average. Indonesia and Vietnam also seem to be slowly moving up to the ASEAN average. Reflecting these scenarios, Figure 1 clearly illustrates the income divide among the ASEAN-10 countries, where we also compute and plot the ASEAN average real per capita GDP (income). We observe that only Brunei and Singapore's incomes are placed far above the ASEAN average income, while the rest of ASEAN fall below this average level. It is clear that there are at least three clusters of countries in ASEAN. We noted that each ASEAN member countries are converging to the ASEAN average albeit very slowly, except for Singapore which is found to be diverging from the ASEAN average.

Table 1 Real GDP per capita, 1970-2015 (ASEAN-10, average =100)

Country	1970	1980	1990	2000	2010	2015
Brunei	789	770	551	442	356	311
Cambodia	9	3	4	5	8	10
Indonesia	9	9	16	18	21	25
Laos	4	3	5	6	8	10
Malaysia	29	35	58	75	82	92
Myanmar	2	1	1	2	5	7
Philippines	20	16	19	16	18	21
Singapore	119	147	310	393	446	464
Thailand	15	14	30	35	44	47
Vietnam	4	3	5	8	11	14
ASEAN-10, average	100	100	100	100	100	100

Note: Authors' calculation. Sources: Computed from United Nation Statistical Division databases.
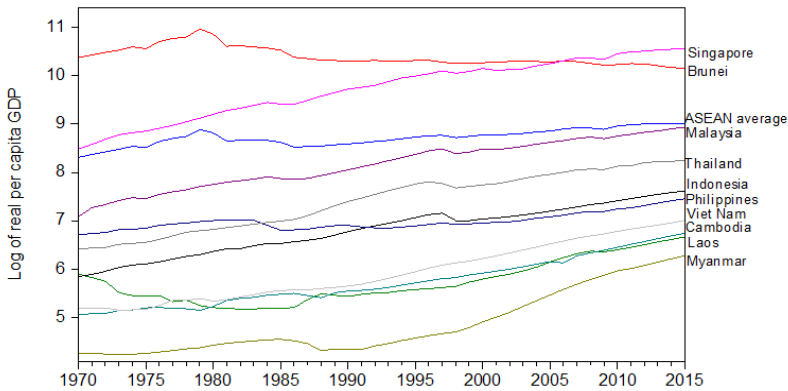
Figure 1: Trend in log real per capita GDP for ASEAN economies

In terms of country ranking, as depicted in Table 2, Brunei has been the leading economy for a significantly long period of forty years, however by mid-2000 Singapore has taken the lead. Meanwhile, Malaysia has since 1970 been the third largest economy among the ASEAN countries. In 2015, Thailand ranked fourth while Indonesia ranked fifth, followed by the Philippines, Vietnam, Cambodia, Laos and Myanmar. The question of whether the ASEAN-10 member countries are converging and/or diverging from the ASEAN average income is an empirical one. Thus, this is the main task of this paper - to examine the presence or absence of income convergence among the ASEAN countries for the period from 1970 to 2015.

Table 2 Ranking by country according to real GDP per capita, 1970-2015

Country	1970	1980	1990	2000	2010	2015
Brunei	1	1	1	1	2	2
Cambodia	6	7	8	9	8	8
Indonesia	6	6	5	5	5	5
Laos	7	7	7	8	8	8
Malaysia	3	3	3	3	3	3
Myanmar	8	8	9	10	9	9
Philippines	4	4	6	6	6	6
Singapore	2	2	2	2	1	1
Thailand	5	5	4	4	4	4
Vietnam	7	7	7	7	7	7

Note: Authors' calculation based on Table 1.

In the next section, we provide some relevant literature on income convergence in ASEAN. Section 3 then discusses the testing procedure for the convergence analysis employed in the study. The empirical results are reported and discussed in section 4 whilst the last section sets out some of our concluding remarks.

INCOME CONVERGENCE IN ASEAN

The study of economic convergence among ASEAN member countries is important in assessing whether the efforts stemming from economic cooperation over the years have been successful in narrowing the development gap. On examining the income convergence among the 10 members of the ASEAN countries, most of the findings turned out to be negative. For example, utilising the Theil entropy index as the measurement for inequality, the results of Park (2000) was consistent with Park and Rahman (2001), where it was found that inter-country inequality among ASEAN-10 countries had been increasing rather than decreasing. Similarly, investigation conducted on nine member countries (Myanmar excluded due to lack of data) conducted by Chowdhury (2005) did not find support for both unconditional or conditional beta and sigma convergence. The explanation provided was that the non-convergence in ASEAN was the result of slow growth of intra-country trade and income per capita. The continuous disparity in income among the ASEAN countries was also attributed to weak governance in some of the ASEAN member countries that hindered economic growth, reduced efficiency and increased poverty among the population (Chowdhury, 2005). Alavi and Ramadan (2008), on the other hand, found that the main reason for the divergence was the failure in the enforcement of action plans among members. Masron and Yusop (2008) disclosed that convergence in ASEAN countries to its leader – Singapore, was conditional upon the level of domestic investment, human capital development, domestic financial deepening and trade, as well as financial openness. However, in the presence of external shocks, the ASEAN countries tended to diverge.

Meanwhile, Ismail (2008) focused on ASEAN-5 economies. Her findings supported both unconditional and conditional convergence hypothesis on the ASEAN-5 countries for the period from 1960 to 2004. According to Ismail (2008), the ASEAN-5 countries tend to converge to a steady state growth rate of per capita income with the speed of convergence ranging from 1.6% to 16.6%. Further support for income convergence was provided by Onwuka *et al*. (2006) that brought forth evidence of both unconditional and conditional beta convergence in terms of growth rate per worker and total factor productivity (TFP) due to similar economic structures among the ASEAN-5 countries.

