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INCOME CONVERGENCE IN THE ASEAN-5 COUNTRIES

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ABSTRACT

Mainstream economic arguments posit that liberalization is the route latecomer economies should pursue to achieve income convergence between countries. The Association of Southeast Asian Nations (ASEAN) offers a useful platform to test if trade liberalization has been accompanied by income convergence since the grouping have been among the most aggressive in promoting the removal of trade restrictions in the world. Owing to data limitations involving Brunei and the transition economies of Cambodia, Laos, Myanmar and Vietnam, the assessment is confined to the founding members, namely, Indonesia, Malaysia, the Philippines, Singapore, and Thailand. The current paper tested the income convergence hypothesis by deploying some innovative and powerful unit root tests, such as the Fourier augmented Dickey–Fuller (FADF) and the Fourier ADF with structural breaks (FADF–SB) methods. However, the results show a positive causal relationship with 10% of the two-country pairings. Sixty percent of the two-country pairings showed no causal relationship at all, while the remaining 30% produced inconclusive results. These findings suggest that other variables, such as government focus on the science, technology and innovation infrastructure to promote structural transformation may be more important than trade liberalization efforts to reduce inter-country income gaps.

***Keywords*:** ASEAN; Income convergence; Trade liberalization; Quantitative analysis

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1. INTRODUCTION

When the Association of the Southeast Asian Nations (ASEAN) was first founded in 1967, its main purpose was to strengthen cooperation among the member countries in order to shield themselves politically from the perceived communist threat posed by China, Cambodia, Lao PDR, Myanmar and Vietnam. It was only in the 1970s when economic considerations began gaining considerable prominence within the ASEAN grouping. The end of the cold war and the collapse of the Soviet Union in 1991 triggered a further expansion in economic collaboration. Thus, the ASEAN Free Trade Area was launched in 1992 with the aim of establishing a common effective preferential tariff mechanism across the founding members of Indonesia, Malaysia, the Philippines, Singapore, Thailand and Brunei. The transition and integration of Cambodia, Laos, Myanmar and Vietnam (or the CLMV countries) from communist states into capitalist world system since the turn of the millennium has expanded the ASEAN grouping from six to ten countries. These developments eventually culminated in the creation of the ASEAN Economic Community (AEC) in 2015.

Recognizing that the transition economies literally stagnated economically under communism, the CLMV countries instituted reforms to stimulate and expand their trade activities. All of the ten member nation governments have since agreed to create a single market and production base within the ASEAN states. This includes freer movement of goods, services, skilled labour, capital and investment in the region. Member nations expect that the reduction of trade and non-trade barriers would considerably improve trade flows among ASEAN member states to stimulate rapid economic growth. In addition, ASEAN countries seek to reduce development gaps within ASEAN and in the process, *inter alia*, lower income inequality among the member countries. Indeed, ASEAN members have made considerable efforts to reduce development gaps in the region with the AEC blueprint that establishes "Equitable Economic Development" as its major pillar.[1]

However, there is a lack of systematic analyses on income convergence in ASEAN. A notable exception is a pioneer research conducted by Habibullah, Chong and Din (2017) who made a significant contribution to the existing literature on this topic. In this context, the basic motivation behind the current study is to apply a newly-proposed unit root test, the FADF–SB test (Furuoka, 2017) to examine income convergence in the region. The main contribution of this study is that it re-examines the issue using an advanced econometric analysis. The advantage of the FADF–SB test is that it can incorporate unknown nonlinearity by using Fourier approximation and unknown structural break by employing a time-dummy in the estimation. This means that the FADF–SB test combines methodological advantages of the Fourier ADF (FADF) method (Enders and Lee, 2012) with those of the ADF with structural break (ADF–SB) test (Zivot and Andrews 1992; Perron and Vogelsang, 1992).

While the assessment of economic convergence involving all ten members of ASEAN would be the most incisive in producing a robust set of results, data limitations make such an option impossible. Data on the CLMV countries do not allow assessments beyond the mid-1980s. In addition, Brunei was excluded from the analysis owing to the country's lack of development of non-oil and gas sectors. Hence, using time series data, this paper seeks to examine how increased economic integration has impacted on inter-country income levels among the founding members of ASEAN, namely, Indonesia, Malaysia, the Philippines, Singapore and Thailand. The rest of the

[1] ASEAN Economic Community Blueprint is available at http://asean.org/wp-content/uploads/archive/5187-10.pdf

paper is organized as follows. Section 2 reviews relevant for the current study literature to locate the analysis. Section 3 explains the data and methods employed. Section 4 empirically tests the validity of the "convergence hypothesis" which stipulates a decrease in the income gap among member countries of a regional integration. In view that the AEC was formed very recently, the reported findings are preliminarily. Nevertheless, the findings may yield some important insights and enable having preliminary assessments of the economic developments within ASEAN member countries. Section 5 concludes.

