Public debt, economic growth and quality of institutions: A panel smooth transition regression approach for EU countries

Iuliana Matei[1]

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Abstract: In the aftermath of the 2008-2009 crisis, EU countries have been concerned by large increases in public debt and fiscal deficits raising questions about their sustainability position under the EU Stability and Growth Pact. Although the nexus between public debt and economic growth has long been examined, the empirical literature remains inconclusive. Some studies have found that public debt deters economic growth while others concluded the opposite. Other recent studies (e.g., Reinhart & Rogoff's debt intolerance ratio) have shown a reconciliation of these views by arguing that while economic growth has linear negative effects on public debt (a decline of the economic growth being, ceteris paribus, related with an increase in public debt), high levels of public debt are likely to be harmful for economic growth, potentially, after a certain threshold has been reached. This paper revisits the public debt–growth nexus by investigating the role that institutions could play in mediating the public debt effect on economic growth debt for 28 EU countries and eleven Emerging European countries (EEU) over the yearly period 2000-2019. The relevance of this hypothesis is investigated by using recent panel econometric techniques (Gonzales et al., 2005, 2017). The paper shows that the quality of institutions is an important driver for the public debt-growth nexus. Also, findings suggest the existence of a non-monotonic relation between public debt and growth for EU28 and EEU11 countries.

Keywords: economic growth, public debt, panel models, Emerging European countries

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[1] Iuliana Matei: University Paris 1, France. Email: iuliana.matei@malix.univ-paris1.fr.

1. Introduction

In the aftermath of the global financial crisis, EU countries have experienced large increases in public debt and fiscal deficits, which has led to concerns about their fiscal sustainability under the EU's Stability and Growth Pact. Emerging EU countries have particularly been hit hard by the financial crisis, as their economies have suffered greater declines in output and increases in the level and the variability of the debt-to-GDP ratio. In this context of historically high levels of debt and deficit, the analysis of the relationship between public debt and economic growth become a dimension which gains growing interest among academics and policymakers.

A rich body of literature in international macroeconomics tried to identify the nature of the impact of public debt on economic growth (e.g., Reinhart and Rogoff, 2010; 2012; Kumar, 2010; Panizza and Presbitero, 2012; Baum et al. 2013; Fincke and Greiner, 2014; Eberhardt and Presbitero, 2015; Chudik et al., 2018; Dombi and Dedak, 2019; Checherita-Westphal, 2019). Two divergent views have been identified in this regard. According to the first view, in the short-run, an increase in public debt resulting from fiscal expansion stimulates global demand and should help the economy grow. The second view emphasises that the impact of public debt on economic growth is not clear, in the long-run. More precisely, a first group of studies finds a negative long-term relationship between public debt and economic growth. The explanation is that an increase in the budget deficit is synonym with an increase in the government demand for "loanable" funds from the private sector which, for a constant supply of savings, may raise interest rates. Growing interest rates crowd out private sector investments and reduce GDP growth. A second group of studies doubt that could be a long-term association between these two dimensions, for low or moderate levels of public debt while other research disregards any long-term association. A more recent literature (e.g., Chudik et al., 2017, 2018 for forty countries on the 1965-2010 period) insists on the fact that persistent accumulations of public debt over long periods are likely to be harmful for economic growth, potentially, after a certain threshold has been reached.

This study provides new evidence that sheds light on the impact of public debt on economic growth for ten Emerging EU countries (EEU) and twenty-eight countries of EU over the period 2000-2019. Specifically, the paper investigates the role that institutions play in mediating the public debt accumulation effect on economic growth. The link between the quality of economic and political institutions should be a key point in explaining the public debt-growth nexus because better economic institutions are able to stimulate economic growth, and economic growth over time should reinforce a demand for better political institutions which will finally reduce public debt. This is why, the article 2 of the EU Treaty stating that "the Union is founded on the values of respect for human dignity, freedom, democracy, equality and rule of law and respect for human rights" and that "these values are common to the member states" is a core principle of the EU's architecture that enforces the principle of mutual trust, influences positively the quality of institutions and thus, its economic performance.

But, in the aftermath of the global financial turmoil and the European debt crisis, the deterioration of financial and economic indicators in many European countries induced sometimes an increase in domestic and European political tensions drawing attention to the importance of political cohesion and of rule of law in this region. Unpopular austerity measures adopted by some EU governments over the last decade and the limited capacity of governing political parties to handle the crisis and to restore growth and employment caused the premature end of the ruling government and power shifts in several EU countries. Furthermore, several autocratization processes in some emerging EU countries (such as Poland and Hungary) as well as a partial

democratic regressing in other places of Europe poses serious challenges for their economic integration process in the euro area.

