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National Fiscal Rules, Maastricht Fiscal Criteria and Non-linear Public Debt Dynamics in Serbia

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ABSTRACT

The aim of the paper is to assess the reaction of fiscal policymakers in Serbia when the public debt-to-GDP ratio is above the 45% limit set in the national fiscal rules. The paper proposes a two-regime nonlinear self-exciting threshold autoregressive (SETAR) model as an appropriate econometric framework for modeling the asymmetries in the dynamics of the public debt/GDP ratio with respect to the 45% public debt limit. The empirical evidence suggests that fiscal policymakers in Serbia do not adhere to the 45% public debt/GDP ceiling and instead use the Maastricht limit of 60% as a target reference point for public debt management. The article contributes to the current policy debate by providing empirical evidence to support the claim that the behavior of fiscal policymakers in Serbia between 2001Q1 and 2023Q2 could jeopardize the credibility of fiscal policy and increase the probability of default by the Serbian government on its maturing public debt.

Keywords: *national fiscal rules, Maastricht fiscal criterion, SETAR model, fiscal crisis*

JEL Classification: H12, H63

INTRODUCTION

In the second quarter of 2008, the public debt of the Republic of Serbia amounted to around 25 percent of GDP. Primarily as a result of the Great Recession, public debt soared to around 70% of GDP at the beginning of 2015. The ratio of public debt to GDP in Serbia recorded the fastest increase among all emerging economies in Central, Eastern and South-Eastern Europe (Andric and Minovic, 2022). The escalating dynamics of public debt in Serbia have violated both the national fiscal rule limit of 45% public debt/GDP and the upper limit of 60% public debt/GDP from the Maastricht fiscal criteria. The described fiscal trends could have a negative impact on both economic growth (OECD, 2015), the probability of default (Badia et al., 2022) and the credibility of fiscal policy (Davoodi et al, 2022) in Serbia. Therefore, the aim of this paper is to assess the reaction of fiscal policymakers in Serbia when the public debt-to-GDP ratio is above the 45% limit set in the national fiscal rules. The paper proposes a two-regime nonlinear self-exciting threshold autoregressive (SETAR) model as an appropriate econometric framework for modeling the asymmetries in the dynamics of the public debt/GDP ratio with respect to the 45% public debt limit. The empirical evidence suggests that fiscal policymakers in Serbia do not adhere to the 45% public debt/GDP ceiling and instead use the Maastricht limit of 60% of public debt/GDP as a target reference point for public debt management.

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Although the institutional fiscal framework of the European Union (EU) is based on the general government debt limit of 60% of GDP and the overall deficit limit of 3% of GDP, as established by the Maastricht Treaty (1992), the Stability and Growth Pact (1997) and the Fiscal Compact (2012), these supranational agreements still leave room for unsustainable fiscal practices at the national level. This is because many of the discretionary fiscal tools and instruments are delegated to the member state level, which is not the case for monetary policy within the European Monetary Union (EMU), for example. The heterogeneity of fiscal policy rules and objectives is also notable in the case of Serbia, even though Serbia is not an official EU member state. For example, the general fiscal rules in Serbia include the public debt-to-GDP ratio ceiling of 45% and the overall deficit ceiling of 1% (Fiscal Council, 2024). The stricter general national fiscal rules have some justification in economic theory and practice, as the probability of sovereign default in emerging and developing countries occurs, on average, at lower levels of public debt (Badia et al., 2022). From the point of view of fiscal sustainability and the credibility of national fiscal institutions, it is important to assess the behavior of public debt in relation to GDP given the 45% public debt threshold, especially since Glavaski and Beker Pucar (2020) argue that the process of EU accession does not necessarily lead to greater fiscal prudence in the case of five Western Balkan economies from 1995-2018.

The article is structured as follows: Section 2 familiarizes the reader with the main contributions to modeling asymmetries in sovereign debt dynamics.[1] Section 3 describes the dataset, presents key stylized facts, and proposes an econometric methodology that is most consistent with the underlying trends in the public debt-to-GDP ratio relative to the national fiscal rule limit of 45%. Section 4 presents and discusses the results of the analysis in detail. Section 5 outlines policy recommendations that are consistent with prudent debt targets, macroeconomic stabilization measures and countercyclical fiscal management in an environment of adverse economic shocks.

RELATED LITERATURE

One of the first contributions to model the asymmetries in the dynamics of the public debt/GDP ratio is Sarno (2001). Sarno (2001) uses an exponential smooth transition autoregressive (ESTAR) model to describe the dynamics of the US government debt/GDP ratio between 1916 and 1995. The results of Sarno (2001) provide an empirical justification for a nonlinear mean-reversion behavior for the US public debt/GDP ratio in a symmetric fashion, i.e., the larger the deviation of the public debt/GDP ratio from its mean, the larger the magnitude of the nonlinear fiscal correction towards the mean value of the public debt/GDP.

