



# Non-linear Growth-Determinants Nexus: The Role of Sovereign Debt

PO-CHIN WU

SHIAO-YEN LIU

*Chung Yuan Christian University*

TSAI-YUAN HUANG

*National Pingtung University*

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## Abstract

We expand the new growth model as a panel smooth transition regression specification to measure the effects of determinants on growth and the role of debt ratio in the growth-determinants nexus. In the model, we consider new determinants (FDI, export and tourism) and use a two-period lagged debt-GDP ratio as the transition variable. The effects of determinants on growth vary across countries and with time, depending on the value of the transition variable. The threshold of the debt-GDP ratio (73.019%) is a referenced index to set the ceiling of debt-GDP ratio for the fiscal stability. For countries with high debt ratios, the policies to accumulate human capital and promote tourism are more effective in boosting growth than to stimulate domestic physical investment and export. For countries with low debt ratios, the conclusion is opposite. Thus, lowering debt ratio is not always favorable for the contributions of individual determinants to growth.

**Keywords:** Panel smooth transition regression (PSTR) model, debt-GDP ratio, new growth theory, foreign direct investment (FDI), international tourism receipts.

**JEL Classification:** O40, H63, C23, C24

## 1. Introduction

Economic growth is a primary development goal for most countries. These countries make great efforts to adopt proper economic policies and plans for stimulating economic growth. In general, governments can make use of sovereign bond markets to finance these plans and resolve recessionary economy. Consequently, sovereign debt, measured by the debt-GDP ratio (hereafter debt ratio), jumped from 62% of world GDP in 2007 to 85% in 2009 and according to the IMF projections it is expected to rise to 118% for G20 countries in 2014.

The economic growth of the Euro area countries has been playing a crucial role in global economic development. However, since the sovereign debt crisis in the spring of

2010, this area's GDP share in the world has declined from 14.49% in 2010 to 13.68% in 2012. The reduction in the GDP share might reflect non-linear economic growth of the Euro area countries. This crisis also has made the growth rate of the world economy rapidly fall from 5.1 % to 3.3% during the same period. More importantly, the sovereign debt of the Euro area has deteriorated speedily. For example, the debt ratio of Greece was 153% in 2010 and rapidly increased to 181.4% in 2012. Ireland had the highest growth rate of debt ratio in the Euro area, from 28% in 2007 to 123.2% in 2012. Other Euro area countries, including Portugal, Italy, and France, had the debt ratios over 100% in 2012.

The sovereign debt crisis has revealed that the monetary and fiscal policy framework of the European Monetary Union is still incomplete. That is, the rules-based framework for fiscal policy created by the Excessive Deficit Procedure and the Stability and Growth Pact (SGP) was insufficient to prevent a debt crisis. In view of this, several reforms have been put forward for the fiscal rules for the Euro area, with a new Fiscal Compact Treaty that has entered into force at the start of 2013<sup>1</sup>. The Fiscal Compact requires that the new fiscal principles be embedded in each country's national legislation. These fiscal governance reforms are based on two principles: first, high public debt levels pose a threat to fiscal stability, and second, the fiscal balance should be close to zero over a business cycle.

The new system focuses on the structural budget balance, thus stripping out cyclical effects and one-off items. A structural budget balance target encourages a government to bank cyclical revenue gains during upturns in exchange for a greater slippage in the overall budget balance during recessions. Under the new system, there is a specified time frame for reducing public debt below the ceiling of 60 percent of GDP, with the excess above the ceiling eliminated at an average rate of one twentieth each year. The purpose of this study is to investigate answers to the following three questions: whether the growth rates of individual Euro area countries display a non-linear process; whether the debt ratios of individual Euro area countries play a critical role in the growth rates, and how the reduction in the debt ratio influences the growth-determinants nexus, especially for the countries with a high debt ratio.

To achieve this objective, we need to construct an appropriate economic growth model. Since the 1950s, economic growth theory has evolved as two distinct generations of models. The first generation of growth models (also known as the exogenous growth models), inspired by the neoclassical model, asserts the exogenous sources of long-term growth and dominates the literature in the field until late 1960s when focus shifted to inflation and unemployment as growth determinants (Tiwari and Mutascu, 2011). The second generation of growth models (also known as the new growth models or endogenous growth models) is pioneered by Romer (1986). Endogenous growth models differ from exogenous growth models in that the long-term growth rate of an economy is endogenous, or largely driven by human decisions. For example, Barro and Sala-i-Martin (1995) show that technology plays an essential role in the process of economic growth.

Although the new growth models have provided a good theoretical framework for constructing empirical models to measure a country's economic growth, it cannot ideally answer

the three questions mentioned above. First, the original new growth model cannot reflect the impacts of other important variables, such as foreign direct investment (FDI) and international tourism receipts, on the growth. The endogenous growth theory (EGT) stresses the effect of technological progress on long-term growth; therefore, FDI should be considered an important factor boosting growth through the transfer of new ideas and advanced techniques across borders (Bashir, 2001). In addition, the tourism-led growth (TLG) hypothesis postulates that the economic growth of countries can be generated by expanding international tourism as a non-traditional export (Durbarry, 2004)<sup>2</sup>. Nowak, Sahli and Cortés-Jiménez (2007) find that economic development and industrialization in Spain were achieved through the imports of capital goods mainly financed by tourism receipts. Cortés-Jiménez *et al.* (2009) indicate that the determinants of the Spanish long-term economic growth rely also on the expansion of inbound tourism in addition to the classical economic production factors, namely physical capital and human capital. Evidently, to estimate the growth of a country employing the EGT, we need to consider two extra determinants: FDI and international tourism receipts.

Second, the vast majority of existing studies on the empirical analysis of economic growth have assumed that there is a linear relationship between growth and its determinants. Another line of growth literature points out that the non-linearities, resulting from threshold effects related to the level of key factor inputs, can generate multiple growth regimes (Kailatzidakis *et al.*, 2001; Desbordes, 2011). For example, Ketteni and Mamuneas (2007) find that there are substantial non-linearities in the growth-human capital nexus. Savvides *et al.* (2006) investigate the impact of human capital to the process of economic growth by allowing the contribution of traditional inputs (capital and labor) as well as that of human capital to vary both across countries and time. These results indicate that the nonlinear economic growth is highly associated with the business cycle of the corresponding country. For example, in recession periods, the use of human capital decreases, which leads to a lower growth. Contrarily, in prosperity periods, a more input of human capital creates a higher growth. Thus, the study of nonlinear growth-determinants nexus and nonlinear economic growth is crucial. However, most previous studies simply used the square term (or cubic term) of a specific determinant to evaluate its non-linear effect on growth. If the value of the determinant is unbounded, the effect is also unbounded, which is extremely irrational.

