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THE IMPACT OF PUBLIC DEBT ON ECONOMIC GROWTH IN SERBIA – AN EMPIRICAL STUDY USING THE ARDL APPROACH

ABSTRACT: *The paper analyses the relationship between public debt and economic growth in Serbia. The empirical analysis was conducted using the autoregressive distributed lag (ARDL) and non-linear autoregressive distributed lag (NARDL) approaches for the period 2001–2023. The estimated long-run parameters in NARDL show that a 1% increase in the public debt-to-GDP ratio is associated with a 0.25% decrease in real GDP per capita growth and that a 1% decrease in public debt is on average associated with a 0.7% increase in real GDP per capita growth, both with the first lag. This shows that real GDP per capita growth reacts asymmetrically to changes in public debt, such that the magnitude of the positive reaction to public debt reduction is*

greater than that of the negative reaction to an increase in public debt. The estimated short-term coefficients also confirm this asymmetry. The long-run coefficient of the public debt service parameter indicates the negative impact of debt service on economic growth, as a 1% increase in public debt service to GDP ratio is associated with a 0.17% decline in real GDP per capita growth. The long-run relationship between the current account deficit and economic growth is positive and shows that the increase in the current account deficit by 1% of GDP correlates with the increase in real GDP per capita growth by 0.26% with the first lag.

KEY WORDS: *public debt, debt service, economic growth, ARDL and NARDL*

JEL CLASSIFICATION: C52, H63, Q47

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1. INTRODUCTION

The increase in Serbia's public debt (PD) can be seen in the period after 2008. Direct and indirect external PD grew more dynamically than the growth of internal PD in the period 2009–2016, followed by a decline in the absolute amount of external PD until 2019. The COVID-19 pandemic accelerated Serbia's external debt, resulting in a large gap between external and internal PD after 2020. The dimensions of this gap in absolute amounts, expressed in euros, are shown in Figure 1. It can be seen that the external public and publicly guaranteed debt increased from around 14 billion euros in 2019 to over 25 billion euros in 2023, with the expected trend of a further increase in the following period¹.

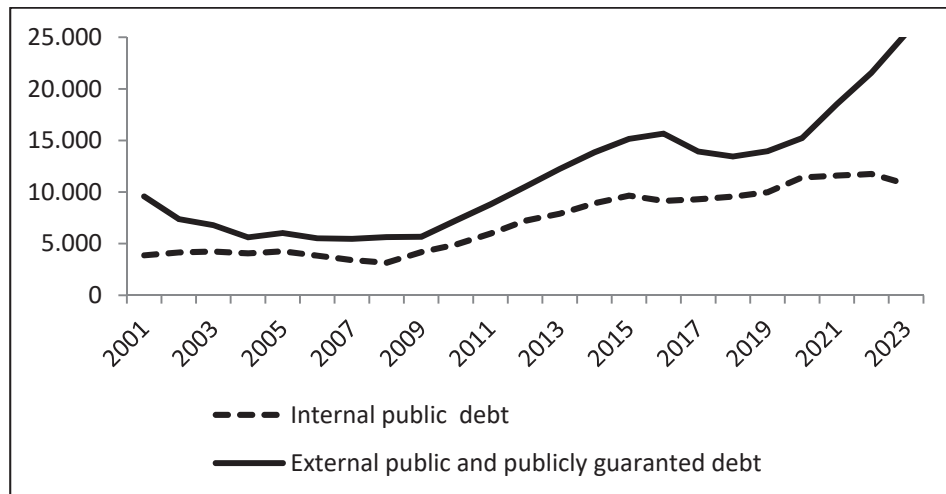
The increase in public investment in infrastructure projects in the period 2008–2015 not only led to an absolute increase in public debt, but also to an increase in the share of PD in gross domestic product (GDP) (Figure 2).

Thanks to GDP growth, PD as a percentage of GDP has been declining since 2015. According to the Ministry of Finance of the Republic of Serbia, the PD of the central government level reached 88.1% of GDP at the end of 2001 and stood at 25.8% of GDP in 2008. This was followed by an increase to 67.2% of GDP in 2015 and a decrease to 52.4% of GDP in 2022, followed by 48.0% in 2023. The trend of growth in external debt in relation to total PD has been observed since 2010. The growth of internal PD has followed the growth of external public debt, albeit at a slower pace.

The increase in external PD and the rise in interest rates led to an increase in the debt service burden on external PD from 1.0% of GDP in 2008 to 6.4% in 2019. The debt service burden of public external debt then declined and amounted to 2.7% of GDP in 2023 (Figure 2). The literature points out that the increase in public borrowing on the domestic capital market leads to a crowding out of private investment (Elmendorf & Mankiw, 1999) and that excessive public borrowing leads to an increase in long-term interest rates for new loans and an increase in the risk premium (von Hagen et al., 2011).

¹ The expected additional borrowing in connection with the infrastructure investments required for the organisation of the "EXPO 2027" exhibition in Belgrade.

Figure 1: Internal and external public and publicly guaranteed debt of Serbia, euro millions



Source: Ministry of Finance of the Republic of Serbia, <https://www.mfin.gov.rs/en/documents2-2/macroeconomic-and-fiscal-data2>, accessed 27/01/2025

The costs of PD include not only the taxes necessary to service the debt, but also the distortions associated with these taxes. Since higher taxes reduce investment incentives, tax distortions form a natural fiscal limit for government debt (Leeper & Walker, 2011). Therefore, excessive PD becomes costly and contributes less and less to economic growth, and above a certain threshold it has a negative impact on economic growth (Reinhart & Rogoff, 2010). The sectoral use of external debt is also important for economic growth. External debt can encourage investment to a certain extent, but if foreign investors begin to doubt a country's ability to properly repay its obligations, a "debt overhang" (Krugman, 1988; Clements et al., 2003) will discourage investors from providing additional capital, negatively impacting investment and economic growth. General government fiscal deficits (public revenues minus public expenditure) can also influence national income. In the short run, general government fiscal deficits can stimulate aggregate demand and thus boost economic growth (while reducing domestic savings). In the long run, however, a decline in savings can reduce the growth of future production and investment, jeopardising long-run economic outcomes. Since 2019, Serbia has entered the general government fiscal deficit zone (in the period 2019–2023, the ratio of the general government fiscal deficit to GDP is -0.2; -7.7;

-3.9; -3.0; and -2.1, respectively)², which may make it difficult to service debt properly and reduce future economic growth. In addition, it is necessary that the increase in PD corresponds to the increase in the share of exports of goods and services in GDP, which is related to the purpose of public debt. If the expected growth in exports of goods and services fails to materialise, we can also expect increasing pressure on the foreign exchange market in the future.

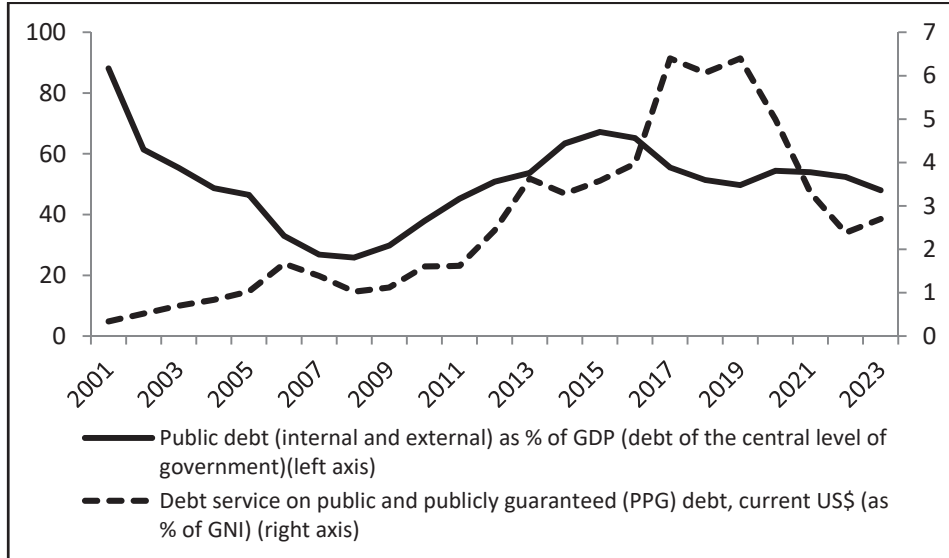
The liberalisation of capital flows and the increasing softening of the domestic financial market have allowed a large inflow of foreign capital, while banks and domestic residents are increasingly investing in the purchase of domestic financial instruments. The optimal share of external debt in total PD is specific to each country. The decline in economic activity during the COVID-19 pandemic led to an increase in Serbia's external PD (debt/GDP ratio), which increased the risk of debt repayment. The cost of external government debt for emerging countries also increased due to the rise in risk premiums with the outbreak of the COVID-19 pandemic³.