2. LITERATURE REVIEW

A review of literature indicates that most of the liberal economic theories establish a direct correlation between regional integration, the opening of markets, the trade liberalization and the increased trade benefits for all member states and particularly for relatively less-developed countries in an economic grouping. As a result, there would occur a decrease in income inequality, or the income convergence would take place, among the member countries. There are numerous studies on income convergence; many of these studies have examined income differences between developed and developing countries. The term ''convergence'' generally means "coming together", while "divergence" has the opposite meaning of "moving apart". As Wade (2001) argued, economic growth in poorer economies tends to be higher compared to the wealthier countries. In this sense, "income convergence" involves a narrowing of the income difference between poorer and richer economies. However, there is an ongoing debate on the validity of the income convergence argument. As Islam (2003) noted, "income convergence" has become a challenging topic in economic literature.

From a historical perspective, Bernard and Durlauf (1996) are the pioneer researchers who proposed a systematic time-series method to test the convergence hypothesis. They defined the income convergence as a long-run equality of per capita incomes in two countries. The researchers suggested using a unit root test to examine the unit root process in the income difference between countries. If a unit root is present in the time-series on income difference, then the convergence hypothesis would be violated. Following the time-series method suggested by Bernard and Durlauf (1996), Greasley and Oxley (1997) examined the log difference of income per capita in the OECD member countries for the period of 1990–1987. Their empirical analysis focused on the four pairs of countries, namely, Sweden−Denmark, Belgium−Holland, France−Italy and Australia−UK. The researchers used the augmented Dickey–Fuller unit root test for the empirical analysis. They concluded that there existed income convergence in three pairs of countries, namely, Belgium−Holland, France−Italy and Australia−UK. However, no income convergence occurred in the pair Sweden−Denmark.

In another study, Li and Papell (1999) used the augmented Dickey–Fuller (ADF) method unit root test with structural break to examine the convergence hypothesis in 16 OECD member countries for the period of 1900–1989. The unit root test was able to reject the null hypothesis of no convergence for more than half of the countries in the sample. Li and Papell concluded that there existed income convergence in the OECD countries. Oxley and Greasley (1999) used the unit root-based test of income convergence or the Bernard-Durlauf (BD) method to analyse the existence of the "Nordic Convergence Club". The researchers applied the ADF test and unit root test with structural break to examine the pairwise income convergence among four Nordic countries,

namely, Demark, Finland, Norway and Sweden, for the period of 1900–1987. They concluded that all four countries, except for Norway, could be considered as members of a "Nordic Convergence Club".

In the 2000s, researchers began applying more advanced econometric methods, such as the Kalman filter method, the fractionally integrated approach, the panel data methods, the Kapetanios–Shin–Snell (KSS) test, to analyse income convergence (Datta, 2003; Cunado, Gil-Alana and de Gracia, 2004; Jungmittag, 2006; Liew and Ahmad, 2009). Among these studies, Datta (2003) employed the Kalman filter method to capture the time-varying trend in the income convergence in 15 OECD countries for the period of 1950–1998. The researcher concluded that the income gap between the US and other OECD countries had been constantly narrowing. Datta also pointed out that countries with bigger income gaps tended to catch up the US income level faster than the countries with smaller income gaps. Cunado et al. (2004) employed the fractionally integrated (FI) analysis. They chose one of the "Asian Tigers", Taiwan, as a case study to examine the country's income convergence with the USA and Japan over the period of 1903–1999. They conducted both parametric and non-parametric Robinson method for the FI analysis and detected the income convergence between Taiwan and Japan. Jungmittag (2006) examined income convergence in 15 EU countries for the period of 1967–1998 using the panel unit root test. The researcher discovered income convergence within the European economic integration area. Liew and Ahmad (2009) employed the KSS test to examine the "Nordic convergence club" phenomenon by analysing income differences in the four Nordic countries for the period of 1950–2000. Their empirical findings indicated the process of income convergence among the Nordic countries.

Currently, income convergence remains a popular topic and researchers apply more sophisticated methods, such as the nonlinear Lagrange Multiplier (NLM) test, the Fourier-type unit root tests, the structural break Lagrange Multiplier (SBLM) test (e.g., King and Ramlogan-Dobson, 2011; King and Ramlogan-Dobson, 2015; Ceylan and Abiyev, 2016). For example, King and Ramlogan-Dobson (2011) employed three types of the NLM method to test the income convergence hypothesis in 15 OECD countries for the period of 1950–2004. Their empirical findings supported the presence of income convergence in the sampled countries. In a following study, King and Ramlogan-Dobson (2015) used the Fourier-type unit root tests to examine income convergence in 18 Latin American countries for the period of 1950–2009. The Fourier-type unit root tests were able to detect income convergence in Latin America. More recently, Ceylan and Abiyev (2016) applied the SBLM method to test the income convergence hypothesis in 15 OECD countries for the period of 1950–2015. The researchers discovered the existence of income convergence among the OECD countries.