Third, Greiner (2013) presents a monetary endogenous growth model to analyze the effects of fiscal and monetary policies on economic growth. The empirical result shows that a balanced government budget gives a higher balanced growth rate and lower inflation than a situation with permanent public deficits. In addition, Pattillo *et al.* (2002) find that debt may have non-linear effects on growth, either through capital accumulation or productivity growth. For example, an increase in public debts leads to a higher interest rate, which crowds out private investment and then partly or completely offsets the contribution created by the rise of public expenditure. In addition, the crowding-out effects would be different as the debt ratios are in low and high levels. Obviously, the fiscal policy variable is an important factor that influences economic growth in the new growth model, and the effect may be non-linear.

To simultaneously resolve the above problems, this study first extends the new growth model proposed by Romer (1986) by decomposing the investments into domestic and foreign components, *i.e.*, domestic physical investment and FDI, and adding export and international tourism receipts as the new determinants. Next, we reconstruct the extended new growth model as a PSTR (panel smooth transition regression) framework to describe the non-linear growth-determinants nexus and allow the contribution of the determinants on growth to vary across countries and with time, depending on the value of a specific transition variable. This study adopts the 12 Euro area countries during 1997-2011 to verify these statements.

The PSTR model, developed by González *et al.* (2005), assumes that the behavior of a series changes smoothly, depending on the value of the transition variable. A simple PSTR model consists of two linear parts linked by a non-linear transition function, and it allows the variable under investigation to move within two different regimes with a smooth transition process, depending on the value of a specific transition variable. The PSTR model is particularly useful for situations in which the non-linear dynamics are driven by a common regime-switching component but where the response to this component can be different across variables. For example, the economic growth of Euro area countries may be influenced by worldwide recessions, but some countries may enter into (or get out of) recessions earlier than others.

Wu *et al.* (2013) further indicate that PSTR models can simultaneously resolve the non-linearity and heterogeneity problems. Most importantly, PSTR models can endogenously determine the threshold value of the transition variable, which provides useful information for policy authority. This study selects a two-period lagged debt ratio as the transition variable, and the estimated threshold value of the two-period lagged debt ratio can be considered as a referenced index to evaluate, from the viewpoint of economic growth, whether the specification of 60% ceiling of the debt ratio in the Fiscal Compact is rational and whether economic growth becomes deteriorated as the debt ratio is over the ceiling. A further introduction of the PSTR model and the selection of transition variable are presented in the next section.

The growth model developed in this study contributes to the existing literature in three distinct ways. First, it provides an alternative empirical and potentially more sound method to evaluate the effects of determinants on economic growth in the Euro area countries. Second, from the actual values of two-period lagged debt ratios and the estimated parameters in transition function, one can explore the non-linearity of the economic growth and the non-linear growth-determinants nexus. Most importantly, using the estimated threshold of the transition variable, the model can investigate whether the threshold value of the debt ratio (*i.e.*, 60%) set by the SGP is rational and whether the debt ratio below the threshold is beneficial for the growth in the Euro area countries.

The remainder of this study is organized as follows. Section 2 briefly introduces the PSTR model of growth for evaluating the threshold effect of debt ratio on the growth-

determinants nexus. The threshold effects imply that the marginal effects of determinants on growth vary with time and across countries, which is quite different from the constant marginal effect that is obtained from traditional linear growth models. Section 3 provides the procedures for testing the non-linearity of our constructed model. Section 4 presents our empirical results. Section 5 uses the estimation results to describe the stylized facts of the economic growth in the Euro area countries, and Section 6 concludes the paper.

## 2. Empirical Model

To measure the effects of determinants on economic growth and evaluate the role of sovereign debt in the growth-determinants nexus, this paper expands the growth model as a PSTR specification based on the classical Cobb-Douglas production function and the new growth theory. Following the standard approach in the literature, this study first builds upon the standard Cobb-Douglas production function within the neoclassical framework (see Tiwari, 2011). That is, the real output ( $Y_t$ ) of a country can be expressed as the function of production technology ( $A_t$ ), physical capital ( $K_t$ ), and human capital ( $H_t$ ).  $t = 1, 2, \dots, T$  is the sample period<sup>3</sup>.

Mankiw (2004) indicates that international trade can be considered as a type of technology to convert non-specialized production into specialized production. That is, export expansion can positively contribute to economic growth through different means such as facilitating the exploitation of economies of scale, or promoting the diffusion of technical knowledge (Grossman and Helpman, 1991). Thus, production function can be revised to include the exports of goods and services. It is also argued that the exports of goods and services provide the opportunity to compete in international markets that lead to technology transfer and improvement in managerial skills. In this sense, the TLG literature translates these arguments into the relationship between inbound tourism expansion and economic growth. Following Durberry (2004), this study adds the exports of goods and services ( $X_t$ ) and international tourism receipts ( $TR_t$ ) as new determinants that influence growth. The export-led growth is confirmed if it is found that exports unidirectionally cause economic growth in the long-term. In addition, the increase in a country's international tourism receipts will contribute to the country's production factors and economic growth.

As mentioned above, FDI is a major catalyst for the development and integration of countries in the global economy. Following the standard approach in the literature (e.g., Kotaridi and Stengos, 2010), this paper allows for physical capital to be decomposed into domestic and foreign components ( $KD_t$  and  $FDI_t$ ). Some studies find that FDI inflows are positively associated with economic growth when countries are sufficiently rich or financially developed (Alfaro *et al.*, 2004). However, Blomström *et al.* (2000) argue that a significant quantity of FDI alone is not sufficient to bring economic prosperity to a host country. In addition, the presence of multinational corporations may adversely affect domestic firms,

given the market power of their proprietary assets such as technology and aggressive marketing techniques and as a result, FDI may crowd out domestic private investment.

According to the variables mentioned above, we can construct the empirical model as a log-linear panel data form:

$$y_{it} = \mu_{i0} + \lambda_t + \theta_1 kd_{it} + \theta_2 h_{it} + \theta_3 x_{it} + \theta_4 tr_{it} + \theta_5 fdi_{it} + \varepsilon_{it} \quad (1)$$

where  $\mu_{i0}$  is a time-invariant individual effect.  $\lambda_t$  is an unobservable time effect and can stand for the production technology.  $\theta_i, i = 1, 2, \dots, 5$ , are the estimated coefficients for the corresponding regressors.  $\varepsilon_{it}$  is a residual term. The explanatory variables in Equation (1) represent the natural logarithm of the corresponding uppercase letters mentioned above.

