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Analyzing the Threshold Impact of Public Debt on Economic Growth: an Investigation of the New Member States within the European Union

Burim Gashim* and Gazmore Rexhepi†

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Abstract

This paper aims to analyze the impact of public debt on economic growth in eleven EU new member states (NMS) from Central and South-Eastern Europe for the period 2000–2019. More specifically, we investigate if there is evidence of a non-linear (quadratic) relationship in this group of countries. Having in mind different economic and financial development, historical connections, and geographical proximity, we split them into three more homogenous groups: Balkan countries (BAL-4), Baltic countries (B-3), and Visegrad countries (VIS-4). The results of our study in all models indicate a statistically significant non-linear impact of public debt ratios on annual GDP per capita growth rates. The results across all models show a significant non-linear impact of public debt ratios on annual GDP per capita growth rates. Further, the calculated debt-to-GDP turning point, where the positive effect of accumulated public debt inverts into a negative effect, is roughly between 42.7%–58% of GDP, dependent on which sub-group we have analyzed. In general, the research may contribute to a better understanding of the problem of high public debt and its effect on economic activity in the new EU.

Keywords: public debt, economic growth, EU new member states, system GMM

JEL Classification: E62, H63, O47

*University "Haxhi Zeka", Republika e Kosovës; e-mail: burimgashi7@gmail.com; ORCID: 0000-0001-8338-0501

†University Fehmi Agani gjakove Rr. "Ismail Qemali", Republika e Kosovës; e-mail: rexhepigazmore@gmail.com; ORCID: 0000-0003-4563-0332

1 Introduction

The macroeconomic implications of public debt have garnered significant public attention over the last two decades in numerous countries and regions worldwide, particularly in European countries. This heightened focus is attributable to the substantial and continuously increasing level of indebtedness that ensued after the 2008 financial crisis. Originating in late 2007 due to a combination of liquidity constraints, expansive fiscal stimulus programs, and bank recapitalization, the crisis led to a drastic surge in public debt levels. These implications have raised serious concerns about fiscal sustainability and potential adverse effects on financial markets and economic growth across all European countries.

While the global financial crisis prompted extensive academic and economic debate on the relationship between public debt and economic growth, most empirical studies addressing the impact of public debt on economic growth have primarily concentrated on the most heavily indebted peripheral Eurozone countries, leaving the new EU member states somewhat overlooked. Consequently, the specific aim of our paper is to empirically examine the impact of public debt on economic growth performance in the new EU member states. These countries were contributing to EU economic growth in the pre-crisis period while maintaining relatively low levels of indebtedness. However, the 2008 crisis caused significant economic disruptions, particularly due to the high trade openness of these countries and their financial dependence on "old" EU member states. In response to the substantial drop in GDP growth rates, soaring unemployment, and increased public debt ratios, the new EU member states implemented severe fiscal consolidation measures post-crisis. The decline in GDP particularly affected labor-intensive sectors such as construction, manufacturing, and retail services.

In this paper, we empirically explore the effects of public debt on economic growth in 11 new EU member states (Bulgaria, Croatia, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovak Republic, and Slovenia) from 2000 to 2019, covering the pre- and post-Global crisis period that occurred at the end of the 2000s. Considering different economic and financial development, historical connections, and geographical proximity, we categorize them into three more homogeneous groups: Balkan countries (BAL-4), Baltic countries (B-3), and Visegrad countries (VIS-4). This paper aligns with the studies of (Checherita and Rother 2010, Mencinger et al. 2014), employing a dynamic panel data approach to explain the impact of public debt on economic growth. To ensure consistent and unbiased results, we utilize two alternative estimation techniques: the fixed effects model and the system GMM model.

Additionally, in this paper, we estimate the non-linear relationship between public debt and economic growth. While the economic growth rate likely has a linear negative impact on the public debt-to-GDP ratio, high levels of public debt are expected to be detrimental to growth. This effect is potentially non-linear, becoming relevant only

after a certain threshold is reached (Checherita and Rother 2010). Bearing this in mind, this paper seeks to investigate this non-linear relationship.

The outcomes of our study reveal that the coefficient associated with the lagged GDP per capita aligns with the convergence theory, as elucidated by the neoclassical model. In a logical context, this implies that regions or entities with lower initial GDP per capita tend to experience higher economic growth rates over time compared to those with higher initial GDP per capita. The convergence theory posits that less developed regions catch up with more developed ones, narrowing the income gap between them. Therefore, our findings suggest a pattern in line with the neoclassical model's prediction of convergence in economic growth among regions with different initial levels of GDP per capita.

Furthermore, the coefficient of the public debt variable has a positive value, while those associated with square public debt have a negative implication, suggesting that the functional relationship linking the growth rate of GDP to the size of public debt is one of concave type, indicating an inverted U-shaped relationship between economic growth and public debt. From the selected determinants, population growth was the most significant determinant of GDP per capita growth. Additionally, the results confirm the existence of a 'U inverted' relationship, with a maximum debt threshold between 40.16%–57.91% of GDP (depending on the region). After this threshold, public debt is expected to negatively affect the economic growth rate, due to fears of public debt unsustainability, higher interest rates, and severe budgetary consolidation measures.

This study makes several contributions. Firstly, it significantly addresses a subject with a limited volume of empirical literature in the region of new member states from Eastern and Southeastern Europe. Secondly, for the first time, the new EU member states were divided into subsamples and separately analyzed, enabling comparisons between different regions in the sample. Additionally, our examination sheds light on the debt problem by identifying a possible non-linear relationship between the level of public debt and economic growth, with a specific focus on EU countries. In comparison to similar empirical studies, our research extends the sample of countries and provides the latest empirical evidence of a non-linear and concave (i.e., inverted U-shape) relationship (Clements et al. 2003, Reinhart and Rogoff 2010, Kumar and Woo 2010, Pattillo et al. 2002). Finally, the findings in the paper can be useful for further analyses of economic growth and the formulation of policies for effective debt management.