3. DATA AND METHODS

This study chose five member countries of ASEAN, namely, Indonesia, Malaysia, the Philippines, Singapore and Thailand, to test the income convergence hypothesis for the period of 1960–2015. It employed real per capita Gross Domestic Product (constant 2010 US$). All the data were transformed into natural log. The data source was the World Development Indicators (World Bank, 2017). In the database, the data are codified as "NY.GDP.PCAP.KD". For the purposes of statistical analysis, the income gap can be expressed as (Bernard and Durlauf, 1996; Greasley and Oxley, 1997):

$$IG_{ij,t} = y_{i,t} - y_{j,t} \quad (1)$$

where $IG_{ij,t}$ is the income gap between country *i* and country *j* at year *t*, $y_{i,t}$ is the natural log of real per capita income in country *i* and $y_{j,t}$ is the natural log of real per capita income in country *j*. Under the income convergence hypothesis, the income gap between the ASEAN member countries would be narrowing. More formally, income convergence can be defined as equality in the long-term forecasted income at a fixed year. The convergence hypothesis would be substantiated if the long-term forecasted per capita income in country *i* and country *j* become equal. The long-run forecasts of per capita incomes in two countries can be expressed as (Bernard and Durlauf, 1996; Greasley and Oxley, 1997):

$$\lim_{k\to\infty} E(y_{i,t+k} - y_{j,t+k} \mid I_t) = \lim_{k\to\infty} E(IG_{ij,t+k} \mid I_t) = 0 \quad (2)$$

where *E* is the expectation operation and I_t is the available information at *t*. Equation (2) indicates that if per capita incomes in two countries reflect all available information, the expected value of income gap between country *i* and country *j* would become zero in the long-run. On the other hand, the convergence hypothesis could be rejected if the long-term forecasted income gap would contain a unit root.

From an econometric perspective, the empirical analysis in the current study was implemented in two stages: (1) the Kalman filter-based state space model (SSM) analysis and (2) the unit root-based test. In the first stage, the SSM analysis was used to capture the time-varying trend in the income gap. In the SSM method, the income gap (*IG*) can be decomposed into (Datta, 2003; Lim and McAleer, 2004):

$$IG_t = TC_t + CC_t \quad (3)$$

where IG_t is the income gap at year *t*, TC_t is the time-varying trend component at year *t* and CC_t is the time-varying cyclical component at year *t*. The trend component would follow a random walk process (Datta, 2003; Lim and McAleer, 2004):

$$TC_t = TC_{t-1} + \varepsilon_{1t} \quad (4)$$

where ε_{1t} is the first error term which is normally and independently distributed with zero mean and variance δ_1. On the other hand, the cyclical component would follow a first-order autoregressive process (Datta, 2003; Lim and McAleer, 2004):

$$CC_t = \rho CC_{t-1} + \varepsilon_{2t} \quad (5)$$

where ε_{2t} is the second error term which is also normally and independently distributed with zero mean and variance δ_2. In the analysis of the SSM model, the Kalman filter method was used to estimate the one-step-ahead of the forecasted income gap and the root mean square error (RMSE).

In the second stage of the analysis, four different unit root tests examined the convergence hypothesis, namely, the augmented Dickey–Fuller (ADF) test (Dickey and Fuller, 1979), the Fourier ADF (FADF) test (Enders and Lee, 2012), the ADF with structural break (ADF–SB) test (Zivot and Andrews 1992; Perron and Vogelsang, 1992) and the Fourier ADF with structural break (FADF–SB) test (Furuoka, 2017).

The null hypothesis for all four unit root tests can be expressed as (Furuoka, 2017):

$$y_t = \mu + y_{t-1} + \varepsilon_t \tag{6}$$

where y_t is the variable of interest, μ is the deterministic term and ε_t is the error term. In the current analysis of the convergence hypothesis, the following four equations were estimated (Furuoka, 2017):

Model A: $$\Delta y_t = \mu + \beta t + \rho y_{t-1} + \sum_{i=1}^{p} c_i \Delta y_{t-i} + \varepsilon_t \tag{7}$$

Model B: $$\Delta y_t = \mu + \beta t + \gamma_1 \sin(\frac{2\pi kt}{T}) + \gamma_2 \cos(\frac{2\pi kt}{T}) + \rho y_{t-1} + \sum_{i=1}^{p} c_i \Delta y_{t-i} + \varepsilon_t \tag{8}$$

Model C: $$\Delta y_t = \mu + \beta t + \delta DU_t + \theta D(T_B)_t + \rho y_{t-1} + \sum_{i=1}^{p} c_i \Delta y_{t-i} + \varepsilon_t \tag{9}$$

Model D:

$$\Delta y_t = \mu + \beta t + \gamma_1 \sin(\frac{2\pi kt}{T}) + \gamma_2 \cos(\frac{2\pi kt}{T}) + \delta DU_t + \theta D(T_B)_t + \rho y_{t-1} + \sum_{i=1}^{p} c_i \Delta y_{t-i} + \varepsilon_t \tag{10}$$