To reflect the probable threshold effect of debt ratio on the growth-determinants nexus, we need to revise Equation (1) as a proper one. While the non-linearity of economic growth has been extensively discussed in the literature, remarkably little has investigated the non-linear effect of a specific public policy, *e.g.*, the control of debt ratio, on economic growth. This examination is particularly important for the sluggish economic growth of European countries in recent years. In view of this, we rewrite Equation (1) as a PSTR specification with two regimes<sup>4</sup>:

$$y_{it} = \mu_{i0} + \theta_1 kd_{it} + \theta_2 h_{it} + \theta_3 x_{it} + \theta_4 tr_{it} + \theta_5 fdi_{it} + (\theta'_1 kd_{it} + \theta'_2 h_{it} + \theta'_3 x_{it} + \theta'_4 tr_{it} + \theta'_5 fdi_{it}) \times W(z_{it-d}; \gamma, c) + \varepsilon_{it} \quad (2)$$

where  $\theta_k$  and  $\theta'_k, k = 1, 2, \dots, 5$ , are the coefficients of the  $k$ -th regressor in different regimes, respectively.  $W(z_{it-d}; \gamma, c)$  is the transition function bounded between 0 and 1 and describes the smooth switching process of real output.  $z_{it-d}$  is a  $d$ -period lagged transition variable, which can be an exogenous variable or a combination of lagged endogenous variables (see van Dijk *et al.*, 2002).  $\gamma > 0$  is the smoothing parameter, describing the slope of transition function;  $c$  is the threshold value of transition variable.  $\gamma$  and  $c$  are endogenously estimated. Notably, this study uses a lagged debt ratio as the transition variable due to the existence of the lagged effect of fiscal policy on economic growth. Thus, we replace  $z_{it}$  used by González *et al.* (2005) with  $z_{it-d}$ . The optimal lag length of transition variable is determined by the minimum Akaike information criterion (AIC) and Bayesian information criterion (BIC). We will interpret the reasons we select the lagged debt ratio as the transition variable in the next section.

Equation (5) values the non-linear process of growth and the threshold effect of a transition variable  $z_{it-d}$  on growth through the specification of a transition function, not the interaction term or square term of a specific determinant frequently used in previous studies. In addition, the marginal effect of the  $k$ -th regressor on real output for country  $i$  at time  $t$  is  $\theta_k + \theta'_k W(z_{it-d}; \gamma, c)$ ,  $k = 1, 2, \dots, 5$ , *i.e.*, a weighted average of parameters  $\theta_k$  and  $\theta'_k$ . It is worth mentioning that these marginal effects vary with time and across countries and are different from the constant marginal effects obtained from using traditional linear models.

Following the PSTR framework used in Wu *et al.* (2013), the logistic transition functions can be used for the transition function:

$$W(z_{it-d}; \gamma, c) = [1 + \exp(-\gamma \prod_{j=1}^m (z_{it-d} - c_j))]^{-1} \quad (3)$$

where  $c1 \leq c2 \leq \dots \leq cm$ .  $m$  is the number of location parameters. Equation (3) is a monotonically increasing function of  $z_{it-d}$  and yields an asymmetric adjustment towards equilibrium. González *et al.* (2005) indicate that from an empirical point of view, it is sufficient to consider only the cases of  $m = 1$  or  $m = 2$  to capture the non-linearities due to regime switching. For a high value of  $\gamma$ , the transition becomes rougher and the transition function  $W(z_{it-d}; \gamma, c)$  tends towards the indicator function  $W(z_{it-d}; c)$  ( $=1$  if  $z_{it-d} > c$ ;  $=0$ , otherwise). When  $\gamma \rightarrow 0$ , the transition function is constant and the PSTR estimation becomes a panel with fixed effects.

### 3. Specification Tests and Estimation

#### 3.1. Specification Tests

In estimating Equation (2), there are two main problems of specification, *i.e.*, the choice of the transition variable and the determination of the number of regimes. Following Colletaz and Hurlin (2006), we adopt a three-step procedure to estimate Equation (2). First, we conduct the linearity testing to investigate whether real output satisfies the linearity condition. Once the linearity is rejected, we determine the number of transition functions. Finally, after the exclusion of individual-specific means, we can apply non-linear ordinary least squares to estimate the parameters of Equation (2).

Following Colletaz and Hurlin (2006), we replace the transition function  $W(z_{it-d}; \gamma, c)$  with the first order Taylor expansion of the transition function at  $\gamma = 0$  to perform the linearity testing of Equation (2). Thus, we have the following auxiliary equation:

$$v_{it} = \pi_i + \sum_{k=1}^5 \pi_k x_{ikt} + \sum_{k=1}^5 \pi'_k x_{ikt} z_{it-d} + \eta_{it} \quad (4)$$

where  $v_{it}$  and  $x_{ikt}$  are the residuals and explanatory variables of the linear components in Equation (2), respectively. The linearity testing is to perform the test of  $H_0: \pi'_k = 0, k = 1, 2, \dots, 5$ . When the linearity testing is rejected, a sequential approach will be used for the testing of no remaining non-linearity in transition function<sup>5</sup>. Let  $PSR_0$  be the panel sum of squared residuals under  $H_0$  (*i.e.*, the linear panel model with individual effects), and let  $PSR_1$  be the panel sum of squared residuals under  $H_1$  (*i.e.*, the PSTR model with two regimes). The corresponding F statistic is then given by the following:

$$LM = [(PSR_0 - PSR_1) / mK] / [PSR_0 / (TN - N - mK)] \quad (5)$$

where  $K$  is the number of explanatory variables. Under the null hypothesis,  $LM$  statistic is an asymptotic chi-square distribution  $\chi^2(K)$  and the  $F$  statistic has an approximate  $F(mK, TN - N - mK)$  distribution.  $(r + 1)$  is the number of regimes.

### 3.2. Selection of Transition Variable

From a generally Keynesian point of view, economic growth may arise when a primary fiscal deficit increases. If a long-term debt ratio is sustainable in the sense that the growth rate exceeds the real interest rate, then in a Keynesian economy a policy-induced expansion in the deficit would increase growth and reduce the debt-GDP ratio in the long-term. There would be cyclical convergence to a new steady-state. These effects are reversed if austerity is expansionary and convergence would be non-cyclical (Taylor *et al.*, 2012). Obviously, as indicated by Pattillo *et al.* (2002), public debt may have non-linear effects on growth, either through capital accumulation or productivity growth.

