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The impact of public debt on economic growth: Evidence from advanced economies and the European Union

Peter Toth
Faculty of Economics,
Technical University in Košice,
Slovakia
peter.toth@tuke.sk
ORCID 0000-0002-5616-5520

Andrea Tkacova
Faculty of Economics,
Technical University in Košice,
Slovakia
andrea.tkacova@tuke.sk
ORCID 0000-0002-6025-1261

Beata Gavurova
Faculty of Mining, Ecology, Process Control and Geotechnologies,
Technical University of Košice,
Košice, Slovakia
beata.gavurova@tuke.sk
ORCID 0000-0002-0606-879X

Abstract. This paper investigates the relationship between public debt and economic growth in selected advanced economies and European Union member states over the period 2000–2022. Using a linear panel regression model, the study analyzes the impact of public debt on GDP growth, while accounting for additional macroeconomic factors such as inflation, unemployment, and gross fixed capital formation. The findings reveal a negative linear relationship between public debt and economic growth, with the effect being more pronounced in EU countries due to their economic integration. While public debt is shown to hinder long-term growth, the analysis acknowledges the possibility of short-term positive effects under specific conditions. These results underscore the importance of tailored fiscal policies and sustainable debt management strategies for fostering economic stability.

Keywords: public debt, economic growth, GDP, advanced economies, panel regression, debt sustainability.

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1. INTRODUCTION

The relationship between public debt and economic growth has long been a focal point of economic research, eliciting diverse theoretical and empirical perspectives. In recent years, the importance of this topic has intensified due to unprecedented levels of public debt triggered by the global financial crisis of 2008, the COVID-19 pandemic, and geopolitical disruptions, including energy crises and war-related expenditures (Chudik et al., 2018; Gómez-Puig et al., 2022). These events have prompted policymakers and researchers alike to reevaluate the sustainability of sovereign debt and its implications for long-term growth.

Contemporary studies underscore that the effect of public debt on growth is rarely linear or universal. Instead, it is context-dependent and shaped by a variety of factors such as institutional quality, macroeconomic policy frameworks, debt composition, and regional integration (Bozatli et al., 2024; Özmen & Mutascu, 2024; Chowdhury et al., 2024). The emergence of threshold effects - points beyond which debt turns from growth-enhancing to growth-inhibiting - has become central in empirical research, though estimates of such thresholds remain highly heterogeneous (Petkovski et al., 2024; Lau et al., 2022).

In the European Union, the Stability and Growth Pact (SGP) was designed to ensure fiscal discipline among member states. Yet, persistent divergences in public debt levels and growth outcomes suggest that a one-size-fits-all framework may not be sufficient. Studies show that even within the EU, national institutional capacities and economic structures significantly influence how debt affects growth (Cooray & Özmen, 2024; Monte & Pennacchio, 2020). Macroeconomic approaches using panel data models have been effectively employed to analyze growth determinants in EU member states, particularly in examining the relationship between various economic factors and sustainable development outcomes (Simionescu, 2023). This heterogeneity calls for nuanced, evidence-based debt management strategies that take into account country-specific fiscal dynamics (Dankiewicz et al., 2022; Jabiyev et al., 2022).

This study contributes to the ongoing discourse by providing updated empirical evidence on the impact of public debt on economic growth in two key groups: selected advanced economies and European Union member states. Our goal is to shed light on the complexity of debt-growth dynamics and inform future policy decisions on sustainable fiscal governance.

2. LITERATURE REVIEW

The relationship between public debt and economic growth is a critical economic issue, particularly for advanced economies. It has been the subject of both theoretical debate and empirical inquiry. Early discussions focused on the dual nature of public debt, with Keynesian perspectives highlighting its role in stimulating demand during economic downturns. At the same time, classical economists cautioned about its crowding-out effect on private investment (Elmendorf & Mankiw, 1999).

Reinhart & Rogoff (2010) initiated a pivotal debate by proposing that when public debt exceeds 90% of GDP, it significantly hampers growth. Their hypothesis sparked widespread empirical testing, with mixed results. Subsequent studies advanced the discussion by examining nonlinearities, debt thresholds, and institutional contexts. For example, Cecchetti et al. (2011) found that rising debt undermines growth prospects in OECD countries, especially when fiscal sustainability is at risk. Checherita-Westphal et al. (2012, 2014) also emphasize that government debt above certain thresholds may hinder growth, particularly in euro area countries subject to fiscal rules.

Recent research has refined these findings using updated data and advanced econometric techniques. Petkovski et al. (2024) examined 11 new EU member states and confirmed an inverted U-shaped

relationship between public debt and economic growth. They estimated country-specific thresholds between 58–73% of GDP, beyond which debt has a negative effect. Similarly, Lau et al. (2022) computed external debt thresholds for 16 Asian economies and concluded that only a few countries can tolerate debt above 60% of GDP without compromising growth. These findings underscore the importance of debt thresholds tailored to country conditions.

Bozatli et al. (2024) studied the G7 countries over the long term and found heterogeneous causality patterns. For some countries like Italy and Japan, bidirectional causality exists, while for others like France, no clear link was identified. These differences reflect the diverse fiscal histories and institutional setups across advanced economies. Özmen and Mutascu (2024), analyzing long-term data for the US, UK, Sweden, and Japan, concluded that economic growth shocks often drive public debt levels, suggesting that causality may run from growth to debt rather than the reverse.

Jacobs et al. (2020) also found no consistent causal effect of public debt on growth in a panel of EU and OECD countries, reinforcing the notion that high debt does not uniformly reduce growth. Their panel VAR model showed that in high-debt countries, growth contributes to lowering debt through improved fiscal dynamics. Bentour (2021) confirmed that no universal debt threshold exists across advanced economies; rather, debt-growth interactions are contingent on structural and temporal factors.