A study by Carmignani (2007) on stochastic convergence failed to find any evidence of convergence within the ASEAN-5 countries. This is further supported by Wang (2012) which similarly did not detect any income convergence for all ten ASEAN countries. On the other hand, Lim and McAleer (2004) managed to detect Malaysia, Thailand, and the Philippines displaying converging trend to the ASEAN-5's average. They explained that a lagging country can benefit from the technology diffusion and therefore grow at a more rapid pace. However, except for Singapore, they failed to prove any catching-up effects among these countries with the United States. Similarly, Jayanthakumaran and Lee (2013) found both beta convergence and stochastic convergence for all the ASEAN-5 member countries relative to their average. However, when taking into account the Asian crisis, beta convergence was found for Malaysia, Indonesia and the Philippines before the Asian crisis, but they have diverged since then. Meanwhile, Thailand has been showing convergence consistently before, during and after the crisis. Singapore, on the other hand, began converging after the Asian crisis. A more recent study by Solarin *et al*. (2014) on ASEAN-9 countries found that only Brunei, Malaysia, the Philippines, Singapore, and Vietnam show convergence towards the ASEAN average.

Nevertheless, economists have recognised that the income growth process is nonlinear and this is one of the reasons why convergence among a group of countries cannot be achieved. Findings by Dobson *et al*. (2003) revealed that convergence can be detected among countries with very low and very high initial income. Convergence was not supported for those countries with intermediate initial income. These results have led to the idea of convergence clubs, indicating the clustering of countries according to their economic growth performance. On the other hand, gradual reform strategy implemented by developing countries can be another cause of nonlinear economic growth. Lai (2006) studied China's development during 1979 to 2005 and found that market-oriented reform and openness were the main forces driving its convergence, which follows the "flying geese" pattern similar to the East Asian model of development. However, China showed an inconsistent pattern of growth performance over the period of study. High growth rates were recorded for the period from 1979 to 1996 but a significant slowdown was later observed for the period from 1997 to 2002. The growth momentum was resumed from 2003 to 2005. The fluctuation in growth rates implies nonlinear growth performance and hence nonlinear convergence, resulting from the reform processes and the inappropriate development policies set by the government.

Empirical evidence of income convergence incorporating nonlinearities can be found in existing literature. In order to include nonlinearities into consideration, Liew and Lim (2005) adopted the nonlinear unit root test proposed by Kapetanios *et al*. (2003). Based on the results obtained, they detected nonlinearities in the income gaps between Japan and the East Asian countries. Furthermore, they reported that only the Four Asian Dragons (Hong Kong, Korea, Singapore and Taiwan) had their income converging to Japan's income. Data for the rest of the countries (China, Indonesia, Malaysia, Thailand, and the Philippines) showed otherwise.

On the other hand, Liew and Ahmad (2007) who limited their study to cover only the Four Asian Dragons, found catching-up effect towards Japan only in Hong Kong, Korea and Singapore, but not Taiwan. Chang *et al*. (2008) conducted a similar study on 15 OECD countries for the period from 1950 to 2000. Nonlinearities were found in the income gaps of 12 OECD countries relative to the United States. Among these countries, it was observed that Australia, Sweden, United Kingdom, and Switzerland were catching-up with the United States while Austria and Netherlands had shown long-run pattern of convergence with the United States.

METHODOLOGY

The traditional test for income convergence, the so-called β-convergence, involves running a regression in a cross-country analysis between average output growth (over a certain time period) and the initial level of per capita output. This test, which was popularised by Barro and Sala-i-Martin (1992) and Sala-i-Martin (1996), has been put to question and criticised, among others by Quah (1996a, 1996b), Evans and Karras (1996), and Bernard and Durlauf (1995). Quah pointed out that the traditional test for convergence does not answer how fast the poor countries are catching-up with the richer countries (convergence mechanism). Instead it demonstrates how a single country has been moving away from its own steady-state level or relative to its own history (growth mechanism). Using the intra-distribution dynamic approach,

Quah (1996a, 1996b) was able to show that cross-country convergence is limited whilst the cross-country distribution demonstrates convergence club or "twin-peaks" dynamics. According to Quah (1996a, 1996c), due to geographical factors and over time, countries are polarised into two convergence clubs – the rich and the poor.

Evans and Karras (1996) argued that the traditional test for convergence produces invalid inferences, unless all the countries' incomes have unit root. In agreement with Bernard and Durlauf (1995), Evans and Karras (1996) suggested using time-series method (the so-called stochastic convergence) to evaluate convergence since the cross-country approach is subject to bias. According to Bernard and Durlauf (1995, 1996) and Evans and Karras (1996), stochastic convergence in time series perspective examines whether common stochastic elements matter. It aims to test whether the differences in income among countries are persistent. Basically, stochastic convergence is realised if the income difference is found stationary through the augmented Dickey-Fuller (ADF) test, with the regression in the following form (Oxley and Greasley, 1995):

$$\Delta y_{it} = \alpha_i + \lambda_{i\,t} + \beta_i y_{it-1} + \sum_{j=1}^{p} \theta_{ij} \Delta y_{it-j} + \epsilon_t \qquad t=1,...,T \qquad (1)$$