In fact, a direct indicator of a debt crisis would be a significant increase in the ratio of public debt<sup>6</sup>. Beyond a certain threshold, one would conclude that a country is facing a problem in financing the debt service. Moreover, the threshold beyond which a crisis is detected depends on the condition of a country. For example, Manasse *et al.* (2003) show that developing countries historically have run into problems at much lower debt ratios than developed countries. The probable reason is that investors might have more confidence in a developed country with high debt than a developing one with low debt. Thus, a debt crisis is hardly detected in Japan, where the debt ratio is reaching 200%, whereas Uruguay experienced a debt crisis in 2002 when this ratio was close to 100%.

Moreover, the European Fiscal Compact requires the member states have enacted, within one year of the Fiscal Compact entering into force for them, a domestic implementation law to establish a self-correcting mechanism, which shall guarantee their national budget in balance or surplus under the treaty's definition. The treaty defines a balanced budget as a general budget deficit less than 3.0% of the GDP, and a structural deficit of less than 1.0% of GDP if the debt ratio is significantly below 60% –or else it shall be below 0.5% of GDP. The treaty also contains a direct copy of the “debt brake” criteria outlined in the Stability and Growth Pact, which defines the rate at which debt levels above the limit of 60% of GDP shall decrease.

In summary, the relationship between debt ratio and growth is close and may be non-linear; therefore, this study uses the debt ratio as the transition variable in Equation (2) to evaluate its threshold effect on growth-determinants nexus. In reality, the policies financed by public debt have a time lag effect on growth, so this study adopts a lagged, not current, debt ratio as the transition variable.

## 4. Empirical Results

Based on the considerations of data availability and heterogeneity across cross-sectional units, this study selects 12 Euro area countries as sample objects, including Austria, Estonia, Finland, France, Germany, Greece, Ireland, Italy, the Netherlands, Portugal, the Slovak Republic, and Spain. Sample period spans from 1997 to 2011. Thus, there are 180 observations. There are four reasons that this paper uses the panel data to conduct empirical studies. First, in evaluating the nonlinear link between growth and its determinants, one needs to consider the heterogeneity of cross-sectional countries. Thus, we have to employ a panel data set to execute the empirical estimation. However, there is a trade-off between the length of time period and the number of countries due to the availability of data. That is, the longer the time series is covered, the fewer the countries we can choose. Nevertheless, this will abandon some degree of heterogeneity of cross-sectional countries.

Second, previous studies have applied similar length of time period to engage in empirical estimation. For example, Ozturk and Acaravci (2009) investigate the long-run relationship between the real GDP and international tourism in Turkey during the time period 1987-2007. Moreover, panel VARs with a short period of time (typically less than 10 periods) have been investigated, for example, by Holtz-Eakin, Newey, and Rosen (1988) and Binder, Hsiao, and Pesaran (2005).

Third, one of the advantages by using panel data to conduct relevant estimation is that the observations are relatively enough. The estimation in our paper is performed by logical procedures and then obtains reasonable results. Once the observations are insufficient, the estimation is unable to be executed. That is, the PSTR model really can be estimated by using the specified dataset. In light of this, the estimation results have certain reference value. Finally, the main purpose of the present paper is to provide a new approach to examine the nonlinear relationship between growth and its determinants. However, the empirical estimation can be further re-investigated as the length of time series is extended in the future.

The measurement of the variables used in this study is displayed in Table 1. There are several proxies of human capital have been developed, such as proportion of people of working age, school enrollment rates, average years of education, and ratio of skilled-adults over total adults (Kwon, 2009). Subject to the availability and heterogeneity of data, this study, following Tiwari (2011), uses the proportion of people of working age as the proxy of human capital. Data set comes from the OECD databank<sup>7</sup>. To save space, we omit the descriptive statistics and standard panel unit root tests (LLC, IPS, and ADF-Fisher) of the variables. All the variables used in this study satisfy the stationarity condition, implying that they are stationary. The results are available upon request.

The estimation results of the economic growth using the PSTR model [Equation (2)] are reported in Tables 2 through 4. In Table 2, the linearity tests lead to a rejection of the null hypothesis of linearity for the PSTR specifications with different numbers of location parameters ( $m=1,2$ ) and different lag lengths of transition variable ( $z_{it-d}$   $d = 0,1,2$ ). The results

show that the economic growth in the 12 Euro area countries displays a non-linear dynamic path, and the relationships between growth and individual determinants are non-linear.

**Table 1**  
**DATA SOURCE AND MEASUREMENT**

| Variable                       | Symbol | Measurement                                         |
|--------------------------------|--------|-----------------------------------------------------|
| Real output                    | $y$    | Real per capita GDP<br>(at constant prices of 2000) |
| Domestic physical capital      | $kd$   | Gross fixed capital formation/<br>GDP               |
| Human capital                  | $h$    | Proportion of people of<br>working age              |
| Exports of goods and services  | $x$    | Exports of goods and<br>services/GDP                |
| International tourism receipts | $tr$   | Real per capita international<br>tourism receipts   |
| Foreign direct investment      | $fdi$  | FDI inflows/GDP                                     |
| Debt-GDP ratio                 | $z$    | Public debt/GDP                                     |

*Source: Authors' elaboration.*

To investigate the endogeneity problem, we perform the standard Durbin-Wu-Hausman test. This study uses the lagged terms of the suspicious independent variables as the instrument variables for the endogeneity test. The lag lengths are determined by the minimum AIC. Compared to using a one-period lagged dependent variable as the instrument variable in Gerber (1998), this treatment can improve the estimation results. The chi-square  $\chi^2$  test statistics and corresponding p-values for  $kd$ ,  $h$ ,  $x$ ,  $tr$ , and  $fdi$  are 0.1764 (0.678), 0.0196 (0.885), 3.8157 (0.124), 0.7622 (0.383), and 2.2015 (0.172), respectively. Evidently, there is no significant endogeneity problem in our constructed estimation model. This result may come from the following reasons. First, the panel data set is used to perform the estimation. According to the argument of Hsiao (2003), the estimation results in a panel data context may exclude the problems endogeneity and heterogeneity and can improve the estimation efficiency. Second, the choice of the instrument variables also influences the test results. Finally, except for the variables  $tr$  and  $y$ , the remaining five variables are measured by a ratio, which may be another reason to cause the endogeneity problem disappear.