Studies on the role that institutions may play to achieve country's economic performance were initiated by North (1990) that defines institutions as the humanly devised constraints or rules that structure political, economic, and social interaction. Rolland (2004) refreshes this view by dividing institutions into "slow-moving" and "fast-moving" where "slow-moving institutions" (culture, beliefs and social norms) impact gradually the "fast-moving institutions" (political institutions). The interaction of the two forms of institutions provides evidence on institutional change and on its impact on the economic growth and development. Finally, more and more economists investigated the institutions-growth nexus and found that the quality of institutions is a key driver of long-term economic growth (Barro, 2000; Acemoglu et al., 2001; Rodrick et al., 2004; Demetriades and Law, 2006; Vieira et al., 2012; Law et al., 2018). Although the institutional quality has been gaining popularity in recent years, only limited econometric evidence shows the mediating effect of institutions on debt-growth nexus, particularly when using non-linear panel data models.

This paper contributes to the empirical literature on public debt-growth nexus in several ways. First, the paper provides additional support to economic views on the relationship between public debt (PD) and economic growth (G). However, it goes further by revealing that the non-monotonous relationship between PD and G is conditional on the country's level of development and the quality of the country's institutions (through rule of law, political stability, government efficiency and so on). To my knowledge, this feature of the public debt-economic growth relationship has not been explored before. Second, the paper focuses on the experiences of 28 EU countries over the period 2000–2019, including both euro area and emerging economies, to capture disparities, if any, in the value of the threshold above and below which the effect of public debt on economic growth may differ between these two groups of countries. The endogenous threshold is estimated by using a panel smooth transition model (PSTR) by González et al. (2017), which is the best model for undertaking the heterogeneity in the impact of public debt on economic growth. The heterogeneity is allowed by assuming that the estimated coefficients are bounded continuous functions of an observable variable and fluctuate between a limited number of "extreme regimes". The homogeneity tests, parameter estimation, and model evaluation (including tests of no remaining heterogeneity) are intermediary steps of the empirical strategy. To my knowledge, the literature on public debt-growth nexus counts only a study using the PSTR approach (Arsić, 2017). However, as explained previously, this paper goes further by investigating the role of institution's quality in settling the public debt effect on economic growth, particularly, for Emerging European Countries (EEU) where little research exists on this topic and with this methodology. Finally, the finding could be insightful for policy makers in the sense that they should consider improving the quality of institutions when assessing the relationship between public debt and economic growth of a country.

Our results show that the effects of public debt on economic growth vary across countries depending on the country's level of development and quality of its institutions. The overall effect of PD on G is negative, but it varies when it is conditioned by institution's quality.

The rest of the paper is structured as follows. The next section describes the empirical specification and the data. The section 3 displays and discusses estimation results. The last section summarizes the main findings and conclusions.

2. Data and methodology

2.1 PSTR specification

To investigate the potential non-linearity of the relationship between public debt and economic growth mediated by the quality of institutions, the study uses a recent empirical approach: the Panel Smooth Transition Regression (PSTR) model by González et al. (2005, 2017). This methodology describes heterogeneous panels and allows estimated coefficients to vary both across countries and over time. At my best knowledge, this model has not be used to explore the debt-growth link in the presence of different institutional indicators for the EU countries.

The specification supposes the existence of an infinite number of intermediary regimes, and the coefficients depend upon these regimes. In the empirical analysis, the PSTR model allows us to capture that an increase in institutional quality does not affect in a linear way the public debt-growth nexus, but rather conditional on the position in the distribution of the institutional factors. Let's take the case with two regimes and a single transition function (this specification being described in more detail in Gonzales et al., 2017):

$$G_{it} = \mu_i + \alpha Debt_{i,t} + \beta Debt_{it} f(q_{i,t};\gamma,c) + \zeta X_{i,t} + \varepsilon_{i,t} \qquad \text{(Eq. 1)}$$

where G_{it} is the dependent variable (the real GDP growth rate of a country *i* at time *t*), μ_i - the individual fixed-effects, $Debt_{i,t}$ is the public debt of the country *i*, at time *t* , the $f(q_i, t; \gamma, c)$ is the transition function, $X_{i,t}$ I the vector of controlling variables such as FDI, fixed brut capital formation, euro area membership..) and $\varepsilon_{i,t}$, the error term which is i.i.d (0, σ_ε^2). The transition function is continuous and integrable on the interval [0,1] and depends on three parameters: $q_{i,t}$ which is the transition variable $Instit_{i,t}$, γ - the slope of the transition function and *c* - the vector of location parameters such as $c = (c_1,...,c_m)'$, with *m* as the vector dimension. Following Gonzalez et al. (2005, 2017), I apply a logistic transition function defined as follows:

$$f(q_{i,t};\gamma,c) = \frac{1}{1+\exp\left(-\gamma \prod_{j=1}^{m}(q_{i,t} - c_j)\right)} \qquad \text{(Eq. 2)}$$