Rising public debt may lead to investors investing less in bonds denominated in local currency. This can lead to an increase in yields on domestic instruments, which has a negative impact on economic growth.

² <https://www.mfin.gov.rs/en/documents2-2/macroeconomic-and-fiscal-data2>, accessed 05.01.2025.

³ Credit rating agencies have confirmed Serbia's creditworthiness for long-term foreign currency loans in 2024: **Standard and Poor's**, 04/05/2024 (BB+ / positive outlook), **Fitch Ratings**, 08/09/2024 (BB+ / positive outlook), **Moody's Investors Service**, 08/30/2024 (Ba2 / positive outlook). Despite the estimated positive outlook, the cost of borrowing in foreign currencies rose as investors perceived an increasing risk. On 4 October 2024 **Standard and Poor's** upgraded Serbia's credit rating to BBB-, which places Serbia in the investment grade category. The limited possibilities of borrowing on the insufficiently deep and liquid market for local currency bonds are prompting the central government to borrow in foreign currency. (https://nbs.rs/en/finansijsko_trziste/informacije-za-investitore-i-analiticare/kreditni_rejting/ accessed 05.01.2025).

Figure 2: Public debt (internal and external, as % of GDP) and servicing of Serbia's public and publicly guaranteed debt (as % GNI), 2001–2023



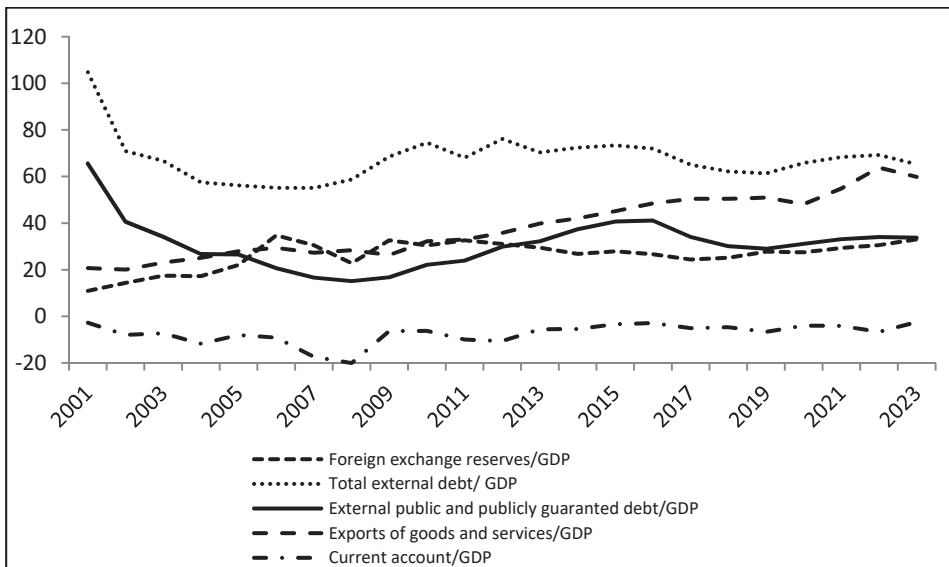
Source: PD (internal and external) as a percentage of GDP is taken from the database of the Ministry of Finance of the Republic of Serbia <https://www.mfin.gov.rs/dokumenti2/makroekonomski-i-fiskalni-podaci>; The data for debt service on public and publicly guaranteed debt, comes from the World Bank database: World Development Indicators, <https://databank.worldbank.org/source/world-development-indicators>. accessed 26/01/2025.

In contrast to public debt, which increased dynamically in the period following the global financial crisis of 2008–2009, the foreign exchange reserves of the National Bank of Serbia (NBS) (excluding the foreign exchange reserves of commercial banks) grew only slowly. As a result, the gap between these two macroeconomic aggregates widened until 2016. In 2007, the foreign exchange reserves were higher than Serbia's total public debt, and in 2023, the total PD was 11 billion euros higher than the foreign exchange reserves⁴. Since foreign exchange reserves are the guarantor of the proper servicing of external debt, it is important that their level instils confidence in foreign lenders. The trend of growth in foreign exchange reserves improved the performance of Serbia's

⁴ The data on foreign exchange reserves are from the NBS (2024c), *Inflation Report* (November 2024), Table B, p. 71, and the data on public debt from the Ministry of Finance of the Republic of Serbia, <https://www.mfin.gov.rs/en/documents2-2/macro-economic-and-fiscal-data2>, accessed 26/01/2025.

external liquidity, resulting in a ratio of foreign exchange reserves to imports of goods and services (in months) of 6.7 months in 2023. However, the current account deficit (CAD) to GDP ratio grew in the period 2001–2008 and reached 20% in 2008. Then this indicator declined and stood at 2.6% in 2023 (Figure 3). A continuous CAD requires borrowing abroad to cover it, which affects the accumulation of external debt.

Figure 3: Serbia's total external debt, public and publicly guaranteed external debt, exports of goods and services, foreign exchange reserves and current account balance (in % of GDP)



Source: Data on PD and GDP are from: <https://www.mfin.gov.rs/en/documents2-2/macroeconomic-and-fiscal-data2> accessed on 26.01.2025. The data on foreign exchange reserves, exports of goods and services, and the current account are taken from the NBS (2006), *Inflation Report* (November 2006, data for the period 2001–2004); NBS (2024b), *Inflation Report* (May 2024, data for period 2005–2009); NBS (2024c). *Inflation Report* (November 2024, data for period 2010–2023).

The indicator for the ratio of public external debt to GDP of 33.1% in 2023 points to cautious further borrowing. This is because further growth in public external debt increases the risk of external liquidity in the event of a sudden reversal in capital flows. On the other hand, a reduction in central government debt is

unlikely in the coming period, especially if we take into account the stated investments related to Expo 2027.⁵

The growth of public debt service as a percentage of GDP in the period 2001–2019 (Figure 2) suggests that this indicator should be included as a variable in the analysis of the impact of Serbian PD on economic growth.

Our paper contributes to the existing literature by analysing the impact of Serbian PD on real GDP per capita growth (RGDP). To our knowledge, the impact of PD on RGDP in Serbia has not yet been widely discussed in the literature. Therefore, the contribution of this paper is to analyse and quantify the relationship between PD and RGDP and, on this basis, to show the possible consequences of an increase in PD. As the impact of public debt servicing (PDS) is also included in the analysis, it is possible to assess the impact of PD on RGDP more comprehensively.

The research question in this paper is whether Serbia's PD influences the RGDP in the short and long run and whether this influence is linear or non-linear.

The major findings of this study can be summarised as follows. The results of our empirical investigation using the non-linear autoregressive distributed lag (NARDL) method show that there is an asymmetric relationship between the PD and the RGDP of Serbia. The estimated long-run coefficient of the positive shock variable PD is negative and shows that a 1% increase in the PD-to-GDP ratio is associated with a 0.24% decrease in RGDP. On the other hand, a negative PD shock of 1% is associated with a 0.7% increase in RGDP. Both coefficients of the PD variable are lagged (-1). The observed asymmetric effects indicate that the stock of PD in Serbia has exceeded the threshold above which the contribution of additional public borrowing to RGDP decreases.