where β is the slope parameter for the deterministic trend, t is the deterministic trend, γ is the slope parameter for the trigonometric term, π is 3.14159, k is the frequency for the Fourier approximation, *sin* is the sine operation, *cos* is the cosine operation, δ is the slope parameter for the structural break dummy, $DU_t = 1$ if $t > T_B$ and $DU_t = 0$ if otherwise, T_B is the breakpoint where structural break occurs, θ is the slope parameter for one-time break dummy, $D(T_B)_t = 1$ if $t = T_B$ and $D(T_B)_t = 0$ if otherwise. In the ADF test (Model A), only the deterministic term and deterministic trend were included in the estimation model; ρ is the slope parameter for the lagged dependent variable, c is the slope parameter for lagged differenced dependent variable, p is the lag length. In addition to the deterministic components, trigonometric terms, namely, sine term and cosine term, were included in the FADF test (Model B). In the ADF–SB test (Model C),

dummy variables for structural breaks and a dummy variable for one-time break were included in the estimation model. Lastly, all these four deterministic components were included in the FADF–SB test (Model D). For the ease of calculation, the optimal frequency for the trigonometric term (k) was set as one; similarly, the optimal lag length (p) was set as one. For the hypothesis testing purpose, the slope parameter for the lagged dependent variable (ρ) should be non-zero if the time-series on the income gap do not contain unit root and the t-statistic was used to test the null hypothesis $\rho = 0$ for all four estimation models.

4. EMPIRICAL RESULTS

In this study, the Kalman filter method-based state space model (SSM) method and the unit root-based test examined the convergence hypothesis in five ASEAN countries. In the first stage of analysis, the SSM model examined time-varying trend in the estimation model. The findings from SSM method are presented in Figure 1. The one-step ahead prediction of the income convergence between Singapore and Malaysia is depicted in Figure 1(a). As can be seen from the figure, income gap between these two countries was relatively small in the beginning of the 1960s. It began widening after Singapore had become an independent country in the mid-1960s. From the end of the 1970s till the end of the 1980s, the Singapore–Malaysia income gap continued widening. However, there was no significant change in the income gap since the 1990s. Next, Figure 1(b) depicts the one-step-ahead forecast of income convergence between Singapore and Thailand. The income gap between these two countries was narrow in the beginning of the 1960s. However, it widened within the two following decades from the mid-1960s to the 1980s. It is interesting to note that the income gap between Singapore and Thailand narrowed again for approximately 15- year period from the mid-1980s to the late 1990s. In the 2000s and the 2010s, there occurred no major changes in the income gap between Singapore and Thailand.

Figure 1(c) shows the pattern of income convergence between Singapore and Indonesia. The income gap between these two countries widened very rapidly from the beginning of the 1960s till the mid-1970s. Over the two following decades, there was no major change in the income gap. In the beginning of the 2000s, there occurred a rapid increase in the income gap between Singapore and Indonesia, which narrowed again in the 2010s. Next, Figure 1(d) represents income convergence between Singapore and the Philippines. The pattern of the income convergence is similar to the one between Singapore and Indonesia. More specifically, the income gap between Singapore and the Philippines widened very rapidly between the early 1960s and the late 1990s. In the 2000s and the 2010s, there was a gradual and steady increase in the income gap.