where ϵ_t is the error term, $i = 1, ...,N$ series, and $j = 1, ...,p$ ADF lag. This test allows one to distinguish between convergence and catching-up. If y_{it} (i.e. $y_{it} = logY_{it} - log\overline{y_t}$) contains a unit root (i.e. β_0), log real GDP per capita for country i, Y_{it} and $\overline{y_t}$ (i.e. $\overline{y_t} = 1/N \sum_{i=1}^{N} log\ Y_{it}$) diverge over time. On the other hand, if y_{it} is stationary (i.e. in the absence of stochastic trend, or $\beta < 0$), three different types of convergence can be identified. Firstly, absolute convergence is realised when $\alpha_i = 0$ and $\lambda_i = 0$ (i.e. the absence of a deterministic trend), implying that the gap between country i and $\overline{y_t}$ has become zero. Secondly, conditional convergence occurs when $\alpha_i \neq 0$ and $\lambda_i = 0$, showing that the income gap diminishes over time and finally becomes a constant. Lastly, $\alpha_i \neq 0$ and $\lambda_i \neq 0$ indicates catching-up between country i and $\overline{y_t}$.

Oxley and Greasley (1995) emphasised that conditional convergence differs from catching-up where the former relates to a particular period, T, equated with long-run steady state equilibrium. In this case, the presence of a time trend in the stationary series would imply a catching-up process to narrow the income gap but not yet converged. On the contrary, the catching-up is considered completed in the absence of time trend.

However, it is claimed that the power for the standard ADF unit root test will be low with the presence of nonlinearities in the dynamics of the variables (Kapetanios *et al*., 2003). Such drawback makes it difficult to distinguish between unit root and nonlinear stationary process. Adoption of linear unit root tests when the true adjustment process is nonlinear can result in failure of rejecting non-stationarity (Gregoriou and Kontonikas, 2006).

The null hypothesis of KSS test refers to non-stationarity. The alternative hypothesis indicates nonlinear but globally stationary exponential smooth transition autoregressive (ESTAR) processes. The KSS test is based on the specific ESTAR model, as follows:

$$\Delta \ddot{y}_{\,iqt} = \gamma \ddot{y}_{iqt-1} [1-exp(-\theta \ddot{y}^2_{iqt-1})] + \varepsilon_t \qquad (2)$$

where ε_t is the error term with zero mean and constant variance. Variable $\ddot{y}_{iqt}$ is the de-meaned or de-trended series of $\ddot{y}_{iqt}$ (country i against benchmark country q). The nonlinear adjustment can be captured by $[1-exp(-\theta \ddot{y}^2_{iqt-1})]$ which is referred to as the exponential transition function.

The null hypothesis of a unit root in $\ddot{y}_{iqt}$ indicates $H_0 : \theta = 0$, while the alternative of a nonlinear but globally stationary process requires that $H_1 : \theta > 0$. The value of θ explains the speed of mean reversion.

The parameter γ in Equation (2) cannot be identified under the null hypothesis and thus re-parameterization of Equation (2) is required. Kapetanios *et al.* (2003) suggested computing the first-order Taylor series approximation to the ESTAR model to obtain the following auxiliary regression,

$$\Delta y_{iqt} = \delta \ddot{y}^3_{iqt-1} + \omega_t \tag{3}$$

where ω_t is a stochastic error term. The following augmented regression is estimated with the intention to whiten the noise,

$$\Delta y_{iqt} = \delta \ddot{y}^3_{iqt-1} + \sum_{i=1}^{k} \varphi_i \Delta \ddot{y}_{iqt-i} + \omega_t \tag{4}$$

with k augmentations to correct for serially correlated errors. The t-test statistics (t_{NL}) tabulated in Kapetanios *et al.* (2003) is referred to in order to test the null hypothesis of non-stationarity, $H_0 : \delta = 0$ against the alternative of $H_1 : \delta < 0$.

The main interest of our study is to examine nonlinear long-run converging and nonlinear catching-up. However, KSS nonlinear unit root test fails to differentiate between the two hypotheses (Liew and Ahmad, 2007; Chong *et al.*, 2008). To overcome such limitation, Chong *et al.* (2008) proposed to include an additive intercept μ and trend component [G(trend)] in Equation (4) and estimated the model using raw data rather than de-meaned or de-trended data, as follows:

$$\Delta y_{iqt} = \mu_t + \phi G(trend) + \rho y^3_{iqt-1} + \sum_{i=1}^{k} \pi_i \Delta y_{iqt-i} + v_t \tag{5}$$

where v_t is the error term. The absence of nonlinear unit root ($\rho < 0$) in Equation (5) implies either nonlinear catching-up (when $\phi \neq 0$) or nonlinear long-run converging (when $\phi = 0$). Otherwise, country i and country q have their income diverge over time with the presence of nonlinear unit root ($\rho = 0$) in y_{iqt}.

Description and sources of data

This study made use of annual time-series data for per capita gross domestic product (GDP) at constant 2005 prices in US dollars for the period from 1970 to 2015. The data was obtained from the United Nations Statistical Division website (at http://unstats.un.org/UNSD/economic_main. htm), and can be freely downloaded from http://unstats.un.org/UNSD/snaama/dnlList.asp. The ten ASEAN countries included in the study are Brunei Darussalam, Cambodia, Indonesia, Laos, Malaysia, Myanmar, the Philippines, Singapore, Thailand, and Vietnam. The ASEAN average income is computed as $\bar{y}_{ASEAN,t} = \frac{1}{10} \sum_{i}^{10} Y_{it}$. In all estimations, the variables were transformed into natural logarithm.