with $c_1 \leq c_2 \leq ... \leq c_m$ and $\gamma > 0$ the slope of the transition function f(.) which captures its smooth trajectory. Gonzalez et al. (2017) show that it is sufficient to consider m = 1 or m = 2 as these values allow for commonly encountered types of variation in the parameters. For this analysis, the empirical literature does not highlight any rule regarding the optimal number of thresholds in studying the debt-growth nexus. However, two tests will be performed in the next section, to confirm the choice of m = 1 as the optimal number of thresholds in the econometric analysis. The fact that m = 1 indicates that there is one single threshold of "institutional quality" around which the effect of public debt on economic growth is non-linear, leading to two extreme regimes. However, even in this case m = 1, there are still a continuum of regimes that lie between the two extreme ones (high and low). Therefore, as the transition variable $q_{i,t}$ *i*ncreases, the effect of "Public Debt" progresses from α in the first regime corresponding to $f(.) = 0$ to $\alpha + \beta$ in the second extreme regime corresponding to $f(.) = 1$, following a single monotonic transition targeted around the threshold value *c* of the transition variable. Between the two extreme cases $f(.) = 0$ and

$f(.) = 1$, the sensitivity of economic growth to public debt depends on the country's institutional quality and can be captured by differentiating the output variable with respect to the "public debt":

$$s_{i,t} = \frac{\partial G_{i,t}}{\partial\, Debt_{i,t}} = \alpha + \beta * f(q_{i,t}; \gamma, c) \qquad \text{(Eq. 3)}$$

Furthermore, the sensitivity of economic growth to the public debt can differ under the two extreme regimes α and $\alpha + \beta$ and can be defined as a weighted average of parameters α and β. Interpreting directly the values of these parameters is not an easy way. Most studies (e.g. Lopez-Villavicencio and Mignon, 2011) prefer to interpret their sign capturing an increase or a decrease in the elasticity, depending on the value of the transition variable as well as the individual and time dimension given by the previous equation.

2.1.2. Test for Linearity (homogeneity) hypothesis

Estimating the PSTR model involves some intermediate steps such as testing for homogeneity against the PSTR alternative or testing for no remaining heterogeneity. If data-generating process is homogeneous, the PSTR model cannot be identified (Gonzales et al., 2017).

Lagrange Multiplier (LM) test of homogeneity is first applied and the asymptotic $\chi 2$ distributions, their F-versions and their HAC versions are studied for each of the institutional variable, as "candidate" transition variables in the PSTR. The LM test considers the null hypothesis of linearity (homogeneity) against the alternative of a logistic (m=1) or an exponent (m=2) PSTR.

The optimal number of transition functions is determined by conducting tests of no-remaining non-linearity. Testing the linearity can be done by testing *H0* : γ= 0 or *H0* : $\alpha = \beta$. But in both cases, the test will be non-standard since, under *H0* the PSTR model contains unidentified nuisance parameters. A solution is to replace the transition function $f\left(q_{i,t}; \gamma, c\right)$ by its first-order Taylor expansion around γ = 0 and to test an equivalent hypothesis in an auxiliary regression as follows:

$$c_{i,t} = \omega_i + \alpha g_{i,t} + \theta_1\, g_{i,t}^2 + \varepsilon_{i,t} \qquad \text{(Eq. 4)}$$

In this first-order Taylor expansion, the parameter θ_1 is proportional to the slope parameter γ. Thus, testing the linearity against the PSTR model simply consists of testing : H0: $\theta_1 = 0$ in this linear panel model. To this end, standard tests (like the F-statistics) could be applied.

2.1.3 Selecting the number of transition function

The next step consists of determining the optimal number of thresholds (*m*) of the logistic transition function by using the LM homogeneity test. The logic is similar when testing the number of transition functions in the model. Gonzales et al. (2005, 2017) propose a sequential approach by testing the null hypothesis of no remaining nonlinearity in the transition function. In the PSTR framework, it is assumed that the linearity hypothesis is rejected. The issue is then to test whether there is one transition function (H0 : r = 1) or whether there are at least two transition functions (H0 : r = 2) in the model (see Gonzales, 2017 for more details on this).

