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Is GDP in ASEAN countries stationary? New evidence from panel unit root tests

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Abstract

This study investigated stationary process in real per capita Gross Domestic Product (GDP) in nine ASEAN countries, namely, Brunei, Cambodia, Indonesia, Laos, Malaysia, the Philippines, Singapore, Thailand and Vietnam. It employed both the 'first generation' and the 'second generation' of panel unit root tests for this purpose. Despite some differences in the findings, the empirical results suggested that per capita GDP had been characterized by a nonstationary process, as the results from the second generation of panel unit root tests indicated. This implies the presence of some common factors in these countries' GDP time series which would persist over time.

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Introduction

Conventional business cycle theory assumes that output series is characterized by a stationary process that would revert to a deterministic trend path in the long run. It proposes that there exists a ‘natural rate’ of output in accordance with which the level of output in the short run could expand above or contract below the long-run trend. In the long run, the output level is expected to return to the natural rate. Thus, the fundamental assumption of the business cycle theory is that the natural rate of output grows at a more or less constant rate (Campbell and Mankiw 1987).

There also exists a different point of view according to which fiscal and monetary shocks are not the only factors that cause output fluctuations. Real factors, such as technological progress, play an important role in determining the long-run path of an economy (Nelson and Plosser 1982). This assumption establishes an empirical foundation for the ‘real business cycle’ theory which rejects the idea that output fluctuations are transitory.

A feasible way to test the validity of these two competing macroeconomic theories would be to conduct empirical analysis of the stationary process in the output data. The output series characterized by a trend stationary process would provide support for the existence of the business cycle theory which proposes that output fluctuations are transitory. On the other hand, the output series with a unit root would support the validity of the real business cycle theory (Mocan 1994).

Numerous research studies on the stationary process in the output data have not produced definitive and consistent evidence in support for either of these theories. Perron and Phillips (1987) who re-examined the US output data concluded that the results were mixed and depended on the sample period. Campbell and Mankiw’s (1987) study could not support the proposition of a transitory nature of the output fluctuations. De Haan and Zelhorst (1993) who have examined the stationarity of output in 12 OECD countries concluded that the traditional unit root tests failed to reject the null hypothesis of a unit root, except for the US data.

Some researchers have employed panel unit root tests in order to improve the power of tests. Hurlin (2004) has examined real per capita GDP in 25 OECD countries in the period from 1963 to 2003. Some of the panel unit root tests detected a unit root in the real per capita GDP while others yielded different results (Hurlin 2004). Chang *et al*. (2008) have employed a panel unit root test with structural breaks to examine stationarity of real per capita GDP in 20 Latin American countries in the period 1960-2000. They concluded that the null hypothesis of stationarity in real per capita income could not be rejected for any of these countries. Chen (2008) has examined stationary process of real per capita GDP in 19 developed countries using one-break and two-break unit root tests. The findings showed that, when one-break unit root tests were used, real per capita income in six countries was a stationary process. On the other hand, when two-break unit root tests were used, the number of countries where real per capita GDP could be considered as a stationary process had increased to 11. Chen (2008) concluded that business cycles in these countries had stationary fluctuations around deterministic trends.

A review of literature indicates a lack of studies that focus on developing countries. This paper addresses this gap and examines stationary process of real per capita GDP in nine ASEAN countries, namely, Brunei, Cambodia, Indonesia, Laos, Malaysia, the Philippines, Singapore, Thailand and Vietnam.[1] The focus on ASEAN countries and the method employed in this study make it the first of its kind because it uses not only the standard 'first generation' but also the more recent 'second generation' panel unit root tests. Following this introductory section, Section 2 explains the data collection and research method. Section 3 reports the research findings and Section 4 offers concluding remarks.

Data and Research Method

The Penn World Table 6.3 (CIC, 2010) is the data source for real per capita GDP in the nine ASEAN countries (i.e., Brunei, Cambodia, Indonesia, Laos, Malaysia, the Philippines, Singapore, Thailand and Vietnam) in the period 1970-2007.

