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The Threshold of Government Size and Economic Growth for ASEAN Countries: An Analysis of the Smooth Transition Regression Model

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Abstract

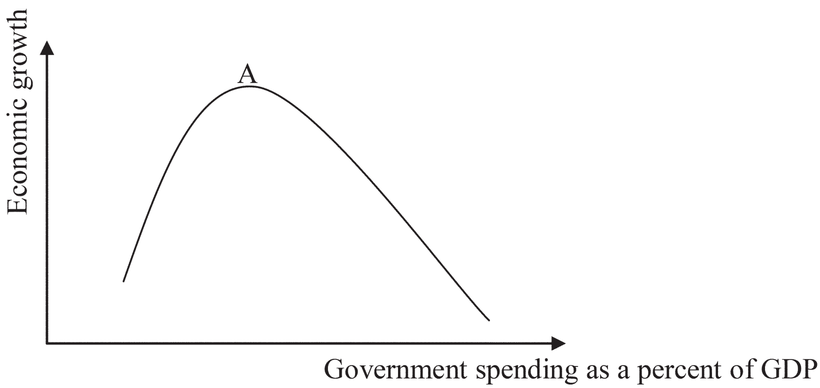
The relationship between the size of government and economic growth is a contentious issue. The present study is undertaken to test the hypothesis that the relationship between government size and economic growth is nonlinear. This panel data study involves ASEAN countries over the period 1980-2011. We modify the empirical model of Chen and Lee (2005) and employ a smooth transition regression model for panel data (PSTR) to test the threshold effect of government size. Robustness checks of the model are conducted by GLS and GMM estimation. Empirical results show that there exists a nonlinear relationship between government size and economic growth for ASEAN countries. The threshold level of government consumption spending is 25.69 per cent of GDP. As government size exceeds this level, economic growth reduces by 0.2 per cent. Our findings suggest that govern-ments in ASEAN countries consider optimal government size at average 25.69 per cent GDP for supporting sustainable economic growth.

Keywords: Threshold of Government Size, Economic Growth, ASEAN Countries, PSTR

1. Introduction

There are several approaches to measures of government size. In the literature, government size tends to be used to refer to the share of total government spending in GDP (Gross Domestic Product) and classifications of government spending as various determinants of government size (Chen and Lee, 2005). Issues regarding the interaction between government size and economic growth are still controversial (Gwartney, Lawson and Holcombe, 1998). As mentioned by Vedder and Gallaway (1998), no society in history has ever attained a high level of economic affluence without government. Many useful functions implemented by government contribute to enhancing economic growth through providing efficient public goods. In endogenous growth models, government spending is considered as an important factor of productive function, and has beneficial effects on steady–state growth rate (Barro, 1990; Barro and Sala-I-Martin, 1992). However, Gwartney, Lawson and Holcombe (1998) show that if over-expanding on government spending continues to grow, higher taxes and additional borrowing will hinder economic growth. As higher taxes and borrowing dominate, marginal government spending will create negative effects on economic growth. Government, therefore, can not expand public spending in order to expand economic growth. Theory of Armey curve developed by Armey (cited in Vedder and Gallaway, 1998, p.1-2) demonstrates relationship between government size and growth as Figure 1 shows:

Figure 1. Armey Curve



The figure is an inverse U shape, reflecting nonlinear relationship between government size and growth. We can find that point A is the standpoint of government spending size and economic growth optimization. If government spending size moves along the curve to the right of point A, additional government spending would eventually impede growth. Friedman (1997) suggests that the threshold of government in economy is probably between 15 per cent and 50 per cent GDP. A review of the literature on this topic found that empirical results were mixed. Hsieh and Lai (1994, p. 1) indicated that the relationship of government spending and output per capita for G-7 countries was uncertain. Dar & AmirKhalkhali (2002), Gwartney, Lawson & Holcombe (1998) showed that the effect of the government size on economic growth is negative. Bose, Haque & Osborn (2007) and Romero-Ávila & Strauch (2008) investigated that government capital expenditure has positive effects on economic growth, while government current expenditure had negative effects. Altunc & Aydın (2013), Vedder & Gallaway (1998), and Odawara (2010) found threshold effects of government expenditure on economic growth for developing and developed countries.

For ASEAN region, after the crisis of 1997, public sector reform in ASEAN has achieved macro-economic stability. The ASEAN Economic Community will be the goal of regional social-economic integration by 2015. ASEAN governments are committed to reducing social-economic development gaps in the region. They have strengthened to develop and implement sound public governance that would further boost the positive effects of economic growth (ASEAN, 2013). In recent years there has been growing interest in empirical research on the relationship between government size and economic growth in ASEAN countries. Rajabi and Muhammad (2013) showed that large government expenditure had negative impact on economic growth in ASEAN-5 countries over the period of 1980-2006. While, Zhu et al. (2010) found that the estimated threshold of government size is 11 per cent for Malaysia, Singapore, and Thailand during the period 1961-2004. It is not clear whether the existence of relationship between government size and economic growth for ASEAN countries is linear or nonlinear.