2.3 Data and variables

The study considers a heterogeneous balanced panel of 11 countries of Emerging Europe (Bulgaria, Czech Republic, Croatia, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia, Slovania) and o17 former EU's members (Austrian, Belgium, Cyprus, Denmark, Finland, France, Italy, Ireland, Germany, Greece, Luxembourg, Malte, Netherlands, Portugal, Spain, Sweeden, United Kingdom) over the period 2000-2019 (according to the data availability). The dependent variable is the growth rate of real GDP per capita (g_{it}). To explain its evolution, the model uses several determinants coming from the endogenous or neoclassical growth theories such as: the population growth rate (¨p*opg*) to capture the labour resource, the gross fixed brut capital formation (also called "investment in fixed capital" - *Inv*), the trade openness (exports plus imports in % of GDP - *TO*), the central government debt (in % of GDP-*Debt*) from Eurostat database, the dummy of euro area membership (*EMU*) and the inflation based on consumer price index (*Inf*). The population growth is expected to have a negative sign and its inclusion is driven by neoclassical growth theory of Solow (1956). In the same vein, the investment growth is expected to have a positive influence on economic growth and its level is defined as "the total value of a producer's acquisitions, less disposals, of fixed assets during the accounting period plus certain additions to the value of non-produced assets (such as subsoil assets or major improvements in the quantity, quality or productivity of land) used by the productive activity of institutional units, in % of GDP" (according to the World Development Indicators - World Bank database). The natural logarithm of initial level of GDP per capita is included in the PMG model as the logarithm of the value of GDP per capita every five years and captures the convergence process of the neoclassical growth theory of Solow (1956). According to this theory, countries with a lower initial capital stock per capita (or a lower initial level of production per capita) grow faster than countries with a higher capital stock per capita. In the empirical model, its expected sign is negative. All variables are in natural logarithms (excepting dummies and growth rates) meaning that each estimated coefficient reflects a constant elasticity of the dependent variable with respect to the independent variable.

The model also integrates data on the quality of institutions; these data come from the Worldwide Governance Indicators (WGI) database of the World Bank and refers to the political stability, government effectiveness, regulatory quality and the control of corruption. The Political Stability and Absence of Violence/Terrorism ranking index, computed, as the other institutional indices, by Kaufman *et al.* (2010) from the WGI database. This indicator measures the perceptions of the likelihood of a government to be destabilized or overthrown by unconstitutional or violent means, including politically motivated violence and terrorism. It corresponds to the percentile rank among all world countries and ranges from 0 (lowest) to 100 (highest) rank or political stability. Since this variable reflects political stability, it is an inverse measure of political risk. Almost all explanatory data come from the World Development Indicators database (except for government consolidated gross debt (minus the excessive deficit procedure) and central government deficit that are provided by AMECO database) and cover the period from 2000 to 2019.

The tables 1a and 1b of Appendix report the correlations between the explanatory variables. It can be observed that correlation among them is globally low (correlation coefficient < 0.50). For the EEC, it can be observed a higher correlation between trade openness and some of the institutional drivers (such as regulation quality and government effectiveness) or public debt and fixed brut capital formation, (% of GDP). The institutional drivers are also highly linked, and this is why, they will not enter simultaneously in the PSTR estimate. For the EU28, it can be observed the same feature: the institutional variables are highly correlated (political stability, government

effectiveness, control of corruption and so on). Also note a correlation between initial level of GDP and population growth.

3. Results and discussion for EEU_11

3.1 The test of linearity

Before testing the PSTR model, several pre-tests should be performed. The first one consists in testing the null hypothesis of linearity, the second one refers to the number of regimes and the third one identifies the optimal threshold.

Table 2a (appendix) shows the linearity test results when the institutional variable is taken as the transition variable meaning that there exists a different effect of public debt on economic growth when the country benefits from high or low levels of institutional performance. Three statistics are used to check the nonlinearity between economic growth and public debt: the Lagrange Multiplier (Wald test), Lagrange Multiplier (F-test) and Likelihood ratio (LR) test. The statistics and the p-values of the Lagrange Multiplier, Fisher and Likelihood ratio tests assess the null hypothesis of linearity against the alternative of a logistic (m = 1) or exponential (m = 2). PSTR models clearly lead to the rejection of the null hypothesis of linearity of the relation between GDP growth and public debt at the 1% or 5% significance level for all samples (except for regulatory quality index as threshold variable). The logistic specification is favored to the exponential one (because the lower LM, LMF and LRT p-values are obtained for the logistic model). In the light of these results, institutional quality influences in different ways GDP growth.

3.2 The test of the number of regimes

As arguing before, the second step consists in identifying the number of transition functions (Table 3a of appendix). To this end, I check the null hypothesis if the PSTR model has one transition function (m = 1) against the alternative hypothesis when the model has at least two transition functions (m=2). If the same LM and LMF statistics of these two tests are statistically significant at 1% or 5%, the decision is to reject the null hypothesis and admit that there are at least two transition functions. In contrary, when coefficients are not significant, the null hypothesis is accepted, and the model has two regimes and one threshold. Based on these results, one single threshold of the quality of institutions is found.

Furthermore, Table 4a of appendix suggests that two extreme regimes (m=1) are sufficient to capture the non-linearity of the debt-growth nexus based on the mediating effect of the institutional quality. The optimal number of location parameters are selected according to the Akaike and Schwartz criterion whose values are also displayed.