Figure 1(a):
SSM analysis of Singapore–Malaysia income gap

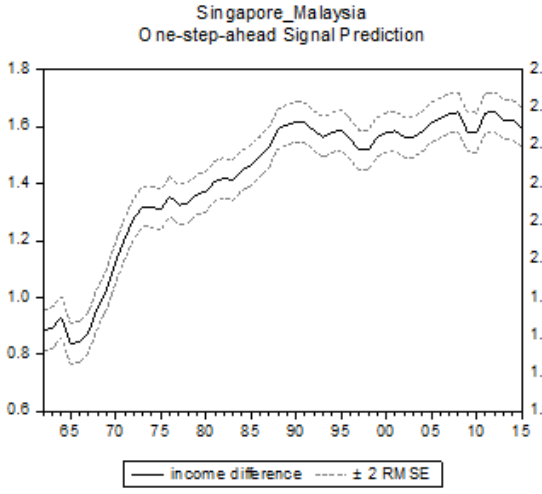


Figure 1(b):
SSM analysis of Singapore–Thailand income gap

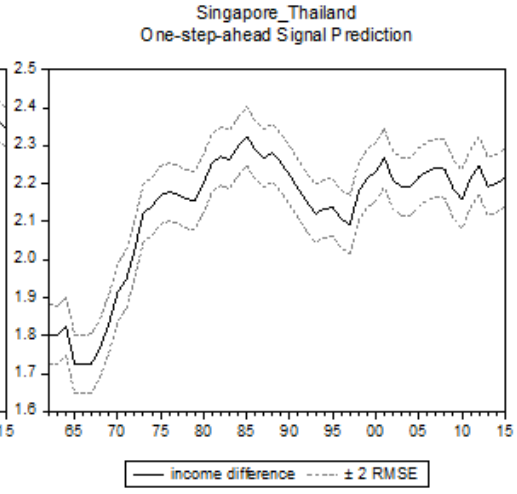


Figure 1(c):
SSM analysis of Singapore–Indonesia income gap

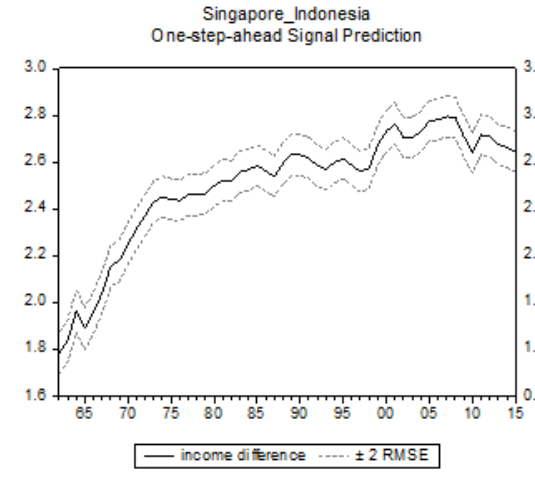
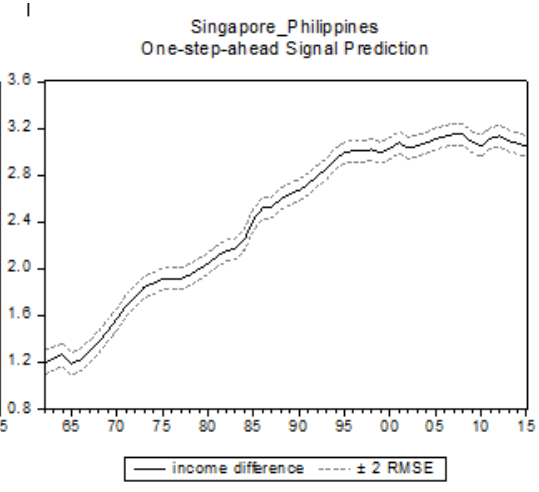


Figure 1(d):
SSM analysis of Singapore–Philippines income gap



The one-step-ahead prediction of income convergence between Malaysia and Thailand is shown in Figure 1(e). The income gap between these two countries was decreasing in the beginning of the 1960s. However, between the early 1970s and the mid-1980s, this trend was reversed and there occurred a steady increase in the income gap. Then, the income level between Malaysia and Thailand kept drastically narrowing for more than one decade or from the mid-1980s until the Asian financial crisis caused a serious deterioration of economic growth in Thailand in the late 1990s. In the beginning of the 2000s, the income gap was narrowing. In the 2010s, the process continued and there was a steady decrease in the income gap. The following Figure 1(f) shows the one-step-ahead forecasted patterns of income convergence between Malaysia and Indonesia. It is interesting to note that there was no major changes in the income gap between Malaysia and Indonesia for approximately 30 years or from the early 1970s till the end of the 1980s. A similar trend was observed beginning from the 2000s until the end of the decade. However, in the end of the 1990s, the Asian financial crisis produced a deeply negative impact on the Indonesian economy. As a consequence, the income gap between Malaysia and Indonesia widened during that period.