The estimated short-term coefficients also confirm the existence of an asymmetric relationship between positive and negative PD shocks and RGDP, with negative shocks having a stronger effect. This result also supports the

⁵ Fiscal Council of Serbia (2024) estimates that Serbia's projected fiscal deficit of 3% of GDP for 2025 is relatively high and that the 2025 budget envisages a high level of public investment of 7.4% of GDP.

assumption that the stock of PD may have exceeded the threshold in PD. The estimated long-run coefficient of the PDS variable shows that a 1% increase in PDS is associated with a 0.17% decrease in RGDP at the first lag. Since the growth in the PD stock also entails an increase in service costs, the negative influence of this variable could increase in the future. Using the NARDL model, a positive relationship was found between CAD and RGDP, such that growth in CAD of 1% is associated with growth in RGDP of 0.27% at lag(-1). This result is to be expected, as CAD enables the transfer of foreign accumulation into the domestic economy, which leads to higher economic growth. The Granger causality test shows that there is a unidirectional Granger causality from PD to RGDP. The results of our study do not differ from the results of previous studies (Asteriou, et al., 2021; Gómez-Puig & Sosvilla-Rivero, 2015; Reinhart & Rogoff, 2010).

As Serbia's external PD has been growing more dynamically than its internal component since 2019 (Figure 1), a possible increase in interest rates on external PD would increase the negative impact on the RGDP. This would mean that more funds would have to be made available in the budget to service external PD. The results obtained indicate that special attention should be paid to the efficiency of PD funds in the coming period. If these funds are used to build high-quality institutions, improve the effectiveness of government, the quality of regulation and the provision of services to the private sector, it can be expected that PD will have a positive impact on RGDP. Higher investment in research and development (R&D) is necessary to improve the competitiveness of the economy⁶.

It is important that the institutional environment has a stimulating effect on private investment by facilitating services to the commercial sector, controlling corruption and strengthening the rule of law. PD also offers the possibility of stabilising macroeconomic development in the event of disruptions, as was the case during the Covid-19 pandemic. It is important to avoid the risk of spending public money on infrastructure projects whose long-term contribution to economic growth is uncertain. It is also important that the level of PD is kept under control, as its accumulation can exceed the limit beyond which it becomes

⁶ According to the OECD (2024, p.146), total investment in R&D in Serbia is at a low level (0.97% of GDP in 2022). At the same time, private sector participation in this type of investment is particularly low.

a major burden on normal debt servicing⁷. The results obtained in this study may also be useful for other Western Balkan countries with similar levels of public debt.

The rest of the paper is organised as follows. The second section provides an overview of previous research on the relationship between PD and RGDP, while the third section presents the data sources and outlines an econometric model. The fourth section discusses the results obtained. The final fifth section contains the conclusions derived from the most important results and the policy implications. Additional results are presented in the appendix.

2. LITERATURE REVIEW

The published works on this topic can be divided into two groups. One contains research findings in which there is no clearly defined threshold (PD as a percentage of GDP) that separates the positive from the negative effects of PD on economic growth. The second group comprises papers in which this threshold has been calculated. First, we present the results of papers that fall into the group without a clearly defined threshold. Calderón and Fuentes (2013) used a large sample of 136 countries from 1970 to 2010 to analyse whether PD promotes or hinders economic growth and whether economic policy mitigates this effect. The authors came to the conclusion that there is a negative relationship between PD and growth. They also concluded that an export-orientated economic policy can help to reduce this negative effect. Siddique et al. (2016) used an ARDL (autoregressive distributed lag) model to investigate whether the debt ratio affects the economic growth of 40 indebted countries in the period 1970–2007. The control variables in the model were trade, population and capital formation. The authors found that debt has a negative impact on economic growth, with the analysed short- and long-run coefficients being statistically significant. According to the authors, a higher level of debt ties an increasing proportion of production to the repayment of foreign loans, which acts as a barrier to investment.

⁷ If public debt exceeds a sustainable level, it can become a generator of instability and a limiting factor for economic growth (Krugman, 1988).

Lim (2019) examines the relationship between total debt (private and public) and economic growth in a sample of 41 countries from 1952 to 2016 using a vector autoregression model (VAR), where the panel VAR is estimated using the generalised method of moments (GMM). The results show that there is a negative relationship between total debt and economic growth, with a one standard deviation change leading to a 0.2% decline in economic growth. By introducing exogenous variables into the system, the author obtained robust results. Asteriou et al. (2021) examine the relationship between PD and economic growth in the short and long run using 14 Asian countries for the period 1980–2012. The authors used the ARDL model and a mean group (MG) estimator to achieve heterogeneity in the short and long run relationship of the observed variables. Average educational age, trade openness and investment were included in the model as control variables. The authors calculated that a 1 percentage point increase in government debt relative to GDP leads to a decrease in economic growth of 0.012 to 0.125 percentage points. Based on these results, the authors came to the conclusion that the increase in PD has a significantly negative effect on economic growth.

Ghourchian and Yilmazkuday (2020) compared the impact of government spending and PD on economic growth in 83 countries between 1960 and 2014 using a two-stage least squares method with the usual control variables as in other studies. According to the results of these authors, a 1 percentage point increase in the ratio of government debt to GDP leads to a decrease in real GDP growth of about 0.01 percentage points, while a 1 percentage point increase in the ratio of government spending to GDP leads to a decrease in real economic growth of about 0.1 percentage points, on average, across the countries in the sample. The authors point out that it is more important for countries with greater trade openness to prevent negative effects on economic growth by limiting government debt. Pegkas et al. (2020) investigated the impact of PD on economic growth of 12 Eurozone countries for the period from 1995 to 2016. The study analyses time series and applies a fully modified least squares approach, with control variables such as investment, human capital and trade openness. The results show that government debt has a long-run impact on economic growth. There is a long-run unidirectional causality from investment, trade openness and human capital to economic growth and a bidirectional causality between PD and economic growth. Based on the results obtained, the authors recommend that Eurozone countries

should base their growth strategies on fiscal consolidation, increasing exports, correcting the use of public investment and improving the quality of human capital, particularly in higher education.

Ješić (2023) analyses the potential determinants of GDP growth in a sample of 19 selected European countries from Central, Eastern and South-Eastern Europe in the period from 2014 to 2020. Using dynamic panel data modelling, the results of the model show that fiscal responsibility is one of the most important determinants of GDP growth. The author found that the effect of PD was small but significant for the observed sample of countries. He also found that PD has a negative effect on GDP growth in the observed countries, although the values of the obtained coefficients were not high in all specifications. The findings of his study support the conclusions of previous studies, according to which the threshold above which PD has a negative effect on economic growth is certainly lower in emerging countries. The second variable from the fiscal corpus – the structural budget balance – contributes significantly to economic growth in all specifications of the model used. According to the author, this result confirms the importance of the hypothesis that fiscal responsibility contributes significantly to GDP growth. Arsić et al. (2021) analysed the impact of PD uncertainty on economic growth for 10 emerging European economies in the period 2000–2015. Empirical analyses using time series and panel data approaches showed that PD uncertainty has a significant negative impact on GDP growth in these economies. This was especially the case during the 2008 recession.

We mention several studies that have identified a threshold as a turning point beyond which the growth of PD has a detrimental effect on economic growth. Reinhart and Rogoff (2010) conducted a thorough analysis of the relationship between debt and economic growth. The analysis was carried out on a sample of 44 countries. The findings of their study show that a high PD-to-GDP ratio (90% or more) (in both advanced and emerging economies) is associated with weaker economic growth. It was found that countries with a debt-to-GDP ratio of more than 90% have about 1.5 percentage points lower economic growth than the group of less indebted countries. Afonso and Jalles (2013) found a negative relationship between debt and economic growth in a sample of 155 countries for the period from 1970 to 2008. An increase in the debt-to-GDP ratio of 10 percentage points impairs economic growth by -0.2 percentage points for

countries with a debt-to-GDP ratio of over 90%. The authors find an endogenous threshold for the debt ratio at 59% of GDP for the entire sample. Padoan et al. (2012) examine the impact of fiscal policy on the growth path of the economy for 28 OECD countries from 1960 to 2011. The authors used a GMM instrumental variable estimation and investigated the existence of a threshold effect found between 82 and 91% of GDP. Namely, their findings show that an increase in PD by 1 percentage point on average reduces GDP growth in the next year by 0.012 percentage points, while average annual growth over the next five years decreases by 0.028 percentage points.

Égert (2015) uses a similar data set to Reinhart and Rogoff (2010) and applies an econometric test to examine whether PD has a negative non-linear effect on economic growth when PD exceeds 90% of GDP. Using a multivariate growth framework and Bayesian model averaging on a sample of 44 industrialised countries for the period 1960 to 2010, the author finds a positive relationship between debt and economic growth at low debt levels, while negative effects occur at higher debt levels. The study finds that the negative non-linear effect occurs at much lower levels of PD (between 20% and 60%), in contrast to most studies, where the negative effect occurs at a threshold of 60% to 100% of GDP. The authors point out that public investment can generate high returns at low levels of debt.