Table 5a of appendix presents the estimated threshold values and the speed of transition found for the institutional variables included in the model. The estimated institutional thresholds contrasts across the four PSTR models: only 40.68 for corruption index, 69.87 for the government effectiveness, 73 for political stability index and 89.31 for the regulatory quality index. The finding of a lower threshold of corruption for emerging economies is not surprising, these countries being more tolerant to corruption than advanced economies. Also, when the PSTR includes the control of corruption channel, it shows that the corruption threshold value is 40.68/100. Once this threshold is reached, other things being equal, a 1% raise in the public debt gives a reduction in economic growth of 1.31% (that is, 7.76-9.07 = 1.31) in the emerging economies. This finding also reflects the "greasing the wheels" effect of corruption on economic growth (Marakbi et al., 2021; Martins et al., 2020) until the threshold of 40.68 in an environment where institutions are quite fragile (besides, the political instability variable exerts a negative effect on GDP growth). In such cases, corruption may help firms to attain their goals by mitigating distortions induced by bad government policies and bureaucracy procedures. Once the threshold of corruption is reached, its effect on economic growth becomes strongly negative (-8.301) and statistically significant. Government effectiveness index captures perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies. Its threshold is equal to 69.87 meaning that below this value the effect of public debt on economic growth is positive and above this value its impact is negative. Thus, a better perception on the quality of public services and of the degree of its independence from political pressures gives a perception of a negative impact of public debt on economic growth. It is also found that above the threshold of the likelihood of political instability (an index > 73/100 meaning a more stable political environment), the impact of public debt on economic growth is negative and statistically non-significant.

3.4 Discussion of results of the PSTR model for EEU-11

Table 6 of appendix gives the estimation of PSTR model for the 11 EEU countries for the period 2000–2019. Before analyzing the effects of our variables of interest on GDP growth, it would be useful to highlight that the parameters values of the PSTR model are not easy to interpret as elasticities. Empirical evidence (Mignon and Lopez-Villavicencio, 2011) indicates that findings should be analyzed by (i) interpretating the signs of the estimated coefficients as a decrease or an increase of the elasticity with the value of the threshold variable or (ii) by considering the time varying and individual elasticity of the output with respect to the institutions.

The preliminary estimations provide evidence consistent with view arguing that the quality of institutions is important for the debt-growth nexus and that the impact of public debt on economic growth is non-linear. The tables 2a and 3a suggest whether the PSTR estimates can assess the effect

of public debt on economic growth. The three statistics (LR, LMF and LRT) show that the hypothesis of homogeneous influence of public debt on economic growth is rejected for the following institutional variables (the political stability, the control of corruption and the government effectiveness) and that a logistic model is favored (LM, LMF and LRT p-values are smaller for the logistic model). In the light of these results, public debt influences in different ways the economic growth. The test of remaining regimes (Table 3a) concludes to the existence of a one threshold of institutional variables (except for the regulatory quality).

The table 6 provides evidence for this hypothesis, too. Coefficients of public debt are found to be significant and positive in the first regime with a high corruption level and negative in the second regime once the threshold value of 40.68 is reached (i.e., less corruption implies a negative effect of public debt on economic growth).

Another argument for this hypothesis is that the slope of the transition function differs between different regimes and the four transition institutional variables. The higher the γ, the sharper is the change from one extreme regime to another. For the gov. effectiveness, I find that any effort in terms of improvements of the quality of public services, the quality of the civil service and the degree of its independence from political pressures by a country just below the threshold value of 69.87 is likely to result in a sharp decrease of the elasticity of economic growth with respect to public debt (from 0.03 to -0.95). However, for a country which is far below this threshold, the same effort will have quasi-no effect on the elasticity. On the opposite, when considering the control of corruption or the political stability indices, it is identified a smooth transition. This means, that contrary to the sharp transition previously defined, any effort to combat corruption, even by a country far below the threshold value (or any effort to achieve more political stability), will always be compensated (by a gradual drop in the marginal effect of debt). Similar features are found for PSTR model with political (in)stability as a transition variable. But, different other alternative specifications have to be estimated to check for the robustness of these interesting findings.

4. Discussion of results of the PSTR model for EU28

The table 7 of appendix shows the PSTR estimations for the EU-28 countries on the period 2000-2019. As in the previous estimations, it can be observed that the "institutional variables" (political stability, control of corruption, rule of law and government effectiveness) exerts statistically significant effects on the GDP growth in the all EU-28 countries. Their values go from 88.15 for corruption index to 98.19 for political stability index. Regarding the impact of public debt on GDP growth, it is clear that the institutional variable mediates the relation between GDP growth and public debt. The relation between the central government debt and economic growth is a non-linear one (because of the alternative effects (positive and negative) of central government debt on economic growth.

Results regarding the test of linearity and choice of number of regimes are shown in the tables 2b and 3b of Appendix. Again, the three statistics (LR, LMF and LRT) indicate that the hypothesis of an homogeneous influence of public debt on GDP growth is rejected for the following institutional variables (the control of corruption, regularly quality and the government effectiveness). Thus, a logistic model should be favored in these cases (LM, LMF and LRT p-values are smaller for the logistic model). Therefore, it appears that public debt influences in various ways economic growth. The test of remaining regimes (Table 3a) concludes to the existence of a one threshold of institutional variables.

