南華大學

經濟學研究所碩士論文

政府規模與經濟成長-平滑轉換迴歸模型之應用

GOVERNMENT SIZE AND ECONOMIC GROWTH: AN APPLICATION OF THE SMOOTH TRANSITION REGRESSION MODEL

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摘要

本研究應用平滑轉換自我迴歸(Smooth Transition Autoregressive, STAR)模型檢定南韓、馬來西亞、新加坡、台灣和泰國之政府規模對經濟成長的影響。樣本期間為 1961 年至 2004 年, 並採政府消費支出占國內生產毛額比作為政府規模的估計變數。由實證結果發現，除了馬來西亞國家外，各國之政府規模與經濟成長變數間存在非線性的關係，並且支持 Barro(1990)所提之假設。當政府規模超出某一門檻將對國家的經濟成長率產生負面衝擊，其中南韓與泰國為 11%，台灣為 16%。因此，根據實證之結果，本文得出政府規模並非越大越好之結論。

關鍵辭：非線性、平滑轉換、STAR、政府規模、經濟成長

Abstract

This paper employs a smooth transition autoregressive (STAR) model to investigate the effects of government size (measured as the share of government consumption expenditure in GDP) on economic growth using South Korea, Malaysia, Singapore, Taiwan and Thailand as sample countries during the period from 1961 to 2004. The empirical results reveal that there is a nonlinear relationship among variables for each country except Malaysia, and confirm the view of Barro (1990) that the government size over a certain threshold will have an adverse impact on economic growth rate for Korea, Taiwan and Thailand. Through the STAR framework, we find that the estimated threshold of government size is 11% for most countries while the government size of Taiwan is 16% and further conclude that the bigger government size is not really the better.

Keywords: Nonlinear, Smooth transition, STAR, Government size, Economic growth

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Yu-Huan Su
Nanhua University
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1. Introduction

For quite a long time, economic scholars as well as policy makers have studied the connection between government size and the long-run growth path of the economy since whether there is a connection or how these two are related is of critical importance for development policy. While highlighting the importance of the issue, two streams of studies generated completely different perspectives. For example, Ram (1986), Grossman (1990) and Ghali (1998) found that the increase in government size has a positive effect on GDP growth. They asserted that a larger government is more likely to promote economic growth since the government has an essential role in reconciling conflicts between private and social interests, and it can secure an increase in productive investment and provide a socially optimal investment environment for economic growth. However, other researchers hold a different view. For example, Landau (1983), Guseh (1997), Tanninen (1999) and Dar and AmirKhalkhali (2002) found a statistically significant negative relationship between GDP growth rate and the government expenditure share of GDP. These studies suggest that a larger government is likely to be an obstacle to efficiency and economic growth because the taxes necessary to support government expenditures distort incentives to work and invest, and absorb funds that could have been used by the private sector in profitable investment. As a result, larger government generally reduces the level of output. In addition, government operations are often carried out inefficiently, and the regulatory process imposes excessive burdens and costs on the economic system.

The above-mentioned literature presumed that there is a linear relationship between government size and economic growth and probed it with general linear approaches and techniques which include multivariate ordinary least squares (OLS) models (for example, Landau, 1983; Ram, 1986; Grossman, 1988; Guseh, 1997), vector autoregressive (VAR) models as well as cointegration and error correction models (ECM) (such as Ghali, 1998). However, Barro (1990) developed a theoretical framework and suggested that the negative effect of government size on economic growth should be expected in countries where the size of government exceeds a certain threshold, and there is an inverted U-shaped relationship between the growth rate of per capita real GDP and the share of government expenditure in GDP. Tanninen's (1999), Fatás and Mihov's (2001) and Dar and AmirKhalkhali's (2002) empirical findings support this point of view and suggest that government expenditure exceeding beyond a certain limit of its core functions would have an adverse impact on economic growth. Yet, the notion to date is rarely empirically tested by a nonlinear method.

Our work distinguishes from the existing literature in three ways. First, we entertain in this paper an augmented version of the Solow's (1957) growth model which postulates that the rate of economic growth is a function of capital stock, labor accumulation and total-factor productivity (TFP) by including the size of government and export. Second, we investigate the possibility that economic growth can be better described by a nonlinear, state-dependent model which has significantly different dynamics in periods following a change in government size. In doing so, the nonlinear smooth transition autoregressive (STAR) models of Teräsvirta and Anderson (1992) and Teräsvirta (1994) are employed to test for the existence of nonlinearities in economic growth and identify the nature of those dynamics. This approach retains the merit of being able to separate the data into two regimes. Conceivably, the smooth transition methodology is followed in this paper for various reasons. The smoothness of the adjustment between regimes can be estimated and we can judge the abruptness of switching from one regime to another. Furthermore, the methodology can be used to properly assess the Barro's (1990) view and, being multivariate in nature, can more precisely identify the role of government via its impact on the output growth rate. In addition, we can estimate the threshold government size, which could have policy implications. Accordingly, the STAR models are an ideal tool. Third, as a contribution to the debate concerning the government size and economic growth, we concentrate on five Asian developing economies including three Newly Industrializing Economies (NIEs), South Korea, Singapore and Taiwan, and two members from Association of South East Asian Nations (ASEAN), Malaysia and Thailand. These developing countries recently exhibit significantly higher growth rates but were rarely studied as sample countries by the existing literature. According to the World Bank's (1997) *World Development Report*, the size and scope of government expanded enormously in developing countries. The share of total government expenditure in GDP has increased drastically and exceeded 20% during the period of 1960 to 1995. Our sample countries' government sizes grew from slightly over 8% to about 20% for our sample period. Furthermore, these sample countries could provide us with a stylized fact on the role of government since these countries either have similar economic characteristics (implementing import-substituting policy in their early stage of development and experiencing export-led growth later) or have more powerful governance accomplishing sustained macroeconomic stability with government guiding firms and intervening in markets in a coherent mode.