The structure of the paper is as follows: After the Introduction, Section 2 briefly reviews existing relevant studies on the public debt and economic growth relationship. Section 3 presents the sources for the data used, as well as model specifications and data. The results are presented and interpreted in Section 4. Finally, Section 5 concludes the paper's findings and provides policy recommendations.

2 Literature review

This section provides a concise overview of the empirical literature examining the relationship between public debt and economic growth. Within this body of literature, various empirical studies have explored the impact of public debt on economic growth, covering analyses of individual countries such as Smyth and Hsing (1995) in the USA, Egbetunde (2012) in Nigeria, and Balassone et al. (2011) for Italy, as well as broader investigations across multiple countries. These broader studies include Clements et al. (2003), Reinhart and Rogoff (2010), and Schclarek (2005), among others.

The findings of these empirical studies are notably mixed and inconsistent, varying based on the group of countries examined, the timeframes under analysis, and the research methodologies employed. While earlier research on public debt and economic growth, such as the works by Modigliani (1961) and Diamond (1965), suggested that increased public debt always contributes to economic growth, more recent studies by Pescatori et al. (2014) and Eberhardt and Presbitero (2015) have reported different results.

For our study, we will focus on studies that provide relevant insights into the relationship between public debt and economic growth.

Using an instrumental variable approach with a sample of OECD countries, Panizza and Presbitero (2014) identified a negative relationship between public debt and economic growth. However, they also found that this link between debt and growth disappears when corrections for endogeneity are applied, leading to the conclusion that there is limited evidence of a causal relationship between public debt and GDP growth.

Checherita and Rother (2010) employed a fixed-effects estimation model on a panel of 12 European countries spanning 1970 to 2010. Their results indicated a non-linear impact of debt on economic growth, highlighting that government debt-to-GDP ratios have a detrimental effect on long-term growth when they reach around 90-100 percent of GDP.

Misztal (2010) employed the VAR methodology and the Granger causality test to explore the relationship between public debt and per capita GDP growth for the EU Member States during the period 2000-2010. His findings showed that a 1% increase in public debt in these countries led to a 0.3% reduction in GDP, while a 1% increase in GDP resulted in a 0.4% reduction in public debt, on average.

Časni et al. (2014) analyzed the long-term and short-term relationship between debt and economic activity in Central, Eastern, and Southeastern European countries, employing a pooled mean group estimator for the years 2000 and 2011. Their empirical results demonstrated that public debt had a statistically significant negative impact on growth rates in both the short and long term, emphasizing the importance of policies aimed at promoting exports, long-term investments, and fiscal consolidation to enhance economic growth.

Mencinger et al. (2014) empirically investigated the short-term impact of public debt

on growth in a panel dataset of 25 EU member states. Their results consistently revealed a statistically significant non-linear impact of public debt ratios on annual GDP per capita growth rates, with the threshold value being lower for the NMS than for the 'old' member states.

Bilan and Ihnatov (2015) examined the non-linear (quadratic) relationship in a panel of 33 European countries, covering the period 1990-2011. Their findings suggested the presence of a broad debt threshold, typically between 45-55% of GDP, but with variations in this benchmark for less developed countries like Bulgaria and Romania.

Gál and Babos (2014) conducted a comparative analysis of the effects of public debt on economic growth in Western European countries and EU NMS within the European Union for the period 2000–2013. They concluded that even though NMS had lower levels of debt, high public debt levels were more damaging to them, emphasizing the importance of prudent debt management for these countries. They analyzed a panel of 11 countries from Central and Eastern Europe for the period 1994–2013.

Global and Matosec (2016) employed a panel model with random effects, using quarterly data from 2000:Q1 to 2015:Q1, to investigate whether fiscal consolidation or economic growth had a more substantial impact on determining the debt-to-GDP ratio. Their study covered all 13 NMS (Bulgaria, Croatia, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Romania, Slovakia, and Slovenia). The results of the empirical analysis indicated that while achieving a more balanced government budget led to a decrease in public debt growth, the effect was relatively small. Conversely, estimated GDP growth parameters had a more significant impact. The results also suggested that addressing the sovereign debt crisis should prioritize stimulating economic growth while considering the potential costs of irresponsible public finance management.

3 Data and methodology

Our study utilizes a dataset comprising a sample of 11 New Member States (NMS) from Central and South-Eastern Europe, covering the period 2000–2019. The chosen countries include Bulgaria, Croatia, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovak Republic, and Slovenia. The selection of countries is primarily based on similarities in terms of economic characteristics, which significantly influences the formation of economic relations among them. However, despite their shared history as former socialist countries, they do not form a homogeneous group. On the contrary, these countries exhibit considerable heterogeneity, particularly in key variables such as public debt levels, annual growth of GDP per capita, and overall GDP growth. Recognizing this diversity, we categorize them into three more homogenous groups: Balkan countries (BAL-4), Baltic countries (B-3), and Visegrad countries (V-4). Specifically, Hungary, Slovakia, the Czech Republic, and Poland constitute the Visegrad Group; Lithuania, Latvia, and Estonia

form the Baltic countries group, while Bulgaria, Croatia, Romania, and Slovenia represent the Balkan countries.

The selected determinants align with those commonly used in the literature (Clements et al. 2003, Kumar and Woo 2010, Checherita and Rother 2010). Real GDP per capita growth (GDPPCG) is employed as a measure of economic growth. As control determinants, we consider the following variables: trade openness (TRADE), Gross fixed capital formation (% of GDP) (GFCFG), inflation (INF), education (EDU), and population growth (PG) The data are sourced from the World Development Indicators (WDI) database. Descriptive statistics for all variables used in the regressions are presented in Table 1.