Baum et al. (2012) analyse the relationship between PD and economic growth. In their study, a dynamic threshold panel method is used to analyse the non-linear effects of PD on GDP growth. The sample consists of 12 Eurozone countries for the period 1990–2010. The empirical results indicate that the short-term impact of debt on GDP growth is positive and highly statistically significant, but declines to zero and becomes less significant beyond a PD ratio of around 67% of GDP. Debt above this ratio has a negative impact on economic activity. These authors also find that the long-term interest rate is subject to increased pressure when the PD-to-GDP ratio is above 70%. Woo and Kumar (2015) analyse the impact of high PD on long-term economic growth and the existence of threshold effects. The analysis is based on a panel of countries with almost 40 years of data. The results of the study show that a 10-percentage point increase in the initial debt-to-GDP ratio is associated with a slowdown in per capita GDP growth of about 0.2% per year. The study finds evidence of non-linearity, with only high debt

levels (above 90% of GDP) having a significant negative impact on economic growth. The authors conclude that the negative effect is reflected in the slowdown in labour productivity growth, which is mainly due to slower capital accumulation. Comprehensive robustness tests confirm the results.

Saloti and Trecroci (2016) analysed panel fixed effects for the period from 1970 to 2009 for a sample of 20 OECD countries using the system GMM estimator. The paper provides weak evidence for the existence of a threshold at 85–90% of GDP. The average country in the sample had an elasticity of investment to debt/GDP ratio of up to -0.10 at a debt level of 54%. Swamy (2020) uses the Solow growth model and estimates panel data growth regressions with country fixed effects and time fixed effects. The author uses a two-stage GMM estimator for a large data set for 252 countries from 1960 to 2009. The results show that there is a negative relationship between PD and growth. The econometric specification suggests that a 10-percentage-point increase in the debt ratio is associated with a 23-basis-point decline in average growth. These results are consistent with those of other studies (Afonso & Jalles, 2013; Woo & Kumar, 2015). The results of the study show that debt has a positive impact on growth for countries with debt below 60% of GDP, while the impact in the zone between 60 and 90% is negligible, while above 90% there is a sharp decline in economic growth.

Bentour (2021) analyses the relationship between PD and economic growth in a sample of 20 industrialised countries over the period 1880–2010 using the regression kink model with an unknown threshold proposed by Hansen (2017). Bentour shows that the relationship between PD and economic growth varies over time and is country specific. In particular, the relationship between PD and economic growth is volatile for each country in the sample over the entire period 1880–2010 and the post-war period 1950–2010 and is subject to data and country heterogeneities. These findings refute the existence of a common threshold that applies to all countries and call for more theory-based models that take into account the fundamentals that differ across countries and influence the interactions between debt and growth.

Andrić et al. (2016) analysed the development of the primary fiscal balance and PD in Serbia in the period 2004Q3–2014Q3. They conclude that the ratio of PD to GDP exhibits the behaviour of a (near) unit root with a general growth trend,

i.e. that the development of the PD-to-GDP ratio was not sustainable in the observed period.

3. DATA AND ECONOMETRIC METHODOLOGY

3.1 Data sources and description

In analysing the impact of PD on Serbia's economic growth, this paper uses annual time series data over the period 2000–2023 taken from the World Development Indicators (WDI) database of the World Bank, the Ministry of Finance of the Republic of Serbia and the National Bank of Serbia (NBS). The description and sources of the variables used can be found in Table 1.

Table 1: Definition of the variables and data sources

Variable	Description	Source
Real GDP per capita growth (RGDP)	GDP per capita growth (annual %)	World Development Indicators (World Bank, 2024)
Public debt (PD)	General government gross debt (% of GDP)	Ministry of Finance of the Republic of Serbia (2024)
Public debt service (PDS)	Public and publicly guaranteed debt service (% of GNI)	World Development Indicators (World Bank, 2024)
Current account (CA)	Current account balance (% of GDP)	World Development Indicators (World Bank, 2024)
Gross domestic savings (GDS)	Gross domestic savings (% of GDP)	World Development Indicators (World Bank, 2024)
Foreign direct investment, net inflows (FDI)	Foreign direct investment, net inflows (% of GDP)	World Development Indicators (World Bank, 2024)
Gross fixed capital formation (GFCF)	Gross fixed capital formation (% of GDP)	World Development Indicators (World Bank, 2024)

Note: Data for net foreign direct investment inflows for the period 2001–2006 are from the National Bank of Serbia, Balance of Payments 1997–2006 (NBS, 2024a); Data for current account for the period 2001–2006 are from the National Bank of Serbia (*Inflation Report*, November 2008, table B, p. 58). Data for PD as a percentage of GDP is taken from the database of the Ministry of Finance of the Republic of Serbia (2024).

Source: Author.

The variables selected are consistent with those commonly used in the literature to analyse the relationship between PD and RGDP (Checherita-Westphal & Rother, 2010; Kumar & Woo, 2010). In the empirical work published to date, there are mixed findings on the relationship between PD and RGDP. Several authors argue in favour of a negative relationship between PD and real GDP growth, especially above a certain threshold (Afonso & Jalles, 2013; Égert, 2015; Law et al., 2021; Liu & Lyu, 2020; Pattillo et al., 2002; Reinhart & Rogoff, 2010). In other studies, particularly those analysing the development of emerging economies, the results show a positive relationship between real GDP growth and PD (Fincke & Greiner, 2014). Based on numerous studies, it can be assumed that this relationship is specific to each country. In our study, we analyse the impact of Serbia's PD on RGDP.

A summary of the descriptive statistics of the variables used in our study can be found in Table A2 in the Appendix. The descriptive statistics show that all variables, with the exception of FDI, are normally distributed based on the Jarque–Bera statistics. The mean value of the PD variable is 3.9 and is therefore half the magnitude of the mean value of the RGDP, which indicates a high level of public debt. The maximum PD value of 4.5 draws attention to jumps in Serbia's PD in individual years. The maximum value of FDI of 2.5 and the minimum value of 1.7 also indicate an uneven dynamic of net inflows of foreign direct investment. The existence of outliers in some time series can be a hint of a structural break in the series, which we will check using unit root tests with breakpoint.

3.2 The econometric methodology

To analyse the relationship between PD and economic growth in Serbia, the following regression equation was estimated for the period 2001–2023:

$$\text{LogRGDP}_t = \alpha_0 + \beta_1 \text{LogPD}_t + \beta_2 \text{LogPDS}_t + \beta_3 \text{LogCA}_t + \beta_4 \text{LogGDS}_t + \beta_5 \text{LogX}_t + \varepsilon_t \quad (1)$$

Here Log denotes natural logarithm. LogRGDP_t is a dependent variable corresponding to log real GDP per capita growth, as the usual approximation for real GDP growth. The regression equation includes several explanatory variables: α is a constant, ε_t represents the error term, LogPD_t is the log of PD (% of GDP), LogPDS_t is the log of public and publicly guaranteed debt service (% of GNI), LogCA is the log of the current account (% of GDP), LogGDS_t is the log of gross

domestic savings (% of GDP), and $LogX_t$ contains the control variables $LogFDI_t$, the log of net foreign direct investment inflows (% of GDP), and $LogGFCF_t$, the log of gross fixed capital formation (% of GDP). The variables included in the regression equation are also significant factors influencing Serbia's economic growth, so their inclusion can contribute to a more accurate separation of the impact of PD on economic growth. The CA balance is included as an explanatory variable because the continuous CA deficit (CAD) in the macroeconomic sense means the transfer of foreign accumulation, which can contribute to the acceleration of economic growth and development of the country. The net inflows of FDI to Serbia also partially contribute to productive investment and exports, which certainly has an impact on economic growth. The growth of domestic savings as a precondition for domestic private sector investment can significantly boost investment demand and thus economic growth. These are the reasons for including these variables in the regression analysis as control variables.