The remainder of this paper is organized as follows. Section 2 outlines the theoretical framework and formulates the nonlinear STAR models. The data sources and variables are also explained and defined. Section 3 presents the empirical results and policy implications. The last section summarizes the study and provides conclusions.

2. Econometric Specification and Data

2.1 Empirical Model

The basic model is an adaptation of the neoclassical production function,

$$Y = TF(K, L), \tag{1}$$

where Y is output, T is total-factor productivity, K is capital, and L is labor. Define $y = Y/L$, $k = K/L$, and $f(k) = F(k,1)$, the production function becomes

$$y = Tf(k), \tag{2}$$

Differentiating and dividing by y yields decomposition similar to that of Solow's (1957) growth accounting equation:

$$\frac{dy}{y} = \frac{dT}{T} + Tf_k \frac{dk}{y}. \tag{3}$$

where dy/y is the per capita output growth rate; dT/T is total-factor productivity growth rate; dk/y is the rate of capital-labor change.

In order to test for the effects of government size on the economic growth, we follow Dar and AmirKhalkhali (1999, 2002) and assume that the total-factor productivity of small economies depends upon both the government and the export. The approach is based on the premise that the output growth rate is determined by the rates of factor accumulation as well as by the rate of export expansion and the size of government, whereby affecting total factor productivity via their impacts on efficiency. Thus, we adapt the function in Equation (3) to include the government size (g/y) and the rate of export expansion (dx/y). The function can be expressed as

$$\frac{dy}{y} = f\left(\frac{g}{y}, \frac{dk}{y}, \frac{dx}{y}\right), \tag{4}$$

From Equation (4), we can examine the relationship between economic growth and government size using an econometric framework of the four-variable vector autoregressive (VAR) model and normalize with respect to dy/y, such as

$$(dy/y)_t = \lambda_0 + \lambda_i' \varpi_t + \varepsilon_t, \tag{5}$$

which λ_0 denotes constant term; λ_i' denotes a $(4p \times 1)$ vector of parameters; $\varpi_t = (dy/y)_{t-1}, \ldots, (dy/y)_{t-p}, (g/y)_{t-1}, \ldots, (g/y)_{t-p}, (dk/y)_{t-1}, \ldots, (dk/y)_{t-p}, (dx/y)_{t-1}, \ldots,$ $(dx/y)_{t-p}$, p indicates the optimal lags length, and ε_t is supposed to be a white noise process with zero mean and finite variance; e.g. $\varepsilon_t \sim n.i.d\ (0, \sigma^2)$. The subscript t index is the time period in the sample.

We propose a nonlinear STAR model in terms of a smooth transition function, which can be interpreted as local dynamics of the growth rate depending on a government size. Rewriting Equation (5) yields

$$(dy/y)_t = \lambda_{10} + \lambda_{1i}' \varpi_t + \left(\lambda_{20} + \lambda_{2i}' \varpi_t\right) \times F\left((g/y)_{t-d}; \gamma, \tau\right) + u_t, \tag{6}$$

where $u_t \sim n.i.d\ (0,\sigma^2)$; $F((g/y)_{t-d}; \gamma, \tau)$ is a continuous transition function that is bounded by zero and one, in which $(g/y)_{t-d}$ is a transition variable; d is the number of periods that the transition variable leads the switch in the dynamics and $d > 0$; the parameter γ represents the speed of transition process; the restriction $\gamma > 0$ is an identifying condition in both functions, and τ is an estimated threshold value for $(g/y)_{t-d}$. Following Teräsvirta and Anderson (1992), we consider two transition function forms: logistic and exponential. While there is no theoretical guidance in distinguishing between these two functions, the choice of the model rests empirically on data.

The logistic function and the exponential function are respectively defined as

$$F\left((g/y)_{t-d};\gamma,\tau\right)=\left\{1+\exp[-\gamma((g/y)_{t-d}-\tau]\right\}^{-1}, \qquad \gamma>0. \tag{7}$$

$$F\left((g/y)_{t-d};\gamma,\tau\right)=1-\exp[-\gamma((g/y)_{t-d}-\tau)^2], \qquad \gamma>0. \tag{8}$$

The first STAR specification is the so-called logistic STAR (LSTAR) model and the second is the so-called exponential STAR (ESTAR) model. These STAR models imply that there are two distinct economic phases regarding the government size's impact (such as positive and negative), but the transition between the two regimes is smooth, governed by the level of the government size $(g/y)_{t-d}$. Used in a broader context, the LSTAR model can characterize asymmetric S-shaped cycles in economy. When $\gamma\to\infty$, $F(\,(g/y)_{t-d}\,;\gamma,\tau\,)$ = 0 for $(g/y)_{t-d}\le\tau$, implying that $(dy/y)_t$ follow a linear VAR specification; $F(\,(g/y)_{t-d};\gamma,\tau\,)$ = 1 for $(g/y)_{t-d}>\tau$, indicating that $(dy/y)_t$ movement is in accordance with a nonlinear adjustment process, and the LSTAR model becomes a two regime threshold model. When $\gamma\to 0$, however, the model reduces to a linear VAR model. On the other hand, the symmetrical U-shaped ESTAR model suggests that the two regimes have rather similar dynamics, while the reaction of economy in the transition period can be different. It reduces to a linear VAR model while $\gamma\to 0$, and the regime mainly corresponds to $(g/y)_{t-d}=\tau$; when $\gamma\to\infty$, the model changes to another regime such as $\left(dy/y\right)_t=\lambda_{10}+\lambda_{1i}'\varpi_t+\left(\lambda_{20}+\lambda_{2i}'\varpi_t\right)+u_t$, suggesting a nonlinear movement of the function regarding $(dy/y)_t$.