The 'first generation' of panel unit root tests employed in this study were the LLC test (Levin, Lin and Chu 2002), the IPS test (Im, Pesaran and Shin 2003) and the MW test (Maddala and Wu 1999). The 'second generation' tests were the Pesaran test (Pesaran 2007) and the Choi test (Choi 2006). The main difference between the two generations of tests concerns the cross-sectional independence assumption. The first generation tests assume that all cross-sections are independent while the second generation tests relax this notion. Also, the latter are more useful when co-movements are observed in the national business cycles of the countries in the same economic area (Hurlin 2004).

First of all, the LLC test used the following adjusted t-statistic:

$$t_{\partial}^{*} = \frac{t_{\alpha} - (NT)\hat{S}_{N}\sigma_{\tilde{\varepsilon}}^{-2}\sigma_{\hat{\alpha}}\mu_{T}^{*}}{\sigma_{T}^{*}} \tag{1}$$

where $\hat{S}_N$ is the average of individual ratios in the long-run to short-run variance for country i; $\sigma_{\tilde{\varepsilon}}$ is the standard deviation of the error term in equation (2); $\sigma_{\hat{\alpha}}$ is the standard deviation of the slope coefficients in equation (2); σ_T^* is the standard deviation adjustment; μ_T^* is the mean adjustment.

Secondly, the IPS test employed a standardised *t*_bar statistic based on the movement of the Dickey–Fuller distribution:

$$Z_{t\_bar} = \frac{\sqrt{N}\{t\_bar - N^{-1}\sum_{i=1}^{N} E(t_{iT})\}}{\sqrt{N^{-1}\sum_{i=1}^{N} Var(t_{iT_i})}} \tag{2}$$

[1] Myanmar, though an ASEAN country, was excluded from the analysis due to a lack of data.

where $E(t_{iT})$ is the expected mean of t_{iT} , and $Var(t_{iT})$ is the variance of t_{iT}.

Thirdly, the present study employed the MW test (Maddala and Wu 1999). This test is based on the combined significance levels (*p*-values) from the individual unit root tests. According to Maddala and Wu (1999), if the test statistics are continuous the significance levels π_i (i =1,2, ……….N) are independent and uniform (0,1) variables. They used the combined *p*-values, or P_{MW} , which can be expressed as:

$$P_{MW} = -2\sum_{i=1}^{N} \log \pi_i \tag{3}$$

where $-2\sum \log \pi_i$ has a χ^2 distribution with the 2N degree of freedom.

Furthermore, Choi (2001) suggested the following standardized statistic:

$$Z_{MW} = \frac{\sqrt{N}\{N^{-1}P_{MW} - E[-2\log(\pi_i)]\}}{\sqrt{Var[-2\log(\pi_i)]}} \tag{4}$$

Under the cross-sectional independence assumption, this statistic would converge to a standard normal distribution (Hurlin 2004).

Among the second generation of unit root tests, or the tests that are based on the assumption of cross-sectional dependency, this paper used the following two: (1) the Pesaran test (Pesaran 2007) and (2) the Choi test (Choi 2006). First of all, in the Pesaran test, the augmented Dickey-Fuller (ADF) regressions are augmented with the cross-sectional average of lagged levels and first-differences of the individual time series (Pesaran 2007). In other words, the common factor can be proxied by the cross-section mean of y_{it} and its lagged values. The Pesaran test uses cross-sectionally augmented ADF statistics, denoted as CADF, which can be estimated from:

$$\Delta y_{i,t} = a_i + b_i y_{i,t-1} + c_i \bar{y}_{t-1} + d_i \Delta \bar{y}_i + e_{i,t} \tag{5}$$

where a_i, b_i, c_i, and d_i are slope coefficients estimated from the ADF test in country *i*; $\bar{y}_{t-1}$ is the mean value of lagged levels, and $\Delta\bar{y}_t$ is the mean value of first-differences; $e_{i,t}$ is the error term.