Comparative analyses highlight contrasting dynamics in developing countries. Law et al. (2021), in a dynamic panel threshold study of 71 developing economies, identified an average debt-to-GDP threshold of 52%, above which debt significantly harms growth. The authors also showed that institutional quality moderates this relationship. Doojav and Baatarkhuu (2024) examined 36 Asian countries and confirmed nonlinear effects with an optimal threshold of about 50% of GDP. They emphasized that regional and institutional differences influence how debt affects growth.

Similarly, Mohsin et al. (2021) focused on South Asia and found that external debt is more detrimental to growth than domestic debt, especially at higher levels. They underscored the moderating effect of governance quality. Farooq et al. (2024) supported this view, revealing that good governance can mitigate the adverse growth effects of both short- and long-term external debt in South Asia.

Panizza and Presbitero (2013) previously highlighted the need to distinguish between domestic and external debt, a point reiterated by more recent studies. The composition, maturity structure, and use of debt all affect its impact on growth. When used for productive investments, public debt can support growth, but poorly allocated resources tend to deepen fiscal vulnerabilities.

In the context of institutional quality, several recent empirical studies emphasize its critical role in shaping the relationship between public debt and economic outcomes. Ojeka et al. (2024) find that in Sub-Saharan Africa, institutional quality significantly moderates the impact of external debt on domestic investment. Only countries exceeding a threshold of governance (as measured by WGI) experience positive investment effects from debt. Similarly, Chowdhury et al. (2024) show that institutional quality can reverse the adverse effects of debt on macroeconomic stability, transforming debt from a destabilizing to a stabilizing force when governance quality surpasses a critical level.

Ramzan et al. (2023) demonstrate that in Pakistan, institutional quality determines whether public debt supports or hinders long-term growth. Cooray and Özmen (2024) find that in EU countries, political stability and control of corruption significantly reduce public debt levels, while other institutional factors like government effectiveness have broader global effects. Monte and Pennacchio (2020) report that in OECD countries, corruption exacerbates public debt burdens, highlighting transparency as a crucial factor for fiscal sustainability.

Further, Kemoe and Lartey (2022) identify a debt-to-growth threshold effect in SSA, conditioned by institutional quality. Lee et al. (2023) confirm that in lower-income countries, strong institutions are essential for debt sustainability, whereas in high-income countries, extremely high institutional quality may lead to

complacency. Finally, Nguyen and Luong (2021) argue that while fiscal discipline is crucial in transition economies, institutional development is a necessary complement for managing debt effectively.

In summary, the recent literature provides robust evidence that the impact of public debt on economic growth is nonlinear and context-dependent. Threshold effects vary by country group, region, and institutional quality. While high public debt can suppress growth, particularly in developing countries or poorly governed contexts, advanced economies exhibit more nuanced patterns, often shaped by policy credibility and economic resilience. The existence of a one-size-fits-all threshold remains questionable, reinforcing the need for tailored fiscal strategies and institutional strengthening as complementary tools for debt sustainability and economic growth.

3. METHODOLOGY

This research examines the impact of public debt on economic growth using empirical data. We analyse trends in key indicators such as public debt, GDP, and GDP growth across various countries and explore their relationships with other factors like inflation and unemployment. Additionally, we aim to identify the underlying causes and sources of these dynamics.

The study employs a linear panel regression model to estimate the effect of public debt on economic growth. After refining the data, we evaluate its integrity, identify outliers, and verify that it meets the assumptions for statistical significance. Similar econometric approaches have been successfully applied in analyzing fiscal policy impacts on economic growth, demonstrating the robustness of regression-based methods in examining macroeconomic relationships (Ziberi & Hodaj, 2020). The analysis accounts for time, individual, fixed, and random effects to ensure robust and meaningful findings.

Countries were divided into two groups. The first group includes 14 selected advanced economies identified according to the OECD classification (OECD, 2023) and the Human Development Index (HDI) scores above 0.8 in 2022 (UNDP, 2023), excluding EU member states. Specifically, the group comprises Australia, Canada, Chile, Costa Rica, Iceland, Israel, Japan, South Korea, New Zealand, Norway, Switzerland, Turkey, the United Kingdom, and the United States. The second group consists of 27 European Union member states: Belgium, Bulgaria, Cyprus, Czechia, Denmark, Estonia, Finland, France, Greece, the Netherlands, Croatia, Ireland, Lithuania, Latvia, Luxembourg, Hungary, Malta, Germany, Poland, Portugal, Austria, Romania, Slovakia, Slovenia, Spain, Sweden, and Italy. The dataset was sourced from Eurostat and the World Bank databases. The two groups are examined separately but we also assess the EU's position within the global context of advanced economies, highlighting differences in the impact of debt and other indicators on economic growth. Finally, we compare regression results between the groups.

The analysis encompasses data recorded over the period 2000 to 2022, which represents the designated timeframe for this study. Data for the model focusing on selected advanced economies were obtained from the World Bank database, whereas the data for European Union member states were sourced from Eurostat. Due to data limitations from the World Bank, the International Monetary Fund (IMF) database was utilized for this variable. To enable meaningful comparisons, the same set of variables was used across both models.