EMPIRICAL RESULTS

In order to test for stochastic convergence, it is required for all income series to have unit root. To test for unit root in the series, we employed three popular standard unit root tests – the augmented Dickey-Fuller (ADF) and Dickey-Fuller generalized least square (DF-GLS) tests (which test the null hypothesis of a unit root), and the Kwiatkowski–Phillips–Schmidt–Shin (KPSS) test (which test the null hypothesis of stationarity in the series). We tested the series in levels as well as in first-differences with constant without trend and with trend. The results of the unit root tests are presented in Table 3. In Panel A, our results suggest that all series are non-stationary or exhibit unit root in levels. On the other hand, after first-differencing, all income series are stationary. Based on this, we concluded that all income series in ASEAN economies are integrated of order one, that is, they are I(1).

Table 3 Results of unit root tests for real GDP per capita series

Country	ADF				KPSS				DF-GLS			
	Const		Const+trend		Const		Const+trend		Const		Const+trend	
	t-stat	lag	t-stat	lag	LM-stat	lag	t-stat	lag	t-stat	lag	t-stat	lag
Panel A: Level												
Brunei	-0.90	2	-2.27	4	0.59**	5	0.17**	1	-0.79	0	-2.84	5
Cambodia	0.54	1	-2.65	3	0.65**	5	0.21**	5	0.01	1	-1.05	1
Indonesia	-1.34	0	-2.47	1	0.86**	5	0.15**	5	0.75	1	-2.07	1
Laos	2.28	0	-0.76	0	0.85**	5	0.21**	5	1.89	1	-0.74	0
Malaysia	-2.47	0	-2.45	1	0.87**	5	0.15**	4	1.53	1	-1.96	0
Myanmar	0.82	1	-1.18	1	0.74**	5	0.21**	5	0.31	1	-1.19	0
Philippines	0.10	1	-1.10	1	0.65**	5	0.17**	5	0.56	1	-1.48	1
Singapore	-2.54	1	-1.74	0	0.86**	5	0.21**	5	0.56	1	-0.94	0
Thailand	-1.16	1	-1.68	1	0.85**	5	0.15**	5	0.25	1	-1.89	1
Vietnam	1.17	5	-1.23	5	0.85**	5	0.22**	5	-0.59	5	-0.82	5
ASEAN10 av.	2.30	9	-2.07	4	0.71**	5	0.35**	0	3.44	9	-2.98	5
Panel B: First-difference												
Brunei	-4.47**	1	-4.46**	1	0.16	3	0.11	3	-2.35**	2	-4.42**	1
Cambodia	-3.80**	0	-5.15**	0	0.45	10	0.17	2	-2.20**	2	-5.26**	0
Indonesia	-4.94**	0	-4.99**	0	0.16	2	0.07	1	-5.00**	0	-5.09**	0
Laos	-5.72**	0	-6.42**	0	0.45	10	0.10	7	-5.68**	0	-6.56**	0
Malaysia	-6.62**	0	-6.60**	0	0.31	3	0.08	2	-2.53**	0	-4.40**	1
Myanmar	-2.42	0	-3.07	0	0.40	8	0.08	5	-2.29**	0	-3.13**	0
Philippines	-3.46**	0	-3.66**	1	0.26	3	0.14	3	-3.47**	0	-3.63**	0
Singapore	-5.01**	0	-5.72**	0	0.45	13	0.04	3	-4.22**	0	-5.71**	0
Thailand	-3.93**	0	-4.02**	0	0.15	3	0.08	3	-3.77**	0	-3.97**	0
Vietnam	-4.23**	0	-4.81**	0	0.43	9	0.09	3	-3.87**	0	-4.92**	0
ASEAN10 av.	-4.70**	1	-7.83**	8	0.14	0	0.13	0	-2.52**	2	-4.55**	1

Notes: Asterisk (**) denotes statistically significant at the 5% level. Critical values for ADF *t*-statistics and DF-GLS *t*-statistics are referred to MacKinnon (1996), while LM-statistics referred to Kwiatkowski *et al.* (1992, Table 1).

Given that all income series are I(1), for a pair of series to exhibit stochastic convergence, the income differential between one country against a benchmark country must be stationary, that is, I(0). However, before we proceed to test for nonlinear convergence, we endeavour to test for "linear" convergence by employing the "linear" unit root as per Equation (1). The results are presented in Table 4. In Panel A, we tested for conditional convergence and the results clearly suggest that all ASEAN member countries diverge from their ASEAN average. Similarly, the test of catching-up as shown in Panel B also indicates that all ASEAN member countries (except Vietnam), show divergence with the ASEAN average. Thus, the "linear" convergence test using Equation (1) failed to find stochastic convergence among the ASEAN member countries with their ASEAN average. As presented in Figure 2, scatter plots between incomes of each ASEAN member countries with their ASEAN average clearly suggest nonlinear association between them. This could be the reason why "linear" unit root test failed to detect stochastic convergence among the ASEAN member countries.