Considine and Gallagher (2008) apply the same econometric methodology as Sarno (2001) to model a non-linear mean-reversion in the dynamics of the UK's public debt/GDP ratio for the period 1919-2001. The estimated ESTAR model of Considine and Gallagher (2008) provides evidence in favor of the active debt management hypothesis, i.e., it provides evidence against the tax smoothing hypothesis of Barro (1979).[2]

In contrast to Sarno (2001) and Considine and Gallagher (2008), Legrenzi and Milas (2011) use a logistic smooth transition autoregressive (LSTAR) model for the public debt time series of

[1] I will use the terms government debt, public debt and sovereign debt interchangeably throughout the text. In each case, government debt is measured as the ratio of total central government debt to GDP. Note that central government debt in Serbia is roughly equal to general government debt, as local government debt is relatively low. See Koczan (2015) for details.

[2] Barro (1979) argues that governments try to smooth taxes in order to reduce the overall burden on taxpayers. As a consequence of the government's assumed objective function, the tax/GDP ratio and the public debt/GDP behave like random walks. The active debt management hypothesis, on the other hand, states that discretionary fiscal policy measures turn public debt into a mean-reverting stationary stochastic process.

Portugal, Ireland, Italy, Greece and Spain (PIIGS). Legrenzi and Milas (2011) opted for the LSTAR specification instead of the ESTAR specification due to the asymmetric transition function of the LSTAR model: the size of the fiscal correction towards the mean value of public debt/GDP varies depending on whether the current debt value is below or above the estimated threshold. The results of Legrenzi and Milas (2011) provide evidence of fiscal sustainability in the PIIGS economies, although the authors express certain concerns about the sustainability of Italian and Greek public finances.

The aforementioned studies used smooth transition autoregressive (STAR) models to capture non-linearities in the dynamics of public debt/GDP. On the other hand, Gnegne and Jawadi (2013) model the asymmetries in the public debt/GDP ratio using a SETAR model specification. The SETAR model, unlike the ESTAR and LSTAR smooth transition specifications, uses a discrete transition function to capture regime shifts. Using the SETAR modeling framework, Gnegne and Jawadi (2013) find nonlinear mean reversion of a discrete nature in the cases of the US and the UK after the collapse of Bretton Woods.

Cuestas and Regis (2018) focus on the case of China. The results of Cuestas and Regis (2018) urge caution regarding the sustainability of public finances in China after 2014. Since the empirical framework chosen by the authors focuses on nonlinear unit root tests, Cuestas and Regis (2018) do not report endogenously determined thresholds for public debt that characterize asymmetries in fiscal policy.

Finally, Cuestas (2019) applies several structural break procedures to examine fiscal sustainability in Central and Eastern Europe before and after the Great Recession. The study by Cuestas (2019), which comes closest to this study in terms of geographical and temporal coverage, distinguishes between two types of economies: countries that managed to stabilize their public debt-to-GDP ratio after 2008 and those where fiscal sustainability may be at risk, with a particular emphasis on Croatia, Lithuania, Romania and Slovenia. Although the structural break tests of Cuestas (2019) correctly identify the timing of the structural break due to the Great Recession, it is worth noting that tests for structural breaks using dummy variables are not very meaningful when the data are generated by a threshold process (Carrasco, 2002). A test for a threshold process using a lagged dependent variable as the threshold variable is able to detect both threshold behavior and structural changes. Carrasco (2002) therefore recommends using the threshold model as a general test for parameter instability.

In light of the above literature review, this paper makes two potential contributions to the study of the asymmetric behavior of public debt relative to GDP. First, we focus in great detail on an emerging small open economy from the Western Balkans, while other related studies, with the exception of the study by Cuestas (2019) to a certain extent, focus on developed and large economies. Second, while previous papers use long annual time series data sets, this paper focuses on a specific period of economic transition, the Great Recession and the COVID-19 pandemic at quarterly business cycle frequency, which allows the model estimates to be readily used by researchers and policymakers for fiscal policy tracking and forecasting.

DATA AND METHODOLOGY

Due to data availability, the beginning of the sample (2001Q1) corresponds to the beginning of political and market reforms in Serbia in the early 2000s. The end of the sample (2023Q2) marks the end of the COVID-19 pandemic officially announced by the World Health Organization (WHO).[3] Public debt data is taken from the monthly Public Finance Bulletin published by the

[3] The WHO announced the end of the global COVID-19 pandemic in May of 2023.