Figure 1(e):
SSM analysis of Malaysia-Thailand income gap

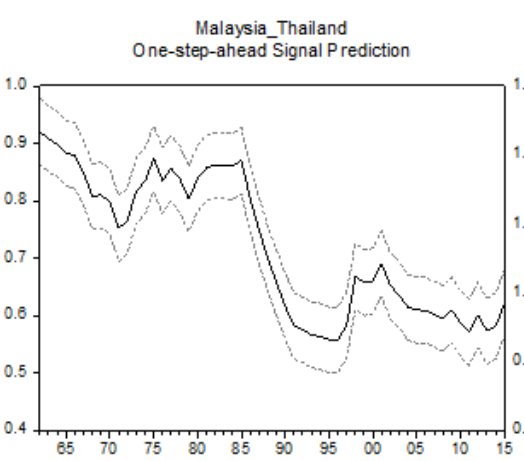


Figure 1(f):
SSM analysis of Malaysia-Indonesia income gap

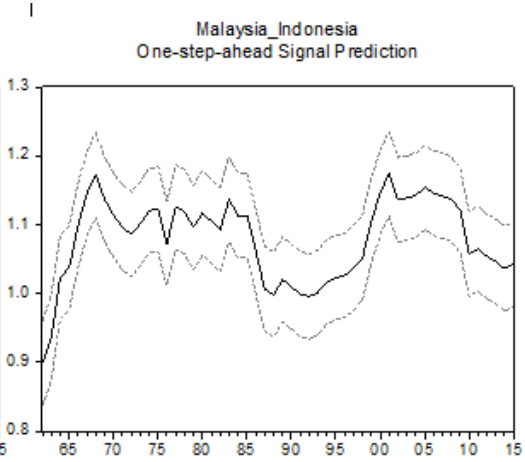


Figure 1(g):
SSM analysis of Malaysia-Philippines income gap

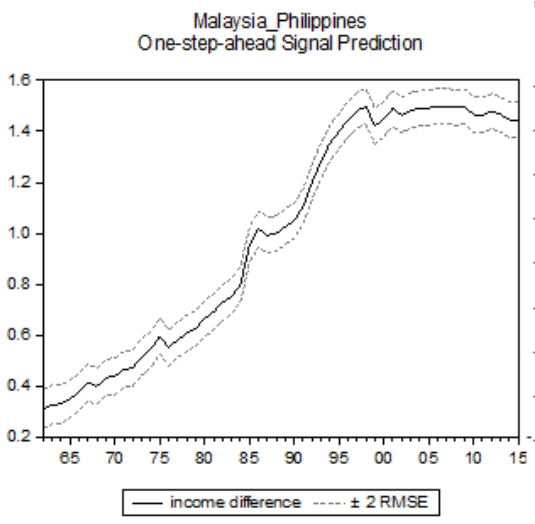
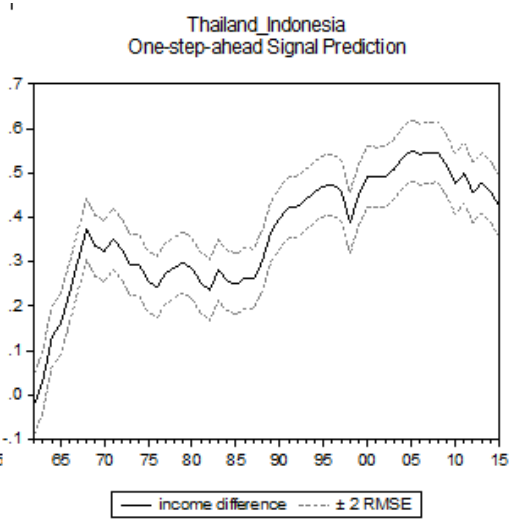


Figure 1(h):
SSM analysis of Thailand-Indonesia income gap



Next, as can be seen from Figure 1(g), the pattern of Malaysia–Philippines income convergence was very different from the income convergence path between Malaysia and Indonesia. The income gap between Malaysia and the Philippines kept widening for more than 40 years or from the early 1960s till the late 1990s. In the 2010s, no major changes had occurred in the pattern of the income convergence. Figure 1(h) depicts the one-step-ahead forecast of income convergence between Thailand and Indonesia. The income gap between the two countries sharply increased in the 1960s. Over the following two decades, no significant change in the income gap was detected. However, the income gap was steadily increasing from the early 1990s till the mid-2000s. It narrowed again between the mid-2000s and the mid-2010s.

Figure 1(i) shows the pattern of income convergence between Thailand and the Philippines. From the beginning of the 1960s till the early 1980s, the income gap between these two countries was increasing relatively slowly. Due to a rapid economic growth in Thailand, the income gap widened rather drastically beginning from the mid-1980s till the late 1990s. In the 2000s and the 2010s, no major changes occurred in the income gap patterns between Thailand and the Philippines. The following Figure 1(j) shows the one-step-ahead forecasted pattern of income convergence between Indonesia and the Philippines. The income gap between the two countries was narrow in the 1960s. Beginning from the 1970s till the mid-1980s, there was a gradual increase in the income gap. The widening in the income gap was rapid between the late 1980s and the late 1990s. No significant change occurred in the income gap pattern from the 2000s till the mid-2010s.

Figure 1(i):
SSM analysis of Thailand-Philippines income gap

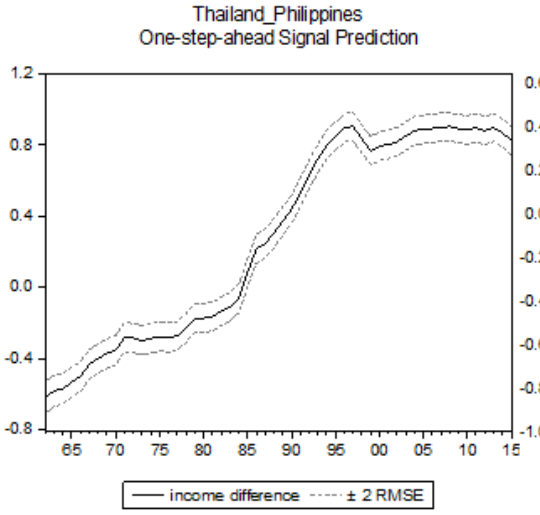
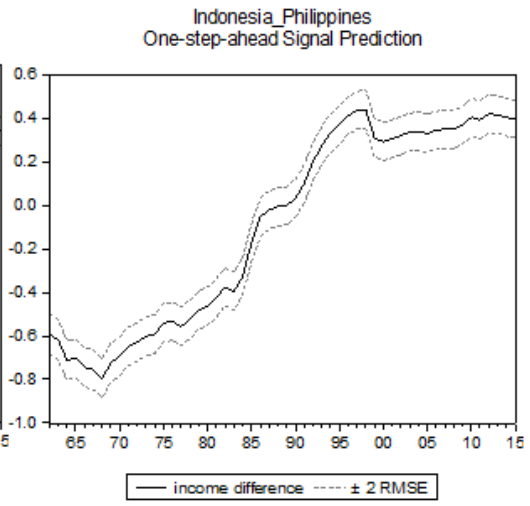


Figure 1(j):
SSM analysis of Indonesia-Philippines income gap



In the next stage of the analysis, four different unit root tests, namely, the ADF test (Dickey and Fuller, 1979), the FADF test (Enders and Lee, 2012), the ADF–SB test (Zivot and Andrews 1992; Perron and Vogelsang, 1992) and the FADF–SB test (Furuoka, 2017) were employed to test the income convergence hypothesis. Table 1 shows the findings from the ADF test. The ADF test failed to reject the null hypothesis of a unit root in the income convergence for all ten pairs of countries, except for the Malaysia–Indonesia pair. This means that the time-series data on pairwise income convergence contained a unit root, except for the time-series on the Malaysia–Indonesia income convergence.