The model employed in this study is a linear panel regression, a widely used statistical method known for its efficacy in analyzing panel data (Croissant et al., 2008). The foundational equation for this model is expressed as:

$$\Delta GDP_{it} = \beta_0+\beta_1 DEBT_{it} + \beta_2 DEBT_{it}^{\,2} + \beta_3 INF_{it} + \beta_4 \Delta POP_{it} + \beta_5 UNEM_{it} + \beta_6 GFCF_{it} + \beta_7 OPEN_{it} + \beta_8 BB_{it} + \beta_9 GC_{it} + u_{it,} \quad (1)$$

where the dependent variable ΔGDP_{it} represents GDP growth per capita: The annual percentage growth rate of GDP at market prices, serving as the dependent variable in the model. The model consists of following independent variables:

- Public debt (DEBT): Total debt obligations issued by the public administration, expressed as a percentage of GDP.
- Inflation (INF): Measured by the Consumer Price Index (CPI), expressed annually as a percentage.
- Population growth (POPGR): The annual percentage growth rate of the population.
- Unemployment (UNEM): Total unemployment, expressed as a percentage of the total labor force, based on ILO modeled.
- Gross fixed capital formation (GFCF): Gross domestic fixed investment as a percentage of GDP.
- Trade openness (OPEN): The external balance of goods and services, defined as exports minus imports of goods and services as a percentage of GDP.
- Government budget balance (BB): Net borrowing (+) or net lending (-) as a percentage of GDP.
- Government spending on final consumption (GC): Public administration expenditures on final consumption, expressed as a percentage of GDP.

To explore the potential nonlinear effects of public debt, the model incorporates quadratic terms and interaction effects. This approach tests the hypothesis that the relationship between public debt and economic growth is not strictly linear, as suggested in the paper's discussion of threshold effects and tipping points in fiscal policy.

Index i denotes the individual country, t represents time, $\beta_1 \ldots \beta_9$ are the estimated coefficients, and u_{it} captures the error term.

The robustness and validity of our panel regression model were ensured through a series of statistical tests designed to address potential concerns related to data structure and underlying assumptions. To examine the stationarity of the panel data, the Levin-Lin-Chu test was applied, testing for the presence of a unit root. This test distinguishes between stationary and non-stationary data, a critical step for ensuring the reliability of regression results.

To determine whether time, individual, or two-sides effects were occurred in the model, we conducted an F-test for fixed effects. This test assessed whether the inclusion of these effects enhanced the explanatory power of the model. Additionally, the pool test was employed to evaluate the need for a panel data structure by examining the homogeneity of explanatory variable coefficients across units. This test provided insights into the potential heterogeneity of variable effects among the observed countries. The choice between fixed effects and random effects was guided by the Hausman test, which evaluates the consistency of effects across units. This step ensured the selection of the most appropriate model specification for capturing inter-unit differences. Furthermore, we tested for serial correlation using the Breusch-Godfrey/Wooldridge test, confirming the independence of residuals, a key assumption in regression analysis. Cross-sectional dependence within the data was assessed using the Pesaran CD test, addressing the potential influence of interdependencies across units. Heteroskedasticity, which can affect the consistency of coefficient estimates, was examined using the studentized Breusch-Pagan test. To account for any violations of classical assumptions, White's robust covariance matrix estimation was employed, providing a reliable framework for standard error estimation.

Together, these tests formed a comprehensive validation process, ensuring that the model accounted for key statistical concerns and provided robust and meaningful results. This rigorous approach enhances the reliability of our findings and supports the validity of the conclusions drawn from the analysis.

4. EMPIRICAL RESULTS AND DISCUSSION

This study focuses on GDP and public debt as key variables. GDP is a primary indicator of economic growth, with GDP per capita and its growth rate prioritized for cross-country comparisons. A higher GDP per capita is viewed positively as it reflects stronger economic performance. Public debt is defined as total gross debt expressed as a percentage of GDP, a standard metric in academic literature for comparing debt levels across economies. Unlike GDP, public debt is not inherently evaluated as positive or negative; instead, its impact on economic growth forms the central research question of this analysis. This approach ensures an objective examination of the relationship between these variables.

4.1. GDP and debt analysis

Figure 1 depicts GDP per capita trends (in thousands of euros) for selected advanced economies from 2000 to 2022. Among the observed countries, Norway and Switzerland consistently maintain the highest GDP per capita throughout the period, with Norway exhibiting a sharp upward trajectory in recent years. In 2022, Norway reaches a GDP per capita of approximately €100,000, significantly outperforming other nations. Notably, both countries, though European, are not part of the European Union. Their GDP per capita exceeds that of major economies like the United States by up to 40%, reflecting their advanced economic status. Both nations benefit from stable and transparent governance and share a history of neutrality in major conflicts. Norway's economy has demonstrated remarkable resilience over the years, attributed to a flexible business sector and policies supportive of entrepreneurship. Significant revenues from oil and gas are managed to benefit society, underscoring Norway's small, open economy's dependence on international cooperation. The Norwegian approach emphasizes collaboration and equality in its economic practices (Norwegian Ministry of Foreign Affairs, 2023). Conversely, Costa Rica, Turkey, and Chile consistently recorded the lowest GDP per capita among the group during the study period. Although these countries are often classified as high-income developing nations, they were included in this analysis under the broader definition of advanced economies. The data highlight a growing divergence between these nations and the remaining group, as evidenced by the widening gap in GDP per capita. Costa Rica, Turkey, and Chile face pronounced challenges, including income inequality, high unemployment, insufficient education, and economic instability, which contribute to their relatively lower economic performance.