Table 4 ADF unit root tests for convergence

Country	ADF t-statistic	p-values	Lags	Remarks
Panel A: Constant, no trend				
Brunei	1.4501	0.9989	0	Divergence
Cambodia	0.1385	0.9645	8	Divergence
Indonesia	-0.5653	0.8680	0	Divergence
Laos	0.4886	0.9844	2	Divergence
Malaysia	-1.1970	0.6667	4	Divergence
Myanmar	0.6792	0.9901	6	Divergence
Philippines	-0.9229	0.7706	4	Divergence
Singapore	-1.8479	0.3529	4	Divergence
Thailand	-0.4642	0.8886	0	Divergence
Vietnam	1.3559	0.9985	0	Divergence
Panel B: Constant and trend				
Brunei	-2.4725	0.3396	0	Divergence
Cambodia	-1.8493	0.6595	9	Divergence
Indonesia	-1.4744	0.8237	0	Divergence
Laos	-3.0991	0.1192	1	Divergence
Malaysia	-1.3194	0.8696	2	Divergence
Myanmar	-0.7043	0.9657	6	Divergence
Philippines	-0.3089	0.9877	4	Divergence
Singapore	-0.6676	0.9689	4	Divergence
Thailand	-1.0757	0.9219	0	Divergence
Vietnam	-4.3287***	0.0068	1	Catching-up

Notes: Asterisks (***), (**), (*) denote statistically significant at 1%, 5% and 10% level, respectively. Lag length chosen is based on SIC. Critical values for unit root test are referred to MacKinnon (1996).
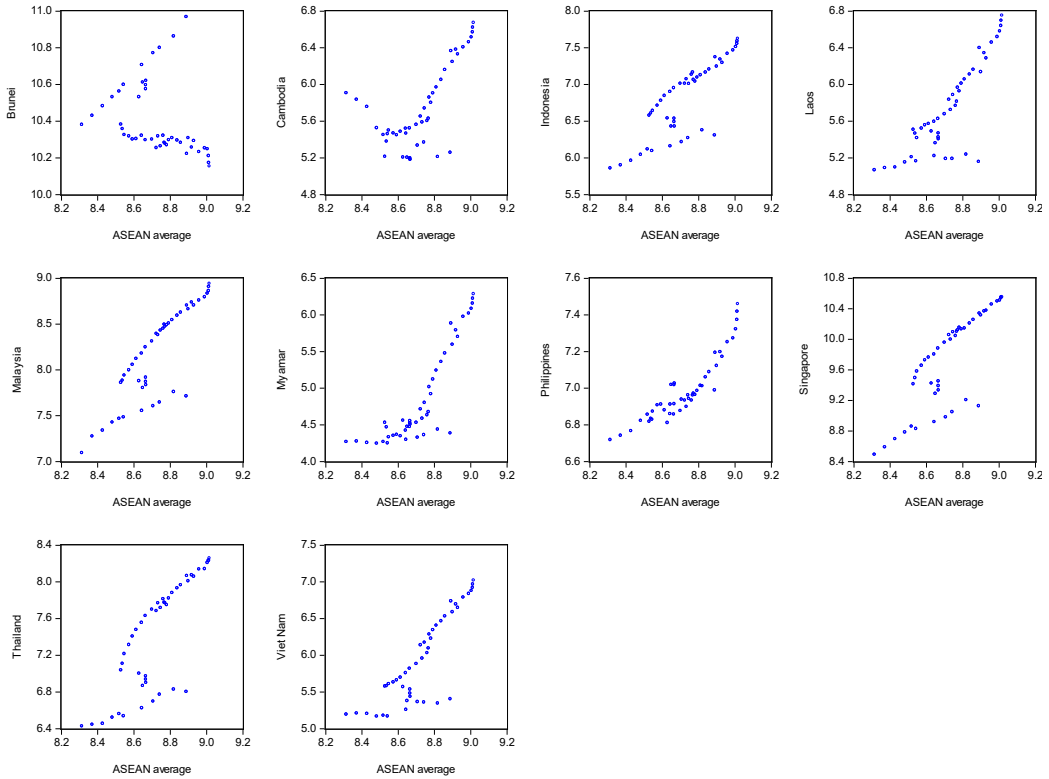
Figure 2: Scatter plot of log real per capita GDP ASEAN average with log real per capita GDP ASEAN economies

Tables 5 to 9 show the results of the KSS-CHLL nonlinear unit root test for the nonlinear long-run convergence and nonlinear catching-up for the ten ASEAN member countries relative to their ASEAN average by estimating Equation (5). From the KSS-CHLL test, the significance of the trend variable helps to distinguish between nonlinear long-run convergence and nonlinear catching-up. A nonlinear catching-up between the two countries is identified when $\rho < 0$ and $\phi \neq 0$, while nonlinear long-run convergence is identified when $\rho < 0$ and $\phi = 0$. However, the income is considered to be diverging when $\rho = 0$. As shown by the scatter plot in Figure 2, the nonlinear relationship (correlation) between real per capita GDP of each ASEAN member country with its ASEAN average income is clearly observed, thus justifying the use of the nonlinear unit root test in this study. Panel A shows the results for including linear deterministic trend while Panel B shows the results for including nonlinear deterministic trend. In this study, we also endeavored to assess the robustness of the convergence tests between sub-samples of different periods: 1970-2015, 1975-2015, 1980-2015, 1985-2015, and 1990-2015.

In Table 5, for the period from 1970 to 2015, none of the ASEAN member countries show convergence to the ASEAN average. Nevertheless, the results suggest that Cambodia, Laos and Vietnam show nonlinear catching-up to the ASEAN average (since the deterministic trend variable is non-zero) when linear deterministic trend is included, but only Cambodia shows catching-up to the ASEAN average when nonlinear deterministic trend is included. A majority

of the ASEAN member countries show divergence from the ASEAN average during this period. On the other hand, as can be seen in Panel A of Table 6, the analysis for the period from 1975 to 2015 indicates that Cambodia, Laos, and Singapore are catching-up to the ASEAN average while the rest are showing divergence from the ASEAN average.