2.2 Hypothesis Testing in the STAR Framework

As suggested by Teräsvirta (1994), the STAR analysis can be split into the following stages. First, a linear VAR model for $(dy/y)_t$ is specified in order to determine the lag length (*p*). In this paper, the optimal lag length is determined by the Akaike Information Criterion (AIC) and Schwarz Bayesian Information Criterion (SBC). Then, we estimate the STAR models containing lags in both the linear and nonlinear parts of the model.

The next step is to test for the presence of nonlinearities. The null hypothesis of the model is that the model is linear, that is identical to setting $H_0 : \gamma = 0$ in the STAR models. Since the STAR models can only be identified under the alternative hypothesis, it would render the application of the conventional Lagrange Multiplier (LM) test of linearity invalid. To deal with this problem, we apply Luukkonen, Saikkonen and Teräsvirta's (1988) method, which is based on a third-order Taylor approximation about $\gamma = 0$. Formulating the products of the regression with the powers of $(g/y)_{t-d}$, we estimate the auxiliary regression as

$$\varepsilon_t = \kappa_0 + \kappa_1'\varpi_t + \kappa_2'\varpi_t\left(g/y\right)_{t-d} + \kappa_3'\varpi_t\left(g/y\right)_{t-d}^2 + \kappa_4'\varpi_t\left(g/y\right)_{t-d}^3 + \xi_t, \tag{9}$$

in which, ε_t is the residual obtained from Equation (5), κ_0 is a constant term, κ_z' is a $(4p \times 1)$ vector, $z = 1, 2, 3, 4$ and $\xi_t \sim n.i.d\ (0, \sigma^2)$. Equation (9) is estimated across a range of values for *d*, and $d \in D = \{1, 2, ..., d_{\max}\}$. If the delay parameter *d* is assumed to be known, then the linearity test is identical to testing the joint restriction that all nonlinear terms are zero as in the following null hypothesis

$$H_0 : \kappa_2' = \kappa_3' = \kappa_4' = 0. \tag{10}$$

Under the null hypothesis of linearity, the use of the LM statistic has an asymptotic F-distribution with $(3m)$ and $(T-4m-1)$ degrees of freedom in the numerator and denominator, which is strongly recommended for small samples. Rejecting the null hypothesis implies that the nonlinear model hypothesis is accepted. Moreover, the LM test of the linearity against the STAR models can be computed as

$$LM_0 = \frac{(ssr_0 - ssr_1)/3m}{ssr_1/T - 4m - 1}, \tag{11}$$

where ssr_0 is the sum of the squared residuals, which is computed out of ε_t and ssr_1 is the sum of the squared residuals of ξ_t, which comes from Equation (9). The notations T and m represent the number of observations and the number of explanatory variables, respectively.

Finally, one possible way to identify the appropriate model between LSTAR and ESTAR models is through a sequence of tests on parameter values from Equation (9). Thus, we consider a sequence of the null hypotheses as follows:

$$\begin{aligned} &H_{01}: \kappa_4' = 0. \\ &H_{02}: \kappa_3' = 0 \mid \kappa_4' = 0. \\ &H_{03}: \kappa_2' = 0 \mid \kappa_3' = \kappa_4' = 0. \end{aligned} \tag{12}$$

We would select the LSTAR model if H_{01} is rejected. If H_{01} is not rejected but H_{02} is rejected, we would adopt the ESTAR model. If both H_{01} and H_{02} are not rejected but H_{03} is rejected, then we select the LSTAR model.

2.3 Data Descriptions and Variable Measurements

Data used in this paper are drawn from the *International Financial Statistic* (*IFS*) of the International Monetary Fund (IMF) except for Taiwan. The data for Taiwan are obtained from the database of the Statistical Abstract of the National Income in Taiwan, the Republic of China (NIAQ). We select the annual observations for the period 1961 to 2004 for South Korea (hereafter Korea), Malaysia, Singapore, Taiwan and Thailand. The symbols used in this paper and their definitions are as follow: Term y is per capita output measured by the per capita gross domestic product (GDP); term g is per capita government consumption expenditure which includes most expenditures on education, defense, health, and the salary of government employees; term k is the capital-labor ratio measured by the gross domestic fixed capital formation plus the changes in nominal stocks and then divided by total population. Total population is also used as a proxy for labor in Ram (1986), Guseh (1997). The term x is per capita export of goods and services. All data are deflated into real terms and measured in millions of local currencies (they are in billions in the cases of Korea and Thailand). The share of government consumption expenditure in GDP and the growth rate of per capita GDP are taken as proxies for government size and economic growth, respectively.

Table 1 provides descriptive statistics of the sample data. In general, the per capita GDP growth rate varies from 4.29% for Malaysia to 8.16% for Korea and the government size ranges from 10.64% of GDP for Singapore to 15.7% for Taiwan. Figure 1 shows that even though economic growth is more variable than government size, the trend in government size and the economic growth tend to move in opposite direction for most countries.