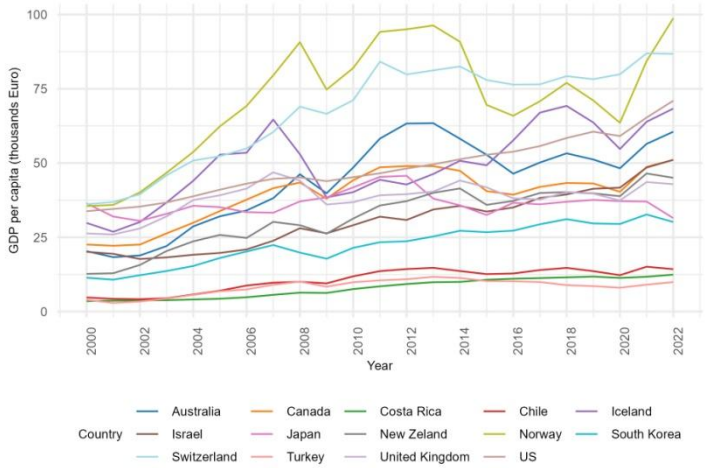

Figure 1. Evolution of GDP per capita in selected advanced economies

Source: Own processing based on World bank and IMF data

Figure 2 presents the trends in GDP per capita (measured in thousands of euros) across the 27 European Union (EU) countries from 2000 to 2022. Luxembourg consistently outperforming other nations in terms of GDP per capita throughout the period. Following Luxembourg, countries such as Ireland, Denmark, and Sweden are positioned among the higher tiers of GDP per capita, indicating their relatively strong economic performance over the observed period. Conversely, Bulgaria and Romania are positioned at the lower end of the spectrum, reflecting lower GDP per capita levels, though both demonstrate gradual improvement over time. This trend is also observed for other Central and Eastern European economies, such as Latvia, Lithuania, and Poland, which exhibit steady upward trajectories, indicative of convergence with the more developed EU economies. A noticeable divergence emerges between older EU member states in Western Europe and newer members in Eastern Europe, highlighting persistent economic disparities. However, the narrowing gap over time suggests gradual economic integration and development among the EU nations. The years following the 2008 financial crisis show a slowdown or slight dip in GDP per capita for many countries, particularly Greece, reflecting the widespread impact of the crisis. Post-2014, most countries display recovery trends, although at varying rates. Overall, Figure 2 underscores the heterogeneity in GDP per capita among EU member states, driven by factors such as geographic location, economic structures, and historical contexts. These dynamics illustrate both challenges and progress in fostering economic cohesion within the EU.

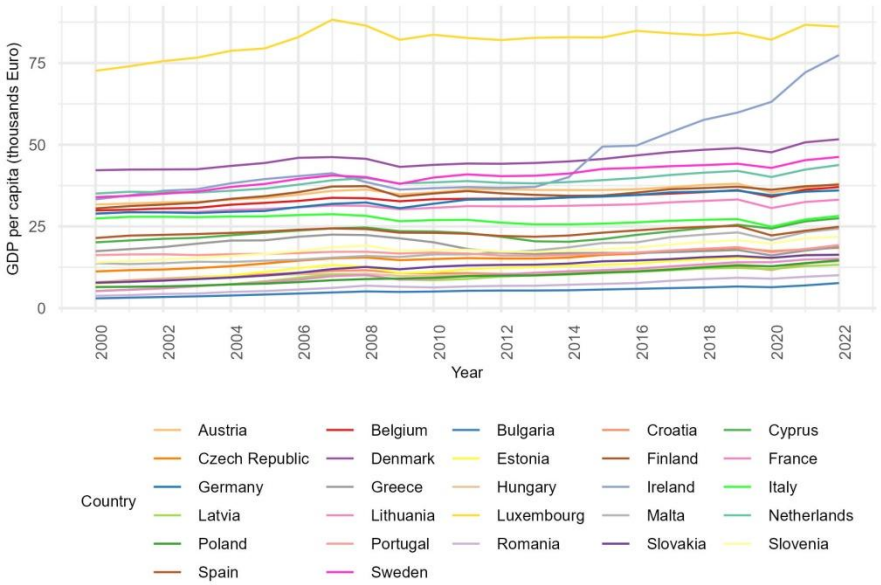

Figure 2. Evolution of GDP per capita in EU Member States

Source: Own processing based on Eurostat data

Similar to GDP, public debt is analyzed individually due to its critical role in this study. As depicted in Figure 3, the trends in public debt across most economies are broadly similar, with notable exceptions in Japan and Iceland. Japan stands out due to its significantly higher initial debt levels compared to other countries. While most economies managed to maintain relatively stable debt levels over the analyzed period, Japan experienced a persistent and substantial increase in public debt. This trajectory is partly attributable to the country's slow recovery following World War II, which laid the foundation for sustained debt accumulation. Additionally, Japan's rapidly aging population has intensified pressure on government spending, particularly on social welfare programs, further exacerbating the debt burden (Ueno et al., 2024). Iceland also exhibits an anomalous debt pattern, marked by a sharp increase during the 2008–2009 financial crisis, driven by the collapse of its banking sector. While the 2009 crisis had a notable impact on Iceland's

debt, its effect was relatively modest compared to the 2020 global crisis. The latter triggered a sudden and pronounced increase in public debt across nearly all analyzed countries, underscoring the widespread fiscal pressures of the pandemic era. These distinctive cases highlight the diverse factors influencing public debt dynamics and their implications for economic stability in different contexts.