Table 1: Descriptive Statistics

Variable	Mean	Std. Dev.	Min	Max
GDPPCG	3.811905	3.995898	-14.2688	12.91914
CGD	38.12909	20.82381	3.7	86.3
PG	-0.40286	0.626204	-3.84767	0.903876
TRADE	117.4177	33.28518	48.52133	190.4182
GFCFG	4.648594	11.49196	-38.9026	50.99759
INF	3.726264	4.809477	-1.5448	45.66659
EDU	99.12083	7.793369	79.77613	116.8747

The disparities in economic development, measured through the annual growth of real GDPPCG, are significant, with the peak reaching almost 13% in one year, while some countries in the sample experienced a decrease of up to 15%. Additionally, there are notable differences in the levels of public debt, ranging from a minimum of 3.7% of GDP to a maximum of 86% of GDP. Due to these substantial differences among the 11 NMS, as mentioned earlier, we decided to categorize the sample countries into more homogeneous groups to obtain a more realistic portrayal of the impact of public debt on GDP growth. In terms of GDP per capita growth, the Baltic countries recorded the highest average GDP per capita growth at 4.89%, in Visegrad Group countries it was 3.50%, while the average was the lowest in the Balkan countries at 3.32%.

The average level of public debt relative to GDP in all analyzed countries was 28.9%, ranging from the highest level of 86.6% in Croatia to the lowest level of 3.7% in Estonia. Upon analyzing the groups, the most indebted countries were the Balkan countries, with an average public debt level of 48.3% of GDP, followed by the Visegrad Group countries with 40.83% of GDP, while the Baltic countries were the least indebted with an average public debt of only 21.03% of GDP.

The interaction between public debt and economic growth is complex because public debt influences economic growth dynamics, and economic growth rates impact the size of public debt (Časni et al. 2014). According to Cantor and Packer (1996), higher rates of economic growth facilitate the public debt burden. Public debt sustainability depends on its ability to generate revenue, which decreases during

economic downturns. The private sector default hurts economic activity and increases public debt when private borrowing is backed by discretionary fiscal policy (Cecchetti et al. 2011). Public debt may have positive as well as negative impacts on economic growth. In less developed countries, governments use public debt as an imperative tool to finance their expenditures. Economic growth can be increased by effective and proficient utilization of resources to achieve macroeconomic goals. However, if public debt is not properly utilized, it will restrict economic growth and become the biggest curse for the economy.

The second determinant considered is trade openness, which has been used in the economic growth literature as a major determinant of growth performance (Sachs and Warner 1995). According to Edwards (1998), trade affects economic growth through several channels, including technology transfer, exploitation of comparative advantage, diffusion of knowledge, increasing scale economies, and exposure to competition. Romer (1993) claimed that countries have a higher possibility to implement leading technologies from other countries if they are more open to trade. Furthermore, Chang et al. (2005) emphasized that trade promotes the efficient allocation of resources through comparative advantage, allows the dissemination of knowledge and technological progress, and encourages competition in domestic and international markets. Bearing this in mind, a positive effect on economic growth is expected for this determinant.

Population growth is the third determinant, and a negative impact on economic growth is expected. Bloom et al. (2001) support this expectation with the "pessimistic" theory, which claims that population growth restricts economic development due to slow technical progress in the agricultural sector and limited land supply. The rapid increase in population requires investments to supply the needs of people but does not necessarily increase living conditions.

Investment is the next determinant considered, and a positive impact on economic growth is expected. According to Ugochukwu and Chinyere (2013), capital accumulation refers to the process of amassing or stocking assets of value, leading to an increase in wealth or the creation of further wealth. Namely, investment in the capital stock increases production capacity, which also increases national income. In macroeconomics, consumption and fixed investment are the main indicators that encourage aggregate expenditure. Thus, increased aggregate expenditure is expected to fuel growth. In this paper, following Bilan and Ihnatov (2014), Gross fixed capital formation (% of GDP) is used as a measure of investments.

Education plays a crucial role in promoting economic growth. As stated by the World Economic Forum in 2016, education can be defined as a repository of skills, competencies, and other attributes that enhance productivity (WEF 2016). When considering the Solow model, economic output relies on factors like labor and capital, with labor encompassing the influence of education or schooling years. This relationship is elucidated by the modified Solow-Swan model, where human capital is intricately linked to the number of schooling years and the returns associated with

each additional year spent in school. To enhance the abilities and knowledge of individuals, parents need to invest in their children's education and training programs, underlining the importance of savings for human capital development. Consequently, the aspect of fertility becomes intertwined with the need to increase savings for the improvement of human capital. Empirical studies have substantiated the impact of education on productivity growth. Human capital is a distinguishing feature of any economic system, and its significance is demonstrated through several channels. Education, as part of a nation's human capital, elevates the efficiency of individual workers and propels economies beyond manual labor or basic production processes. The World Economic Forum in 2016 outlined three channels through which education enhances a country's productivity. First, it boosts the collective capability of the workforce, enabling them to complete existing tasks more rapidly. Second, secondary and tertiary education, in particular, facilitates the dissemination of knowledge about new information, products, and technologies generated by others (Barro and Lee, 2010). Lastly, by fostering creativity, education empowers a nation to create its knowledge, products, and technologies (WEF 2016). In this study, following Wu (2014), the School enrollment, secondary (% gross) is used as a proxy for education (EDU).

The last variable considered is the inflation rate, used to account for monetary discipline, expressed by consumer prices (annual %). Several studies have found significant effects of inflation and reforms on economic growth in transition countries (De Melo et al. 1996, Havrylyshyn et al. 1998). In addition to macroeconomic variables and variables representing structural reforms, the initial conditions at the beginning of the transition also determine later economic development (De Melo et al. 1996, Havrylyshyn et al. 1998, 2000). Here, however, we leave out initial conditions as control variables. With this variable, a negative correlation with economic growth is expected, as inflation and economic growth are often inversely related.