The empirical analysis applied in this paper is based on the bounds testing approach to cointegration (the linear ARDL approach to cointegration), in line with the recommendations in Cho et al. (2015). We also apply the NARDL to test whether Serbia's PD has an asymmetric impact on GDP growth. In contrast to the traditional ARDL models, which show a symmetric change in the dependent variable in response to changes in the independent variable, the NARDL model is able to separate asymmetric effects from changes in the independent variable on the dependent variable, if such effects exist. The NARDL framework proposed by Shin et al. (2014) is a model in which short-run and long-run nonlinearities are estimated as positive and negative sums of the changes in the explanatory variables.

ARDL models applied to cointegration are more efficient in identifying long-run relationships between variables on smaller samples, from 30 to 80 observations, compared to other cointegration methods, and provide good results regardless of whether the variables are stationary $I(0)$ or $I(1)$ or mutually cointegrated (Pesaran et al., 2001). It must first be established that the variables in the model are not integrated of order $I(2)$. If this condition is met, we can apply the NARDL model in error correction (EC) form:

$$\Delta y_t = -\phi ECA_t + \sum_{j=1}^{p-1} \gamma_j \Delta y_{t-j} + \sum_{r=1}^k (\eta_r^+ \Delta x_{r,t}^+ + \eta_r^- \Delta x_{r,t}^-) + \sum_{r=1}^k \sum_{j=1}^{p_r-1} (\delta_{r,j}^+ \Delta x_{r,t-j}^+ + \delta_{r,j}^- \Delta x_{r,t-j}^-) + \sum_{i=1}^m \alpha_0 d_{i,t} + \epsilon_t, \quad (2)$$

where ECA is the asymmetric equilibrium error correction term defined as: $\sum_{j=1}^{p_r-1} (\delta_{r,j}^+ \Delta x_{r,t-j}^+ + \delta_{r,j}^- \Delta x_{r,t-j}^-) + \sum_{i=1}^m \alpha_0 d_{i,t} + \epsilon_t$.

$$ECA_t = y_{t-1} - \sum_{r=1}^k \left(\frac{\lambda_r^+}{\phi} x_{r,t-1}^+ + \frac{\lambda_r^-}{\phi} x_{r,t-1}^- \right), \quad (3)$$

where ϕ represents the error correction parameter, while λ_r^+/ϕ and λ_r^-/ϕ for $r = 1, \dots, k$ are the long-term equilibrium parameters for the explanatory variables, while $\eta_r^+, \eta_r^-, \delta_{r,j}^+, \delta_{r,j}^-$ represent short-run parameters for the explanatory variables.

Starting from the variables we use in our study, we can present the traditional (symmetric) ARDL model as:

$$\begin{aligned} \Delta \text{LogRGDP}_t = & \beta_0 + \beta_1 \text{LogRGDP}_{t-1} + \beta_2 \text{LogPD}_{t-1} + \beta_3 \text{LogPDS}_{t-1} + \\ & \beta_4 \text{LogCA}_{t-1} + \beta_5 \text{LogGDS}_{t-1} \\ & + \sum_{i=1}^p \beta_6 \Delta \text{LogRGDP}_{t-i} + \sum_{i=0}^q \beta_7 \Delta \text{LogPD}_{t-i} + \sum_{i=0}^r \beta_8 \Delta \text{LogPDS}_{t-i} + \\ & \sum_{i=0}^s \beta_9 \Delta \text{LogCA}_{t-i} + \sum_{i=0}^m \beta_{10} \Delta \text{LogGDS}_{t-i} + u_t \end{aligned} \quad (4)$$

Since in our study we also examine the asymmetric impact of LogPD on LogRGDP , this implies the introduction of positive and negative (PD_t^+ and PD_t^-) changes in LogPD . In this way, a partial decomposition of the variable PD_t is performed around the threshold PD_0 , so that we get partial sums of values above and below this specific threshold, which represents the initial value of LogPD :

$$PD_t^+ = \sum_{i=1}^t \Delta PD_t^+ = \sum_{i=1}^t \max(PD_i, 0) \quad (5)$$

$$PD_t^- = \sum_{i=1}^t \Delta PD_t^- = \sum_{i=1}^t \min(PD_i, 0)$$

Equation (3) can be rearranged in the NARDL model, taking into account the aforementioned asymmetry in the PD variable:

$$\begin{aligned} \Delta \text{LogRGDP}_t = & \beta_0 + \beta_1 \text{LogRGDP}_{t-1} + \beta_2 \text{LogPD}_{t-1}^+ + \\ & \beta_3 \text{LogPD}_{t-1}^- + \beta_4 \text{LogPDS}_{t-1} + \beta_5 \text{LogCA}_{t-1} + \beta_6 \text{LogGDS}_{t-1} + \\ & \sum_{i=1}^p \beta_7 \Delta \text{LogRGDP}_{t-i} + \sum_{i=0}^q \beta_8 \Delta \text{LogPD}_{t-i}^+ + \sum_{i=0}^k \beta_9 \Delta \text{LogPD}_{t-i}^- + \\ & \sum_{i=0}^r \beta_{10} \Delta \text{LogPDS}_{t-i} + \sum_{i=0}^s \beta_{11} \Delta \text{LogCA}_{t-i} + \sum_{i=0}^m \beta_{12} \Delta \text{LogGDS}_{t-i} + u_t, \quad (6) \end{aligned}$$

where $\Delta \text{LogRGDP}_t$ is the dependent variable, LogPD_{t-1}^+ , LogPD_{t-1}^- , LogPDS_{t-1} , LogCA_{t-1} , and LogGDS_{t-1} are explanatory variables, β are coefficients of short-term and long-term dynamics and u_t is a random error. Δ is the first difference of the variables. The first part of the model represents the long-term relationship between the dependent variable and the explanatory variables, while the second part shows the short-term relationships between the variables. All regression models contain the variable *DAMMY*, which models the structural break in the RGDP series.

In contrast to the traditional cointegration tests proposed by Engle and Granger (1987), Phillips and Ouliaris (1990) or Johansen (1995), which assume that all variables in the VAR system are I(1), Pesaran et al. (2001) propose a cointegration test that is robust regardless of whether the variables are I(0), I(1) or mutually cointegrated. These bound tests are formulated as standard *F*-tests or Wald tests of the significance of parameters in the cointegration relationship of the conditional error correction (CEC) model for the following null and alternative hypotheses:

$$H_0: \{\emptyset, \lambda_1, \dots, \lambda_k\} = 0,$$

$$H_1: \{\emptyset, \lambda_1, \dots, \lambda_k\} \neq 0.$$

Pesaran et al. (2001) introduced critical values for the *F*-statistic (critical value bounds for the null hypothesis that there is no level relationship between the dependent variable and the regressors in the conditional error correction regression [CEC] mode – the lower bound is calculated assuming that all model variables are stationary in level, while the upper bound is based on the assumption that all series are stationary at the first difference). If the calculated value of the *F*-statistic is below the critical value of the lower bound, the null hypothesis cannot

be rejected, i.e. there is no cointegration between the variables. If the calculated value of the F -statistic is greater than the upper critical value, the null hypothesis that there is no level relationship is rejected, regardless of whether the integration level of the variable is $I(0)$ or $I(1)$. If the estimated F -statistic lies between the upper and lower critical values, the F -test is not meaningful, so that the test must be continued by determining the cointegration rank. If all variables are integrated $I(1)$, the decision is made on the basis of the upper bound. If the variables are integrated with the order $I(0)$, the decision is made on the basis of the lower bound. Before estimating the ARDL model, we check the level of integration of the time series used in the model. It is important to note that no variable in the model is $I(2)$.

Since none of the time series in our study are of integration order $I(2)$, we estimate the ARDL model and its NARDL variant. We apply diagnostic tests for specification, autocorrelation and stability of the selected models. We use the Ramsey RESET test and the test for omitted variables to check whether the regression equation is well specified. Then we use the standard Breuch–Godfrey Serial Correlation LM test to check for the presence of autocorrelation, while we use the CUSUM and CUSUMQ test of recursive residuals to assess the stability of the model (Brown et al., 1975). According to these tests, the parameters of the equation are stable if the calculated cumulative sum of the recursive residuals is within the critical limits of the interval (the critical line of 5%). To check whether there is heteroscedasticity of the residuals in the analysed model, we apply the Breusch–Pagan–Godfrey heteroscedasticity test. When estimating the NARDL model, we use the NARDL coefficient symmetry tests to check whether the explanatory variables have an asymmetric influence on the dependent variable. If the absence of autocorrelation and heteroscedasticity of the residuals in the analysed model and the stability of the model parameters are established, the presence of cointegration is checked according to the procedure described above. If there is cointegration between the variables of the model, we check whether the long-run coefficients of the estimated cointegration equation are statistically significant. Then we will estimate the speed of adjustment to equilibrium in the cointegration equation using the ARDL and NARDL error correction regression. The error correction term is one of the regressors of the ARDL and NARDL error correction regression and represents the speed of adjustment to equilibrium in each period.