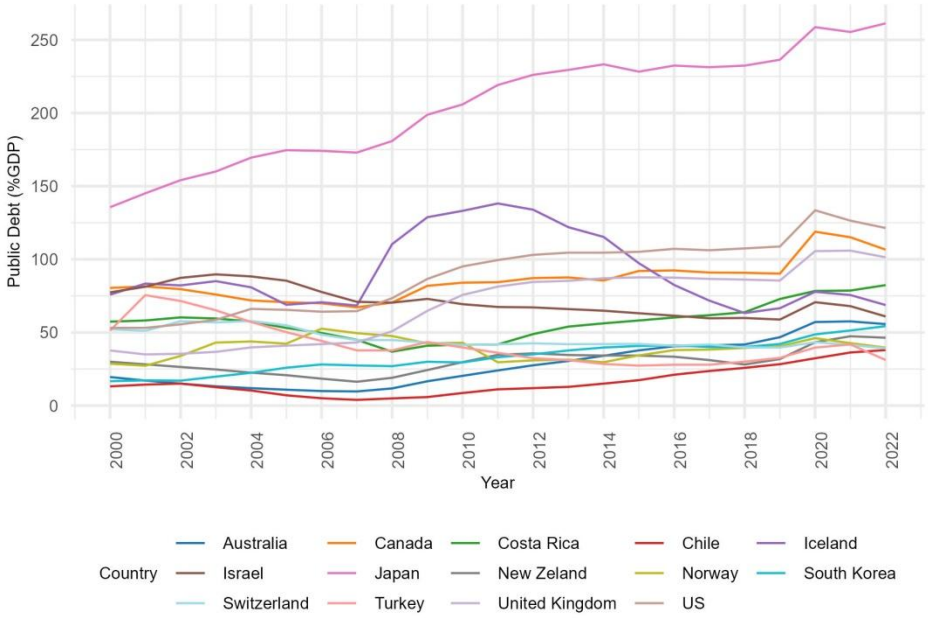

Figure 3. Evolution of public debt in selected advanced economies

Source: Own processing based on World bank and IMF data

The evolution of public debt reveals common patterns during global crises, particularly in 2009 and 2020, when debt levels surged across most economies. According to Figure 4, Greece exhibited exceptionally high public debt, nearing Japan's levels. The euro crisis, which emerged from the mismanagement of unexpected financial inflows following the adoption of the euro, played a central role in Greece's debt trajectory. These inflows spurred unsustainable demand, primarily through private credit channels in peripheral countries, but in Greece, this occurred almost exclusively via fiscal channels. A sharp rise in public pensions, transfer payments, and wages drove the fiscal deficit from 4% of GDP in 2000 to over 15% in 2009, leading to a severe accumulation of public debt. By 2011, Greece faced both economic and political crises, marked by a collapse of the banking system, an exodus of investments, and a protracted decline in GDP. Debt repayment difficulties culminated in near-bankruptcy by 2016, forcing the country to implement reforms aimed at achieving fiscal stability. Despite these efforts, Greece's recovery has been slow. Initial projections estimated an eight-year return to pre-crisis GDP per capita levels, yet current forecasts extend this timeline into 2034, highlighting the persistent impact of the debt crisis (Thomsen, 2019). Throughout the period, Greece struggled with excessive public spending exceeding revenues, exacerbating its unsustainable debt levels and leaving it with the highest debt burden in the European Union. Ireland's debt trajectory mirrors Iceland's (as illustrated in Figure 14), displaying an inverted U-shape. This pattern underscores the impact of crises, which overwhelmed fiscal systems unprepared for such shocks and led to rapid debt accumulation. Other Southern European countries, including Italy, Portugal, and Spain, also reported high debt levels. These nations share geographic and economic challenges, such as low GDP per capita, sluggish economic growth, high unemployment, weak productivity, and insufficient economic diversification. These structural issues have compounded their fiscal vulnerabilities and hindered economic performance. In contrast, Luxembourg, Estonia, and Bulgaria maintained relatively low public

debt levels. Their fiscal prudence highlights the diverse economic landscapes within Europe, where some countries manage to uphold stability despite broader regional challenges.

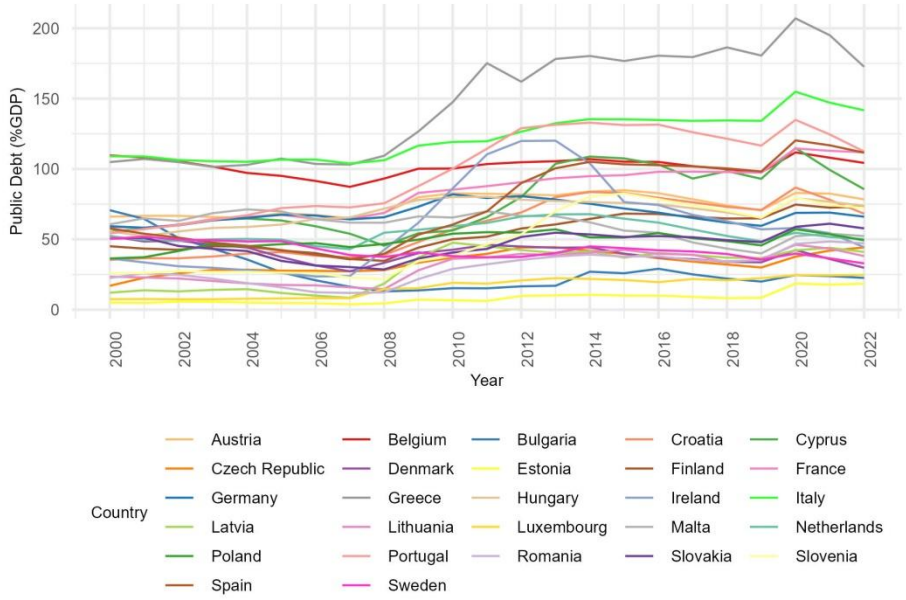

Figure 4. Evolution of public debt in EU Member States

Source: Own processing based on Eurostat data

Figure 5 illustrates the trajectories of GDP per capita (orange line) and public debt (blue line) across the analyzed economies. For clarity, we chose not to depict GDP growth on the same graph due to the significant differences in scale between GDP growth rates and debt levels, which would obscure the visual representation. GDP per capita is expressed in thousands of euros, while public debt is shown as a percentage of GDP. The y-axis values are customized for each economy to enhance readability. The trends in these variables are highly heterogeneous across countries. Similar patterns emerge in Japan, Canada, Costa Rica, the United States, the United Kingdom, and Turkey, where public debt levels, varying by country, coincide with modest growth in GDP per capita. However, the possibility of reverse causality warrants consideration, as explored by Paniza et al. (2013), who argued that declining GDP might contribute to increasing public debt. Norway and Switzerland present a distinct case, where GDP per capita significantly exceeds debt levels, and no notable upward trend in debt is observed. Iceland and Israel are particularly noteworthy, with declining public debt accompanied by rising GDP trends. In these cases, it could be argued that debt reduction fosters economic growth or, conversely, that economic growth facilitates debt reduction. Identifying a universal rule for the relationship between public debt and GDP is inherently challenging due to the unique economic, political, and historical characteristics of each country. The observed variability underscores the complexity of these dynamics, emphasizing the importance of context-specific analyses when assessing the interplay between debt and economic growth.