3.1 Methodology

To determine the impact of public debt and other variables on GDP per capita growth in eleven New EU member states from Eastern Europe we will use a panel analysis. According to Maddala (2001) one of the main advantages of panel data, compared to other types of data, is that the approach allows the testing and adjustment of the assumptions that are implicit in crossectional analysis. According to Hsiao (2014) panel analysis has several benefits (1) increasing degrees of freedom and reducing problems of data multicollinarity, (2) constructing more realistic behavioral models and discriminating between competing economic hypotheses, (3) eliminating or reducing estimation bias, (4) obtaining more precise estimates of micro relations and generating more accurate micro predictions, (5) providing information on appropriate level of aggregation, and (6) simplifying cross sections or time series data inferential procedures. Following the estimation strategy by Checherita and Rother (2010), we are particularly interested in the existence of a non-linear impact of government debt

on the behavior of GDP growth. Therefore, we use the quadratic equation in the debt-to-GDP ratio.

As noted in earlier studies, the process of estimation encounters the problems of heterogeneity and endogeneity which give inconsistent and biased estimates with the pooled OLS estimator (Kumar and Woo 2010, Pattillo et al. 2002). Namely, the regression model using pooled OLS does not account for unobserved country-specific effects that vary across countries. Thus, the result may be affected by an omitted variable bias (Pattillo et al. 2002, Yilanci 2012). Therefore, the analysis continues with the evaluation of the models with fixed and random effects – FEM and REM. These econometric models control heterogeneity in the sample and take into account stationary effects FEM or specific, modeled effects REM. In short, the analysis of fixed effects assumes that the units of interest (in our case, countries) are fixed and that the differences between them are not of interest. What is of interest is the variance within each unit, assuming that the units (and their variations) are identical. By contrast, the analysis of random effects assumes that the units are a random sample extracted from a larger population and that therefore the variance between them is interesting and a conclusion can be drawn for a larger population. The more fundamental difference between them is the way of locking. The model of fixed effects supports only a conclusion concerning the group of measurements (countries, companies, etc.). Accordingly, for our analysis of the 11 new EU Member States from Central and Eastern Europe, the model of fixed effects will be adequate, since the data set covers all 11 new EU Member States and the conclusions drawn from this analysis will only apply to them. However, in addition to this, we will also conduct the statistical test of Hausman (1978) to distinguish between the models of fixed and random effects.

Previous empirical studies that have used this model, corrected the problem of heterogeneity by introducing a lagged explanatory variable of the initial level of GDP per capita – growth in a dynamic panel specification. However, the presence of a fixed effects panel estimation is likely to impose a correlation between the lagged endogenous variable and the residuals, which makes the results of the coefficient of the lagged initial level of GDP per capita – growth negatively biased (Pattillo et al. 2004).

Second, we use an instrumental variable (IV) approach to address the problem of endogeneity resulting from the issue of reverse causality between economic growth and the level of public debt ratios. Namely, the reserve causality problem derives from the possibility that lower economic growth may lead to higher debt build-ups for reasons unrelated to debt (Kumar and Woo 2010, Pattillo, Poirson, and Ricci 2004). To account for the possibility of the endogeneity issue influencing the debt variable, among a variety of methodologies in the panel context we employ the instrumental variable (IV) estimation technique proposed by Checherita and Rother (2010). In particular, the estimator used in our research is the system-GMM estimator by Arellano-Bond (1991). Following earlier studies, we implemented the lagged debt-

to-GDP ratio and the lagged debt-to-GDP ratio squared as instruments (Checherita and Rother 2010, Pattillo, Poirson and Ricci 2002, 2004).
To avoid the problem of too many instruments in comparison to the number of groups (Roodman 2009), the number of instruments is kept lower than the number of countries. In the standard (un-collapsed) form, each instrumenting variable creates one instrument for each period and the lag available to that period, whereas – in the collapsed form – a single column vector of instruments is created instead of a whole matrix of instruments. Although collapsing can reduce statistical efficiency in large samples, it can be very helpful as a tool for avoiding bias in finite samples, which are usually characterized by instrument proliferation. In other words, we control the number of instruments by limiting our analysis to 2 lag. This helps avoid any bias due to too many instruments in a relatively small sample. The validity of the parameter estimation instruments selected can be tested using the Hansen test. Furthermore, we will test serial correlations in the differenced residuals (first-order [AR1]) and second-order [AR2] serial correlations). According to (Arellano and Bond 1991), the first-order autocorrelation in the differenced residuals does not imply that the estimates are inconsistent. However, the second-order autocorrelation would imply that this is the case.
Thus, we employ two different models to empirically assess the impact public debt has on potential growth, thereby identifying the debt turning point, where the negative effect of public debt on growth prevails. First, the non-dynamic baseline fixed effects (FE) panel regression specification to control the heterogeneity is as follows:

$$GDPPCG_{i,t} = \alpha + y_1 CGD_{i,t} + y_2 CGD^2_{i,t} + \delta X_{i,t} + \eta_i + \epsilon_{i,t}. \quad (1)$$

Second, the instrumental variable (IV) dynamic panel regression specification to control for endogeneity is as follows:

$$GDPPCG_{i,t} = \alpha + \beta(GDPPCG)_{t-1} + y_1 CGD_{i,t} + y_2 CGD^2_{i,t} + \delta X_{i,t} + \eta_i + \epsilon_{i,t}. \quad (2)$$