Ministry of Finance of the Republic of Serbia, while GDP data is taken from the Statistical Office of the Republic of Serbia.[4]

Figure 1 shows the dynamics of the public debt-to-GDP ratio in Serbia for the period 2001Q1-2023Q2. It also shows the fixed 45% ratio of public debt/GDP, which corresponds to the national fiscal rule, and the fixed 60% ratio of public debt/GDP, which results from the Maastricht fiscal criteria. From Figure 1, the reader can see that between 2001Q1 and 2008Q2, the public debt/GDP ratio in Serbia declined sharply due to debt relief programs approved by international creditors and strong economic growth driven by domestic absorption. From 2008Q2 to 2014Q4, Serbia's public debt ratio recorded extraordinary growth of around 45 percentage points.[5] In 2012Q1, the public debt/GDP ratio breached the 45% public debt-to-GDP threshold of the national fiscal rules, while in 2014Q2 it breached another 60% ceiling from the Maastricht fiscal criteria. In early 2015, the Serbian government launched a three-year fiscal consolidation program, which resulted in the public debt-to-GDP ratio falling below 60% of GDP again in early 2018.

From 2018 until the end of the sample, the public debt-to-GDP ratio in Serbia remained below 60% of GDP, even during the COVID-19 pandemic, but it never returned below the 45% threshold set in the national fiscal rules. Overall, Figure 1 shows that the dynamics of the public debt/GDP ratio exhibit a pronounced non-linear pattern with several structural breaks in the trend function, stabilizing around the 60% public debt/GDP threshold towards the end of the sample.

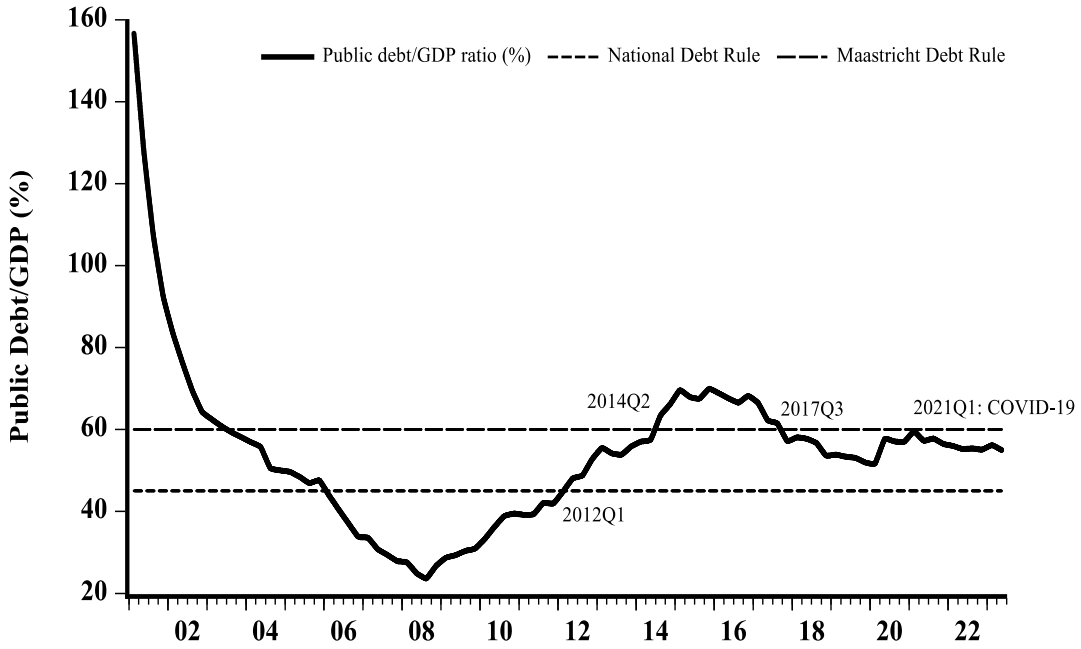

Figure 1. The Dynamics of Public Debt/GDP ratio in Serbia, 2001Q1-2023Q2.

Source: Author's calculations.

To complement the results from Figure 1, Table 1 contains autocorrelation and partial autocorrelation coefficients for the public debt/GDP ratio up to 11 quarters. The number of lags is taken from Schwert (1989), who recommends that the number of lags should be equal to $lags =$

[4] Various issues of the Public Finance Monthly Bulletin are publicly available and can be downloaded from https://www.mfin.gov.rs/en/activities/bulletin-public-finance-2. The data for the quarterly nominal GDP according to the expenditure approach (SNA 2008/ESA 2010 methodology) are publicly available and can be downloaded in Excel format from the National Accounts database.

[5] For a more comprehensive overview of the underlying fiscal and macroeconomic trends, see Andric and Minovic (2022).

$[12 \times ((T+1)/100)^{0.25}]$, where T (T=89) is the sample size and $[\cdot]$ denotes the floor function. The analysis of the autocorrelation and partial autocorrelation functions from Table 1 shows that the government debt/GDP ratio exhibits very persistent behavior with a partial first-order autocorrelation coefficient of 0.82 and an associated 95% ($1.96/\sqrt{T}$) confidence interval of [0.61, 1.03].