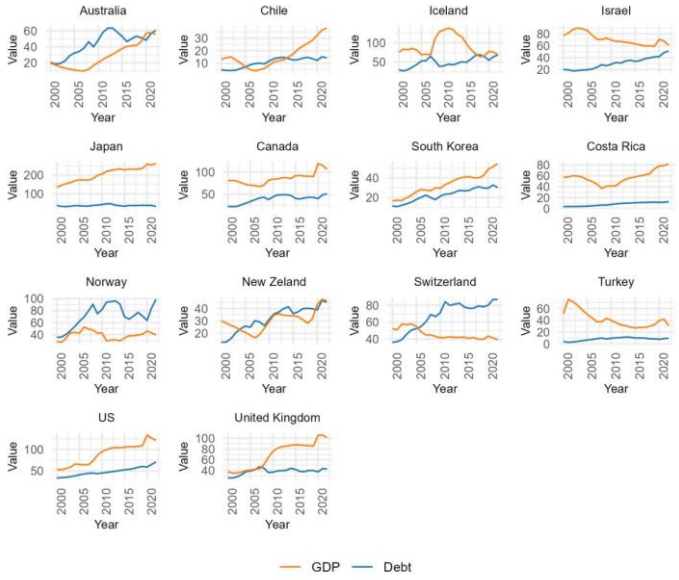

Figure 5. Evolution of GDP per capita and public debt in selected advanced economies

Source: Own processing based on World bank and IMF data

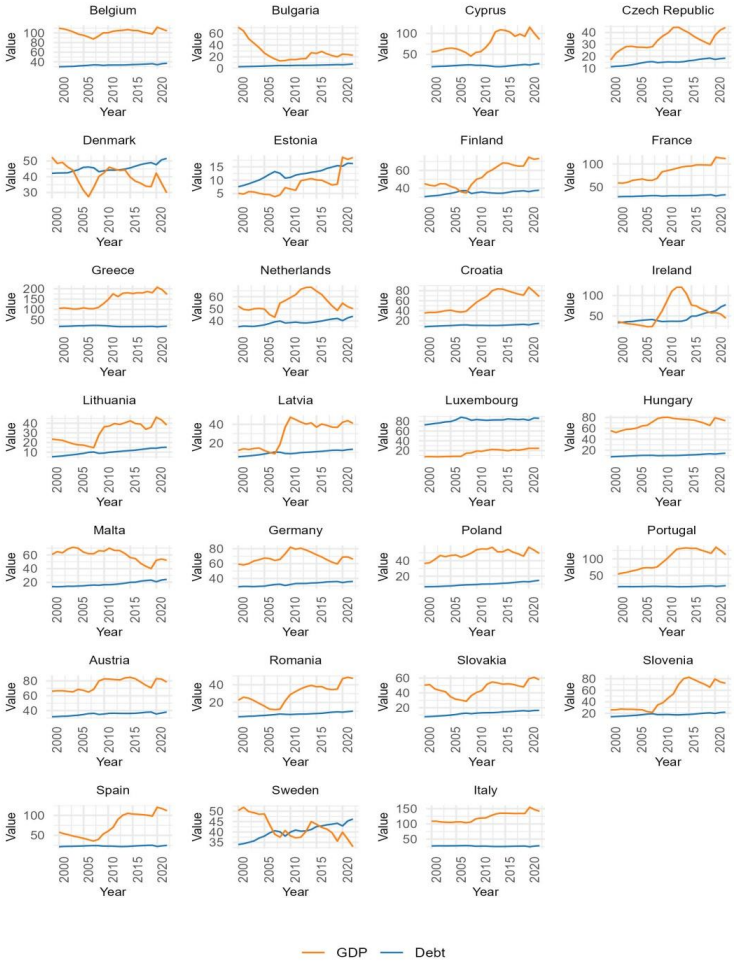

Figure 6. Evolution of GDP per capita and public debt in EU Member States

Source: Own processing based on Eurostat data

Figure 6 presents the same type of graphs as Figure 5 but focuses on the countries of the European Union. In contrast to the previously analyzed economies, the EU countries display much greater homogeneity. This similarity is particularly evident in the consistent growth of GDP per capita (orange line) across these nations, while public debt (blue line) generally follows an upward trend. Luxembourg emerges as an outlier, consistently maintaining a significantly higher GDP per capita than its public debt levels. In this regard, Luxembourg aligns more closely with countries such as Norway and Switzerland, as observed in Figure 5. Another noteworthy case is Ireland, which exhibits a remarkable increase in GDP per capita coupled with a significant decline in public debt since 2015. These observations underline the relatively uniform economic dynamics within the EU, while also highlighting specific instances, such as Luxembourg and Ireland, that deviate from the broader regional trends. These deviations offer valuable insights into the diverse ways fiscal and economic policies can influence the relationship between GDP and public debt.