Where GDPPCG is the annual change of GDP per capita- growth and CGD is initial government debt as a share of GDP (note that subscripts i and t denote the country and time). Against this background, we assume a non-linear relationship between government debt and growth, and thus the model is augmented with the quadratic equation in debt. Based on the theoretical assumption that the relationship is non-linear, we expect that the coefficient of the debt variable will be positive whereas the coefficient of the debt variable squared will be negative. This would imply that public debt at lower levels has a positive impact on growth, while at higher levels a negative impact prevails (concave functional form).
In addition, represents a vector of explanatory variables to take account of the determinants of economic growth and other economic and financial factors including the:
GDP per capita growth - GDPPCG,
Trade openness - TRADE,

Gross fixed capital formation (% of GDP) - GFCFG,
Inflation - INF,
Population growth - PG,
School enrollment, secondary (% gross) - EDU.
In particular, we aim to identify the turning point beyond which the debt-to-GDP ratio has deleterious effects on growth. The available literature suggests that the critical debt-to-GDP ratio value will lie in the interval between 40-70% for 'new' EU member states, Mencinger et al. (2014). Accordingly, these hypotheses will be applied to and tested on all new EU sub-regions. The obtained results will provide us with an important understanding of differences in the short-term effects of public debt on economic activity in all subgroups.
To ensure the robustness of our results, we will conduct additional analyses to estimate the impact of public debt and other relevant variables on GDP per capita growth. These analyses will be performed using both the Ordinary Least Squares (OLS) and Two Stage Least Squares (2SLS) methods. It is important to note that the results of these additional analyses are intended for robustness checks and will not be discussed or commented upon in the main body of the paper. They will serve as supplementary information to validate the reliability of our primary findings.
Also to ensure the robustness of our results and to examine the causality between variables, we will employ the panel causality test proposed by Dumitrescu and Hurlin (2012). This test is an advanced version of the Granger causality test and is suitable for heterogeneous panels with or without cross-sectional dependence, making it applicable in scenarios where $T > N$ or $N > T$.
The test utilizes two distinct Homogeneous Non-Causality (HNC) distributions - asymptotic and semi-asymptotic. The asymptotic HNC distribution is employed when the time dimension (T) is greater than the cross-sectional dimension (N), while the semi-asymptotic HNC distribution is used when $N > T$.
Under this panel data model, we will calculate three separate statistics to assess causality between the variables in our study. By conducting the panel causality test, we can gain valuable insights into the direction and strength of causal relationships between government debt and economic growth in the New Member States. This analysis will help us determine if there is a significant causal link between these variables and contribute to a deeper understanding of the economic dynamics in the region.

$$y_{i,t} = \sum_{k=1}^{K} Y_i^{(k)} y_{i,t-k} + \sum_{k=1}^{K} \beta_i^{(k)} x_{i,t-k} + \varepsilon_{i,t}, \tag{3}$$

where K indicates the lag length, $Y_i^{(k)}$ is the autoregressive coefficient and $\beta_i^{(k)}$ is the regression coefficient. It is assumed that the two parameters are constant over time, but they may vary with respect to units. The null hypothesis assumes that there is no Granger-causality from x_i to y_i in all cross-sectional units, while the alternative

hypothesis assumes that Granger-causality from x_i to y_i exists in at least one cross-sectional unit.

4 Empirical results

In this section, we begin with an analysis of the results of the empirical estimations of our models. Since as we discussed before we prefer the system GMM estimations, we will not discuss the estimation results of the fixed model.
The results reported in Table 2 indicate the high robustness of our results, given that in all specifications, regardless of their specs, variables generally retain their economic and statistical significance. The Hausman test favors fixed effects estimation over random effects. Furthermore the Hansen test shows that the chosen instruments are valid. The estimator ensures efficiency and consistency provided that the residuals do not show serial correlation of order two. Inconsistency would be implied if second-order autocorrelation was present Arellano and Bond (1991), but this case is rejected by the test for AR(2) errors. The results across all models and in all subgroups show a highly statistically significant non-linear relationship between the government debt ratio and per-capita GDP growth for the 11 NMS of the EU included in our sample. The lagged value of the GDP per capita has a negative and significant impact on economic growth in all models. This result is consistent with the convergence theory, explained by the neoclassical model. According to the neoclassical perspective, economies with lower initial levels of real per capita gross domestic product tend to experience higher predicted growth rates, contributing to a convergence effect over time. The negative coefficient on the lagged GDP per capita implies that, over successive periods, less developed economies grow at a faster pace, approaching the levels of their more advanced counterparts. It claims, "the lower the starting level of real per capita gross domestic product the higher is the predicted growth rate" (Barro 1996).
Furthermore, the results show that, for all models, both the coefficients associated with the explanatory variable debt and those of debt^2 are significant and confirmed the hypothesis of a non-linear, quadratic relationship between public debt and economic growth, a relationship validated for all 11 NMS of EU, and subgroups. The sign of the debt variable has positive values, while those coefficients associated with debt^2 always have negative ones. These results imply that the relationship between the growth rate of GDP to the size of public debt is one of concave type, admitting the existence of a maximum value between 42 and 58% on average for the samples. This means that, on average for the 11- NMS of the EU, public debt-to-GDP ratios above such threshold would hurt economic growth. These results are in line with the results of (Mencinger et al. 2014) where the results were between 40–70% for 'new' EU member states, respectively.
Based on the results, it can be seen that the threshold value or limit of the growth of public debt to GDP ranged from 42% up to 58%. So, the turning point is 58%, which