Table 5 Results of KSS-CHLL test for nonlinear long-run convergence, 1970-2015

Countries	Lag	ρ		ϕ		Remarks
		Coefficient	t-statistic	Coefficient	t-statistic	
Panel A: Linear trend						
Brunei	3	-0.0141	-2.0203	-0.0028	-2.1634	Divergence
Cambodia	0	-0.0057***	-4.5266	0.0059***	6.5382	Catching-up
Indonesia	3	-0.0081	-1.5965	0.0023	1.3328	Divergence
Laos	1	-0.0095*	-3.2955	0.0074**	3.5918	Catching-up
Malaysia	0	-0.0223	-0.9296	0.0002	0.2863	Divergence
Myanmar	3	-0.0019	-1.7919	0.0039	2.2560	Divergence
Philippines	1	-0.0295	-2.3854	0.0005	0.8796	Divergence
Singapore	0	-0.0913	-2.9788	0.0076*	2.6279	Divergence
Thailand	3	-0.0089	-1.2516	0.0013	0.8170	Divergence
Vietnam	1	-0.0080**	-3.5314	0.0072***	3.8544	Catching-up
Panel B: Nonlinear trend						
Brunei	3	-0.0029	-0.6916	-1.37×10^{-5}	-0.9112	Divergence
Cambodia	1	-0.0073***	-4.9169	0.0001***	6.1057	Catching-up
Indonesia	3	-0.0043	-1.1584	1.96×10^{-5}	0.7784	Divergence
Laos	1	-0.0075	-2.6174	0.0001*	2.8789	Divergence
Malaysia	0	-0.0156	-0.8575	8.93×10^{-7}	-0.0565	Divergence
Myanmar	3	-0.0042	-2.7975	0.0001**	3.0831	Divergence
Philippines	1	-0.0305	-2.5481	1.50×10^{-5}	1.3098	Divergence
Singapore	3	-0.0315	-1.2998	4.30×10^{-5}	0.9209	Divergence
Thailand	3	-0.0046	-0.8789	5.97×10^{-6}	0.2474	Divergence
Vietnam	1	-0.0028	-1.3258	5.45×10^{-5}	1.5948	Divergence

Notes: Asterisks (***), (**), and (*) denote statistically significant at the 1%, 5% and 10% level respectively. Critical values are referred to Chong *et al.* (2008), Table 1a for the t-statistic of ρ; while Table 1b for the *t*-statistic of Φ for T=50.

Table 6 Results of KSS-CHLL test for nonlinear long-run convergence, 1975-2015

Countries	Lag	ρ		ϕ		Remarks
		Coefficient	t-statistic	Coefficient	t-statistic	
Panel A: Linear trend						
Brunei	3	-0.0133	-1.8802	-0.0027	-1.9765	Divergence
Cambodia	0	-0.0072*	-3.2746	0.0071***	4.1248	Catching-up
Indonesia	3	-0.0081	-1.5875	0.0022	1.2402	Divergence
Laos	1	-0.0114*	-3.3289	0.0092**	3.4550	Catching-up

Table 6. (Cont.)

Malaysia	0	-0.0105	-0.4091	-8.89x10^{-5}	-0.0852	Divergence
Myanmar	3	-0.0019	-1.6606	0.0039	2.0816	Divergence
Philippines	1	-0.0321	-2.3544	0.0006	0.9470	Divergence
Singapore	0	-0.1233*	-3.0627	0.0110*	2.7316	Catching-up
Thailand	3	-0.0077	-1.0937	0.0008	0.5161	Divergence
Vietnam	1	-0.0074	-2.2375	0.0066	2.3155	Divergence
Panel B: Nonlinear trend						
Brunei	3	-0.0034	-0.8225	-1.47x10^{-5}	-0.9780	Divergence
Cambodia	1	-0.0079	-3.0752	0.0001**	3.4258	Divergence
Indonesia	0	-0.0033	-0.9319	9.39x10^{-6}	0.3997	Divergence
Laos	1	-0.0073	-2.4256	0.0001	2.5591	Divergence
Malaysia	0	-0.0069	-0.3317	-5.80x10^{-6}	-0.3633	Divergence
Myanmar	3	-0.0043	-2.6546	0.0001*	2.9293	Divergence
Philippines	1	-0.0336	-2.4909	1.65x10^{-5}	1.3446	Divergence
Singapore	3	-0.0349	-1.4452	4.59x10^{-5}	0.9928	Divergence
Thailand	3	-0.0048	-0.9316	2.60x10^{-6}	0.1087	Divergence
Vietnam	0	-0.0006	-0.3387	1.64x10^{-5}	0.4956	Divergence

Notes: Asterisks (***), (**), and (*) denote statistically significant at the 1%, 5% and 10% level respectively. Critical values are referred to Chong *et al*. (2008), Table 1a for the *t*-statistic of ρ; while Table 1b for the *t*-statistic of ϕ for T=50.

However, the results as shown in Table 7 show some interesting scenarios for the period from 1980 to 2015. In Panel A with linear deterministic trend, three of the founding ASEAN member countries - Indonesia, Malaysia and Singapore - exhibit nonlinear long-run convergence with the ASEAN average income, while Laos and Vietnam show nonlinear catching-up. Meanwhile in Panel B, with the inclusion of nonlinear deterministic trend, our results suggest that nonlinear long-run convergence is found for Indonesia, Malaysia, and Thailand, while Laos and Singapore exhibit nonlinear catching-up to the ASEAN average.