Table 1
Descriptive Statistics of the Variables for Each Country, 1961-2004

Country	Variable	Obs.	Mean	Std. Dev.	Min.	Max.	Jarque-Bera
Korea	dy/y	43	0.0816	0.0593	-0.0924	0.2238	6.3284*
	g/y	43	0.1092	0.0130	0.0827	0.1407	1.2855
	dk/y	43	0.0277	0.0461	-0.1322	0.1031	12.312**
	dx/y	43	0.0208	0.0273	-0.0363	0.1149	33.980**
Malaysia	dy/y	43	0.0429	0.0640	-0.1067	0.1978	0.3467
	g/y	43	0.1474	0.0227	0.0976	0.1925	1.1449
	dk/y	43	0.0138	0.0482	-0.1811	0.0767	55.533**
	dx/y	43	0.0468	0.0646	-0.1336	0.2236	3.4496
Singapore	dy/y	43	0.0543	0.0570	-0.0695	0.1490	1.6709
	g/y	43	0.1064	0.0122	0.0835	0.1425	5.1820
	dk/y	43	0.0218	0.0510	-0.0885	0.1521	1.5773
	dx/y	43	0.0745	0.1114	-0.1507	0.3127	2.2824
Taiwan	dy/y	43	0.0609	0.0507	-0.1089	0.1780	7.0554*
	g/y	43	0.1570	0.0175	0.1244	0.2001	0.4756
	dk/y	43	0.0146	0.0335	-0.0880	0.0861	4.2259**
	dx/y	43	0.0294	0.0279	-0.0487	0.0946	0.2336
Thailand	dy/y	43	0.0450	0.0481	-0.1045	0.1383	2.8734
	g/y	43	0.1083	0.0117	0.0916	0.1352	3.4323
	dk/y	43	0.0164	0.0432	-0.1535	0.1017	55.034**
	dx/y	43	0.0243	0.0313	-0.0100	0.1188	22.734**

Notes:1. **, * denote significant at the 1% and 5% level, respectively. 2. The J-B statistics are computed to test the null hypotheses H_0: X ~ Normal(μ,σ^2),

$$JB=\frac{T-n}{6}\left(s^2+\frac{1}{4}(k-3)^2\right),$$

where n is number of parameters estimated; T is number of usable observations; s is skewness, and k is kurtosis. JB is asymptotically χ^2 distributed with 2 degrees of freedom and the critical values are 9.21 and 5.99 at 1% and 5%, respectively.

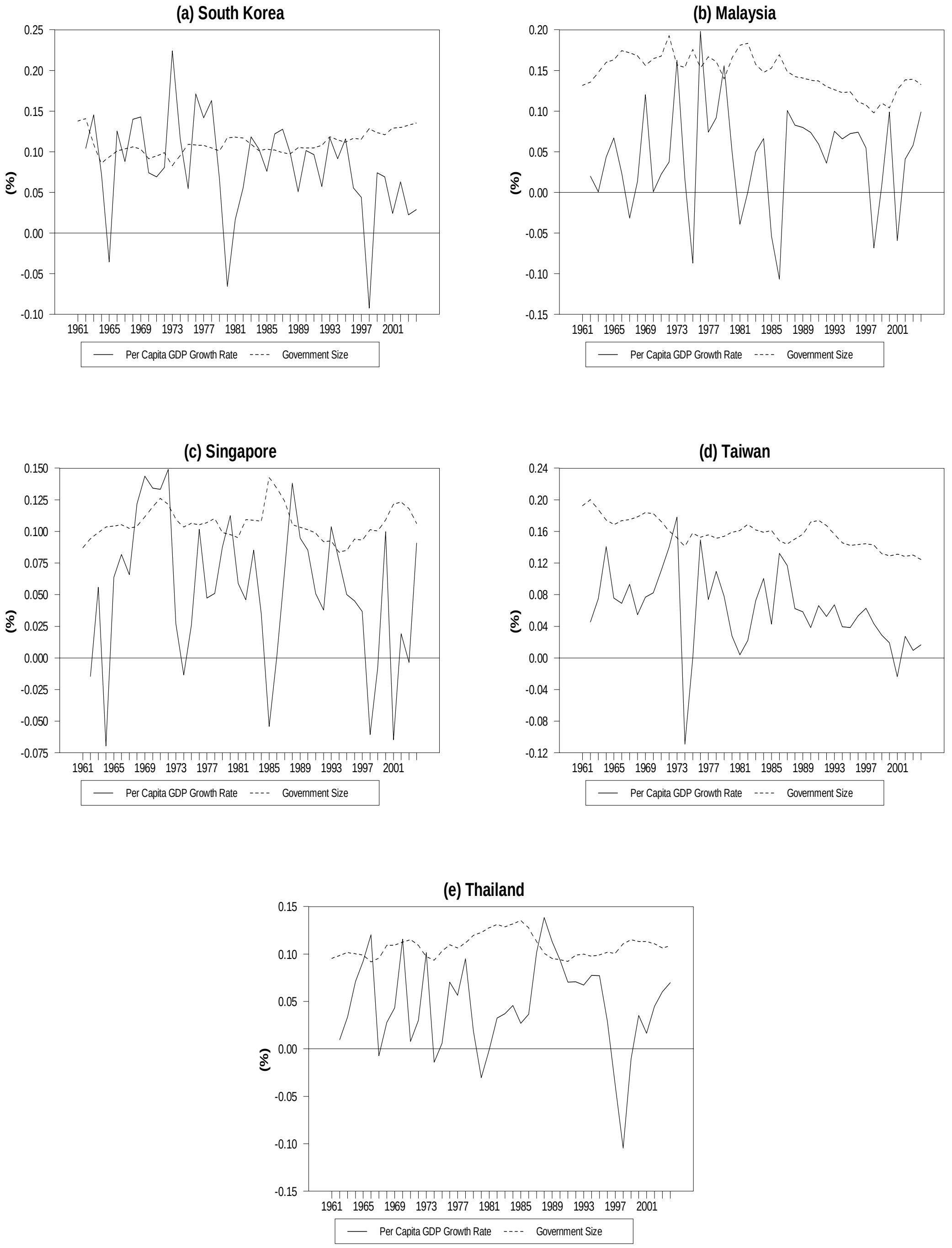

Figure 1. Government Size and Economic Growth for Each Country, 1961-2004

3. Empirical Results and Policy Implications

3.1 Unit Root Tests

It is imperative that each of the variables be stationary in a VAR framework. For this purpose, the Phillips-Perron (PP) unit root test is used to examine the variables in Equation (4). Table 2 reports the stationarity test results. If the calculated PP statistics are less than their critical values (both in absolute values) at the 5% and 1%, it implies that we cannot reject the unit root null hypothesis. The result denotes all variables are stationary at the level except for government size (g/y) series which is stationary in first-difference.