4.2. Modeling the impact of public debt on GDP growth

The model for the selected advanced economies, referred to as the "WORLD" was built using balanced panel data spanning 14 countries over 23 years (2000–2022), resulting in 322 total observations. A thorough evaluation ensured no missing values and equal observations for all variables across countries. Initial correlation analysis revealed multicollinearity between gross fixed capital formation and trade openness, with a correlation exceeding 90%. To maintain model integrity, trade openness was excluded in favour of fixed capital formation due to its greater relevance for interpretation.

Stationarity testing indicated that public debt, gross fixed capital formation, and government consumption expenditures were non-stationary, with p-values exceeding 0.05. These variables were differenced to eliminate trends, and subsequent tests confirmed their stationarity (p-values < 0.05). Further testing demonstrated the necessity of incorporating individual and time effects into the model. Individual effects yielded an F-statistic of 3.620 ($p < 0.001$), and time effects showed an F-statistic of 6.760 ($p < 0.001$), supporting their inclusion. Poolability tests confirmed the heterogeneity of the data, rejecting pooled regression in favour of panel regression ($F = 4.722$, $p < 0.001$). To determine the appropriate model type, the Hausman test indicated that random effects were inconsistent ($\chi^2 = 211.21$, $p < 0.001$). Consequently, a fixed-effects panel regression, accounting for individual and temporal effects, was selected as the most suitable approach. Diagnostic tests were conducted to ensure the validity of the final model. Despite marginal results for autocorrelation ($\chi^2 = 34.003$, $p = 0.049$), cross-sectional dependence ($Z = -2.821$, $p = 0.005$), and heteroskedasticity ($BP = 63.839$, $p < 0.001$), adjustments using robust standard errors ensured reliable interpretations. These rigorous steps validated the fixed-effects model for analyzing the nuanced relationship between public debt and GDP growth. Given that key assumptions were violated, which could undermine the reliability of the results, a robust estimation was employed to address these issues. The robust model results are presented in Tab. 1, ensuring the validity and interpretability of the estimated relationships.

The "EU" model, encompassing data from 27 European Union countries across 23 years (2000–2022), consists of a balanced panel with 621 total observations. Correlation analysis revealed no significant multicollinearity among variables, with all correlations below 52%. Outlier values, primarily from crisis years, were retained to preserve the integrity of the dataset, ensuring sufficient data for analysis.

Stationarity testing identified public debt, gross fixed capital formation, government consumption expenditures, and trade openness as non-stationary variables, with p-values exceeding the 0.05 significance level. After differencing, all non-stationary variables were confirmed to be stationary, allowing their inclusion in the model. The necessity of including individual and time effects was validated. The F-test for individual effects produced a statistic of 4.817 ($p < 0.001$), while time effects yielded an F-statistic of 8.516 ($p < 0.001$). Both tests rejected the null hypothesis, confirming the need for these effects. Poolability testing also

indicated significant heterogeneity ($F = 4.119$, $p < 0.001$), supporting the use of panel regressin. The Hausman test ($\chi^2 = 60.294$, $p < 0.001$) demonstrated the inconsistency of random effects, affirming fixed effects as the appropriate model choice. Diagnostics further tested model assumptions. Autocorrelation was detected ($\chi^2 = 73.054$, $p < 0.001$), while cross-sectional dependence was not significant ($Z = -1.834$, $p = 0.067$). Heteroskedasticity was confirmed through the Breusch-Pagan test ($\chi^2 = 57.636$, $p < 0.001$). Given the presence of autocorrelation and heteroskedasticity, robust estimation methods were applied to ensure the reliability of results. The findings from the robust fixed-effects model are presented in Tab. 1, providing adjusted insights into the relationships among variables.

Table 1

Estimated regression models

Variable	**WORLD**	**EU**
DEBT	-0.117***	-0.248***
$DEBT^2$	0.002	0.000
INF	-0.083***	-0.129*
ΔPOP	0.107	-0.027***
UNEM	-0.250***	-0.145***
GFCF	0.003***	0.005
OPEN	-	0.020
BB	-0.002	-0.053
GC	-0.825*	-1.518***
R^2	**0.319**	**0.419**

Note: "***", "**", "*" denote significance levels 0.001, 0.01, and 0.05 respectively.
Source: Own processing from RStudio software

In the first model (WORLD), several variables, including quadratic debt ($DEBT^2$), population growth (ΔPOP), and current account balance (BB), were statistically insignificant. Among the significant variables, gross fixed capital formation (GFCF) positively impacts GDP growth, while public debt (DEBT), inflation (INF), unemployment (UNEM), and government consumption (GC) have a negative effect.

In the second model (EU), similarly, variables such as quadratic debt ($DEBT^2$), gross fixed capital formation (GFCF), trade openness (OPEN), and current account balance (BB) were statistically insignificant. Unlike the WORLD Model, no variables showed a positive impact on GDP growth. Negative influences on GDP growth were identified for public debt (DEBT), inflation (INF), population growth (ΔPOP), unemployment (UNEM), and government consumption (GC).

The negative linear relationship between debt and GDP growth aligns with findings by Cecchetti et al. (2011), Afonso et al. (2013), Kumar et al. (2010), and Gómez-Puig et al. (2022). The detrimental effect of inflation corroborates previous research by Gómez-Puig et al. (2022) and Okwoche et al. (2022). Similarly, the negative impact of population growth is consistent with Checherita-Westphal et al. (2012), and the adverse effect of unemployment aligns with Checherita-Westphal et al. (2014). The positive influence of gross fixed capital formation parallels findings from Afonso et al. (2013), Checherita-Westphal et al. (2014), and Gómez-Puig et al. (2022).

Nonlinear effects of debt on growth, noted in other studies, diverge from our findings, possibly due to differences in methodology, country samples, or time periods. Trade openness, deemed significant by Cecchetti et al. (2011), was found insignificant in our analysis, echoing results by Kumar et al. (2010).