We hypothesized that relationship between government size and economic growth is nonlinear for ASEAN countries. The present study was designed to test the hypothesis by assessing the relationship between government size and economic growth for ASEAN countries, namely Brunei, Cambodia, Indonesia, Laos, Malaysia, the Philippines, Singapore, Thailand and Vietnam. Using a panel data of the ASEAN countries over the period 1980–2011, we modify the empirical model of Chen and Lee (2005) and employ the Panel Smooth Transition Regression (PSTR) model developed by González, Terävirta and Dijk (2005) to estimate threshold level of government size in these countries. GLS and GMM specifications are also used to check the robustness of empirical results.

This paper is organized as follows. The second section briefly presents previous literature review. In the third empirical model is presented. The PSTR model is described in the fourth section. We present data and variable measurements in the fifth section. Empirical results are analyzed in the sixth section. Discussion and conclusion are drawn in the final section.

2. Literature review

There is a vast empirical literature investigating the relationship between government size and economic growth. Previous studies generally have found significant effects, either positive or negative, of government size on economic growth.

Gwartney, Lawson and Holcombe (1998) showed that there existed a negative relationship of total government spending and economic growth for 23 OECD countries. Kneller, Bleaney and Gemmell (1999) demonstrated that government spending enhanced economic growth for 22 OECD countries over the period 1970-1995. Dar and AmirKhalkhali (2002) used growth – accounting model to examine the role of government size in explaining economic growth for OECD-19 countries during 1971-1999. They highlighted that total factor productivity growth and the capital productivity were weaker in countries that government size is larger. The conclusion was drawn that the country where a government sector was small had the greater advantage to increase in efficiencies resulting from reducing tax burden and distortion, and exploited the greater market discipline to improve efficiency of resource distribution and use. Moreover, a small government could potentially be effective in providing the legal, administrative, and infrastructure critical for growth, as well as for offsetting market failures. Over-expanding government needed more taxes to finance government spending, but expanding taxes would hinder economic growth.

Considering the components of government expenditure, Bose, Haque and Osborn (2007) examined the growth effects of government expenditure for a panel of 30 developing countries over the period 1970-1980. Their findings suggested that government capital expenditure was positively and significantly correlated with economic growth, while current expenditure was insignificant. By estimating a distributed lag model for EU-15 countries over 40 years, Romero-Ávila and Strauch (2008) argued that government consumption and direct taxation negatively affected growth rates of GDP per capita, while public investment had a positive impact. Alexiou (2009) provided further evidence that government spending on capital formation had positive and significant effect on economic growth for developing economies in the South Eastern Europe.

Some recent studies have supported an opinion that total government spending was over-expanding; this led negative impacts on economic growth. Using a model of asymmetric adjustments of output growth to changes in growth of government spending, Wahab (2011) investigated the effects of aggregate and disaggregate government spending variables on output growth.

The empirical results showed that positive growth effects of total government spending occur primarily when total spending growth was below its trend-growth. Productivity in public sector for non-OECD countries was higher than productivity in private sector when spending growth was below-trend growth. Considering components of government spending, growth effects of government consumption spending had no statistical significance, but positive growth effects of government investment spending occurred when its growth fell below its trend-growth; and this effect turned negative when government investment spending growth exceeded its trend-growth. Afonso and Furceri (2010) estimated the effects of total public revenue and expenditure on growth for OECD countries over the period 1970-2004. Each fiscal variable was measured by size as a percentage of GDP and business-cycle volatility. They came to the conclusion that total government revenue and spending both size and volatility measures had a negative effect on growth. By employing the quantile regression to analyze relationship between government size and economic growth for 24 OECD countries, Chen, Chen and Kim (2011) argued that the effect of government size on economic growth varied through the quantiles. When the economic growth was low, increasing the size of the government could stimulate economic growth and had a positive effect. However, as the economic growth rate increased highly, increasing the size of the government had a negative effect. Rajabi and Muhammad (2013) investigated the impact of government expenditure on the economic growth in ASEAN-5 countries during 1980-2006. They believed that large government expenditure had negative effects on economic growth in these countries.