Table 3 displays the results of the no remaining non-linearity tests and provides information about the optimal number of transition functions. Following González *et al.* (2005), this study allows the number of location parameters ( $m$ ) to be either one or two. In addition, van Dijk *et al.* (2002) have documented that  $F$  versions of the  $LM$  test statistics have better size properties in small samples than the  $\chi^2$  variants. Thus, this study uses  $LMF$  as the selection criterion for the number of transition functions. The  $PSTR$  model with one location parameter ( $m=1$ ), one transition function ( $r=1$ ), and a two-period lagged debt ratio  $z_{it-2}$ , and the  $PSTR$  model with  $r=m=2$  and a two-period lagged debt ratio  $z_{it-2}$  both can describe the non-linear process of economic growth.

**Table 2**  
**LINEARITY TEST**

| Lag length of transition variable | Testing statistic | Number of location parameters ( $m$ ) |               |
|-----------------------------------|-------------------|---------------------------------------|---------------|
|                                   |                   | $m=1$                                 | $m=2$         |
| $d=0$                             | LMF               | 0.702 [0.623]                         | 1.125 [0.347] |
| $d=1$                             | LMF               | 1.483 [0.199]                         | 0.910 [0.526] |
| $d=2$                             | LMF               | 3.557 [0.005]                         | 2.564 [0.008] |

Notes: The transition variable in the PSTR model is the (lagged) debt ratio,  $Z_{it-d}$ ,  $d=0,1,2$ . The digits in brackets are the  $p$ -values.  $H_0$ : linear model against  $H_1$ : PSTR model with at least one threshold variable. LMF denotes the statistic of the Fisher test.

Source: Authors' elaboration.

**Table 3**  
**TEST OF NO REMAINING NON-LINEARITY**

| Lag length of transition variable | Testing statistic | Number of location parameters ( $m$ ) |               |
|-----------------------------------|-------------------|---------------------------------------|---------------|
|                                   |                   | $m=1$                                 | $m=2$         |
| $d=0$                             | LMF               | –                                     | –             |
| $d=1$                             | LMF               | –                                     | –             |
| $d=2$                             | LMF               | 1.619 [0.160]                         | 2.032 [0.114] |

Notes: The transition variable in the PSTR model is the (lagged) debt ratio,  $Z_{it-d}$ ,  $d=0,1,2$ . The digits in brackets are the  $p$ -values.  $H_0$ : PSTR with  $r = 1$  against  $H_1$ : PSTR with at least  $r = 2$ . LMF denotes the statistic of the Fisher test. "–" stands for the estimated model is linear based on the results in Table 2.

Source: Authors' elaboration.

According to the minimum AIC (or BIC) criterion, the optimal model for evaluating the non-linear dynamics of growth is the PSTR model with  $r=m=2$  and  $z_{it-2}$ <sup>8</sup>. Table 4 reports the estimation results. The estimated threshold value ( $c$ ) and transition parameter ( $\gamma$ ) are 73.093% and 0.191, respectively, and optimal transition variable is the two-period lagged debt ratio. That is, the two-period lagged debt ratio has a threshold effect on the growth-determinants nexus, and the threshold value is 73.093%.

The effect of export on growth is significantly positive, *i.e.*,  $0.418 - 0.381 * W(z_{it-2}; 0.191, 73.093\%) > 0$ . In the two extreme cases, *i.e.*,  $W(z_{it-2}; 0.191, 73.093\%) = 0$  and  $W(z_{it-2}; 0.191, 73.093\%) = 1$ , the effects are 0.418 and 0.037, respectively. Evidently, this result supports the export-led hypothesis. However, the larger the two-period lagged debt ratio is, the smaller the marginal effect of export on growth would be, implying that a debt financing policy is harmful for the marginal effect of export on growth. One of the reasons is that public debt may have non-linear effects on growth, either through capital accumulation or productivity growth, which further push the export (Pattillo *et al.*, 2002).

As expected, human capital exerts a significantly positive effect on growth, *i.e.*,  $2.936 + 1.475 * W(z_{it-2}; 0.191, 73.093\%) > 0$ , and has the largest effect on growth among the determinants. The higher the

two-period lagged debt ratio is, the larger the positive effect of human capital on growth would be. Because the transition function (Equation (3)) is a logistic one, this result supports the argument proposed by Kalaitzidakis *et al.* (2001) and Savvides *et al.* (2006) that there are substantial non-linearities in the growth-human capital nexus. However, the non-linear relationship estimated in this study works through the two-period lagged debt ratio, not human capital.

The effect of domestic physical capital on growth is ambiguous, *i.e.*,  $2.859-5.532*W(z_{it-2}; 0.191, 73.093\%)$ . The larger the two-period lagged debt ratio is, the smaller the positive effect of domestic physical capital on growth would be. In the extreme case of  $W(z_{it-2}; 0.191, 73.093\%)=1$ , the effect becomes negative,  $-2.673$ . According to the debt overhang theory, as sovereign governments service their debt by taxing firms and households, high levels of debt imply an increase in the private sector's expected future tax burden. Thus, high debt ratio will discourage further domestic and foreign investment and thus harm growth (see, for example, Krugman, 1988). In addition, an important channel through which public debt accumulation can influence growth is that of long-term interest rates. Higher long-term interest rates, resulting from more debt-financed government budget deficits, can crowd out private investment, thus dampening potential output growth<sup>9</sup>. That is, a high debt ratio will crowd out domestic physical investment.

International tourism receipts have a negative effect on growth, *i.e.*,  $-2.288+1.324*W(z_{it-2}; 0.191, 73.093\%) < 0$ . In the sample period, the population, price level, and international tourism receipts rise faster than the nominal GDP; therefore, the growth effect is negative. However, the higher the two-period lagged debt ratio is, the smaller the negative effect of international tourism receipts on growth would be. That is, excluding the disturbances of population growth and inflation, high debt ratio is harmful for tourism to stimulate the growth in the Euro area countries. The reason may be that the rise of debt ratios leads to a depreciation of domestic currency, which attracts foreign tourists to travel to home country (see, for example, Leitao, 2010). Although there is a non-linear relationship between FDI and growth, *i.e.*,  $0.019+0.056*W(z_{it-2}; 0.191, 73.093\%) > 0$ , the relationship is statistically insignificant and depends on the value of the two-period lagged debt ratio, not the FDI verified by Kottaridi and Stengos (2010).