Since the upper 95% confidence interval for the first-order autocorrelation coefficient includes a unit root, Table 2 shows the results of the unit root tests by Elliott et al. (1996) and the results of the stationarity test by Kwiatkowski et al. (1992). The results from Table 2 overwhelmingly support the notion that the public debt/GDP ratio in Serbia is better characterized as a persistent stationary AR(1) process rather than an AR(1) process with a unit root.

It is important to emphasize some statistical points in relation to the results from Table 2. First, the choice of a particular set of deterministic components determines to a considerable extent the power of the unit root test (stationarity test) in question. Consequently, and given the dynamics of the public debt/GDP ratio from Figure 1, both a constant and a linear time trend are included when performing the tests from Table 2 for the levels of the public debt/GDP ratio. Similarly, in the case of first-differenced debt, which approximates the value of the overall fiscal balance corrected for stock-flow discrepancies, only an intercept term is used. Second, as Chortareas et al. (2008) emphasize, the particular choice of a non-linear alternative hypothesis also influences the power of the respective unit root test. Since this paper is concerned with testing the null hypothesis of a unit root against the alternative of a non-linear mean reversion, the natural choice for an alternative hypothesis would be to use regression specifications with (a)symmetric fit as defined in Enders and Granger (1998).

Table 1. Autocorrelations & partial autocorrelations for public debt/GDP ratio

Lags	1	2	3	4	5	6	7	8	9	10	11
B_t	0.82	0.69	0.60	0.52	0.45	0.40	0.35	0.31	0.27	0.23	0.18
	0.82	0.04	0.04	0.03	0.01	0.00	0.01	0.01	-0.01	-0.02	-0.02
	63.30	108.5	142.2	168.2	188.3	203.8	215.9	225.5	232.9	238.2	241.8
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)

Notes: Author's calculations. First cell entry: autocorrelation coefficient; second cell entry: partial autocorrelation coefficient; third cell entry: Ljung-Box portmanteau Q-statistics for the null hypothesis that there is no autocorrelation up to the prespecified lag; fourth cell entry: p-values associated with the Ljung-Box Q-statistics.

Note, however, that Enders (2001) reports that the traditional Dickey-Fuller unit root test of Dickey and Fuller (1981) has higher power than the unit root tests proposed by Enders and Granger (1998). The problem, however, with the Dickey-Fuller unit root test is that it has low power in the case of AR(1) processes with an AR(1) coefficient close to one. Following the recent recommendations of Bec et al. (2022) regarding the choice of unit root tests in the case of very persistent AR(1) processes, the analysis in this paper focuses on the unit root tests proposed in Elliott et al. (1996). The maximum number of lags in both tests is set to 11, as in Table 1. The optimal number of lags in both tests is based on the modified AIC criterion (MAIC) of Ng & Perron (2001), while the estimation of the long-run variance is done using AR spectral GLS detrending. Third, according to Bohn (2007), stationarity is the most important econometric condition if one is interested in analyzing nonlinear fiscal adjustments given the public debt-to-GDP ceiling, The results of the stationarity test of Kwiatkowski et al. (1992) are also reported, where Andrews's bandwidth for the truncation lag and the quadratic spectral kernel for estimating the long-run variance are used (the results are robust when opting for the Bartlett kernel and the Newey-West bandwidth). In summary, the results of the KPSS test complement the results of the unit root tests of Elliott et al. (1996) by rejecting the unit root type behavior of the government debt/GDP ratio in Serbia from 2001Q1 to 2023Q2.

Although the results of the unit root and stationarity tests from Table 2 are consistent with the finding that the shocks to the government debt/GDP ratio are transitory in nature, they are linear and do not provide much insight into the nonlinear behavior of the public debt/GDP ratio for the period in question. To test for the presence of potential nonlinearities in the behavior of government debt/GDP, Table 3 contains the results of Tsay's (1989) nonlinearity test. The essence of the test is to compare the null hypothesis of linear autoregressive behavior with the alternative of the SETAR-type behavior. The rows of Table 3 correspond to a lag (*d*) at which the threshold change potentially occurs, while the columns of the table correspond to an autoregressive order (*p*) whose maximum value is set to four (*p=4*) since quarterly data are analyzed. Each of the entries in the table corresponds to a particular *F*-statistic (*p*-values in [ ]) from the corresponding autoregression with an intercept term as the only deterministic component. From Table 3, the reader can see that the highest value of the *F*-statistic (the lowest *p*-value) is for the rejection of the null hypothesis of a linear AR(1) process versus the alternative of a SETAR (2, 1, 1) behavior for the case *p*=*d*=1. In other words, the statistical evidence supports the rejection of the linear AR(1) process with a constant in favor of a nonlinear SETAR (2, 1, 1) process with level shifts.[6]

Table 2. Unit root and stationarity tests for public debt/GDP ratio $\boldsymbol{B_t}$ and $\Delta\boldsymbol{B_t}$