Based on Armey Curve theory, recent studies have found threshold effects of government spending on economic growth. Vedder and Gallaway (1998) pointed out the Armey Curve peak where optimum total government expenditure as a share of GDP is 17.45 per cent for U.S, 21.37 per cent for Canada, 20.97 per cent for Britain, 22.23 per cent for Italy, 19.43 per cent for Sweden and 26.14 per cent Denmark. Chen and Lee (2005) believed that there existed a threshold effect and a non-linear relationship of the Armey curve existed in Taiwan. They provided evidence that the threshold level was 22.83 per cent GDP for total government expenditure, 7.30 per cent GDP for government investment expenditure, and 14.96 per cent GDP for government consumption. Zhu et al. (2010) employed a smooth transition autoregressive model to estimate the effects of government size on economic growth for South Korea, Taiwan, Malaysia, Singapore, and Thailand during the period 1961-2004. Empirical results showed that the estimated threshold of government expenditure was 11 per cent GDP for most countries. Odawara (2010) investigated a nonlinear relationship between government size and macroeconomic performance. The main findings suggested that threshold level of government consumption was 19.6 per cent GDP for U.S, 26.8 per cent GDP for U.K, 14.7 per cent GDP for Japan, 24.2 per cent Canada, and 19 per cent GDP for Australia. Adopting the method of ARDL estimation, Altunc and Aydın (2013) found an optimal government expenditure percentage of 25, 20 and 22 of for Turkey, Romania and Bulgaria, respectively. Using different government size indicators to estimate threshold effects of government size on economic growth for 15 European countries, Hajamini and Falahi (2012) identified that threshold level is 41.7 per cent GDP for total expenditures, 15.8 per cent GDP for final consumption expenditures and 19.4 per cent GDP for current expenditures.

In an attempt to estimate threshold effects of government size on economic growth for ASEAN countries over the period 1980-2011, we use the Panel Smooth Transition Regression (PSTR) model developed by González, Terävirta and Dijk (2005). The novelty of this model is that it allows the government size-growth coefficient to vary according to the country and with the time; it offers a parametric approach of the cross-country heterogeneity and of the time change of the government size-growth coefficients, because these parameters change smoothly as a function of a threshold variable

3. Empirical model

In this study, theoretical model is based on the model of Chen and Lee (2005), which is extended on the production theory of Ram (1986, cited in Chen and Lee, 2005). The production (Y) is classified into two sectors: the government sector (G) and non-government sector (C). Output in each sector depends on labor ($LABO$) and capital inputs (K). The output in the government sector (government size) has an externality effect on output in the non-government sector.

The Ram's model extended by Chen and Lee (2005) is indicated as follows:

$$\frac{dY}{Y} = \alpha(\frac{K}{Y}) + \beta LABO + \delta\frac{dG}{G}\frac{G}{Y} \tag{1}$$

Where α and β indicate the marginal production of the capital and the production elasticity of the labor in the non-government sector, respectively; and δ is the marginal externality effect from the production of the government sector imposed on the production of the non-government sector. To estimate Eq. (1), modifications are made as in accordance with panel data:

$$y_{it} = u_i + \alpha INV_{it} + \beta LABO_{it} + \delta G_{it} GS_{it} + \varepsilon_{it} \tag{2}$$

or

$$y_{it} = u_i + \alpha INV_{it} + \beta LABO_{it} + \delta GOV_{it} + \varepsilon_{it} \tag{3}$$

Where:

- $t=1, 2, ..., T$ and $i = 1, 2, ...,N$;
- ε_{it} is a white noise process with zero mean and finite variance, $\varepsilon_{it} \approx i.i.d(0,\delta^2)$; u_i is individual effects of i;
- y = GDP growth;
- INV = Investment capital as a share of GDP;
- $LABO$ = Labor force growth;
- G = Government spending growth;
- GS = Government spending as share of GDP; and
- $GOV = G*GS$ = the product of G and GS.

In Eq. (3), the product of G and GS reflects the multiple effects of government sector. That is, government sector impacts economic growth through two channels: *(i)* direct effect through the government sector (factor productivity differential) and *(ii)* indirect effect of government sector through the non-government sector (externality effect) (Chen and Lee, 2005; Odawara, 2010). The sign of δ indicates the multiple effects. If $\delta < 0$, marginal productivity of government sector is lower than non-government sector; and $\delta > 0$ indicates the opposite. To analyze the asymmetric relationship, the share of government spending in GDP (GS) is proxy for government size, which is used as a threshold variable.