Table 1: Findings from ADF Test (Model A from Equation7)

	Singapore	**Malaysia**	**Thailand**	**Indonesia**	**Philippines**
Singapore	---	*-1.296*	*-1.603*	*-2.012*	*0.276*
Malaysia	---	---	*-1.930*	*-3.380**	*-0.350*
Thailand	---	---	---	*-2.999*	*-0.882*
Indonesia	---	---	---	---	*-1.706*
Philippines	---	---	---	---	---

***Notes*:** * indicates significance at the 10 percent level. Critical values for the ADF test were obtained from Table 3 (Furuoka, 2017).

Next, the findings from the FADF test are reported in Table 2. This unit root test was expected to capture untreated nonlinearity in the time-series data on income convergence by using the Fourier approximation method. As can be seen from Table 2, the FADF test largely confirmed the findings from the ADF test. A minor difference between the results is that the ADF test rejected the null

hypothesis of a unit root for the Malaysia–Indonesia income convergence; by contrast, the FADF test failed to reject the null hypothesis for the same pair of countries.

Table 2: Findings from FADF Test (Model B from Equation 8)

	Singapore	**Malaysia**	**Thailand**	**Indonesia**	**Philippines**
Singapore	---	*-3.093*	*-3.004*	*-1.554*	*-2.788*
Malaysia	---	---	*-2.557*	*-2.955*	*-3.471*
Thailand	---	---	---	*-3.705*	*-3.235*
Indonesia	---	---	---	---	*-3.182*
Philippines	---	---	---	---	---

***Note*:** Critical values for the ADF test were obtained from Table 3 (Furuoka, 2017).

Table 3 shows the findings from the ADF–SB test. This unit root test was expected to capture unknown structural break in the time-series data on income convergence by using two dummy variables. The ADF–SB test was able to reject the null hypothesis of a unit root in the time-series on Singapore–Malaysia income convergence at the 10 percent level of significance. It also rejected the null hypothesis for Singapore–Thailand income convergence at the 5 percent level of significance. At the same time, the ADF–SB test failed to reject the null hypothesis for Singapore's income convergence with Indonesia and the Philippines. It also rejected the null hypothesis for Malaysia's income convergence with Thailand and Indonesia. The unit root test with structural break failed to reject the null hypothesis for Malaysia–Philippines income convergence. The test was able to reject the null hypothesis for Thailand–Indonesia and Indonesia–Philippines income convergence. However, it failed to reject the null hypothesis for the Thailand–Philippines income convergence.

Table 3: Findings from ADF–SB Test (Model C from Equation 9)

	Singapore	**Malaysia**	**Thailand**	**Indonesia**	**Philippines**
Singapore	---	*-3.209**	*-3.849***	*-2.991*	*-1.271*
		[1968]	*[1968]*	*[2007]*	*[2006]*
Malaysia	---	---	*-4.193***	*-4.659****	*-2.007*
			[1984]	*[1997]*	*[1983]*
Thailand	---	---	---	*-4.087***	*-3.156*
				[1987]	*[1987]*
Indonesia	---	---	---	---	*-4.182***
					[1982]
Philippines	---	---	---	---	---

***Notes*:** * indicates significance at the 10 percent level, ** indicates significance at the 5 percent level, *** indicates significance at the 1 percent level. Critical values for the ADF test were obtained from Table 3 (Furuoka, 2017). Numbers in brackets indicate breakpoint (T_B).

Finally, Table 4 shows the findings from the FADF–SB test. This powerful unit root test was expected to capture untreated nonlinearity and unknown structural break in the time-series data by using the Fourier function and dummy variables. Both the ADF–SB and FADF–SB were able to reject the null hypothesis for Singapore–Malaysia and Singapore–Thailand income convergence.

However, the two unit root test failed to reject the null hypothesis for Singapore–Indonesia income convergence. On the other hand, the FADF–SB rejected the null hypothesis for Singapore–Philippines income convergence. In a similar way, both tests rejected the null hypothesis for Malaysia–Indonesia income convergence. The FADF–SB rejected the null hypothesis for Malaysia–Philippines income convergence but failed to reject the null hypothesis for Malaysia–Thailand income convergence. The two unit root test rejected the null hypothesis for Indonesia–Philippines income convergence but failed to reject the null for Thailand–Philippines income convergence. By contrast, the FADF–SB failed to reject the null hypothesis for Thailand–Indonesia income convergence.