In the work of Reinhart and Rogoff (2010), they indicate that when gross external debt reaches 60% of GDP, a country's annual growth declines by 2%, and for levels of external debt in excess of 90% GDP, growth is roughly cut in half. Appearing in the aftermath of the financial crisis of 2007-2008, it provides support for pro-austerity policies. However, academic critics demonstrate that the paper uses weak methodology, and that the underlying data does not support the authors' conclusions. For example, Herndon *et al.* (2014) find that the average real GDP growth at public debt ratios over 90 percent is not dramatically different than when debt ratios are lower. Mencinger *et al.* (2014) argue that the result of Reinhart and Rogoff leads to unjustified adoption of austerity policies for countries with various levels of public debt. Bell *et al.* (2015) argue that the nexus between debt and growth varies significantly between countries, implying that an average rule suggested by Reinhart and Rogoff, has little policy relevance.

In the present paper, the impacts of determinants on growth are non-linear and vary with time ( $t$ ) and across countries ( $i$ ), depending on the value of the two-period lagged debt ratio. According to the overall marginal effects of the determinants on growth in Table 4, the growth decreases with the rise in the debt ratios. In the extreme case of  $W(.)=1$ , *i.e.*, the debt ratio is absolutely over the threshold 73.093%, the growth decreases 3.06%. These results obviously cover the divergent conclusions in the previous studies.

Besides, the estimation results using a linear fixed-effect model show that except for the international tourism receipts, the effects of the remaining determinants on growth are over-estimated.

**Table 4**  
**ESTIMATION RESULTS OF GROWTH MODELS**

| Model       | PSTR model (Equation (2)) | Linear model       |
|-------------|---------------------------|--------------------|
| Parameter   | $r=m=1, Z_{it-2}$         |                    |
| $\theta_1$  | 0.4078<br>(2.106)**       | 0.4843<br>[0.000]  |
| $\theta_2$  | 2.9364<br>(1.696)         | 6.5538<br>[0.000]  |
| $\theta_3$  | 2.8588<br>(4.286)***      | 3.0783<br>[0.000]  |
| $\theta_4$  | 0.0186<br>(0.083)         | 0.3238<br>[0.000]  |
| $\theta_5$  | -2.2882<br>(-4.10)***     | -2.7079<br>[0.000] |
| $\theta'_1$ | -0.3811<br>(-1.804)*      |                    |
| $\theta'_2$ | 1.4748<br>(2.562)**       |                    |
| $\theta'_3$ | -5.5315<br>(-3.201)***    |                    |
| $\theta'_4$ | 0.0557<br>(0.054)         |                    |
| $\theta'_5$ | 1.3242<br>(1.906)*        |                    |
| $c$         | 0.1910                    |                    |
| $\gamma$    | 73.093%                   |                    |
| AIC         | 4.8277                    |                    |
| BIC         | 5.2226                    |                    |

Notes:  $r$ ,  $m$ , and  $Z_{it-2}$  denote the number of transition functions and the number of location parameters, and the two-period lagged debt ratio, respectively. The optimal PSTR model is the model with the minimum AIC and BIC. Howe-

ver, the PSTR model with  $r=1$  and  $m=d=2$  has  $AIC=4.8426$  and  $BIC=5.2451$ .  $\theta_i$  and  $\theta'_i$ ,  $i=1,2,3,4,5$  are the estimated coefficients of export, human capital, domestic physical capital, foreign direct investment, and international tourism receipts, in two different regimes, respectively. The digits in parentheses and brackets are the t-values and the p-value, respectively. The linear model is estimated using fixed effects with a cross-section SUR model. The errors in each equation can pass standard residual tests. To save space, we do not display the test results of the residuals in each estimated equation; however, they are available upon request.

Source: Authors' elaboration.

## 5. Stylized Facts and Policy Propositions

In this section, we apply the estimation results in Table 4 to investigate the actual time paths of growth and debt ratio and suggest the policies to stimulate growth in the 12 Euro area countries. Regarding the series of real per capita GDP, except for Estonia, Germany, and the Slovak Republic, the remaining countries had the lowest value in 2011. In addition, one-half and one-fourth of the 12 sample countries had the highest real per capita GDP in 1999 and 2006, respectively. Evidently, the growth of most sample countries faced a turning point during 1997-2011 (Figure 1).

We can classify the debt ratios of the 12 sample countries into five different groups (see Figure 1), including countries with debt ratio above the threshold (73.019%) (Greece and Italy), below the threshold (Estonia, Finland, and the Slovak Republic), quick deterioration (Greece, Ireland, and Portugal), moderate improvement (Estonia and Finland), and moderate deterioration (Austria, France, Germany, the Netherlands, and Spain). In 2011, Greece, Ireland, Italy, and Portugal had debt ratios over 100%, obviously higher than the 60% ceiling imposed by the SGP. Only Estonia and the Slovak Republic had debt ratios below the ceiling over the entire sample period. Besides, the debt ratios in the 12 Euro area countries had increased since 2008, revealing that the debt ratios had displayed different non-linear time paths.

The correlation coefficients between the two-period lagged debt ratio and current real per capita GDP in 12 individual countries ranged from  $-0.893$  (France) to  $0.239$  (Italy). The correlation coefficients for countries with debt ratio above the estimated threshold, 73.019%, were  $0.853$  (Greece) and  $0.239$  (Italy); for countries with debt ratio below the estimated threshold were  $-0.565$  (Estonia),  $-0.557$  (Finland), and  $-0.51$  (the Slovak Republic); for countries with quick deterioration in debt ratio were  $-0.893$  (France),  $0.853$  (Greece),  $-0.681$  (Ireland), and  $-0.880$  (Portugal). Clearly, the sovereign debts caused non-linear impacts on the growth-determinants nexus in the panel data context.

The results in Table 4 show that the effects of the five determinants on growth are extremely different, depending on the debt ratios of individual countries. Moreover, the estimated threshold value of the two-period lagged debt ratio (73.019%) can be considered as a referenced ceiling of the debt ratio in the Euro area countries. The reason is direct. Only two of the twelve sample countries had debt ratios under the threshold in 2011, and most importantly, the threshold is endogenously determined by simultaneously considering the economic conditions of the 12 sample countries.