The table 7 provides evidence for this hypothesis, too. For example, coefficients of public debt are found to be significant and negative in the first regime with a high corruption level (<88.147**)** and positive in the second regime once the threshold value of 88.2 is reached (i.e., less corruption implies a negative effect of public debt on economic growth).

5. Conclusions

The aim of this paper was to investigate the role that institutions play in mediating the public debt effect on economic growth debt for 11 EEU and 28 EU over the period 2000-2019. It also proposed to explore the non-linear relationship between public debt and economic growth (e.g., Reinhart & Rogoff's debt intolerance ratio) stating that while the economic growth has a linear negative effect on the public debt (a decline in the economic growth being, ceteris paribus, related with an increase in public debt), high levels of public debt are likely to be harmful for economic growth, potentially, after a certain threshold has been reached. The data indicate that the relevance of this approach can be appreciated through a panel specification – PSTR by (Gonzales et al., 2017). The paper shows that the quality of institutions is an important driver for the public debt-growth nexus. Also, findings suggest the existence of a non-monotonic relation between public debt and economic growth for these countries mediated by the quality of institutions.

Appendix

Results for EEC-11:

Table 2a. LM, LMF and LRT tests of linearity (p-values)

Stats	Thresholds			
	m=1		m=2	
	PSTR with Political Stability			
LM	17.234*	(0.016)	8.403	(0.298)
LMF	2.454*	(0.019)	1.079	(0.378)
LRT	17.878*	(0.013)	8.552	(0.286)
	PSTR with Gov. Effectivness			
LM	18.957 *	(0.008)	4.036	(0.776)
LMF	2.720*	(0.010)	0.509	(0.827)
LRT	19.741*	(0.006)	4.070	(0.772)
	PSTR with Reg. Quality			
LM	7.656	(0.264)	5.741	(0.453)
LMF	1.225	(0.294)	0.863	(0.523)
LRT	7.780	(0.255)	5.810	(0.445)
	PSTR with Control of Corruption			
LM	20.677*	(0.004)	4.888	(0.674)
LMF	2.990*	(0.005)	0.618	(0.740)
LRT	21.614*	(0.003)	4.938	(0.668)

Table 3a. Test for the number of regimes

Institut. Var.	Hypotheses	Test	Stat	(p-value)
			PSTR with Pub. Debt	
Political Stability	H0 : m= 0 vs H1 : m=1	LM	17.234*	(0.016)
		LMF	2.454*	(0.019)
	H0 : m= 1 vs H1 : m=2	LM	8.403	(0.298)
		LMF	1.079	(0.378)
Gov. Effecti.	H0 : m= 0 vs H1 : m=1	LM	18.957 *	(0.008)
		LMF	2.720*	(0.010)
	H0 : m= 1 vs H1 : m=2	LM	4.036	(0.776)
		LMF	0.509	(0.827)
Regulator yQuality	H0 : m= 0 vs H1 : m=1	LM	7.656	(0.264)
		LMF	1.225	(0.294)
	H0 : m= 1 vs H1 : m=2	LM	5.741	(0.453)
		LMF	0.863	(0.523)
Corruption Control	H0 : m= 0 vs H1 : m=1	LM	20.677*	(0.004)
		LMF	2.990*	(0.005)
	H0 : m= 1 vs H1 : m=2	LM	4.888	(0.674)
		LMF	0.618	(0.740)

Note: * indicates the statistical significance at 1% or 5% level

Table 4a. Determination of the Number of Location Parameters

Political Stability	Optimal no. of transition functions	1
	Residual Sum of Squares	336.104
	Number of Parameters	18
	AIC Criterion	0.534
	BIC Criterion	0.764
Gov. Effectivness	Optimal no. of transition functions	1
	Residual Sum of Squares	294.814
	Number of Parameters	18
	AIC Criterion	0.402
	BIC Criterion	0.633
Regulatory Quality	Optimal no. of transition functions	1
	Residual Sum of Squares	352.724
	Number of Parameters	16
	AIC Criterion	0.556
	BIC Criterion	0.758
Corruption Control	Optimal no. of transition functions	1
	Residual Sum of Squares	326.706
	Number of Parameters	18
	AIC Criterion	0.505
	BIC Criterion	0.736

Notes: (i) For each model, the optimal number thresholds, denoted r (m), is determined according to a sequential procedure based on the LMF statistics of the hypothesis of non-remaining nonlinearity. (ii) The RSS value is given for each couple (m; r). (iii) The AIC and BIC criterions are shown for each PSTR.

Table 5a. Results of threshold values of institutional variables.