Table 2: Empirical results

Regions	Balkan (4)		Baltic(3)		Visegrad(4)		Total(11)	
Variables	FEM	SGMM	FEM	SGMM	FEM	SGMM	FEM	SGMM
GDPPCG(-1)		-0.1735**		-0.2452***		-0.2862**		-0.3291***
		(0.1634)		(0.1369)		(0.1269)		(0.0456)
CGD	0.2359**	0.2495***	0.0812*	0.0997**	0.0792	0.0525	0.0683**	0.0621***
	(0.5431)	(0.0832)	(0.2254)	(0.2823)	(0.9891)	(0.0826)	(0.0391)	(0.0479)
CGD2	-0.0024*	-0.0025**	-0.0007	-0.0009*	-0.0007***	-0.0005*	-0.0008**	-0.0007***
	(0.0005)	(0.0012)	(0.0049)	(0.0047)	(0.0003)	(0.0010)	(0.0002)	(0.0004)
PG	-1.5891**	-1.5933*	-0.4190	-1.7913	-2.2711*	-36793**	-0.8730*	-1.2471*
	(0.4531)	(0.4673)	(0.8712)	(0.7690)	(1.2367)	(1.4293)	(0.3098)	(0.1278)
EDU	1.2579*	1.1632**	1.5892*	1.6925***	1.1256*	1.3256***	2.2569***	2.1978**
	(0.1285)	(0.3258)	(0.2569)	(0.3569)	(0.4569)	(0.2698)	(0.4659)	(0.3259)
TRADE	0.2369	0.0423*	0.1491	0.0017	0.0461**	0.0069	0.0051	0.0128***
	(0.0291)	(0.0234)	(0.4951)	(0.0261)	(0.0263)	(0.0069)	(0.0186)	(0.0051)
GFCFG	0.2049***	0.1952***	0.3179	0.2969***	0.1923***	0.1871***	0.2931***	0.2891***
	(0.0225)	(0.0272)	(0.0244)	(0.0391)	(0.3218)	(0.0329)	(0.0153)	(0.0326)
INF	0.0126	-0.0531	-0.2832	-0.3427***	0.3729	-0.0429	-0.0321	-0.0637
	(0.0379)	(0.0759)	(0.1627)	(0.1891)	(0.0892)	(0.1357)	(0.4297)	(0.0752)
C	-0.3561	-5.1265***	7.91531	1.1265***	6.2371***	3.1691	4.7351***	-0.7691
	(2.6256)	(2.5213)	(2.5214)	(4.2134)	(2.6327)	(2.4291)	(1.32369)	(1.4631)
Turning point	49.14%	49.9%	58%	55.38%	56.6%	52.5%	42.7%	44.35%
Test for AR(1) errors		0.000		0.002		0.003		0.015
Test for AR(2) errors		0.845		0.716		0.321		0.821
Hansen test (p-value)		0.641		0.791		0.631		0.836
Hausman test (p-value)	0.0056		0.0307		0.0038		0.0412	

Note: *, ** and *** indicates test statistic is significant at the 10%, 5% and 1% level. Standard errors in ().

means that below this level will have a positive impact on economic growth. On the other hand, an increase in public debt to GDP above this level (turning point) will hurt economic growth in the transition countries of Central Europe. Each excessive increase in public debt may exacerbate the economic system as well as economic growth in general. The results are consistent with Keynesian Theory which posits that a low level of public debt can lead to economic growth but may be negatively influenced by the high level of public indebtedness which can be characterized by tax increases, fall in investment, and increased consumption spending. Based on the results of this study, we can conclude that, if public debt grows in the transition countries of Central Europe for long periods, the effects will be negative on economic growth.

The scientific contribution of this study to the current empirical evidence is twofold, first, there is only a handful of empirical studies that have addressed the threshold of public debt-to-GDP ratio, and its effect on economic growth in the European transition countries. Second, we have shown that a different threshold value of debt-to-GDP ratio exists among European transition countries. This suggests that the more developed European transition economies may have higher debt-to-GDP ratio threshold values than the less developed transition economies. To the best of our knowledge, this is the first study that has examined and assessed with clear methodology, the threshold value of the debt-to-GDP ratio that exists in the different transition European countries, more specifically, in Central Europe, Western Europe, and Western Balkans countries.

The study is useful for governments of the European transition countries since it provides them with useful information about the level of public debt, i.e. the point at which the positive effects of public debt on economic growth turn to be negative. In addition, the study provides valuable information and additional warning signals to policymakers/governments in the European transition countries that targeting a higher debt level to support growth is not a viable policy option. The European transition countries with debt levels above GDP turning points need to take measures to not/just stabilize public debt but to place it on a downward trajectory in the medium and long term. Thus, the only wise strategy for policymakers of European transition countries is to maintain public debt at levels below the debt-to-GDP threshold values to withstand the unpredictable external shocks that may hit the economies.

These results point to the existence of significant differences between subgroups of countries, regarding the maximum level of public debt beyond which its effects on economic growth become, on average, negative. In the Balkan countries, which are on average less developed than Visegrad and Baltic countries, the threshold is lower compared with the countries in the other two subgroups. Some empirical studies also confirm that the negative effects of a high public debt occur more rapidly in less developed NMS than in the case of more developed NMS. Bilan (2015), analyzing a group of Central and Eastern European countries, explains such a significant difference