Series/Test	DF-GLS	ERS	KPSS	Result
B_t	-1.43	235.72***	0.11	**I(0)**
ΔB_t	0.09***	127.95***	0.44*	**I(0)**

*Notes: Author's calculations. *** 1% significance level, ** 5% significance level, * 10% significance level. Unit root test regressions include a constant and linear time trend for levels, and only a constant for the first difference. The maximum number of lags in test regressions is 11, according to the Schwert (1989) criterion. The optimal number of lags in test regressions determined by the MAIC criterion of Ng & Perron (2001) for DF-GLS and ERS unit root tests of Elliott et al. (1996), and by Andrews's bandwidth for the KPSS stationarity test of Kwiatkowski et al. (1992). The long-run variance estimation method is AR spectral GLS detrending in the case of DF-GLS and ERS unit root tests, and quadratic spectral kernel in the case of KPSS stationarity test.*

Given the results of Tsay's (1989) nonlinearity test, this paper presents estimates for the SETAR (2, 1, 1) model specification with an exogenously imposed public debt-to-GDP threshold of 45%, which represents the current upper bound of national fiscal rules on the dynamics of public debt-to-GDP. In particular, following Bai & Perron (2003), equation (1) is estimated via conditional least squares

$$B_t = \begin{cases} \phi_0^{(1)} + \phi_1^{(1)} B_{t-1} + \varepsilon_t^{(1)} & B_{t-1} \leq 45\% \\ \phi_0^{(2)} + \phi_1^{(2)} B_{t-1} + \varepsilon_t^{(2)} & 45\% < B_{t-1.} \end{cases} \qquad (1)$$

The estimated SETAR (2, 1, 1) specification from equation (1) implies the existence of two regimes for the government debt/GDP dynamics: one above the 45% ceiling and the other below the 45% public debt/GDP ratio. Note that the exogenous 45% public debt/GDP limit is motivated not only by national fiscal rules, but also by the economic considerations of Badia et al. (2022), who find a higher probability of default for emerging markets when public debt exceeds 40% of GDP. Given the threshold, the public debt/GDP ratio in each of the regimes follows an AR(1) process, which is captured by the regime-specific parameters $\phi_1^{(1)}$and $\phi_1^{(2)}$. In addition, the model contains regime-specific intercept terms $\phi_0^{(1)}$ and $\phi_0^{(2)}$, which represent the mean levels around

[6] Tsay (1989) does not consider linear time trends in the construction of his test statistics. However, one could linearly detrend the original data on public debt relative to GDP and then perform Tsay's (1989) test on the residual values of such a regression. As for the robustness of the results presented in Table 3, the results do not change in the case of this study.

which the stationary public debt/GDP series fluctuates. The regime-specific independently and identically distributed (i.i.d) residual values with zero mean are denoted by $\varepsilon_t^{(1)}$ and $\varepsilon_t^{(2)}$, respectively. Finally, the lag parameter (d) for the threshold variable is set to one, so that the threshold switching occurs in B_{t-1} which further implies that the public debt/GDP ratio values from the previous quarter have the greatest statistical impact on the contemporaneous dynamics of the public debt/GDP ratio, (B_t), as noted in Table 3.

Table 3. Tsay's non-linearity test

p/d	**1**	**2**	**3**	**4**
1	**31.55 [0.00]**	-	-	-
2	4.13 [0.01]	1.95 [0.13]	-	-
3	2.05 [0.09]	1.20 [0.32]	0.16 [0.96]	-
4	1.93 [0.10]	1.49 [0.20]	0.77 [0.58]	0.80 [0.57]

Notes: Author's calculations. Tsay's (1989) "arranged" autoregressions include only a constant term. p-AR order; d-delay parameter. Table entries correspond to Tsay's (1989) F-statistics, while [ ] denotes corresponding p-values

RESULTS AND DISCUSSION

Table 4 shows the estimates of equation (1). The estimated values for the parameters $\phi_1^{(1)}$and $\phi_1^{(2)}$ are 0.99 and 0.74, respectively. The estimated values for the parameters $\phi_1^{(1)}$ and $\phi_1^{(2)}$ imply that the underlying SETAR (2, 1, 1) process is ergodic and globally stationary. Both estimates are statistically significant at the 1% significance level.[7] The reader should focus on a value of 0.99 for $\hat{\phi}_1^{(1)}$which is close to a unit root, with a 95% confidence interval of [0.79, 1.19], allowing for the possibility of both unit-root and explosive-root in the stochastic process for public debt.[8]

Even at a significance level of 10%, the result of the Wald coefficient restriction test (p=0.93 for the $\chi^2(1)$ test statistic) cannot reject unit root type behavior for government debt below the threshold of 45% for government debt/GDP, i.e., the results are consistent with the hypothesis that $\hat{\phi}_1^{(1)} = 1$. This finding is consistent with the tax smoothing hypothesis of Barro (1979), which

[7] The results do not change if we allow the error distributions to differ across the 45% public debt/GDP threshold, as in Bai and Perron (2003). Since the residuals of equation (1) show a slight autocorrelation, the standard errors are corrected according to the Newey-West correction with the quadratic spectral kernel for the long-run covariance matrix estimate, along with the Andrews's bandwidth for lag truncation and single pre-whitening lag.