4. EMPIRICAL RESULTS AND DISCUSSION

In order to check the stationarity of the time series, a modified Augmented Dickey–Fuller (ADF) test adjusted for series with structural breaks (Peron, 2006) was used in this study. A version of the ADF test in which the existence of a structural break is assumed both in the cross-section and in the trend of the time series was used. The results of the unit root tests are presented in Table A1 in the Appendix and show that all variables of the applied models are stationary either at the level or in the first difference, confirming that the ARDL approach is appropriate for our study. The variables *LogRGDP*, *LogGDS* and *LogFDI* are stationary at the level, while the other variables are stationary in the first difference. Thus, it has been confirmed that none of the variables in the regression equation is integrated with order I(2). The unit root test detected a break for the RGDP variable in 2008. Therefore, when estimating the regression models, we introduced a dummy variable that has the value 0 for the period before 2008 and the value 1 for 2008 and other observations. The structural break in the data for *LogPD* is also in 2008 according to the unit root test. When we look at the untransformed *LogPD* series, we also find that the structural break in the series occurred in 2008.

In the next step, we will estimate the ARDL and NARDL models. One lag for the dependent variable RGDP and two lags for the explanatory variables were used in the estimation, and the optimal model was selected according to the Akaike information criterion (AIC). We tested the dynamic stability properties of the variables using the break-unit root test and found that the ARDL model and its nonlinear extension (NARDL) were appropriate for our study. Using the NARDL model, we test whether the Serbian PD variable has an asymmetric effect on RGDP growth. In the study, we formed three regression models: one estimated using the ARDL approach (Model 1), the second based on the NARDL approach (Model 2), and the third model testing the robustness of the estimated NARDL model (Model 3). All three models contain the same set of variables, with an additional variable (gross fixed capital formation – GFCF) included as a control variable in the NARDL-ROBUST model. The ARDL and NARDL models were estimated for the period 2001–2023, while the third model (NARDL-ROBUST) was estimated for the period 2008–2023. The task of the NARDL-ROBUST model is to check the robustness of the estimated NARDL model for the entire time sample. Therefore, an additional explanatory variable was included in this model

and the observation period was shortened to 2008–2023. To check the robustness of the results for the NARDL, the period after the structural break in the PD series in 2008 (according to the unit root test in first difference) was analysed, and 2008 was also the time of the break for the RGDP variable. After the break in the PD data in 2008, there is a strong increase in PD relative to GDP. Diagnostic tests were performed for all three models (Table 2).

Table 2: Specification tests of the ARDL, NARDL, and NARDL-ROBUST models

Model specification	Model 1	Model 2	Model 3
Sample period	2001–2023		2008–2023
Lag of variable	ARDL (1,1,2,1,2)	NARDL (1,2,2,2,2)	NARDL-ROBUST (2,1,1,1,1,1)
Akaike info criterion	-4.82	-7.21	-8.93
Model specification tests	Model 1	Model 2	Model 3
	<i>p</i>-value		
JB test for normality of the residuals, null hypothesis: the data follow a normal distribution	0.7301	0.3430	1.0573
Breusch-Godfrey Serial Correlation LM test, null hypothesis: no serial correlation at up to 2 lags	0.7966	0.5018	0.6058
Breusch-Pagan-Godfrey heteroscedsticaly test, null hypothesis: homoscedasticity	0.6343	0.9982	0.7187
Omitted variables test, null hypothesis: <i>LogFDI</i> , <i>LogGFCF</i> are jointly insignificant*	0.0746	0.6937	0.3656
Ramsey RESET test, null hypothesis: model is correctly specified	0.4489	0.5770	0.1128

CUSUM test	Correctly specified at 5% significance	Correctly specified at 5% significance	Correctly specified at 5% significance
CUSUM of squares test	Correctly specified at 5% significance	Correctly specified at 5% significance	Correctly specified at 5% significance
Coefficient symmetry test – long-run for <i>LogPD</i> variable** null hypothesis: coefficient is symmetric		0.0552	0.0198
Coefficient symmetry test – short-run for <i>LogPD</i> variable** null hypothesis: coefficient is symmetric		0.0685	

Note: *For NARDL and NARDL-ROBUST included *LogFDI* as additional explanatory variable, null hypothesis is: *LogFDI* is not significant. ** Only for NARDL and NARDL-ROBUST model.

Source: Author

Based on the diagnostic tests in Table 2, all three models fulfil the assumptions of a correct model specification (the residuals are normally distributed, not autocorrelated and the assumption of homoscedasticity is fulfilled). The test for omitted variables and the Ramsey test confirm that the models are correctly specified. The CUSUM test and the CUSUM of squares test also confirm the stability of all three models, i.e. that all models are well specified. The symmetry test for the PD variable (long-run and short-run) for the NARDL model shows that it is asymmetrically associated with RGDP, while the same variable in the NARDL-ROBUST model has an asymmetrical relationship with RGDP in the long run, but a symmetrical one in the short run (The test for asymmetry should show whether positive and negative effects are the same, symmetrical, or different, asymmetrical).

After performing the diagnostic tests, we tested the existence of a long-term relationship (cointegration) between the dependent variable and the independent variables in all three models. The results of the cointegration test are shown in Table 3.

Table 3: Cointegration test of variables in ARDL, NARDL and NARDL-ROBUST model

	Model 1		Model 2		Model 3	
Lag of variable	ARDL (1,1,2,1,2)		NARDL (1,2,2,2,2)		NARDL-ROBUST (2,1,1,1,1,1)	
<i>F</i> -statistic	10.64203		27.42279		47.78103	
<i>t</i> -statistics	-6.188152		-9.426854		-8.87630	
Critical bounds	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
	F-statistic					
Sample size	30	30	30	30	30	30
10%	2.752	3.994	2.578	3.858	2.457	3.797
5%	3.354	4.774	3.125	4.608	2.970	4.499
1%	4.768	6.670	4.537	6.370	4.270	6.211
<i>t</i>-statistic						
Sample size	Asympt.	Asympt.	Asympt.	Asympt.	Asympt.	Asympt.
10%	-2.570	-3.660	-2.570	-3.860	-2.570	-4.040
5%	-2.860	-3.990	-2.860	-4.190	-2.860	-4.380
1%	-3.430	-4.600	-3.430	-4.790	-3.430	-4.990

Note: Null hypothesis: No levels relationship.

Source: Author.

The results of the *F*-bounds test in Table 3 show that the calculated *F*-statistic is significantly higher than the upper bound critical value I(1) at the 1% level, which means that the null hypothesis that there is no level relationship can be rejected in all three models and confirms the existence of a cointegration relationship between the dependent variable (*LogRGDP*) and the observed explanatory variables.

After performing the ARDL, NARDL and NARDL-ROBUST *F*-bound test, we estimated the long-run (equilibrium) coefficients in the cointegration relationship. The results can be found in Table 4.