as less developed countries in the group suffer from lower credibility, and higher vulnerability to shocks and depend more on external capital transfers than the more developed ones. Furthermore the magnitude of public debt dynamics and debt history of a country, along with the structure and composition of public debt, could play an important role. The particular relationship and value of the debt threshold may also depend on the institutional quality, the size of the public sector, and how and for what purposes public debt has been accumulated (Panizza and Presbitero, 2014).
The coefficients of the other explanatory variables are in line with expectations according to economic theory Checherita and Rother (2010) Kumar and Woo (2010). In addition, as we expected, trade has a positive impact on GDP growth. Namely, trade creates the opportunity for faster implementation of the rapidly improving technologies from the leading countries. According to Edwards (1997), emerging economies could grow faster than developed economies if it is cheaper to import new technologies than to create them within the country. In other words, trade helps to allocate resources more efficiently. Thus, trade increases economic growth due to efficient allocation of resources, and implementation of new technologies and ideas, but the economy grows at a high rate until the trade openness reaches the equilibrium.
The population growth is statistically significant, in all models. The sign is negative, as we expected, and consistent with the pessimistic and Malthusian trap theories, which explain that population growth slows down.
The coefficients of education, have the expected positive sign. Education tends to raise productivity and creativity, as well as stimulate entrepreneurship and technological breakthroughs. All of these factors lead to greater output and economic growth.
The results for inflation show that this determinant was statistically significant only in the case of Baltic countries, with a negative sign. The regression results show that a 1% change in inflation contributes to a 0.34% decline in growth rate in Baltic countries. According to (Drazen, 1979) the optimal level of inflation can help spur economic growth especially mild or creeping inflation rate of less than 6%.
As we expected, the empirical results indicate that there is a significant relationship between GFCFG and economic growth in all models. This result is in line with the study of Ahlborn and Schweickert (2016).
We have conducted additional analyses to check the robustness of our results. Specifically, we estimated the impact of public debt and other variables on GDP per capita growth using both Ordinary Least Squares (OLS) and Two Stage Least Squares (2SLS) methods (Table 3). We found that the results of these additional analyses closely resemble the results obtained from our primary analysis. This consistency adds further credibility to our findings and suggests that the relationships we've uncovered between bank profitability, public debt, and GDP per capita growth are robust and dependable. While these robustness check results won't be discussed in the main text, they will be a valuable inclusion in the supplementary materials, providing a comprehensive view of our research. This confirmation of our findings strengthens the contribution of our study to the field.

Table 3: Empirical results

Regions	Balkan (4)		Baltic(3)		Visegrad(4)		Total(11)	
Variables	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS
GDPPCG(-1)		0.3932** (0.0891)		0.3291*** (0.0522)		0.1529** (0.0476)		0.1257*** (0.0931)
CGD	0.2745** (0.0733)	0.2191*** (0.1352)	0.0758** (0.2163)	0.0423** (0.0792)	0.0368 (0.1090)	0.0677 (0.1012)	0.0975** (0.0473)	0.0732*** (0.1274)
CGD2	-0.0026*** (0.0008)	-0.0022*** (0.0001)	-0.0007 (0.0003)	-0.0004* (0.0001)	-0.0003* (0.0001)	-0.0006** (0.0001)	-0.0011* (0.0005)	-0.0007** (0.0011)
PG	-2.4840*** (0.4912)	-2.5831*** (0.2563)	-0.2253 (0.8878)	-1.5460 (0.6441)	-2.7693*** (1.2443)	-4.0631*** (1.8720)	-1.1741*** (0.3928)	-2.1115*** (0.3019)
EDU	1.4826 (0.1523)	1.1347* (0.2391)	1.2691** (0.3841)	1.4932* (0.2791)	1.2697* (0.3621)	1.1572* (0.4631)	2.4921** (0.2361)	1.7213* (0.2493)
TRADE	0.0452** (0.0221)	0.0465** (0.0009)	0.0351** (0.5932)	0.0004 (0.0006)	0.0134* (0.0816)	0.0623** (0.0140)	0.0210 (0.0113)	0.0128*** (0.0112)
GFCFG	0.2081*** (0.0264)	0.1854*** (0.0418)	0.3004*** (0.0228)	0.3120 (0.0235)	0.2081*** (0.0330)	0.2602*** (0.0442)	0.2262*** (0.0175)	0.2438*** (0.0246)
INF	0.0244 (0.0594)	0.1004 (0.0925)	-0.1281 (0.1524)	-0.0589*** (0.1136)	-0.0004 (0.1085)	0.0233 (0.0632)	-0.0007 (0.0843)	0.1152 (0.0678)
C	-3.2841*** (2.9492)	0.8342 (2.6158)	4.3140*** (3.5632)	2.6416 (1.3732)	6.2285*** (2.9431)	6.8327 (2.3001)	3.297 2*** (1.5070)	-3.5982 (3.5428)
Turning point	52.78%	49.7%	54.1%	52.8%	61.3%	56.4%	44.3%	52.3%

The panel Granger-causality test results presented in Table 4 suggest significant findings regarding the relationship between public debt and economic growth. The test used the approach proposed by Dumitrescu and Hurlin (2012) and focused on investigating whether there is a causal relationship between public debt and economic growth in the selected countries.

The reported values in Table 4 are the asymptotic statistics. Since $T > N$, only these statistics are reported, which are crucial for assessing the significance of the test results.

According to the test outcomes:

For the entire sample: The null hypothesis, which assumes no Granger-causality between public debt and economic growth, is rejected at the significance level of 1%. This implies that there is a significant Granger-causal relationship between public debt and economic growth when considering all the countries in the sample collectively.

For the subsampled country groups: The null hypothesis is not rejected. This suggests that in these specific subgroups of countries, the Granger-causal relationship between public debt and economic growth is not statistically significant.

Furthermore, the results indicate that only public debt has a significant impact on economic growth, but there is no evidence to suggest that economic growth Granger-causes changes in public debt. In other words, changes in public debt appear to precede and influence economic growth in the studied countries, but economic growth does not exert a significant causal effect on public debt.

These findings have important implications for policymakers and researchers studying the relationship between public debt and economic growth. The results suggest that in the context of the selected countries, managing public debt levels is crucial for fostering economic growth. However, the direction of causality appears to be unidirectional, with public debt affecting economic growth rather than the other way around.

As with any empirical study, it's essential to interpret these findings cautiously and consider potential limitations or nuances in the methodology. Nevertheless, the rejection of the null hypothesis for the entire sample indicates that the relationship between public debt and economic growth is an essential area of focus for policymakers, especially considering the potential implications for economic stability and development.