Table 2
Results of Phillips-Perron Unit Root Test

Variables	Korea	Malaysia	Singapore	Taiwan	Thailand
Levels					
dy/y	-4.719**	-6.228**	-4.505**	-5.050**	-3.893**
g/y	-2.557	-2.042	-2.692	-1.422	-2.177
dk/y	-5.975**	-5.430**	-5.184**	-5.703**	-4.001**
dx/y	-5.094**	-4.282**	-4.504**	-6.364**	-4.713**
First-difference					
dy/y	-25.023**	-30.561**	-13.787**	-27.051**	-14.432**
g/y	-5.635**	-8.004**	-5.414**	-5.194**	-4.075**
dk/y	-25.064**	-20.003**	-22.181**	-22.503**	-15.556**
dx/y	-12.297**	-20.014**	-18.681**	-21.375**	-14.817**

Notes: Asterisk *, ** denote the null hypothesis of a unit root is rejected at the 5% and 1% significant levels, respectively. We judge the test results by the MacKinnon (1996) critical value. The critical values that contain a constant and no trend are –3.5966 and –2.9331 at 1% and 5%, respectively.

3.2 Tests for Linearity and Selection of STAR Models

To test the model's linearity, we consider a set of plausible values for the delay parameter (*d*), which ranges from 1 to 5. The optimum value of *d* is chosen based on the minimum *P*-values of the LM test statistic in estimating Equation (9). Table 3 indicates the null hypothesis of linearity ($H_0 : \kappa_2' = \kappa_3' = \kappa_4' = 0$) can be rejected at the 10% level of significance, a strong evidence of nonlinearity for almost all countries with the exception of Malaysia. Our empirical results later in the paper also verify that this is the case for Korea, Singapore, Taiwan and Thailand. Table 3 also reports the results of the tests regarding the choice between the LSTAR and the ESTAR models. By examining the test statistics for various hypotheses in Table 3, we conclude that the LSTAR model is a more appropriate model for Korea, Singapore, Taiwan and Thailand.

Table 3
Results of Linearity Tests and Models Selection (*P*-values)

Country	Delay(*d*)	H_0	H_{01}	H_{02}	H_{03}	Model Type
Korea	1	0.0082	0.0050*	0.3952	0.1421	LSTAR
Malaysia	1	0.1001	0.2470	0.0240	0.8278	Linear
Singapore	4	0.0278	0.1753	0.1962	0.0229*	LSTAR
Taiwan	2	0.0688	0.2303	0.1734	0.0795*	LSTAR
Thailand	1	0.0405	0.1183	0.2613	0.0509*	LSTAR

Notes: 1. The delay (*d*) is the number of periods that the transition variable $(g / y)_{t-d}$ leads the switch in dynamics. 2. The asterisk * indicates the minimum *P*-value over the interval $1 \leq d \leq 5$ while the null hypothesis H_0 is rejected at the 10% significance level. 3. In the nested hypothesis testing, the rejection of H_{01}: $\kappa'_4 = 0$ results in LSTAR selection; the acceptance of H_{01} and rejection of H_{02}: $\kappa'_3 = 0 | \kappa'_4 = 0$ implies ESTAR selection; and the acceptance of both H_{01} and H_{02}, combined with the rejection of H_{03}: $\kappa'_2 = 0 | \kappa'_3 = \kappa'_4 = 0$, indicate the appropriateness of LSTAR modeling.

3.3 Estimates of the VAR and the STAR Models

We apply the linear VAR model of 1-lag system which is chosen based on the AIC and SBC when examining the effects of government size on growth. Table 4 presents estimated parameters of the four-variable linear VAR model, and also reports the residual standard deviation of the VAR model (σ_{VAR}). Residuals are tested against first and fourth-order ARCH using the LM test of Engle (1982), and the normality is checked by the Japque-Bera normality test. In addition, we carry out the Ramsey's RESET specification tests for the models. The results of Ramsey's RESET test, for instance, RESET(1) = 4.136 for Korea, 3.846 for Singapore, 4.913 for Taiwan and 13.061 for Thailand, reject the null hypothesis of no misspecification in the linear VAR model. It is therefore reasonable to suspect that nonlinearity in the system could have caused these results. As indicated in Table 4, the growth of government size and the rate of export expansion which are applied to measure the total-factor productivity growth have a negative impact on economic growth for Singapore, Taiwan and Thailand, but the results are statistically insignificant. The findings possibly indicate that, on the whole, the effects of total-factor productivity growth on GDP growth are weaker in these countries. Out of the premise that the economic growth lies in the use of more efficient total-factor productivity (given the government size and export), the adverse coefficients suggest that there could be a possibility of inefficiency in the government expenditure to reduce the economic growth across the countries. Hence, we further consider the nonlinear approach between the government size and the economic growth in order to be able to adequately capture the real dynamics during the economic activities process.