Table 4: Long-run regressors of the cointegration equation (dependent variable: RGDP)

Independent variable		Model 1	Model 2	Model 3
Variable lags		ARDL (1,1,2,1,2)	NARDL (1,2,2,2,2)	NARDL- ROBUST (2,1,1,1,1,1)
LogPD(-1)	Coefficient	0.017173		
	Std. Error	0.035080		
	<i>p</i> -value*	0.6376		
LogPD ⁺ (-1)	Coefficient		-0.247286	-0.440055
	Std. Error		0.063389	0.063081
	<i>p</i> -value*		0.0599	0.0199
LogPD ⁻ (-1)	Coefficient		0.703311	0.078408
	Std. Error		0.181762	0.025020
	<i>p</i> -value*		0.0608	0.0885
LogPDS	Coefficient			
	Std. Error			
	<i>p</i> -value*			
LogPDS(-1)	Coefficient	-0.003126	-0.178352	-0.041797
	Std. Error	0.026922	0.038841	0.007916
	<i>p</i> -value*	0.9104	0.0443	0.0340
LogCA(-1)	Coefficient	-0.000840	0.266483	0.231259
	Std. Error	0.032646	0.060211	0.040396
	<i>p</i> -value*	0.9801	0.0474	0.0292
LogGDS	Coefficient			
	Std. Error			
	<i>p</i> -value*			
LogGDS(-1)	Coefficient	-0.017926	0.857092	0.642610
	Std. Error	0.038723	0.200920	0.097238
	<i>p</i> -value*	0.6557	0.0508	0.0221
LogGFCF(-1)	Coefficient			0.096491
	Std. Error			0.036800
	<i>p</i> -value*			0.1199

Note: **p*-values do not account for model selection.

Source: Author.

In the context of the ARDL and NARDL models in our study, "long-run" should be interpreted as the average change over the sample period, while "short-run" refers to a period of one year. The estimates of the long-run coefficients can be found in Table 4. The coefficients in Model 1 are not statistically significant, indicating that the ARDL methods could not demonstrate a long-run relationship between PD and RGDP. In contrast to the ARDL approach, the application of the NARDL methodology provides statistically satisfactory results. Therefore, we will analyse the results of the NARDL model in more detail. As we have already seen, NARDL makes it possible to separate the influence of the explanatory variable on the dependent variable by showing the influence of positive and negative changes in the explanatory variable on the dependent variable separately. In our study, the influence of positive and negative PD shocks on RGDP was separated using the NARDL approach. The estimated coefficient for the positive PD shock of -0.247 is statistically significant at the level of 0.06 (less than 10% and slightly more than the usual 5%). This means that a positive shock to PD of 1% is associated with a decrease in RGDP of 0.25%. The estimated coefficient of the negative shock to PD of 0.70 is also statistically significant at the 0.06 significance level, which means that a negative PD shock of 1% is associated with an increase in RGDP of 0.7%. These coefficients show that the positive relationship between the reduction in the PD-to-GDP ratio and RGDP is stronger than the negative relationship in the case of an increase in PD. This discrepancy confirms that there is a non-linear relationship between PD and RGDP. Our empirical results are in line with the findings of other studies, such as Woo and Kumar (2015) and Reinhart and Rogoff (2010). The impact of an unexpected increase in PD on RGDP depends on the initial level of PD. Previous studies show that an unexpected increase in PD has a greater negative impact on growth in countries with a higher initial debt level (de Soyres et al., 2022, p. 12, Figure 4). Since the stock of external PD of Serbia rose after the COVID-19 pandemic, the country is sensitive to changes in the conditions for new external borrowing. Possible interest rate shocks can increase external debt burden and restrict fiscal space (Brunnermeier & Reis, 2023). The problems can be very serious if a potential external financial crisis leads to a withdrawal of foreign capital from the country.

The long-run impact of PDS on RGDP is negative (the estimated long-run coefficient in the NARDL approach, in lag(-1), is -0.17 and is statistically significant at the 5% level) and shows that growth in the stock of PD is

accompanied by an increase in PDS. An unexpected increase in interest rates could increase the burden of PDS, which would have a negative impact on RGDP. Using the NARDL model, a positive relationship was found between CAD and RGDP, such that growth in CAD of 1% is associated with growth in RGDP of 0.27% for lag(-1). The result is consistent with the theoretical expectation that the transfer of foreign accumulation, expressed by CAD, can stimulate the economic growth and development of the country. This can be seen in cases where CAD is used to finance investment, equipment imports and to improve the investment climate. The estimated long-run coefficient of the GDS variable is also statistically significant at the 5% significance level and shows that a 1% increase in GDS is associated with a 0.86% increase in RGDP. This result is also consistent with the theoretical expectation that growth in savings opens up the possibility of growth in private investment, with the expected positive effects on economic growth. However, if domestic PD continues to grow, the positive contribution of GDS to RGDP could decline. A higher absorption of GDS by the government reduces the amount of GDS that can be used to finance the private sector. This may also lead to an increase in domestic interest rates as crowding out occurs.

In order to check the robustness of the NARDL model analysed, Model 3 was estimated of the sample period being shortened to 2008–2023 and a control for the GFCF variable being introduced. It was previously shown that there was a structural break in the RGDP and PD series in 2008. The estimated coefficient of the parameter for the positive PD shock is -0.44 and is statistically significant at the 5% level. This means that a 1% increase in PD leads to a decrease in RGDP of 0.44, which is almost double the magnitude of the decrease observed in the entire period 2001–2023. The estimated coefficient of a negative PD shock of 0.08 is statistically significant at a level of 10% and shows that a negative PD shock of 1% is associated with 0.08 growth in RGDP. The movement of these coefficients with the PD variable shows that in the period after 2008, the influence of PD on the slowdown in RGDP increased. This is to be expected considering that there was dynamic growth in PD after 2008. The other explanatory variables in Model 3 show the same direction of influence on RGDP as in the NARDL model. The estimated control variable GFCF in Model 3 is not statistically significant, so its introduction as an explanatory variable had no effect on the change in conclusions based on the estimated NARDL model. It can therefore be concluded that Model 3 confirms the robustness of the results of the NARDL model estimated.

Table 5 shows the short-term coefficient estimates for all three models. In contrast to the long-run coefficients of the estimated ARDL model, which are not statistically significant, the short-run coefficient of the PB variable is statistically significant at the 1% significance level and shows that an increase in PD of 1% is associated with a decrease in RDGP of 0.2%, with the other terms remaining unchanged. In the short term, i.e. within one year, PDS growth also had a negative impact on RGDP: an increase of 1% in PDS is associated with a decrease of 0.03% in RGDP. Although the influence of PDS on RGDP is not strong according to this assessment, the negative coefficient shows that this variable has the potential to slow down RGDP growth.

The results of the NARDL model show that there is a non-linear relationship between PD and RGDP even in the short run. The estimated coefficients of the NARDL model show that a positive PD shock of 1% is associated with a slowdown in RGDP of 0.31%, while a negative PD shock is associated with increase in RGDP of 1.19%. The estimated coefficients are statistically significant at the 1% level. Therefore, the short-term coefficients also confirm the non-linear relationship between PD and RGDP. It can be observed that the effect of the negative shock of PD in the short run is larger than the effect of the negative shock in the long run. CAD and GDS have a significant positive impact on RGDP, and the estimated coefficients are statistically significant at the 1% level.

The estimated short-run coefficient in the NARDL-ROBUST model with the PD variable (symmetric variable in the short-run) is statistically significant at the 5% level and shows that an increase in PD of 1% is associated with a 0.24% decrease in RGDP. Therefore, this coefficient confirms the robustness of the NARDL model for the entire sample period.

Table 5 shows the estimated adjustment coefficients for all three models with correction for the equilibrium error (EC term). The EC term measures the speed of adjustment to the long-run relationship in the movement of the dependent and explanatory variables and, according to theory, should be negative in the interval between 0 and 1.

The estimated coefficient of the EC term for all three models estimated in our study has the expected negative sign, and the coefficients are highly statistically significant at the 1% level. However, the magnitude of the negative value of the

estimated coefficient is greater than 1, which is a deviation from the theoretical expectation. This may be a consequence of the rapid convergence of the RGDP to the equilibrium relationship with the other variables in the estimated equation if there was a disturbance in the previous period. In the estimated NARDL model, the EC term (-3.13) shows that the deviation of the dependent variable in the previous period is only corrected for a few months in the current year. This is a super-fast restoration of the equilibrium relationship between the variables in all three estimated models. The EC term also confirms that there is a long-run relationship between the variables in the model.