4. Methodology

4.1 PSTR model

To detect the potential non – linear relationship between government size and economic growth, we use PSTR model developed by González, Terävirta and Dijk (2005). From the Eq. (3), we express the simplest case of a PSTR with threshold one or two extreme regimes and a single transition function to illustrate relationship between government size (gs_{it}) and economic growth (y_{it}):

$$y_{it} = \mu_i + \theta_0 x_{it} + \beta_0 gov + \beta_1 gov_{it} \Gamma(gs_{it}, \gamma, c) + \varepsilon_{it} \quad (4)$$

Where $i = 1....N$, $t = 1.....T$; N and T denote the cross – section and time dimensions of the panel, respectively; μ_i represents the fixed individual effect and ε_{it} is the errors. The dependent variable y_{it} is a scalar; the set x_{it} (including inv_{it}, $labo_{it}$) and gov_{it} are k-dimensional vectors. Transition function $\Gamma(gs_{it}, \gamma, c)$ is a continuous function and depends on threshold variable (gs_{it}) and normalized to be bounded between 0 and 1, and these extreme values are associated with regression coefficients β_0 and ($\beta_0 + \beta_1$). González, Terävirta and Dijk (2005) consider, following Granger and Teräsvirta (1993) for the time series STAR models, the following logistic transition function:

$$\Gamma(gs_{it}, \gamma, c) = \left(1 + \exp(-\gamma \prod_{j=1}^{m} (gs_{it} - c_j))\right)^{-1} \text{ with } \gamma > 0 \text{ and } c_1 \leq c_2 \leq ...c_m \quad (5)$$

Where cj = (c_1,...., c_m)', which is an m – dimensional vector of parameters; the slope parameter γ determines the smoothness of the transition. For m = 1, the model has the two extreme regimes separating low and high values of gs_{it} with a single monotonic transition of the coefficients from β_0 to ($\beta_0 + \beta_1$) as gs_{it} increases. For a higher value γ, the transition becomes rougher and transition function $\Gamma(gs_{it}, \gamma, c)$ becomes the indicator function $\Gamma(gs_{it}, c)$. When γ tends towards infinite, indicator function $\Gamma(gs_{it}, c) = 1$ if event $gs_{it} > c$ occurs, and indicator function $\Gamma(gs_{it}, c) = 0$ otherwise. When γ is close to 0, the transition function $\Gamma(gs_{it}, \gamma, c)$ is constant. In that case, the PSTR converges towards the two–regime panel threshold regression (PTR) of Hansen (1999). In general, for any value of m, the transition function $\Gamma(gs_{it}, \gamma, c)$ is constant when γ is close to 0. In which case, the model in Eq. (4) becomes a linear panel regression model with fixed effects.

With regard to the specifications of panel analysis or PTR, the main advantage of the PSTR is that it allows the government spending-growth coefficient to vary according to the country and with the time. The PSTR model allows individuals move between groups and over time depending on changes in the threshold variable. The PSTR model also provides a parametric approach of the cross-country heterogeneity and of the time instability of government spending-growth coefficients, since these parameters change smoothly as a function of a threshold variable. The elasticity of growth to government spending for the i^{th} country at the time t is defined as follows:

$$\frac{\partial y_{it}}{\partial gs_{it}} = \beta_0 + \beta_1 * \Gamma(gs_{it}, \gamma, c) \tag{6}$$

4.2 Model specification tests

González, Terävirta and Dijk (2005) propose the following specification procedure for PSTR: *(i)* Test the linearity against the PSTR model; *(ii)* Parameter estimation; *(iii)* Test for number of transition function.

(i) Testing for linearity

Testing the linearity in a PSTR model, Eq. (4) can be done by testing $H_0 : \gamma = 0$ or $H_0 : \beta_0 = \beta_1$. However, in both cases, the test will be nonstandard since under H_0 the PSTR model contains unidentified nuisance parameters. This issue is evident from the literature devoted to the time series threshold models Hansen (1999). Therefore, following González, Terävirta and Dijk (2005), we replace $\Gamma(gs_{it}, \gamma, c)$ in Eq. (4) by its first–order Taylor expansion round $\gamma = 0$ and obtain the auxiliary regression:

$$y_{it} = \mu_i + \theta_0 x_{it} + \beta_0 gov_{it} + \beta'_1 gov_{it}^2 + ... + \beta'_m gov_{it}^m + \varepsilon'_{it} \tag{7}$$

Where the parameter vectors $(\beta'_1, ..., \beta'_m)$ are multiples of γ. Testing H_0 in Eq. (4) is equivalent to testing the $H_0^{*}: \beta'_1 + ... + \beta'_m = 0$ in Eq. (7). This null hypothesis may be conveniently tested by a Wald and Likelihood ratio tests. If we denote SSR_0 the panel sum of squared residuals under H_0 (linear panel model with individual effects) and SSR_1 the panel sum of squared residuals under H_1 (PSTR model with two regimes), the Wald LM test can be written as:

$$LM_W = \frac{NT(SSR_0 - SSR_1)}{SSR_0} \tag{8}$$

The Likelihood ratio test can be written as:

$$LR = -2[\log(SSR)_1 - \log(SSR_0)] \tag{9}$$

(ii) Parameter estimation

The parameters (β_0, β_1, γ, c) in Eq. (4) are estimated in two steps: *(i)* eliminate the individual effects by removing individual–specific means and *(ii)* apply nonlinear least squares (NLS) to the transformed data.