Table 4
The Estimates of the VAR model

Independent	Dependent $(dy / y)_t$				
	Korea	Malaysia	Singapore	Taiwan	Thailand
Constant	0.042 (0.018)**	0.037 (0.015)*	0.046 (0.013)**	0.055 (0.012)**	0.037 (0.012)***
$(dy / y)_{t-1}$	0.910 (0.240)***	0.308 (0.278)	0.352 (0.227)	0.478 (0.164)**	0.335 (0.238)
$d(g / y)_{t-1}$	3.295 (1.008)***	1.127 (1.046)	-1.342 (1.168)	-0.760 (1.120)	-1.586 (1.418)
$(dk / y)_{t-1}$	-0.792(0.297)**	-0.223 (0.283)	0.078 (0.232)	-0.706 (0.261)**	0.021 (0.262)
$(dx / y)_{t-1}$	-0.738(0.359)**	-0.089 (0.206)	-0.141 (0.101)	-0.543 (0.294)*	-0.296 (0.261)
σ_{VAR}	0.047	0.063	0.051	0.043	0.041
JB	3.462 [0.177]	0.721 [0.697]	6.551 [0.037]	61.390 [0.000]	9.723 [0.007]
ARCH(1)	0.056 [0.812]	0.158 [0.690]	0.613 [0.433]	2.123 [0.145]	1.030 [0.310]
ARCH(4)	1.385 [0.846]	1.996 [0.736]	2.320 [0.677]	2.391 [0.664]	2.772 [0.596]
RESET(1)	4.136 [0.050]	2.489 [0.124]	3.846 [0.058]	4.913 [0.033]	13.061 [0.000]
AIC	-89.312	-66.026	-82.969	-97.302	-100.639

Notes: 1. Asymptotic standard errors are in parentheses and asterisk * ,**,*** denotes significance at the 10%, 5% and 1% level, respectively. 2. The notation σ_{VAR} represents the estimated standard deviation of residuals for VAR model. 3. Statistic JB is the Jarque-Bera normality test; ARCH is the autoregressive conditional heteroscedasticity test of Engle (1982); RESET is the Ramsey specification test. The *P*-values of the tests are given in brackets.

Since the coefficients of the STAR models are multiplicative, the ordinary least square method (OLS) cannot be used to obtain the estimates of the parameter values and the method of nonlinear least-squares (NLLS) is adopted instead. Following Teräsvirta (1994), the LSTAR model is scaled using the standard deviation ($\sigma_{g/y}$) of transition variable. Aside from assisting convergence during estimation, this normalization of the deviations in the switching variable can facilitates interpretation of the smoothness parameter. The parameter estimates together with diagnostic statistics are reported in Table 5.

Several findings from Table 5 stand out. First, most of the estimated coefficients are significant at the 5% level. Second, the results from the diagnostic tests on serial correlation, the ARCH effect, and the RESET model specification all support the STAR model specification for most countries. Moreover, the variance of residuals of the STAR model is less than that of the linear VAR model, as shown by the variance ratio ($\sigma^2_{STAR}/\sigma^2_{VAR}$). For example, the reduction in the residual variances relative to the linear VAR model is 20.2% for Korea and, 35.4%, 17.8%, 39.1% for Singapore, Taiwan and Thailand, respectively. From the outcomes of the residual comparison and variance ratio test, we conclude the nonlinear STAR specification outperforms the linear VAR.

It is also clear from the examination of the STAR model estimates that the estimated transition coefficients (γ) take different values for different countries. An estimated small value of γ would imply a very slow and smooth transition from one regime to another. Take Taiwan for an example, the LSTAR model estimate of γ is 1.756, which indicates that the government size slowly impacted economic growth. On the contrary, a greater value of γ for Korea ($\gamma = 22.355$) leads to a sharper transition function, which is reflective of a faster speed in regime switching. We also find that some of the estimated transition coefficients are not statistically significantly different from zero. Teräsvirta (1994) asserted that this should not be interpreted as evidence of weak nonlinearity since linearity has already been rejected in the earlier tests.

Table 5
The Estimates of the STAR model

	Dependent $(dy/y)_t$			
	Korea	Singapore	Taiwan	Thailand
Independent	LSTAR	LSTAR	LSTAR	LSTAR
Constant	0.041 (0.018)**	0.051 (0.010)***	0.032 (0.011)***	0.011 (0.013)
$(dy/y)_{t-1}$	1.212 (0.285)***	0.546 (0.215)**	0.139 (0.152)	0.809 (0.242)***
$d(g/y)_{t-1}$	6.971 (1.312)***	-3.724 (1.160)***	0.232 (0.931)	4.748 (1.959)**
$(dk/y)_{t-1}$	-1.463 (0.345)***	0.168 (0.217)	-0.494 (0.236)**	0.152 (0.285)
$(dx/y)_{t-1}$	-0.176 (0.599)	-0.296 (0.092)***	-0.094 (0.267)	-0.315 (0.283)
Constant′	0.009 (0.027)	-0.033 (0.028)	0.050 (0.000)***	0.048 (0.018)**
$(dy/y)'_{t-1}$	-0.474 (0.424)	0.123 (0.372)	0.478 (0.000)***	-0.780 (0.349)**
$d(g/y)'_{t-1}$	-7.012 (2.097)***	15.495 (6.657)**	-0.760 (0.000)***	-12.446 (2.596)***
$(dk/y)'_{t-1}$	0.579 (0.604)	-1.566 (0.661)**	-0.706 (0.000)***	-0.483 (0.422)
$(dx/y)'_{t-1}$	-0.556 (0.696)	1.006 (0.443)**	-0.543 (0.000)***	-0.053 (0.415)
τ	0.108 (0.000)***	0.110 (0.001)***	0.159 (0.000)***	0.108 (0.002)***
γ	22.355 (18.483)	13.527 (9.506)	1.756 (0.990)*	6.226 (4.583)
σ_{STAR}	0.042	0.041	0.039	0.032
$\sigma^2_{STAR}/\sigma^2_{VAR}$	0.798	0.646	0.822	0.609
JB	13.016 [0.001]	19.753 [0.000]	31.287 [0.000]	6.146 [0.046]
ARCH(1)	0.002 [0.959]	0.038 [0.844]	1.923 [0.165]	0.273 [0.600]
ARCH(4)	1.322 [0.857]	0.888 [0.926]	2.366 [0.668]	0.878 [0.927]
RESET(1)	1.001 [0.325]	1.053 [0.313]	16.237 [0.000]	4.398 [0.044]
RESET(2)	0.500 [0.611]	0.526 [0.596]	2.788 [0.078]	2.199 [0.129]
AIC	-86.293	-83.500	-91.117	-106.876