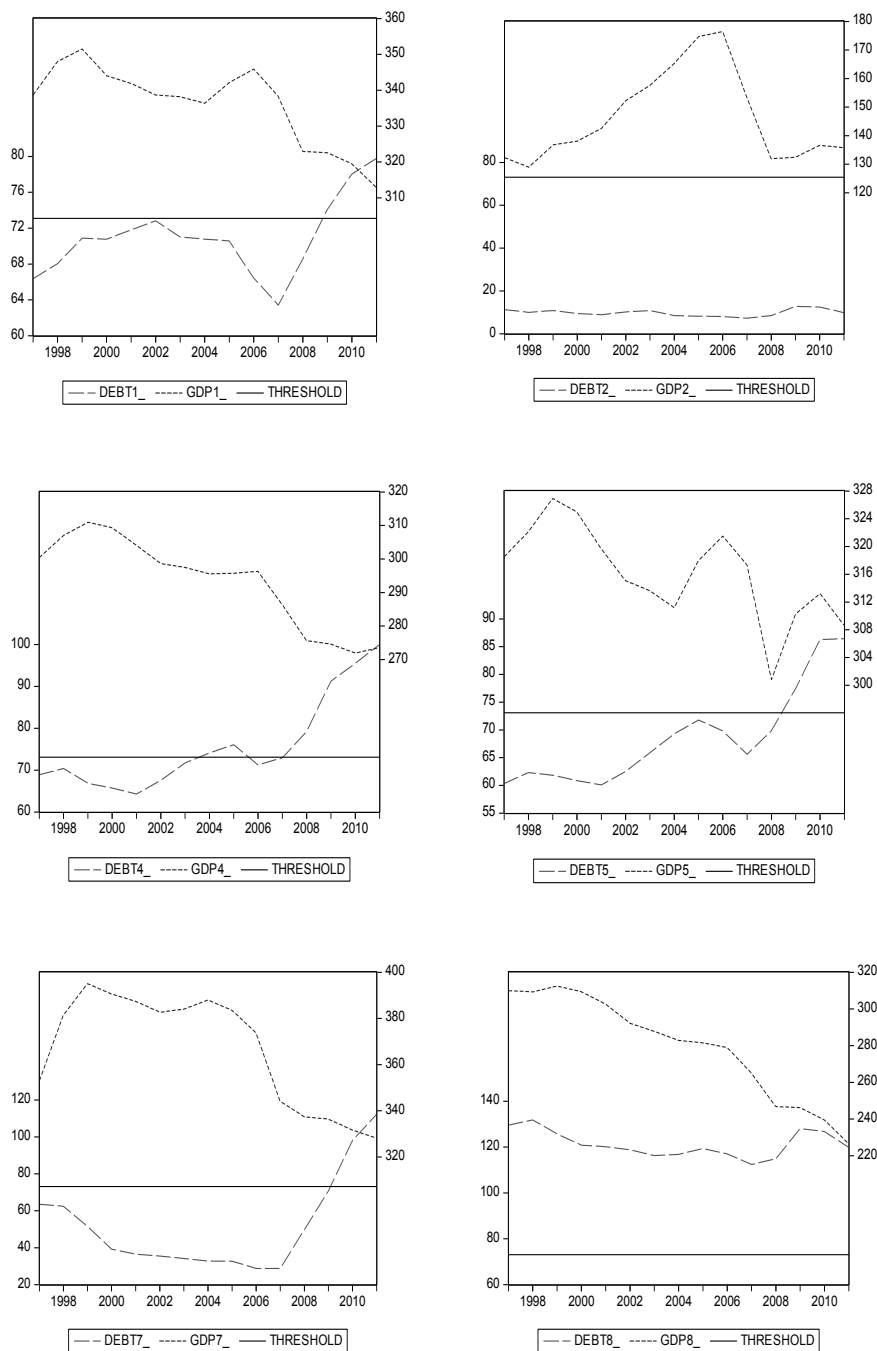


**Figure 1: Growth, debt-GDP ratio and its threshold value**

*Source: Authors' elaboration.*

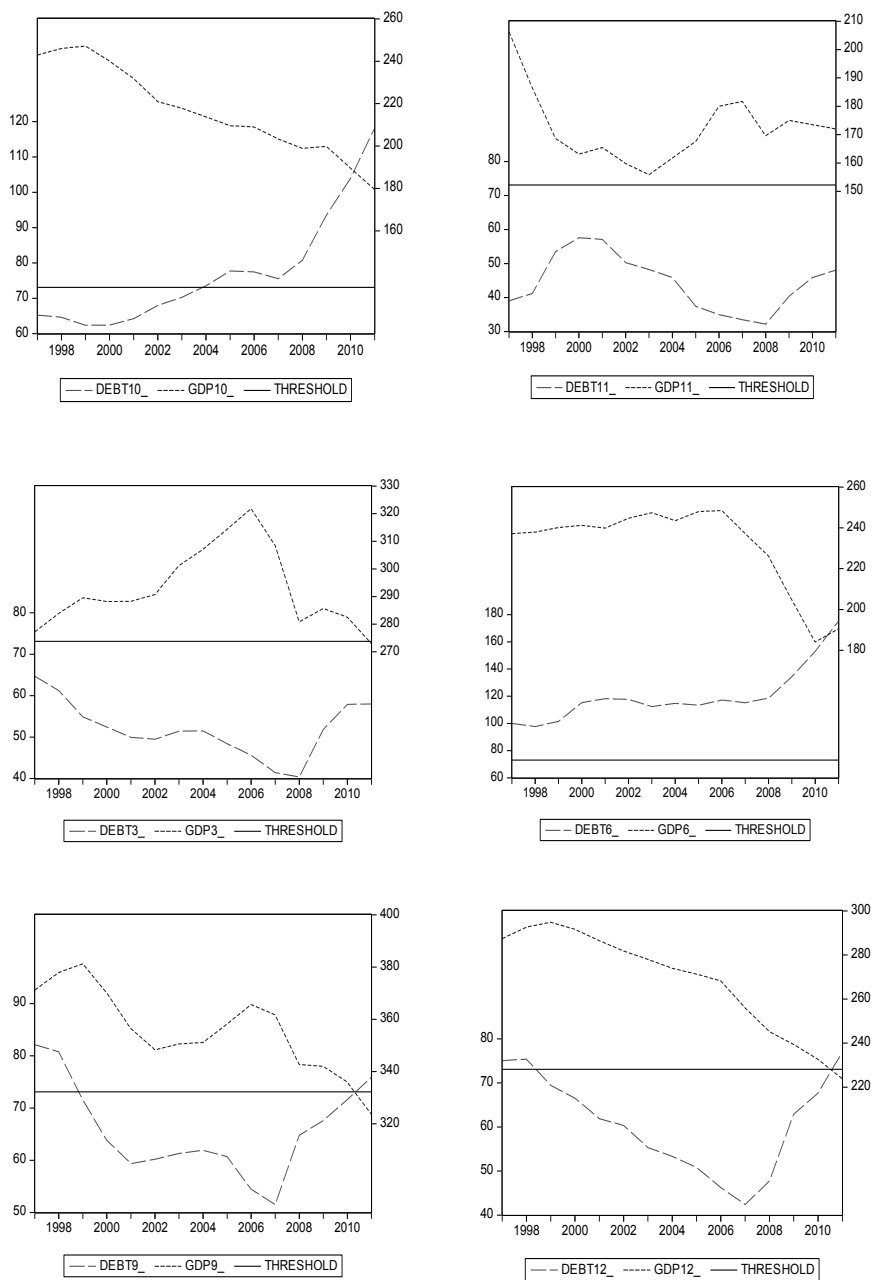


**Figure 1 (Cont.): Growth, debt-GDP ratio and its threshold value**

Source: Authors' elaboration.