We apply NLS to determine the values of these parameters that minimize the concentrated sum of squared errors. While estimating the PSTR model, a practical issue that deserves special attention is the selection of starting values for γ and c such that $\gamma > 0$, $c_{j,\min} > \min(gs_{it})$, $j = 1,....,m$. The values minimizing $Q^C(\gamma, c)$ can be used as starting values of the nonlinear optimization algorithm.

(iii) Testing for the number of transition function

The logic is similar when it comes to testing the number of transition functions (r) in the model or equivalently order of extreme regimes ($r + 1$). González, Terävirta and Dijk (2005) propose a sequential approach by testing the null hypothesis of no remaining nonlinearity in the transition function. In the PSTR framework, we assume that the linearity hypothesis is rejected. The issue is then to test whether there is one transition function ($H_0 : r = 1$) or whether there are at least two transition functions ($H_0 : r = 2$). Consider the model with $r = 2$ or three regimes:

$$y_{it} = \mu_i + \theta_0 x_{it} + \beta_0 gov_{it} + \beta'_1 gov_{it}\Gamma_1(gs^1_{it}, \gamma_1, c_1) + \beta'_2 gov_{it}\Gamma_2(gs^2_{it}, \gamma_2, c_2) + \varepsilon'_{it} \tag{10}$$

We can replace the second transition function $(gs^2_{it}, \gamma_2, c_2)$ by its first-order Taylor expansion around $\gamma_2 = 0$, and then in testing linear constraints on the parameters. Therefore, the model in Eq. (10) becomes:

$$y_{it} = \mu_i + \theta_0 x_{it} + \beta_0 gov_{it} + \beta'_1 gov_{it}\Gamma_1(gs^1_{it}, \gamma_1, c_1) + \lambda gov_{it} gs_{it} + \varepsilon'_{it} \tag{11}$$

The test of no remaining nonlinearity is simply defined by $H_0 : \lambda = 0$. Let us denote SSR_0 the panel sum of squared residuals under H_0, i.e. in a PSTR model with one transition function. Let us denote SSR_1 the sum of squared residuals of the transformed model in Eq. (11). The testing procedure is then as follows. Given a PSTR model with $r = r^*$ we will test the null $H_0 : r = r^*$ against $H_1 : r = r^* + 1$. If H_0 is not rejected the procedure ends. Otherwise, the null hypothesis $H_0 : r = r^* + 1$ is tested against $H_0 : r = r^* + 2$. The testing procedure continues until the first acceptance of H_0.

4.3 Robust test

For the robustness tests, we employ a growth regression, which contains a quadratic interaction term as follows:

$$y_{it} = \mu_i + \delta_0^{'} x_{it} + \chi_0^{'} gov_{it} + \chi_1^{'} (gov_{it} gs_{it}) + \xi_{it}^{'} \tag{12}$$

We use the method of generalized least squares (GLS) to fit panel-data linear model of Eq. (12). The GLS method allows estimation in the presence of AR(1) autocorrelation within panels and cross-sectional correlation and heteroskedasticity across panels. Moreover, government size may not be an exogenous variable in Eq. (12), and the coefficient estimates may thus be biased. The seriousness of this problem will depend on whether the direction of causality is developed mainly from government size to economic growth, in which case the endogenous problem may occur. Therefore, we apply generalized method of moments (GMM) to estimate Eq. (12). The GMM estimator allows moment conditions of the form $E(z_i u_i(\beta)) = 0$, where z_i is a vector of instruments and $u_i(\beta)$ is often an additive regression error term, as well as more general moment conditions of the form $E(h_i(z_i; \beta)) = 0$

5. Data Description and variable measurements

The study is designed as a panel data investigation. Data from ASEAN countries (namely Brunei, Cambodia, Indonesia, Laos, Malaysia, the Philippines, Singapore, Thailand and Vietnam) over the period 1980-2011 are collected from Penn World Table (PWT) 8.0. Variables in Eq. (4) are measured as follows: y is GDP per capita growth rate measured by first difference of logarithm of real GDP per capita at constant 2005 national prices; *INV* is share of gross capital formation in real GDP (at current PPPs); population growth rate is used as a proxy for labor growth rate (*LABO*) in the study by Zhu et al. (2010); *G* is government spending growth measured by first difference of logarithm of government consumption spending, which involves most spending on education, defense, health and the salary of government employees; *GS* is government consumption spending as a share of real GDP (at current PPPs), which is proxy for government size in the study by Zhu et al. (2010); and *GOV* is the product of government consumption spending growth and the share of government consumption spending in GDP.