Notes: 1. Asymptotic standard errors are in parentheses and asterisk * ,**,*** denotes significance at the 10%, 5% and 1% level, respectively. 2. The notation σ_{STAR} represents the estimated standard deviation of residuals for STAR model. The ratio between the residuals variance of the STAR and the VAR models ($\sigma^2_{STAR}/\sigma^2_{VAR}$) is less than unity which means that the STAR model marginally outperforms the VAR model. 3. Statistic JB is the Jarque-Bera normality test; ARCH is the autoregressive conditional heteroscedasticity test of Engle (1982); RESET is the Ramsey specification test. The *P*-values of the tests are given in brackets.

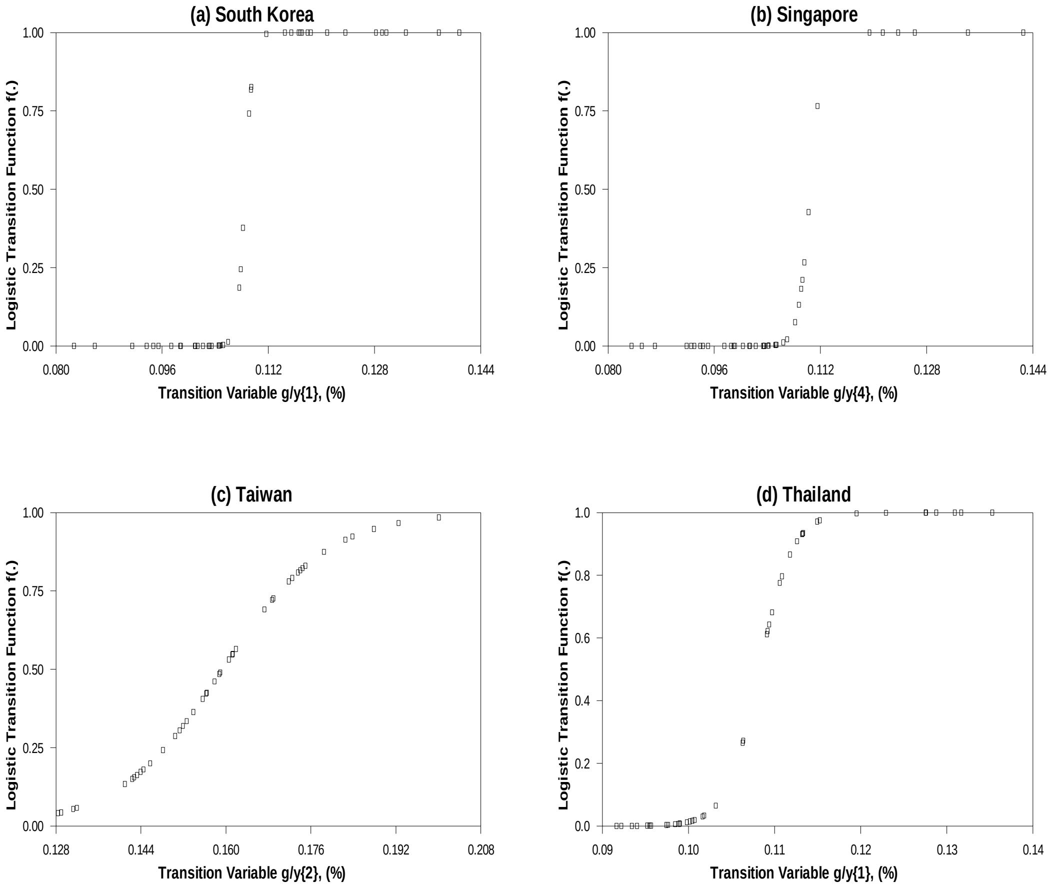

Figure 2. Estimated Transition Functions for Each Country

Figure 2 illustrates the estimated logistic transition functions against the appropriate lagged values of government size level $(g/y)_{t-d}$ to reveal the anticipated asymmetries and discrepancies in the curvature across countries. The logistic transition function for Korea, Singapore and Thailand are both plotted around the threshold of the government size 11% (τ = 0.108, 0.110, 0.108, respectively) via an asymmetric S-shaped pattern while Taiwan exhibits a higher government size threshold 16% (τ = 0.159).