Pesaran (2007) suggested modified IPS statistics based on the average of individual CADF, denoted as a cross-sectionally augmented IPS (CIPS), which can be estimated from:

$$CIPS = \frac{1}{N}\sum_{i=1}^{N} t_i(N,T) \tag{6}$$

where $t_i(N,T)$ is the t-statistic of the OLS estimate of b_i in equation (5).

The next test in this study – the Choi test -- is based on the statistic that combines p-values from ADF tests in which their non-stochastic trend components and cross-sectional correlations are eliminated using the Elliott, Rothenberg and Stock's GLS-based detrending and the conventional cross-sectional demeaning for the panel data (Choi 2006). It is called the Dickey-Fuller-GLS statistic. Based on this statistic, Choi suggested the following three Fisher's type statistics:

$$P_m = -\frac{1}{\sqrt{N}}\sum_{i=1}^{N}[\ln(p_i)+1] \qquad (7)$$

$$Z = \frac{1}{\sqrt{N}}\sum_{i=1}^{N}\Phi^{-1}(p_i) \qquad (8)$$

$$L^* = \frac{1}{\sqrt{\pi^2 N/3}}\sum_{i=1}^{N}\ln(\frac{p_i}{1-p_i}) \qquad (9)$$

where p_i is the p-values of the Dickey-Fuller-GLS statistic for country i; Φ is the cumulative distribution of a standard normal variable.

Empirical Results

As the first step, this study employed the augmented Dickey-Fuller ADF unit root test (Dickey and Fuller 1979) and the Phillips-Perron (PP) test (Phillips and Perron 1988) to examine the existence of a unit root in the individual time series. The results are reported in Table 1. The two tests could reject the null hypothesis of a unit root at levels for only two of the nine ASEAN countries, i.e., Indonesia and Singapore. This indicates that real per capita GDP in these countries was integrated of order zero, $I(0)$. For Brunei, Laos and the Philippines, either the ADF test or the PP test, could reject the null hypothesis. For Cambodia, Malaysia, Thailand and Vietnam, neither the ADF test nor the PP test could reject the null hypothesis, which means that these countries' real per capita GDP had a unit root.

The results from the first generation of panel unit root tests are reported in Table 2. They show that the null hypothesis of a unit root could be rejected at levels, which means that real per capita GDP in the nine ASEAN countries were integrated of order zero, $I(0)$. In other words, real per capita GDP could be stationary at levels.

The findings from the second generation of panel unit root tests are reported in Table 3. They clearly show that the null hypothesis of a unit root could not be rejected at levels. Thus, in contrast to the findings from the first generation of panel unit root tests, the results from the second generation unit root tests indicate that real per capita GDP in the nine ASEAN countries had a unit root.

For the robustness testing purpose, panel unit root tests with structural breaks (Carrion-i-Silvestre *et al.* 2005, Chang *et al*. 2008) were used to examine stationarity of real per capita GDP. As Table 4 shows, there were no structural breaks in the GDP time series data. In line with the findings from the first generation of panel unit root tests, the null hypothesis of stationarity could not be rejected at levels, which means that real per capita GDP in the nine ASEAN countries was integrated of order zero.

In short, under the assumption of cross-sectional independence, the first generation of panel unit root tests indicated that real per capita GDP in the nine ASEAN countries did not have a unit root. By contrast, under the assumption of cross-sectional dependency, the second generation of panel unit root tests showed that real per capita GDP did have a unit root.

Hurlin (2004) contends that due to the persistence of international shocks, GDP in the countries within the same economic area have a strong connection. So it is probable that there existed a co-movement in the national business cycles in the nine ASEAN countries. As far as their real per capita GDP are concerned, the cross-sectional independence assumption could be quite restrictive. This may suggest that these countries' per capita GDP were characterized by a nonstationary process, as the results from the second generation of panel unit root tests indicated.