[8] Theorem 2.1. by Petrucelli and Woolford (1984) states the following necessary and sufficient condition for the ergodicity and global stationarity of the SETAR (2, 1, 1) process: $\phi_1^{(1)}$ <1, $\phi_1^{(2)}$ <1 and $\phi_1^{(1)}\,\phi_1^{(2)} < 1$. See also Theorem 2.1. in Chan et al. (1985) for conditions including a SETAR model with an intercept term. Moreover, Theorems 3.1. and 3.2. from Petrucelli and Woolford (1984) and Chan et al. (1985) imply that if conditions for ergodicity and global stationarity are satisfied, then the coefficient estimates $\hat{\phi}_1^{(1)}$ and $\hat{\phi}_1^{(2)}$are consistent and asymptotically normally distributed. More importantly, in the case of a known exogenous threshold, González and Gonzalo (1997) report that the coefficient estimates $\hat{\phi}_1^{(1)}$and $\hat{\phi}_1^{(2)}$ are consistent and asymptotically normally distributed *even* in the case of the self-exciting threshold unit root (SETUR) model which allows for a possibility of a unit root in one of the regimes (partial unit root), given that conditions of Theorem 2.1. from Chan et al. (1985) are satisfied. Finally, Hansen (2017) treats the US sovereign debt/GDP ratio after World War II as near-unit root, but globally ergodic and stationary, stochastic process, consistent with the approach taken in this paper.

postulates that there is no "target" value for the public debt/GDP ratio. Instead, the government debt/GDP ratio moves randomly in line with movements in transitory government spending and cyclical output shocks. The government debt/GDP ratio essentially "mimics" the random behavior of the tax/GDP ratio - the government sets the tax rate to smooth the overall tax burden over time, but GDP shocks lead to unpredictable behavior of tax dynamics.

Although the statistical evidence cannot refute the notion of a unit root in the dynamics of the public debt/GDP ratio below the 45% threshold, this result seems unlikely for several reasons. First, due to political frictions, it is questionable whether governments smooth taxes over time to reduce the overall tax burden. Roubini and Sachs (1989) were the first to argue against optimal intertemporal optimizing behavior of governments due to problems related to political fragmentation, coalition management, and the expected tenure of governments in OECD countries after 1973. One could reasonably assume that these political considerations are only more pronounced in relatively young market economies such as Serbia's. For example, Arsic et al. (2017) find that governments in Central and Eastern Europe tended to engage in pre-election fiscal manipulation prior to the Great Recession, which is inconsistent with Barro's (1979) tax-smoothing approach and unit-root type public debt/GDP behavior. Second, the idea that the public debt/GDP ratio contains a unit root would mean that a) given enough time, the public debt could break through any ceiling with probability one and b) the variance of the public debt/GDP ratio approaches infinity over time. Such behavior is difficult to reconcile with documented fiscal developments in both advanced and emerging economies (Jiang et al., 2024). Instead, one can observe in the data that arbitrarily high ratios of public debt-to-GDP are followed by either a) market reactions of government bonds b) fiscal consolidations; c) financial repression; and d) accelerating inflation, as Jiang et al. (2024) document.

The explosiveness of public debt in relation to GDP ($\hat{\phi}_1^{(1)} > 1$) below the 45% threshold also seems unlikely for both economic and econometric reasons. On economic grounds, one would expect to find an explosive ($\hat{\phi}_1^{(2)} > 1$) root in the upper regime (above the 45% threshold) consistent with the fiscal fatigue hypothesis of Ghosh et al. (2013). The fiscal fatigue hypothesis of Ghosh et al. (2013) implies that above a certain public debt/GDP threshold sovereign debt becomes explosive because the government is incapable of further increasing primary fiscal balances in order to finance current interest expenses and consequently stabilize public debt/GDP ratio. On a related issue, there is an economic rationale that the public debt/GDP ratio could exhibit *mildly explosive* behavior in some periods of the sample under study, but one would expect to find such public debt behavior during wars (Yoon, 2012; Esteve and Prats, 2023) and economic downturns (Creel et al., 2023), i.e., during periods of escalating public deficits and debts at public debt/GDP ratios above the 45% threshold.