We take 2-year moving averages for the panel data to help smooth time series and reduce the effects of random variation. After taking the first difference and 2-year moving average, we thus only cover the period 1981-2011 to have balanced panel data. Table 1 shows descriptive statistics of the sample data. The average growth rate of GDP per capita for ASEAN countries is round 3 per cent, the average growth rate of labor is 0.2 per cent, the average share of gross capital formation is 24,8 per cent GDP, the average of government consumption spending growth is 4,8 per cent, and the average share of government consumption spending is 17,8 per cent GDP. As shown in Table 2 the average share of government consumption spending for ASEAN countries varies from 10.2 per cent GDP for Malaysia to 28.2 per cent GDP for Brunei.

Table 1. Definition and descriptive statistics of variables in the model

Variable	Obs	Mean	Std. Dev.	Min	Max
GDP per capita growth rate at constant 2005 national prices measured by first difference of logarithm of real GDP, (*y*)	279	.029	.036	-.129	.134
Population growth rate measured by first difference of logarithm of number of persons engaged in labor market, (*LABO*)	279	.002	.0007	.005	.047
Share of gross capital formation in real GDP (at current PPPs), (*INV*)	279	.248	.122	.064	.653
Government spending growth measured by first difference of logarithm of government consumption (at current PPPs), (*G*)	279	.048	.074	-.246	.384
Share of government consumption spending in real GDP (at current PPPs), (*GS*)	279	17.829	7.233	6.667	38.631
The product of *G* and *Gs*, (GOV)	279	.879	1.252	-3.913	6.714

Source: Penn World Table (PWT) 8.0.

Table 2. List of countries and summary statistics of government consumption spending' share in GDP (%)

Countries	Obs	Mean	Std.Dev.	Min	Max
Brunei	31	28.288	6.474	12.051	38.631
Indonesia	31	17.219	1.989	14.785	20.637
Cambodia	31	12.591	4.293	6.666	20.207
Laos	31	27.107	6.098	14.381	36.040
Malaysia	31	10.209	2.391	6.926	15.265
Philippines	31	14.176	5.400	6.713	19.314
Singapore	31	13.140	2.184	10.249	18.656
Thailand	31	20.134	3.211	16.284	26.947
Vietnam	31	17.352	0.870	15.672	19.414

Source: Penn World Table (PWT) 8.0.

All the asymptotic theory for STR models and PSTR model extended by (González, Teräsvirta et al., 2005) are for stationary variables. Therefore, the procedures of PSTR specification rely on the assumption that all variables in Eq. 4 are *I(0)* process. To analyze stationarity properties, we test unit root by panel unit root tests. Table 3 shows that stationarity results are estimated by test statistics of Levin-Lin-Chu (LLC) (Levin, Lin and Chu, 2002), Im–Pesaran-Shin (IPS) (Im, Pesaran and Shin, 2003) and Fisher-Dfuller (Choi, 2001) with constant and no trend. The LLC, IPS and Fisher-Dfuller tests reject the null hypothesis at 1 per cent, 5 per cent and 10 per cent significance level in the examined series. We conclude that all variables in the study are *I(0)* process.

Table 3. Results of unit root test

Variables	Levin-Lin-Chu	Im-Pesaran-Shin	Fisher-type
Y	-2.3558^{**}	-3.6170^{***}	-7.6043^{***}
INV	-3.1200^{***}	-1.9204^{*}	-2.2714^{**}
LABO	-4.0585^{***}	-4.7037^{***}	-4.7534^{***}
GOV	-3.3193^{***}	-4.0676^{***}	-5.5600^{***}

Note: Estimated results contain a constant and no trend; (***), (**), (*) are significant at 1%, 5% and 10%, respectively.

6. Empirical results

Tests for linearity

To test linearity of the model, we check whether the order *m* is one or not. Table 4 presents the results of linearity tests in Eq. (7). The table shows the *p*-value of Lagrange multiplier and Likelihood-ratio test for the null hypothesis of linearity against the alternative of logistic (*m=1*) or exponent (*m=2*) PSTR specification. The null hypothesis of linearity is rejected at the 1 per cent significance level. Moreover, rejection of linearity is stronger for *m=1*, the logistic specification (*m=1*) is preferred to exponent one (*m=2*). The preliminary investigations suggest that there may exist non-linear relationship between government size and economic growth for the ASEAN countries. We thus need to employ the estimation of non-linear growth model.