Conclusion

The present paper examined stationarity of real per capita GDP in nine ASEAN countries, namely Brunei, Cambodia, Indonesia, Laos, Malaysia, the Philippines, Singapore, Thailand and Vietnam. It employed the first generation and the second generation of panel unit root tests for this purpose.

Under the cross-sectional independence assumption, the results of the first generation of tests showed that outputs in the nine ASEAN countries were characterised by a stationary process. However, under the cross-sectional dependency assumption, the findings from the second generation of panel unit root tests indicated that the outputs had a unit root.

As a conclusion, despite some differences in the findings the empirical results suggested that per capita GDP in the nine ASEAN countries had been characterized by a nonstationary process, as the results from the second generation of panel unit root tests indicated. This implies the presence of some common factors in these countries' GDP time series which would persist over time.

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Appendix

Table 1: Unit Root Test

	ADF		PP	
Country name	Constant without trend	Constant with trend	Constant without trend	Constant with trend
Brunei	-2.213(2)	-4.002(5)*	-2.057(3)	-2.189(3)
Cambodia	1.450(1)	-3.102(6)	1.999(1)	-2.549(3)
Indonesia	-4.019(9)**	-2.907(9)	-4.513(1)**	-1.528(1)
Laos	-2.398(2)	-2.092(2)	-4.822(25)**	-1.564(14)
Malaysia	-2.639(2)	-2.325(3)	-2.933(3)	-2.550(2)
Philippines	-2.787(0)	-3.708(2)*	-2.568(1)	-2.336(0)
Singapore	-3.554(0)*	-2.206(1)	-3.554(0)*	-2.218(0)
Thailand	-1.996(1)	-1.778(1)	-1.924(3)	-0.995(3)
Vietnam	-1.745(5)	-3.358(5)	-1.745(5)	-3.358(5)

Notes: Figures in parentheses indicate number of lag structures
** indicates significance at 1% level
* indicates significance at 5% level
* indicates significance at 5% level

Table 2: First Generation of Panel Unit Root Tests

Types of test statistic	**Test statistic**	**1 percent critical value**	**5 percent critical value**	**10 percent critical value**
LLC test statistic computed in equation (1)	-6.263**	-2.326	-1.644	-1.281
IPS test statistic computed in equation (2)	-1.756*	-2.326	-1.644	-1.281
MW test statistic computed in equation (3)	2.916**	2.326	1.644	1.281

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

Table 3: Second Generation of Panel Unit Root Tests

Types of test statistic	**Test statistic**	**1 percent critical value**	**5 percent critical value**	**10 percent critical value**
Pesaran test statistic computed in equation (6)	-2.039	-2.558	-2.334	-2.210
Choi test statistic computed in equation (7)	-1.421	2.326	1.644	1.281
Choi test statistic computed in equation (8)	1.822	-2.326	-1.644	-1.281
Choi test statistic computed in equation (9)	1.762	-2.326	-1.644	-1.281

Table 4: Panel Unit Roots Test with structural breaks

	Individual KPSS test			
Country name	Test statistic	Number of structural breaks	10 percent critical value	5 percent critical values
Brunei	0.022	0	0.118	0.139
Cambodia	0.015	0	0.120	0.138
Indonesia	0.028	0	0.119	0.140
Laos	0.016	0	0.119	0.136
Malaysia	0.025	0	0.119	0.138
Philippines	0.015	0	0.120	0.137
Singapore	0.018	0	0.120	0.143
Thailand	0.015	0	0.118	0.141
Vietnam	0.021	0	0.119	0.141
	Panel unit root test: Carrion-i-Silvestre (2005)			
Assumption	Test statistic	10 percent critical value	5 percent critical value	1 percent critical values
Homogenous long-run variance assumption	-3.333	2.123	2.905	4.657
Heterogeneous long-run variance assumption	-3.360	2.057	2.776	4.431

Note: Critical values for individual KPSS test are computed by the Monte Carlo simulation using 10,000 replications.