On econometric grounds, the explosiveness of public debt in relation to GDP ($\hat{\phi}_1^{(1)} > 1$) below the 45% threshold would imply that past shocks to the public debt/GDP ratio have an increasingly stronger influence on the current dynamics of the public debt/GDP ratio. For example, an exogenous shock to the public debt/GDP ratio due to the Great Recession in 2008Q2 would have an increasing impact on current public debt/GDP ratio values over time.[9] As Figure 1, Table 1 and Table 2 show, there is no evidence of such behavior in the sample examined in this study.[10]

The exclusion of a potential unit root as well as an explosive root in the case of the coefficient $\hat{\phi}_1^{(1)}$ implies that the government debt/GDP ratio below the 45% threshold exhibits behavior close to a unit root, which is consistent with the theoretical predictions of Aiyagari et al. (2002) and

[9] Explosive roots are usually a feature of macroeconomic time series during hyperinflations. Evidence for this can be found in Juselius and Mladenovic (2002).

[10] If an underlying time series exhibits explosive behavior, than differentiating the series does not eliminate the stochastic trend (Juselius and Mladenovic, 2002). This is not the case with the public debt/GDP ratio in Serbia between 2001Q1 and 2023Q2, as the reader can see from Figure 1 and Table 1.

Bhandari et al. (2017). Aiyagari et al. (2002) claim that the behavior of the public debt/GDP ratio close to the unit root is a consequence of incomplete markets in the sense that governments cannot issue state-contingent debt, which imputes, consequently, a relatively high degree of persistence in the dynamics of sovereign debt.[11] The persistence of public debt dynamics is directly and proportionally related to a) higher persistence and volatility of government spending shocks and b) debt limits imposed on governments.[12]

Table 4. SETAR (2, 1, 1) model for public debt/GDP with exogenous 45% threshold

Regressors	***Coefficients***	***Standard errors***	$t-stat$
$B_{t-1} \leq 46.87$ $(N_1 = 25)$			
c	0.57	4.37	0.13
B_{t-1}	0.99***	0.13	7.36
$46.87 < B_{t-1}$ $(N_2 = 64)$			
c	14.74***	1.29	11.39
B_{t-1}	0.74***	0.02	42.91

*Notes: Author's calculations. *** 1% significance level, ** 5% significance level, * 10% significance level for t-statistics with heteroscedasticity and autocorrelation (HAC) standard errors and heterogeneous error distributions across 45% public debt/GDP threshold from Bai and Perron (2003). B_t: dependent variable (public debt as % of GDP). B_{t-1}: threshold variable. N_1: number of observations below the fixed 45% public debt/GDP threshold. N_2: number of observations above the fixed 45% public debt/GDP threshold.*

Both features could be important in assessing the fiscal policy stance in Serbia, as a) government spending is more volatile in emerging markets (Koczan, 2015); and b) international creditors and investors, who hold a large share of Serbia's foreign currency-denominated sovereign debt, could impose additional public debt ceilings on policymakers to protect the market value of their bond holdings (Koczan, 2017).

The estimated value for the parameter $\phi_1^{(2)}$, $\hat{\phi}_1^{(2)}$, that denotes the AR(1) coefficient in the upper regime, equals 0.74 and is statistically different from $\hat{\phi}_1^{(1)}$ at the significance level of 10% (p=0.06 for the $\chi^2(1)$ test statistic) according to the results of the Wald coefficient restriction test. The estimated coefficient $\hat{\phi}_1^{(2)}$ implies a lower persistence in the upper regime above the 45% public debt/GDP threshold. This result is to some extent consistent with the theoretical predictions of Blanchard (1990) and Sutherland (1997).[13] Although the models in Blanchard (1990) and Sutherland (1997) imply a consolidation of public debt, the empirical evidence in this paper shows that the government failed to stabilize public debt at 45% of GDP after exceeding the national fiscal rule. In fact, from the upper regime estimates presented in Table 4, the reader can deduce that the long-term target for the public debt-to-GDP ratio is 14.74/(1-0.74)=56.7 percent, which is slightly below the 60% target for the public debt-to-GDP ratio defined in the Maastricht fiscal criteria. Figure 2 and Figure 3 below provide further evidence for this assertion. In particular, Figure 2 shows the residual values of the public debt/GDP ratio (y-axis) from an AR(1)

[11] Bhandari et al. (2017) relax the unrealistic assumption of Aiyagari et al. (2002) that the government can only trade in riskless securities and investigate optimal fiscal policy in a more general setting of incomplete markets. However, their results also imply an ergodic but highly persistent stochastic process for government debt.

[12] Aiyagari et al. (2002) define two debt limits: 1) a natural debt limit, which is a maximum debt limit that a government can almost certainly repay under an optimal fiscal policy, and 2) an ad hoc debt limit, which is always stricter than the natural debt limit.