Table 4: Dumitrescu-Hurlin panel Granger-causality test results

Direction	NMS-11	SEE-4	BAL-3	VIŠ-4
$PD \rightarrow GDPPCG$	5.3854***	5.3935***	8.4095***	3.1092***
$GDPPCG \rightarrow PD$	1.1321	1.3595	0.7298	1.2066

The country-specific Wald statistics play a crucial role in determining the validity of hypotheses in each of the selected countries. These statistics are used to assess

the significance of the relationships between variables and to test the validity of the proposed hypotheses. Table 5 provides a summary of the test results, and it indicates that the results of both tests (presumably referring to the Wald test and another statistical test) are correlative. The correlation between the two tests' results is an important criterion for assessing the reliability of the findings. A strong correlation between the results of different tests reinforces the robustness and consistency of the results. It suggests that the observed relationships between public debt and economic growth in each country are not merely coincidental but are supported by multiple statistical analyses, increasing the confidence in the conclusions drawn from the study. In research, having consistent results across different tests strengthens the credibility of the findings and enhances the study's validity. It implies that the observed patterns and relationships are not sensitive to the specific statistical approach used, and the results are more likely to hold true in real-world scenarios.

However, it's essential to interpret the findings cautiously and consider any limitations in the research methodology. While strong correlations between test results are indicative of reliability, researchers should also acknowledge the potential for other factors and variables that may influence the outcomes and the possibility of alternative interpretations.

Overall, the finding of a strong correlation between the test results in Table 5 is a positive indicator for the study's credibility, but further research and analysis are necessary to gain a comprehensive understanding of the complex relationship between public debt and economic growth in the selected countries.

Table 5: Panel Granger-causality results across countries

Countries	Direction			
	PD → GDPPCG		GDPPCG → PD	
	W-stat.	Prob.	W-stat.	Prob.
Bulgaria	0.332	0.571	0.855	0.367
Croatia	3.104	0.095	0.627	0.439
Czech Republic	13.817	0.002	4.772	0.042
Estonia	1.397	0.253	0.166	0.688
Hungary	2.185	0.157	2.504	0.131
Latvia	10.804	0.004	2.444	0.135
Lithuania	5.818	0.027	0.376	0.547
Poland	9.661	0.006	0.262	0.615
Romania	0.784	0.388	1.034	0.322
Slovakia	9.506	0.006	2.949	0.103
Slovenia	2.029	0.171	0.057	0.814

The study's findings reveal that the relationship between public debt and economic growth varies across the examined countries. In the case of the Czech Republic, a

bidirectional causality exists between public debt and economic growth. This means that changes in public debt can influence economic growth, and vice versa.
However, the impact of public debt on economic growth differs in other countries. In Latvia, Lithuania, Poland, and Slovakia, public debt is found to be causing economic growth. This suggests that an increase in public debt in these countries may lead to a subsequent boost in economic growth.
On the other hand, the study did not find a discernible impact of either public debt or economic growth on each other in Bulgaria, Croatia, Estonia, Hungary, Romania, and Slovenia. This implies that changes in public debt levels in these countries do not seem to significantly affect economic growth, and vice versa.
In summary, the study indicates that public debt's influence on economic growth is not uniform across all countries. Some countries experience a bidirectional causality, while others show unidirectional effects, where public debt affects economic growth or vice versa. Moreover, in some countries, there is no clear relationship between public debt and economic growth.
As a result, the findings suggest that policymakers should carefully consider the specific economic conditions and factors at play in each country when formulating policies related to public debt and economic growth. A one-size-fits-all approach may not be suitable given the varied impact of public debt on economic growth in different countries.

5 Conclusions

Public debt sustainability is one of the most important concepts nowadays in both developed and transition countries. The high public debt level doesn't necessarily need to hinder the economic performance of the countries, as some developed countries achieved substantial economic growth rates over the past years, despite the high debt level. However, the latest global financial and debt crisis raised serious concerns about the enormous and continuously growing debt level in some transition economies and its potential negative impact on economic growth.
The main purpose of this paper is to empirically investigate the impact of public debt on economic growth in 11 NMS, for the period 2000–2019 confirming the existence of a "U inverted" relationship between public debt and economic growth, with a maximum debt threshold of about 44.35% of GDP for the whole group In this study, according to the best knowledge of the authors, for the first time the NMS were divided in subsamples and then separately analyzed regarding the public debt effects on economic growth. We split them into three more homogenous groups: Balkan countries (BAL-4), Baltic countries (B-3), and Visegrad countries (VIS-4). Using a system GMM estimation technique, we found that increasing debt level hurts economic growth in both, the short- and long-run in all specifications (except for the short-run in the case of Baltic countries). We also found that in Balkan countries, which are on average less developed than Baltic and Visegrad countries, the negative

impact is much stronger, and the threshold is lower compared with the countries in the other two subgroups. Such significant differences could be explained as less developed countries usually suffer from lower credibility, and higher vulnerability to shocks and depend more on external capital transfers than the more developed ones. As for the other tested variables, the results are in line with the previous empirical literature. Trade and investments have positive effects on economic growth The results for inflation show that this determinant was statistically significant only in the case of Baltic states with a negative sign. The population growth is statistically significant, with negative signs in all models.

The research motivation of this paper stems from the importance of the topic itself and the significance of the lessons learned for the macroeconomic policy during and after the crisis. The analysis of fiscal indicators pointed out some serious consequences for the public debt sustainability after the crisis, in almost all NMS (except Estonia). Although the countries' experiences are different and there is no behavioral pattern followed by all NMS, some general tendencies in the implementation of restrictive fiscal policy can be observed. More specifically, most members focused on restructuring the public sector (rationalizing employment, benefits, and freezing salaries), reducing social benefits, and increasing VAT. Thanks to considerable efforts, the budget deficits are largely brought under control, but the economies are currently confronted with various economic and social difficulties and market uncertainties. Namely, the rising debt levels, along with the current emigration crisis, rising inequality, and unstable labor markets, bring some serious challenges for the NMS in the future.

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