Table 5: Short-run regressors of the cointegration equation with error correction (dependent variable: RGDP)

Independent variable		Model 1	Model 2	Model 3
Lag order		ARDL (1,1,2,1,2)	NARDL (1,2,2,2,2)	NARDL- ROBUST (1,0,1,0,0,1)
ΔLogPD	Coefficient	-0.197085		-0.249289
	Std. Error	0.032951		0.007890
	<i>p</i> -value*	0.0001		0.0000
ΔLogPD^+	Coefficient		-0.314225	
	Std. Error		0.020303	
	<i>p</i> -value*		0.0000	
$\Delta \text{LogPD}^+(-1)$	Coefficient		-0.019213	
	Std. Error		0.023606	
	<i>p</i> -value*		0.4425	
ΔLogPD^-	Coefficient		1.190489	
	Std. Error		0.059015	
	<i>p</i> -value*		0.0000	
$\Delta \text{LogPD}^-(-1)$	Coefficient		-0.378014	
	Std. Error		0.031391	
	<i>p</i> -value*		0.0000	
ΔLogPDS	Coefficient	-0.035874	0.033469	0.081092
	Std. Error	0.015341	0.005638	0.003640
	<i>p</i> -value*	0.0375	0.0006	0.0000
	Coefficient	-0.052449	0.123767	

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$\Delta \text{LogPDS}(-1)$	Std. Error	0.016441	0.007724	
	p -value*	0.0078	0.0000	
ΔLogCA	Coefficient	0.0116457	0.188474	0.056149
	Std. Error	0.008446	0.009289	0.001512
	p -value*	0.0751	0.0000	0.0000
$\Delta \text{LogCA}(-1)$	Coefficient		0.027471	
	Std. Error		0.004798	
	p -value*		0.0007	
ΔLogGDS	Coefficient	-0.001630	0.338304	0.221967
	Std. Error	0.008889	0.020496	0.004456
	p -value*	0.8576	0.0000	0.0000
$\Delta \text{LogGDS}(-1)$	Coefficient	-0.016309	-0.077018	
	Std. Error	0.007731	0.008814	
	p -value*	0.0566	0.0001	
$\Delta \text{LogGFCF}$	Coefficient			0.130559
	Std. Error			0.005695
	p -value*			0.0000
$EC_{(t-1)}^{**}$	Coefficient	-1.412802	-3.131626	-5.959423
	Std. Error	0.158139	0.130498	0.162929
	p -value*	0.0000	0.0000	0.0000
C	Coefficient	6.537557	13.50430	25.88476
	Std. Error	0.731244	0.562303	0.707908
	p -value*	0.0000	0.0000	0.0000
$DUMMY$	Coefficient	-0.016007	-0.005172	
	Std. Error	0.017515	0.008131	
	p -value*	0.3787	0.5450	

Note: * p -values do not account for model selection; ** Error correction term – EC . Deterministic: C . Due to the introduction of lags, the number of observations is smaller than the original sample (Model 1: 21, Model 2: 20, Model 3: 16).

Source: Author.

To test the direction of causality between RGDP and PD, we applied the Granger causality test (Granger, 1969) (see Table 6).

Table 6: Pairwise Granger Causality Tests

Null hypothesis:	Obs	<i>F</i> -statistic	<i>p</i> -value
<i>LogPD</i> does not Granger cause <i>LogRGDP</i>	20	5.63673	0.0107
<i>LogRGDP</i> does not Granger cause <i>LogPD</i>		1.10189	0.3835

Note: Sample: 2001–2023; Lags: 3.

Source: Author.

According to the *F*-statistic and the *p*-value in Table 6, we cannot reject the hypothesis that RGDP is not a Granger cause of PD, but we do reject the hypothesis that PD is not a Granger cause of RGDP. This means that Granger causality runs in one direction, from PD to RGDP.

5. CONCLUSION AND POLICY IMPLICATIONS

This study examines the relationship between the RGDP and PD of Serbia using the ARDL and NARDL methods. The estimated coefficients using the ARDL approach, which shows the long-run relationship between the observed variables, are not statistically significant. Unlike the ARDL approach, the application of the NARDL methodology gives satisfactory statistical results. The results obtained show that the positive relationship between the reduction in PD and RGDP is stronger than the negative relationship observed between these variables in the case of an increase in PD. This gap confirms that there is a non-linear relationship between PD and RGDP in Serbia. The results are consistent with recent empirical studies that show the existence of a non-linear relationship between the PD of some countries and their economic growth (Gómez-Puig & Sosvilla-Rivero, 2015; Reinhart & Rogoff, 2010).

Public and publicly guaranteed debt service (% of GNI) increased from 1.6% in 2010 to 6.7% in 2019. The growth of this burden is the result of the accumulation of public external debt and the rise in interest rates on the international capital market. Our results suggest that the government needs to plan for higher fiscal reserves, which would act as a shock absorber in the event of a sudden rise in international interest rates.

The limitation of the research in this paper is reflected in the fact that the directions of consumption expenditure based on PD (structural budget) have not been taken into account. This is a recommendation for future research. In addition, future research could investigate the channels through which PD growth affects real GDP, taking into account the macroeconomic performance of the country. If PD is used for public investment (infrastructure, environmental protection, energy sector, education) the increase in PD could have a positive effect on economic growth (Furceri et al., 2018). However, if the increase in PD is used for non-investment expenditures or investments that do not generate new production or the export of goods and services, the impact on GDP may be different.

The recommendation for policymakers is that caution should be exercised with regard to additional public borrowing for several reasons. Firstly, the scope for forced additional borrowing due to a possible unexpected development in the global market as a result of global geopolitical fragmentation should be preserved. The rise in imported energy prices could be a reason for additional public borrowing. The risk of a sudden rise in interest rates on the global market could then further increase the country's debt burden. The fact that the increase in the burden of servicing PD could tighten the country's fiscal policy (tax increases), which would have a negative impact on economic growth, should also be taken in account. It should also be noted that the country has a significant presence of foreign capital, and any disruption in the international capital markets could trigger the withdrawal of this capital, which would put considerable pressure on the exchange rate. An important policy implication of these findings is that high PD could be a limiting factor in stabilising the country's macroeconomic performance. This should be considered when determining the future level of public debt. One of the possible consequences of excessive public borrowing must not be forgotten. Namely, if the long-run interest rates on the PD (r) are higher than the output growth rate (g), an increasing proportion of GDP will have to be used to service the public debt.

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APPENDIX

Table A1: Unit root test with breakpoints (Augmented Dickey–Fuller test)

Variable	At levels		At first difference		Inference
	<i>t</i> -statistics	Break date	<i>t</i> -statistics	Break date	
LogRGDP	-6.067661*	2009	-7.077820*	2009	I(0)
LogPD	-3.534193	2008	-5.658729*	2008	I(1)
LogPDS	-3.235420	2009	-5.628136*	2017	I(1)
LogCA	-4.288563**	2014	-5.303265*	2008	I(1)
LogGDS	-6.195839*	2012	-6.882583*	2007	I(0)
LogFDI	-5.061282*	2011	-7.843691*	2006	I(0)
LogGFCF	-4.459348**	2016	-4.981261*	2009	I(1)

Notes: * Indicates significance at the 1% level (rejecting the null hypothesis, $H_0 - Has a unit root$); ** Indicates significance at the 5% level; *** Indicates significance at the 10% level. Break selection: Minimise Dickey–Fuller *t*-statistics; Lag length: Automatic – based on Schwarz information criterion, maxlag=4. Break selection: Minimise Dickey–Fuller *t*-statistics. Break in the intercept and trend.

Source: Author.

Table A2: Descriptive statistics of the variables used in the applied models

	Mean	Median	Maximum	Minimum	Std. Dev.	Skewness	Kurtosis	Jarque–Bera	Probability
LogRGDP	4.641719	4.649134	4.691096	4.577250	0.030438	-0.407530	2.282836	1.129963	0.568371
LogPD	3.867240	3.939638	4.475062	3.165475	0.305560	-0.604625	3.210312	1.443743	0.485842
LogPDS	0.688666	0.867121	1.860531	-1.074061	0.824865	-0.342321	2.233764	1.011858	0.602945
LogCA	1.812525	1.785070	2.966018	0.875469	0.578904	0.226910	2.370721	0.576858	0.949440
LogGDS	1.964067	1.726602	2.843666	0.753674	0.690117	-0.279763	1.884475	1.492572	0.472224
LogFDI	1.731316	1.869633	2.549445	0.262364	0.499448	-1.060271	4.493159	6.445961	0.039836
LogGFCF	2.939579	2.957733	3.174553	2.470668	0.177502	-0.621615	3.207031	1.522295	0.467130

Source: Author.