Similarly, budget balance, identified as significant by Checherita-Westphal et al. (2012), did not show statistical significance in our models.

The results of the models provide several key insights into the relationship between key economic variables and GDP growth. In the EU model, population growth (ΔPOP) shows a negative impact on economic growth. While an increasing population can enhance labor supply, tax revenues, and productivity, excessive growth relative to economic expansion may strain resources, elevate unemployment, and exacerbate inflation, all of which negatively affect economic performance. Government consumption (GC) also exhibits a negative effect on GDP growth, consistent with the crowding-out effect discussed in prior literature. Increased government spending can reduce private sector activity, particularly if it fosters skepticism among citizens regarding fiscal sustainability. A lack of trust in economic policy may lead to higher household savings and reduced consumption and investment, further dampening economic growth.

In contrast, gross fixed capital formation (GFCF) has a positive impact on economic growth. Investments in technology, modernization, infrastructure, and other sectors expand production capacity, enhance efficiency, and create jobs, thereby supporting overall economic performance. Foreign direct investments (FDI) play a crucial role in this context, particularly in smaller economies. Studies have shown that FDI contributes significantly to labor productivity, output growth, and employment stability, facilitating Slovakia's convergence with more advanced EU economies (Hošková, 2001; Jenčová et al., 2023). These findings emphasize the nuanced relationship between economic variables and growth, underscoring the importance of targeted policies to address demographic challenges, optimize public spending, and promote investments for sustained economic development.

The model indicates that rising unemployment (UNEM) negatively impacts economic growth by reducing total production and overall economic performance. High unemployment leads to increased social welfare costs, lower productivity, and reduced monetary circulation. Individuals with limited incomes spend less, diminishing tax revenues, including income and value-added taxes. Governments often mitigate these effects through policies promoting job creation, employment support, and demand stimulation.

Inflation (INF) also exerts a significant negative impact on economic growth. High inflation erodes purchasing power as prices rise faster than incomes, reducing demand for goods and services. This decline discourages consumption and investment, further undermining economic expansion. Recent global crises, including the COVID-19 pandemic, geopolitical conflicts, and energy disruptions, have exacerbated inflationary pressures in many countries. These crises have particularly affected low-income households, increasing the risk of poverty and social exclusion despite governmental interventions.

One common policy response has been the introduction of price caps on essential goods and services. While such measures may provide short-term relief, their long-term sustainability is questionable. Historical evidence suggests that price controls can lead to delayed inflationary spikes once the caps are lifted, highlighting their potential unintended consequences.

These findings emphasize the intricate relationships between unemployment, inflation, and economic growth. Effective policy responses must balance immediate relief measures with sustainable, long-term strategies to promote economic stability and growth. The results in Tab. 1 indicate that public debt (DEBT) has a negative linear impact on economic growth, while the hypothesized inverted U-shaped non-linear relationship ($DEBT^2$) was not confirmed. This suggests that, over the long term, increasing public debt generally hampers GDP growth. However, due to the simplicity of the modeling approach and the limitations of the dataset, we cannot entirely dismiss the possibility of a non-linear effect. It is plausible that public debt could have a positive impact on economic growth up to a certain threshold. The effectiveness of public debt depends largely on how borrowed funds are utilized. Studies suggest that for debt to positively influence growth, it must be allocated efficiently and sustainably to enhance government revenues, increase production, and improve overall welfare. Inefficient use of debt that fails to generate sufficient returns

constrains an economy's ability to reduce debt in the future, leading to its unsustainable accumulation and ultimately negative effects on growth.

These findings emphasize the importance of prudent fiscal management and strategic allocation of debt. Without ensuring its productive use, high public debt can become a significant burden, limiting a country's long-term economic development and stability.

The impact of public debt on economic growth remains a subject of considerable debate, with differing conclusions based on the period analyzed, country groupings, and research methodologies. Public debt is undoubtedly a critical factor for economic performance, and governments need to monitor and maintain it within sustainable limits. However, determining an optimal threshold or breaking point for public debt continues to be contentious, with varying opinions among economists and researchers. The heterogeneity of countries adds complexity to defining a universal debt threshold, particularly within diverse groupings such as the European Union. Given these variations, it is recommended that individual countries independently assess the specific debt level that constitutes a sustainable limit for their economies. Establishing and adhering to such a tailored threshold would help prevent the adverse effects of excessive public debt on economic growth, ensuring fiscal stability and long-term development (Vural Jane & Ojaghlou, 2025)

5. CONCLUSION

We employed linear panel regression to analyze the impact of public debt on economic growth for the selected countries and period. A notable finding was the absence of a non-linear relationship between public debt and economic growth, which contrasts with conclusions in much of the existing literature. We attribute this discrepancy to the limitations of our data and methodology. However, our analysis confirmed a negative linear relationship, indicating that higher public debt correlates with lower economic growth in the countries studied. This effect was observed for both the selected advanced economies and the European Union countries, with the negative impact being slightly stronger in the EU, likely due to the interconnectedness of its integrated economies.

As demonstrated in this study, economic growth is influenced by multiple variables beyond public debt. Key factors that require monitoring and support include inflation, unemployment, and gross fixed capital formation. Public debt remains significant, particularly over the long term and at high levels, where its negative impact on economic growth is well-documented by prior research and corroborated by our findings. However, we acknowledge the possibility of a short-term positive effect of public debt on growth, provided it remains below a certain threshold. We do not believe a single debt threshold applies universally to all countries due to their inherent heterogeneity, as shown in our analysis. Identifying a breaking point specific to homogeneous country groups or individual nations is crucial and represents an important avenue for future research.

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