Tests	Speed of transit. - γ	Threshold param- c
Political Stability	5.7339	4.2972
Gov. Effectivness	1859.4	4.2466
Regulatory Quality	43222	4.4921
Corruption Control	7.7092	3.7058

Results for EU-28:

Table 2b. LM, LMF and LRT tests of linearity (p-values)

Stats	Thresholds			
	m=1		m=2	
	PSTR with Political Stability			
LM	8.429	(0.393)	7.127	(0.523)
LMF	1.001	(0.434)	0.819	(0.586)
LRT	8.493	(0.387)	7.173	(0.518)
	PSTR with Gov. Effectivness			
LM	34.633***	(0.000)	16.921**	(0.031)
LMF	4.318***	(0.010)	1.978**	(0.047)
LRT	19.741***	(0.006)	17.182**	(0.028)
	PSTR with Reg. Quality			
LM	35.726***	(0.000)	18.711**	(0.016)
LMF	4.463***	(0.000)	2.195**	(0.027)
LRT	36.917***	(0.000)	19.030**	(0.015)
	PSTR with Control of Corruption			
LM	41.400***	(0.000)	15.228*	(0.055)
LMF	5.229***	(0.000)	1.775*	(0.080)
LRT	43.010***	(0.000)	15.439**	(0.051)

Note: ***, **, * - significant at 1% level, 5% level and 10% level, respectively

Table 3b. Test for the number of regimes

Institut. Var.	Hypotheses	Test	Stat	(p-value)
			PSTR with Pub. Debt	
Political Stability	H0 : m= 0 vs H1 : m=1	LM	8.429	(0.393)
		LMF	1.001	(0.434)
	H0 : m= 1 vs H1 : m=2	LM	7.127	(0.523)
		LMF	0.819	(0.586)
Gov. Effecti.	H0 : m= 0 vs H1 : m=1	LM	34.633***	(0.000)
		LMF	4.318***	(0.010)
	H0 : m= 1 vs H1 : m=2	LM	16.921**	(0.031)
		LMF	1.978**	(0.047)
Regulator yQuality	H0 : m= 0 vs H1 : m=1	LM	35.726***	(0.000)
		LMF	4.463***	(0.000)
	H0 : m= 1 vs H1 : m=2	LM	18.711**	(0.016)
		LMF	2.195**	(0.027)
Corruption Control	H0 : m= 0 vs H1 : m=1	LM	41.400***	(0.000)
		LMF	5.229***	(0.000)
	H0 : m= 1 vs H1 : m=2	LM	15.228*	(0.055)
		LMF	1.775*	(0.080)

Note: ***, **, * means significant at 1% level, 5% level and 10% level, respectively.

Table 4b. Determination of the Number of Location Parameters

Political Stability	Optimal no. of transition functions	1
	Residual Sum of Squares	3894.037
	Number of Parameters	18
	AIC Criterion	2.038
	BIC Criterion	2.177
Gov. Effectivness	Optimal no. of transition functions	1
	Residual Sum of Squares	6947.4
	Number of Parameters	18
	AIC Criterion	1.973
	BIC Criterion	2.112
Regulatory Quality	Optimal no. of transition functions	1
	Residual Sum of Squares	3492.366
	Number of Parameters	18
	AIC Criterion	1.929
	BIC Criterion	2.068
Corruption Control	Optimal no. of transition functions	1
	Residual Sum of Squares	3627.327
	Number of Parameters	18
	AIC Criterion	1.967
	BIC Criterion	2.106

Notes: (i) For each model, the optimal number thresholds, denoted r (m), is determined according to a sequential procedure based on the LMF statistics of the hypothesis of non-remaining nonlinearity. (ii) The RSS value is given for each couple (m; r). (iii) The AIC and BIC criterions are shown for each PSTR.

Table 5b. Results of threshold values of institutional variables.

Tests	Speed of transit. - γ	Threshold param- c
Political Stability	33207.0	4.5876
Gov. Effectivness	69474.0	4.4578
Regulatory Quality	43222	4.4921
Corruption Control	39.8611	4.4786

Table 1a: Matrix correlation between the explanatory variables for EEU-11

	Polstab	*Gov_effect*	*Reg.Quality*	*Corruption*	Pub. debt	Investment	Openess	Pop.Growth	Inflation	EU	EU*pub. debt
Polstab	1										
Gov_effect	0,68	1,00									
Reg. Quality	0,50	0,69	1,00								
Control corr	0,62	0,83	0,77	1,00							
Public debt	0,17	0,03	-0,28	-0,11	1,00						
Investment	0,13	0,12	0,29	0,19	***-0,58***	1,00					
Openess	0,48	**0,61**	**0,63**	0,49	0,05	0,05	1,00				
Pop. Growth	0,45	0,33	0,19	0,35	0,17	0,11	0,27	1,00			
Inflation	-0,11	-0,29	-0,24	-0,23	-0,23	0,30	-0,32	-0,07	1,00		
EU	0,08	0,18	0,40	0,20	0,09	-0,07	*0,56*	0,09	-0,36	1,00	
EU*pub. debt	0,13	0,17	0,30	0,16	0,36	-0,24	*0,54*	0,13	-0,42	0,94	1,00