Table 4. LM and LR tests of linearity

Test	m=1		m= 2	
	Statistic	***p-value***	**Statistic**	***p-value***
Lagrange multiplier (LM)	5.38	0.0211**	2.83	0.0611*
Likelihood-ratio test (LR)	5.59	0.0180**	0.29	0.5871

Note: (**), (*) denote significance at 5% and 10%, respectively.
H_0: Linear model; H_1: PSTR model with m = 1 or m = 2.

Government size threshold and transition parameter

We apply a grid search to identify threshold values *c* for the PSTR model. The optimal threshold value is one that minimizes the sequence of RSS in Eq (4). We conduct the search from 10 per cent to 82 per cent for the sample. Percentiles of threshold variable and estimated results are indicated in Table 5. The β_0, β_1 coefficients in Eq. (4) are not significant in a range from first to 37th percentile; the β_0 coefficient is positive and significant but the β_1 coefficient is not significant in a range from 38th to 81st percentile; ant at 82nd percentile the β_0 coefficient is positive and significant, and β_1 coefficient is negative and significant. Table 6 summarizes the test results for the existence of threshold value and provides information about transition parameter γ.

The minimization values of the RSS, AIC and BIC occur at the government consumption spending level of 25.69 per cent GDP, which is at 82nd percentile of observations.

Table 5. Percentiles of threshold variable and estimated results of β_0 and β_1 in Eq. (4)

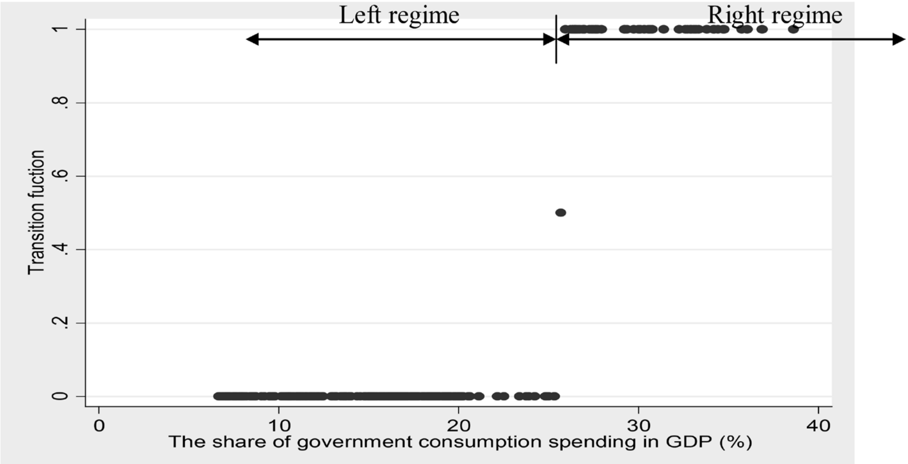
Percentiles	Value of threshold variable(gs)	Estimated results of β_0 and β_1
1.	6.832173	β_0 and β_1 in Eq. (4) are not significant.
…	…	
37.	15.73287	
38.	15.86415	β_0 in Eq. (4) is positive and significant but β_1 is not significant.
….	…..	
81.	24.88456	
82.	25.69337	β_0 in Eq. (4) is positive and significant, and β_1 is negative and significant.
….	……	

Table 6 Test results of threshold values

Search range for threshold level	Optimal threshold Value (gs)	Transition parameter γ	RSS	AIC	BIC
(1,2,3…..82)	25.69%.	37.2	.24377	-1163.155	-1144.999

Figure 2 shows the transition function with respect to the transition variable (*gs*), threshold value c = 25.69 per cent and transition parameter g = 37.2. The graph indicates that countries in the left regime with the government size close to 25.69 per cent are more likely to make the transition to the right regime. Similarly, countries in the right regime with the government size near 25.69 per cent are more likely to pass to the left regime. The change from low government size regime to high government size is very rapid.

Figure 2. Estimated transition function of the PSTR in Eq. (4)



Estimation results of PSTR, GLS and GMM

Table 7 shows the tests to investigate whether there is remaining non-linearity after assuming a two regime model. We have strong evidence on the existence of one threshold in the model. In the case (1), the hypothesis without threshold ($r = 0$) is rejected at the 1 per cent significance for two tests. In the case (2), the hypothesis with at least two thresholds ($r = 2$) is also rejected. This means that the relationship between government size and economic growth has only one threshold or two regimes for research data.

Table 7. LM and LR test of no remaining linearity

Hypothesis	Test	Statistics	P-value
(1) $H_0 : r = 0; H_1 : r = 1$	Lagrange multiplier (LM)	5.98	0.0151**
	Likelihood-ratio test (LR)	6.20	0.0128**
(2) $H_0 : r = 1; H_1 : r = 2$	Lagrange multiplier (LM)	0.18	0.6688
	Likelihood-ratio test (LR)	0.19	0.6604

Note: (**) denotes significance at 5%.