Table 7 Results of KSS-CHLL test for nonlinear long-run convergence, 1980-2015

Countries	Lag	ρ		ϕ		Remarks
		Coefficient	*t*-statistic	Coefficient	*t*-statistic	
Panel A: Linear trend						
Brunei	3	-0.0161	-2.4732	-0.0027	-2.2091	Divergence
Cambodia	1	-0.0105	-3.2461	0.0089**	3.0793	Divergence
Indonesia	0	-0.0159***	-4.2949	0.0021	1.8829	Convergence
Laos	1	-0.0152***	-5.9885	0.0105***	5.1365	Catching-up
Malaysia	2	-0.0813**	-3.8799	-0.0002	-0.2944	Convergence
Myanmar	1	-0.0015	-1.2562	0.0033	1.4501	Divergence
Philippines	1	-0.0357	-2.7538	0.0002	0.3029	Divergence
Singapore	2	-0.1040**	-3.3591	0.0070	2.1814	Convergence
Thailand	1	-0.0133	-2.7167	2.09x10^{-5}	0.0191	Divergence
Vietnam	1	-0.0085*	-3.1791	0.0065*	2.7826	Catching-up

Table 7 (Cont.)

Panel B: Nonlinear trend						
Brunei	0	-0.0095	-2.3486	-2.68×10^{-5}	-1.9781	Divergence
Cambodia	1	-0.0078	-3.0939	0.0001*	2.9111	Divergence
Indonesia	2	-0.0141***	-4.6522	2.66×10^{-5}	1.5822	Convergence
Laos	2	-0.0111***	-5.5765	0.0001***	4.7924	Catching-up
Malaysia	2	-0.0834***	-4.6442	-2.46×10^{-6}	-0.2190	Convergence
Myanmar	3	-0.0043	-2.6159	0.0001*	2.7443	Divergence
Philippines	1	-0.0371	-2.8711	1.11×10^{-5}	0.8907	Divergence
Singapore	2	-0.0874***	-5.3296	9.30×10^{-5}**	3.2167	Catching-up
Thailand	1	-0.0131*	-3.2801	-3.60×10^{-7}	-0.0232	Convergence
Vietnam	1	-0.0046	-2.6464	5.61×10^{-5}	2.0749	Divergence

Notes: Asterisks (***), (**), and (*) denote statistically significant at the 1%, 5% and 10% level respectively. Critical values are referred to Chong *et al.* (2008), Table 1a for the *t*-statistic of ρ; while Table 1b for the *t*-statistic of ϕ for T=50.

The nonlinear long-run convergence test for the period from 1985 to 2015 is shown in Table 8. For this sub-period, nonlinear long-run convergence is detected for Singapore when linear trend is included, while long-run convergence is also detected for Indonesia, Singapore, and Thailand when nonlinear time trend is included in Equation (5). On the other hand, Cambodia shows nonlinear catching-up to the ASEAN average when linear trend is included. Cambodia and Laos show the same when nonlinear trend is included in the estimating equation. However, when further analysis is conducted for more recent time periods, our nonlinear unit root test for the period from 1990 to 2015 as presented in Table 9 (both Panels A and B) shows only Thailand exhibiting nonlinear long-run convergence, and the remaining ASEAN member countries showing divergence from the ASEAN average.

Table 8 Results of KSS-CHLL test for nonlinear long-run convergence, 1985-2015

Countries	Lag	ρ		ϕ		Remarks
		Coefficient	*t*-statistic	Coefficient	*t*-statistic	
Panel A: Linear trend						
Brunei	3	-0.0167	-2.4005	-0.0034	-2.3290	Divergence
Cambodia	3	-0.0116*	-3.2365	0.0092**	3.1378	Catching-up
Indonesia	0	-0.0219	-2.8316	0.0025	1.8658	Divergence
Laos	0	-0.0132	-2.1572	0.0092	2.3723	Divergence
Malaysia	0	-0.0717	-1.1585	-1.07×10^{-6}	-0.0012	Divergence
Myanmar	3	-0.0022	-2.2048	0.0055	2.6061	Divergence
Philippines	0	-0.0038	-0.3557	0.0012	1.8484	Divergence
Singapore	0	-0.0701*	-3.2502	0.0053	2.4646	Convergence
Thailand	1	-0.0212	-3.0286	0.0005	0.6035	Divergence
Vietnam	1	-0.0113	-2.2099	0.0082	2.1844	Divergence

Table 8 (Cont.)

Panel B: Nonlinear trend						
Brunei	3	-0.0141	-2.2571	-3.65x10-5	-2.1896	Divergence
Cambodia	3	-0.0124**	-3.8930	0.0001**	3.8005	Catching-up
Indonesia	0	-0.0212*	-3.1834	4.06x10-5	2.1522	Convergence
Laos	1	-0.0356***	-4.7125	0.0003***	4.9182	Catching-up
Malaysia	0	-0.0755	-1.4127	1.09x10-6	0.0946	Divergence
Myanmar	3	-0.0032	-2.4293	0.0001*	2.6672	Divergence
Philippines	0	-0.0066	-0.6181	2.29x10-5	2.1186	Divergence
Singapore	0	-0.0500*	-3.3907	5.36x10-5	2.2680	Convergence
Thailand	1	-0.0207*	-3.2897	7.92x10-6	0.6458	Convergence
Vietnam	0	-0.0037	-1.1666	4.15x10-5	1.1129	Divergence

Notes: Asterisks (***), (**), and (*) denote statistically significant at the 1%, 5% and 10% level respectively. Critical values are referred to Chong *et al*. (2008), Table 1a for the *t*-statistic of ρ; while Table 1b for the *t*-statistic of ϕ for T=50.