Table 2a: Matrix correlation between the explanatory variables for EEU-11

	GDPPCG	*PS*	*COR*	*GE*	*RQ*	*CGDEBT*	*GDPRLEV*	*GFKF*	*TO*	*POPG*	*INFC*	*ZE*
GDPPCG	1											
PS	0,05	1										
COR	-0,21	0,52	1									
GE	-0,22	**0,55**	**0,93**	1								
RQ	-0,17	**0,52**	**0,88**	**0,86**	1							
CGDEBT	-0,42	-0,01	0,33	0,34	0,19	1						
GDPRLEV	-0,34	0,40	**0,83**	**0,81**	**0,76**	0,37	1					
GFKF	0,31	0,16	0,00	-0,04	0,08	-0,36	-0,18	1				
TO	0,15	0,48	0,11	0,17	0,23	-0,37	0,12	0,08	1			
POPG	-0,25	0,31	**0,57**	**0,54**	**0,53**	0,09	**0,69**	0,00	0,28	1		
INFC	0,18	-0,17	-0,36	-0,39	-0,35	-0,19	-0,37	0,25	-0,09	-0,20	1	
ZE	-0,27	0,10	0,37	0,38	0,29	0,05	0,53	-0,19	0,07	0,38	-0,26	1

Table 6: PSTR estimates with the quality of institutions as the threshold variable: 2000-2019 for EEU-11

Variable	PSTR		PSTR		PSTR		PSTR	
	with Pol Stab		with Gov effect		with Reg. quality		with Corruption	
	coeff.	t-Stat	coeff.	t-Stat	coeff.	t-Stat	coeff.	t-Stat
Debt	-0,17	-0,34	**0,03**	0,07	**-0,49**	-1,39	**7,76****	2,68
Debt*g(.)	-0,39	-0,40	**-0,95****	-2,03	**0,10**	0,11	**-9,07*****	-2,97
Transition parameters								
Speed of transition - gamma	5,734		1859,40		43222,00		7,71	
Threshold parameter - c	4,30	**73**	4,25	**69,87**	4,49	**89,31**	3,71	**40,68**
Control variables								
Institution	-6,40***	-2,99	**6,70*****	4,69	-3,54***	-2,20	10,93	1,07
Domestic Investment	**1,85**	1,48	1,51*	1,91	**2,59*****	3,31	-10,35	-1,17
Openness	**4,12****	2,61	5,67***	4,38	**2,09*****	3,23	1,69	0,25
Pop. Growth	0,06	0,10	**-0,79****	-2,29	**-0,61***	-1,97	-2,19*	-1,57
Inflation	-0,23	-1,16	0,25*	1,80	-0,07	-0,70	0,29	0,38
EMU	-2,21***	-3,47	-2,08***	-4,83	-	-	**-8,14**	-1,79
No. Obs	242x9		242x9		242x8		242x9	
No. Countries	11		11		11		11	

Table 7: PSTR estimates with the quality of institutions as the threshold variable: 2000-2019 for EU28

Variable	PSTR		PSTR		PSTR		PSTR	
	with Pol Stab		with Gov effect		with Reg. quality		with Corruption	
	coeff.	t-Stat	coeff.	t-Stat	coeff.	t-Stat	coeff.	t-Stat
Public Debt	-7.018***	-4.615	-23.457***	-6.823	-20.024***	-6.541	-26.208***	-7.3824
Public Debt*g(.)	-33.036***	-3.278	19.336***	4.677	15.675***	3.935	24.144***	5.7024
Transition parameters								
Speed of transition - gamma	33207		69474		3298.6		39.8611	
Threshold parameter - c	4.587	**98.199**	4.458	**86.315**	4.4865	**88.854**	4.4786	**88.147**
Control variables								
Institutions	2.4865***	2.748	4.113*	1.541	-8.566***	-3.082	3.072*	1.502
GDP initial	-11.089***	-6.641	-10.167***	-7.131	-8.197***	-6.049	-9.331***	-6.701
Domestic Investment	6.886***	5.125	6.457***	5.937	7.544***	7.548	4.963***	4.361
Openness	12.320***	6.997	10.047***	6.836	9.915***	6.967	7.834***	4.898
Pop. Growth	-0.759***	-2.572	-1.498***	-4.527	-1.333***	-4.694	-1.511***	-4.332
Inflation	-0.009	-0.212	-0.026	-0.517	-0.058	-1.424	-0.036	-0.713
EMU	0.418	0.617	0.615	0.888	0.122	0.206	0.720	1.069
No. Obs	560x10		560x10		560x10		560x10	
No. Countries	28		28		28		28	

Note: *** - p-value<1%; ** - p-value<5%; * - p-value<10%.