The estimated results of PSTR are presented in column 2 of Table 8 for the ASEAN countries over the period of 1980-2011. The remarkable result to emerge from the estimation is that the effects of government size on growth are non-linear. For low government size regime, government size coefficient (β_0) is estimated to be 0.007 (or 0.7 per cent) and statistically significant at 1 per cent level. For high government size regime, government size coefficient (β_1) is found to be -0.005 (or -0.5 per cent) and statistically significant at 10 per cent. Therefore, government size coefficient ($\beta_0 + \beta_1$) = 0.002 (or 0.2 per cent). These results highlight that as government size exceeds threshold level (25.69 per cent), economic growth reduces by 0.2 per cent. These results have further strengthened our confidence in hypothesis that threshold effects exist between government size and growth for ASEAN countries over the period 1980-2011. The threshold regime of government consumption spending is 25.69 per cent GDP and the transition parameter g is 37.2.

Table 8. PSTR and GLS and GMM estimation (Dependent Variable: Growth rate of GDP)

Variables (1)	**PSTR (2)**		**GLS (3)**		**GMM (4)**	
	Coef	**p-value**	**Coef**	**p-value**	**Coef**	**p-value**
Labor growth rate	-0.860	0.008***	-1.404	0.002***	-1.393	0.000***
Share of gross capital formation in real GDP	0.104	0.000***	0.085	0.001***	0.065	0.002***
The product of G and GS (GOV)	0.007	0.000***	0.013	0.013***	0.017	0.003***
GOV* $\Gamma(gs_{it}, \gamma, c)$	-0.005	0.088*				
GOV*GS			-0.003	0.004***	-0.006	0.017**
Constant	9.88e	1.000	0.036	0.003***	0.038	0.000***
Transition parameters						
Error! Objects cannot be created from editing field codes.	25.69%					
Error! Objects cannot be created from editing field codes.	37.2					
Obs	279		279		261	
R-squared	0.156					
Adjusted R-squared	0.144					
Wald chi 2(4)			37.96			
Prob>chi2			0.000			
Hansen test, chi2 (6)					8.070	
Prob>chi2					0.233	

Note: (***), (**), (*) denote significance at 1%, 5%, and 10%, respectively

This study obtains other interesting findings. First, the coefficient of investment variable is positive and significant at 1 per cent. Its positive sign suggests that the governments of ASEAN countries can promote growth by stimulating investment and capital accumulation. Second, the relationship between labor growth rate and economic growth is negative and significant at 1 per cent. This means that the higher population growth will reduce income per capita. As such, we recommend that the governments of ASEAN countries reduce population growth rate in order to increase per capita income growth.

Further tests carried out by GLS and GMM are reported in column 3 and 4 of Table 8. Estimated results confirm that all coefficient signs of threshold variable for GLS and GMM estimation are consistent with those of PSTR estimation. For the GMM method, we choose all variables in the model as instruments, in which the lags of variables (*gov* and gov^{*} *gs*) are distributed from 1 to 4. To examine the validity of our instruments, we apply Hansen's J test, where the null hypothesis is that the instruments as a group are exogenous. The p-values of the Hansen J statistics fail to reject the null hypothesis, implying that our instrument set is robust.

7. Discussion and conclusion

Few studies have been published on the relationship between government size and economic growth in ASEAN countries. Various approaches have been proposed to solve this issue. However, it is not clear whether the existence of relationship between government size and economic growth for ASEAN countries is linear or nonlinear. The present study is to investigate the existence of a threshold level for government size for ASEAN countries over the period 1980–2011. It is found that there exists a nonlinear relationship between government size and economic growth for ASEAN countries.

This study confirms that the threshold value is 25.69 per cent GDP, which is at 82^{nd} percentile of observations and transition parameter g = 37.2. The change from low government size regime to high government size is very rapid. The value of threshold variable is much higher than those reported by Zhu et al. (2010). Interestingly, as government size exceeds threshold level (25.69 per cent), economic growth reduces by 0.2 per cent. For this, government size is optimized when government consumption spending stands at

25.69 per cent GDP. These results suggest that when the government size exceeds the threshold, economic growth is hampered but if the government size is smaller than the threshold, an increase in government size would promote economic growth.

To sum up, our work has led us to support the idea that government plays an important role in economic growth, but an excessively large government reduces economic growth. ASEAN Community has focused on public sector reform to improve service delivery for citizens, enhancing trust in government, strengthening efficiency and addressing corruption (ASEAN, 2013). The evidence from this study suggests that governments in ASEAN countries should consider optimal government size at round 25.69 per cent GDP for supporting sustainable economic growth.

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