Table 4: Findings from FADF–SB Test (Model D from Equation 10)

	Singapore	**Malaysia**	**Thailand**	**Indonesia**	**Philippines**
Singapore	---	-4.594**	-4.542**	-2.910	-4.521**
		[1968]	[1996]	[1997]	[1997]
Malaysia	---	---	-3.907	-4.279*	-4.783**
			[1984]	[1984]	[1990]
Thailand	---	---	---	-4.061	-4.101
				[1986]	[1987]
Indonesia	---	---	---	---	-5.954***
					[1997]
Philippines	---	---	---	---	---

Notes: * indicates significance at the 10 percent level, ** indicates significance at the 5 percent level, *** indicates significance at the 1 percent level. Critical values for the ADF test were obtained from Table 3 (Furuoka, 2017). Numbers in brackets indicate breakpoint (T_B).

A summary of the empirical findings from the unit root-based test are reported in Table 5. As the findings show, there were considerable discrepancies in the results obtained from the four different tests. In order to enable a further analysis, the following criteria to assess the overall results were applied: if more than two different tests rejected the null hypothesis of a unit root in the time-series data on income convergence, the overall result could be considered as "convergence". If only two different tests reject the null hypothesis, the overall result could be considered as "inconclusive". In the cases when less than two tests rejected the null hypothesis, the overall findings could be considered as "no convergence".

Table 5: Summary of Empirical Findings

Country pairs	ADF test Equation 7	FADF test Equation 8	ADF–SB test Equation 9	FADF–SB test Equation 10	Overall
Singapore-Malaysia	No convergence	No convergence	Convergence	Convergence	Inconclusive
Singapore-Thailand	No convergence	No convergence	Convergence	Convergence	Inconclusive
Singapore-Indonesia	No convergence	No convergence	No convergence	No convergence	No convergence
Singapore-Philippines	No convergence	No convergence	No convergence	Convergence	No convergence
Malaysia-Thailand	No convergence	No convergence	Convergence	No convergence	No convergence
Malaysia-Indonesia	Convergence	No convergence	Convergence	Convergence	Convergence
Malaysia-Philippines	No convergence	No convergence	No convergence	Convergence	No convergence
Thailand-Indonesia	No convergence	No convergence	Convergence	No convergence	No convergence
Thailand-Philippines	No convergence	No convergence	No convergence	No convergence	No convergence
Indonesia-Philippines	No convergence	No convergence	Convergence	Convergence	Inconclusive

According to these criteria, income convergence among the five ASEAN countries was found to exist only between Malaysia and Indonesia. Inconclusive results were obtained for three pairs of countries, namely, Singapore–Malaysia, Singapore–Thailand and Indonesia–Philippines. No convergence was found for six pairs of countries, namely, Singapore–Indonesia, Singapore–Philippines, Malaysia–Thailand, Malaysia–Philippines, Thailand–Indonesia and Thailand–Philippines.

5. CONCLUSIONS

The current study has yielded some interesting and policy-relevant results. The empirical findings indicated that income convergence existed for only one pair of the ASEAN countries—Malaysia and Indonesia. No income convergence was found among the pairings Singapore–Indonesia, Singapore–Philippines, Malaysia–Thailand, Malaysia–Philippines, Thailand–Indonesia and Thailand–Philippines. The results were not conclusive for the remaining three pairs of countries, namely, Singapore–Malaysia, Singapore–Thailand and Indonesia–Philippines. In sum, ten percent of the findings for the five ASEAN countries under study have offered empirical evidence in support of the income convergence hypothesis; sixty percent of the findings have indicated that no income convergence was evident; the remaining 30 percent of the results are inconclusive. In other words, these empirical findings lend support to the results reported in the earlier studies. In particular, the findings have confirmed a recent study by Habibullah, Chong and Din (2017) who reported mixed results concerning the income convergence in the region.

By and large, the empirical evidence does not support the emergence of income convergence among the ASEAN-5 countries. However, it might be premature to argue that the ASEAN-5 countries will be better off economically without continuing with their trade integration efforts because the counterfactual was not tested in the current paper. Given the evidence of economic benefits associated with trade, discontinuation of trade integration efforts might slow down economic growth in each of the five ASEAN countries. In recent decades, intra-ASEAN trade as a percentage of the overall trade among ASEAN member nations rose from about 15 percent in the mid-1990s to about 25 percent in 2015. It has to be recognized that trade liberalization among the ASEAN-5 has already undergone massive changes since the 1980s, and most of the goods and services are traded at low tariff rates and without quotas. It is only in the cases of some items that the restrictions are still high.

The results of the current study suggest that other factors might be more important in reducing inter-country income gaps among the ASEAN-5. Hence, these countries, especially Indonesia, Malaysia, the Philippines and Thailand, need to focus on their own national initiatives to quicken the transition of economic activities from low to high value-added activities. Some efforts have been made in recent years as all these countries have launched science, technology and innovation (STI) policies. However, policies need to be introduced that aim at integrating the STI infrastructure with the rest of the economy to ensure that innovation inputs (e.g., R&D expenditure, incentives and grants) are productively translated into innovation outputs (e.g., patents and scientific publications) and innovation performance (e.g., commercialization and improvements in intellectual property rights and trade balance).

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