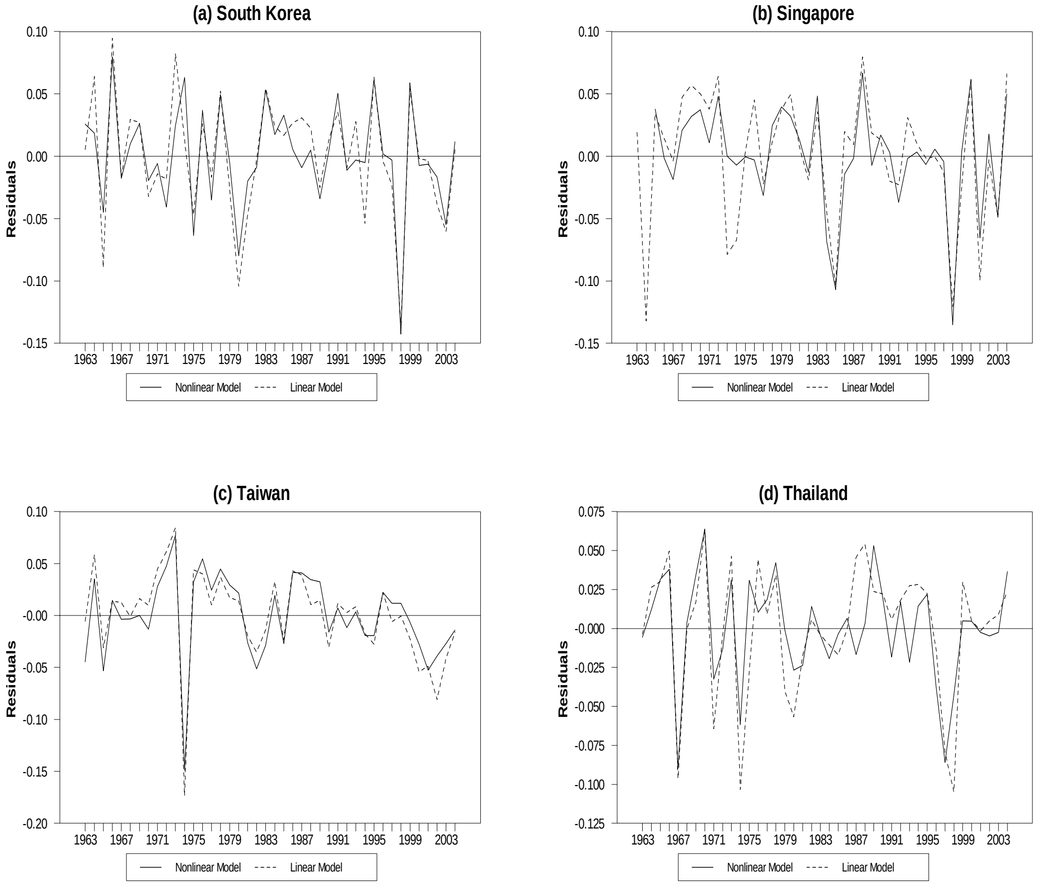

Figure 3. Estimated Residuals for Each Country

The graph of estimated residuals from the linear VAR model and the nonlinear STAR models is illustrated in Figure 3. We find that the nonlinear models capture the recovery of per capita GDP growth rate from the oil shocks (1973 – 1979 period) and the Asian financial crisis (1997 – 1998 period) better than the linear mode. For other periods, the linear and nonlinear models fit the data equally well and the gain from fitting the nonlinear models to the data measured by the ratio of residual variances remains rather small.

Finally, we report the parameter estimates of the relationship between government size and economic growth for the different regimes (Regime I and Regime II). In the LSTAR model, these regimes correspond to $F((g/y)_{t-d};\gamma,\tau)=0$ as

$(g/y)_{t-d} \leq \tau$ and $F((g/y)_{t-d};\gamma,\tau)=1$ as $(g/y)_{t-d} > \tau$, respectively. Using LSTAR model on countries like Korea, Thailand and Taiwan, it shows that the majority of the government size term have a statistically significant positive impact on economic growth in Regime I with an exception of Taiwan (0.232) while in Regime II, the sum of coefficients is negative and statistically significant for each countries. This result lends support to Barro's view that the government size over a certain threshold would have an adverse impact on economic growth. This finding can also be consistent with the proposition that the larger the size of the government, the less efficient the government is, and, the less efficient government can jeopardize economic growth. Our results suggest that a country should pay attention to the effective allocation of government expenditure and to the size of the government. Even though we do not directly test it, but our result seems to advocate that the advantage of a small government size, in general, likely reflects the greater efficiencies resulting from fewer policy-induced distortions, and the greater discipline of market forces which fosters efficiency of resource use. However, from the policy perspective, this does not mean that the optimal policy is one that minimizes the size of government. Rather, a small as opposed to a large government could potentially be as effective in providing legal and administrative services and infrastructure critical for growth, as well as for offsetting market failures.

Our results, however, do not suggest that it is universally true from our sample that smaller government caters better to economic growth. The empirical evidence for Singapore points to the opposite. Specifically, when the government size is smaller than 11%, the effect of government size is negative (-3.724), but when the government size is larger than 11%, the impact becomes positive. A possible explanation for the result is that Singapore government may be stronger and more efficient when it gets bigger compared with other countries in the sample.

4. Concluding Remarks

This paper aims to investigate the possibility of nonlinear effects of government size on economic growth in South Korea, Malaysia, Singapore, Taiwan and Thailand. We find the evidence of nonlinearity for all countries except Malaysia. In carrying out the research, we employ the smooth transition autoregressive (STAR) models. Empirically we find that the asymmetric logistic specification is an appropriate model for Korea, Singapore, Taiwan and Thailand. Barro (1990) suggested that there is an inverted U-shaped effect of government size on economic growth – after passing a certain threshold in government size, the impact can be changed from positive to negative. We find just that in our sample. The threshold level of the share of government consumption expenditure in GDP is found to be about 11% for Korea, Singapore and Thailand and about 16% for Taiwan. Our results also suggest that when the government size is smaller than the threshold, economic growth is promoted under expanding government expenditure; but if the government size is larger than the threshold, then an increase in government size would tend to lower the economic growth rate. However, Singapore is an exception to this general finding. In light of all these findings, we conclude that our results generally refute the notion that the bigger government, the higher economic growth rate is.

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