Table 9 Results of KSS-CHLL test for nonlinear long-run convergence, 1990-2015

Countries	Lag	ρ		ϕ		Remarks
		Coefficient	*t*-statistic	Coefficient	t-statistic	
Panel A: Linear trend						
Brunei	3	-0.0454	-2.3166	-0.0065	-2.4551	Divergence
Cambodia	3	-0.0077	-2.4489	0.0072*	2.6635	Divergence
Indonesia	1	-0.0315	-2.1540	0.0034	2.0458	Divergence
Laos	0	-0.0162	-2.4039	0.0128*	2.7500	Divergence
Malaysia	0	-0.3267	-2.1913	0.0010	1.0909	Divergence
Myanmar	1	-0.0028	-1.7132	0.0080	1.8435	Divergence
Philippines	1	-0.0132	-2.1353	0.0020**	3.6604	Divergence
Singapore	0	-0.0776	-2.7144	0.0058	2.3315	Divergence
Thailand	0	-0.0881*	-3.1658	0.0028	2.0361	Convergence
Vietnam	0	-0.0021	-0.4226	0.0016	0.4479	Divergence
Panel B: Nonlinear trend						
Brunei	0	-0.0381	-2.4870	-8.10x10-5	-2.6082	Divergence
Cambodia	3	-0.0086	-2.2643	0.0001	2.4254	Divergence
Indonesia	1	-0.0360	-2.5218	5.92x10-5	2.4487	Divergence
Laos	0	-0.0253	-3.0918	0.0002**	3.3731	Divergence
Malaysia	0	-0.3151	-2.3676	1.53x10-5	1.1904	Divergence
Myanmar	3	-0.0020	-1.1510	6.64x10-5	1.0204	Divergence
Philippines	1	-0.0166	-2.6489	3.35x10-5***	3.9445	Divergence
Singapore	0	-0.0711	-2.9434	7.93x10-5	2.5022	Divergence
Thailand	0	-0.0843*	-3.3856	3.98x10-5	2.1680	Convergence
Vietnam	0	0.0005	0.1701	-5.06x10-6	-0.1437	Divergence

Notes: Asterisks (***), (**), and (*) denote statistically significant at the 1%, 5% and 10% level respectively. Critical values are referred to Chong *et al*. (2008), Table 1a for the *t*-statistic of ρ; while Table 1b for the *t*-statistic of ϕ for T=50.

A general inference which can be made from the above analyses is that the detection of convergence and/or catching-up is not time invariant. Most of the evidences show that nonlinear long-run convergence and/or nonlinear catching-up occurred during the period of 1980 to 2015 and 1985 to 2015. The more developed ASEAN member countries (except for Brunei and the Philippines) exhibit nonlinear long-run convergence with the ASEAN average. Interestingly, the nonlinear catching-up process is experienced by Cambodia, Laos and Vietnam (but not Myanmar), which suggest that these countries have been emulating and moving towards the level of growth of the ASEAN-6 economies even before joining ASEAN in the late 1990s.

CONCLUSION

Convergence has been the most popular economic concept tested by economists and researchers for the last three decades, despite the mixed results. The widening income gap between the more developed ASEAN countries (ASEAN-6) and their less developed counterparts (CLMV) has always posed a concern to the ASEAN government. Thus, the time required for the poor countries to economically converge with the richer countries and the appropriate policy prescriptions to facilitate the process are crucial considerations for policy formulations. As such, this study endeavored to employ the concept of stochastic convergence proposed by Bernard and Durlauf (1996) and to test the income convergence in ASEAN using the Kapetanios *et al.* (2003) nonlinear unit root tests, as well as using the Chong *et al.* (2008) nonlinear long-run convergence approach.

Our findings showed that more nonlinear long-run income convergence can be detected in the period from 1980 to 2015 and from 1985 to 2015 as experienced by Indonesia, Malaysia, Singapore, and Thailand. However, nonlinear long-run converging was only found to apply to Thailand in the sub-period from 1990 to 2015. Meanwhile, the CLV countries experienced nonlinear catching-up in most of the sub-periods apart from the sub-period of 1990 to 2015. On the other hand, Brunei, the Philippines and Myanmar failed to show any signs of nonlinear catching-up or nonlinear convergence throughout the sample periods. We can therefore conclude that income convergence hypothesis is not time invariant. In order for the ten ASEAN economies to realize the aspiration of the AEC, more effort needs to be put in towards reducing the income gap through harmonization of economic and political policies. From both an economic and a political perspective, ASEAN integration is the right path to go down. With "borderless" ASEAN economies, the less developed ASEAN member countries will benefit the most through easy transfer of capital (both physical and human capital) and technology from the richer to the poorer economies. In other words, the less developed ASEAN economies will benefit from having easy access to the resources (capital, technology and human resources) in the richer countries as there is no more "barrier" than can hinder these poor countries from progressing. As a matter of fact, Quah (1996a: p.105-106) contended that "geography (or history) determines the pattern of capital markets integration across the distribution" and "the polarization into rich and poor…. would vanish if capital markets were integrated." Nevertheless, whether the capital markets in the ASEAN ten-member countries are integrated or otherwise is a matter of empirical investigation.

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