Since the transition function in Equation (3) is a monotonically increasing function of the two-period lagged debt ratio, a specific regressor contributes to growth through its corresponding estimated coefficients in the two regimes of Equation (2) and the value of transition function. The estimated coefficients of human capital and FDI have same signs in two different regimes; therefore, the marginal effects of the two regressors on growth decrease as the debt ratio decreases. Contrarily, the estimated coefficients of export, domestic physical capital, and tourism have different signs in two different regimes. Consequently, the marginal effects of the three regressors on growth increase as the debt ratio decreases. Thus, for countries with a relatively high debt ratio (for example, over the threshold, 73.019%), including Greece, Italy, Portugal, and Ireland, aggressively accumulating the stock of human capital and the receipts of international tourism can resist the harmful impacts of domestic physical capital and export on growth. Contrarily, for countries with a relatively low debt ratio, including Estonia, Slovak, and Finland, actively stimulating domestic physical investment and expanding export are beneficial for their economic growth.

## 6. Conclusion

This study investigates the role of debt ratio in the growth-determinants nexus by extending the new growth model as a PSTR framework to allow the effects of determinants on growth vary across countries and with time. In the constructed model, we decompose the physical capital in the new growth model into the domestic physical capital and foreign direct investment; consider the export and international tourism receipts as new determinants, and use a two-period lagged debt ratio as the transition variable.

Our empirical results from the 12 Euro area countries during 1997-2011 confirm that the five determinants have non-linear effects on growth, depending on different countries, time, and two-period lagged debt ratios. Export and human capital have positive effects on growth, but FDI has a statistically insignificant effect on growth. Excluding the disturbance of the increases in inflation and population, tourism has a positive effect on growth. The countries with debt ratios above or below the threshold (73.019%) of debt ratio have different policies to stimulate economic growth.

The results have the following policy implications. The monetary union in the Euro area was not accompanied by a significant degree of fiscal union, implying that the fiscal policy in the Euro area is decentralized. The decentralization of fiscal policy generates the need of a process of coordination. Thus, the threshold 73.019% provides a referenced index for the Fiscal Compact to set the ceiling of debt ratio for the consideration of fiscal stability in the Euro area. Moreover, the two-period lagged debt ratio is a useful indicator for individual governments to evaluate how to adopt proper policies to stimulate economic growth. For countries with a high debt ratio, the policies to accumulate human capital and stimulate international tourism inbound are more effective in boosting economic growth than to encourage domestic physical investment and export. However, for countries with a low debt ratio,

the conclusion is opposite. Thus, lowering debt ratio is not always favorable for the contributions of individual determinants to growth.

## Notes

1. Other proposal of reforms is the introduction of common areawide Eurobonds with the goal of avoiding the disruptive impact of destabilizing speculative attacks on national sovereign debt markets inside the Euro area (Favero and Missale, 2012).
2. A comprehensive review on the TLG hypothesis is provided by Cortés-Jiménez *et al.* (2009).
3. In our empirical analysis, labor and the proxies of human capital develop by Kwon (2009) have high multicollinearity; therefore, we replace labor with human capital. In addition, we use the standard Cobb-Douglas production function instead of the CES (constant elasticity of substitution) production function, because our purpose is to determine the factors influencing economic growth, not to investigate the elasticity of substitution between capital and labor.
4. It is easy to extend the PSTR model to more than two regimes. For more details, see González *et al.* (2005). This study excludes the time effects based on three reasons. First, the results of the redundant fixed effects tests show that the time-specific fixed effects are insignificant. Second, the inclusion of country-and-time effects could overcorrect an estimation model. Third, as indicated by Teräsvirta (1994), the transition variable has the function of controlling for other factors associated with the dependent variable.
5. For more details on the testing of no remaining non-linearity, see Colletaz and Hurlin (2006).
6. This paper tries to use the indices of risk premiums: government bond spreads as the transition variable; however, the government bond spreads are as volatile as the debt-GDP ratios. Thus, we omit the estimation results by employing the PSTR model with government bond spreads as the transition variable.
7. The correlation coefficients of the five regressors and the debt ratio range from  $-0.56$  (debt ratio and export) to  $0.54$  (FDI and export), revealing that the high multicollinearity problem does not occur.
8. We only display the estimation results of the optimal PSTR model; however, the remaining estimation results are available upon request.
9. Other considerations imply that high debt levels may also constrain growth by lowering total factor productivity growth. For example, governments may be less willing to undertake difficult and costly policy reforms if it is perceived that the future benefit in terms of higher output will accrue partly to foreign creditors.

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## Resumen

Este artículo amplía el nuevo modelo de crecimiento mediante la especificación de una regresión con transición suave para datos de panel que mide los efectos de los determinantes del crecimiento, así como el papel de la ratio de deuda como nexo de aquellos. En el modelo consideramos nuevos determinantes del crecimiento (inversión directa extranjera, exportaciones y turismo) y utilizamos la ratio deuda/PIB retardada dos períodos como variable de transición. Los efectos de los factores en el crecimiento varían entre los países y en el tiempo, dependiendo del valor de la variable de tran-

sición. El umbral de la ratio deuda/PIB (73,019%) es un índice de referencia para fijar el techo de la propia ratio en aras a la estabilidad fiscal. Para los países con altos coeficientes de endeudamiento, las políticas para acumular capital humano y promover el turismo son más eficaces para impulsar el crecimiento que estimular la inversión física doméstica y las exportaciones. Para los países con coeficientes de deuda bajos, la conclusión es la opuesta. Por lo tanto, la reducción del coeficiente de deuda no siempre es singularmente favorable a todos factores determinantes del crecimiento.

*Palabras clave:* modelo de regresión con transición suave para datos de panel, ratio deuda/PIB, nueva teoría del crecimiento, inversión directa extranjera, ingresos del turismo internacional.

*Clasificación JEL:* O40, H63, C23, C24