[13] Blanchard (1990) develops a theoretical framework in which the government runs a deficit so that the national debt increases. When public debt reaches a certain level, the government raises taxes to stabilize the ratio of government debt to GDP. Sutherland's (1997) model is a stochastic version of Blanchard's (1990) model with similar policy prescriptions.

autoregression of the form $B_t = c + B_{t-1} + e_t$ as a function of B_{t-1}(x-axis), a one-quarter lagged sovereign debt/GDP ratio. Note that AR(1) autoregression in question is identical to our preferable Tsay's (1989) arranged autoregression from Table 3. From Figure 2 it is evident that the residual values of sovereign debt/GDP ratio cluster around the threshold value of approximately 60%.

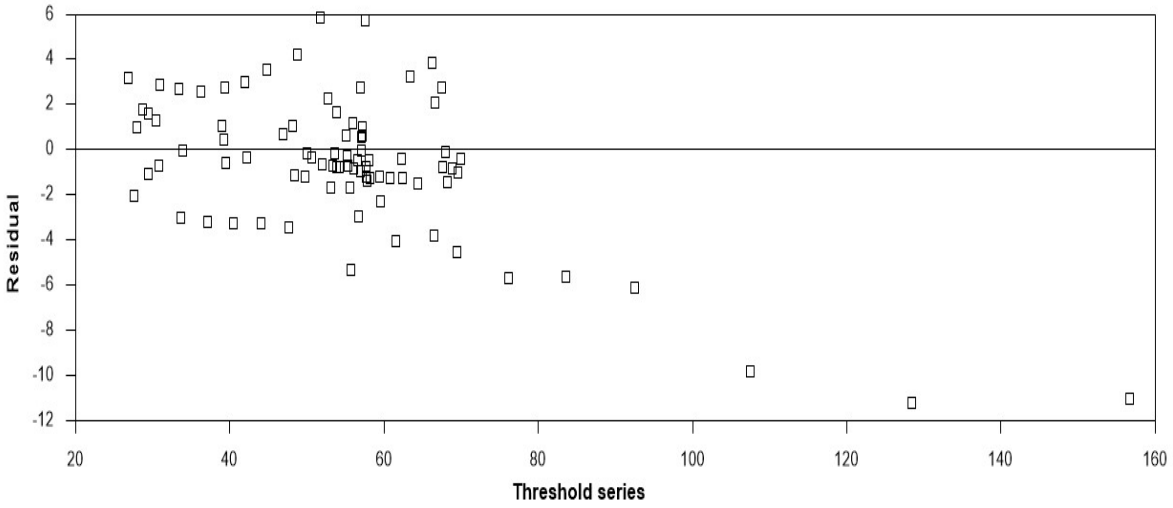

Figure 2. Scatter Plot from Tsay "arranged" autoregression $\boldsymbol{B_t = c + B_{t-1} + e_t}$. y-axis: residuals from the AR(1) autoregression. x-axis: lagged public debt/GDP ratio.

Source: Author's calculations.

Consistent with Figure 2, Figure 3 depicts standardized values of cumulative sums of recursive residuals (CUSUM) on the y-axis as a function of time (x-axis) from the estimated SETAR (2, 1, 1) model presented in Table 4.[14] The bold line on the graph plots the values of the CUSUM test statistics of Durbin et al. (1975). The dashed lines from Figure 3 correspond to the 5% significance level lines computed by connecting the points $\left[k, \pm -0.948(T-k)^{1/2}\right]$ and $\left[T, \pm 3 \times 0.948(T-k)^{1/2}\right]$ where k denotes the number of estimated coefficients and T denotes the sample size.

The recursive residuals from Figure 3 convey three important messages. First, the estimated coefficients show signs of instability from 2008Q2 onwards, corresponding to the arrival of the global financial crisis in Serbia. Second, the CUSUM test statistic breaks the 5% significance line in 2011Q4-2012Q1, corresponding to a quarter in which the public debt/GDP ratio exceeded the 45% threshold of the national fiscal rules for the public debt/GDP ratio. Third, the observed coefficient instability continues across the entire sample and only slowly returns to the area of coefficient stability represented by two dashed lines. Overall, the results from Figure 3 are consistent with our earlier conclusion that fiscal policymakers in Serbia are not complying with the 45% public debt to GDP limit, which could jeopardize the credibility of fiscal policy in the eyes

[14] The recursive least squares method involves repeated estimation of the relevant regression equation using larger and larger subsets of the sample data. If the number of coefficients in the regression equation is *k*, then the first *k* observations are used to produce the first estimate of the coefficient vector. Then the next observation is added, and *k+1* observations are used to create the second estimate of the coefficient vector. The process continues until the end of the sample *T* is reached, resulting in *T-k+1* estimates of the coefficient vector. At each step, the last estimate of the coefficient vector can be used to predict the next value of the dependent variable. The one-step-ahead forecast error, divided by its standard deviation, represents a recursive residual. Consequently, the standardized values of the recursive residual sums correspond to the recursive residual sums divided by their respective standard deviations.

of sovereign bond investors, creditors and international financial institutions (Davoodi et al., 2022).

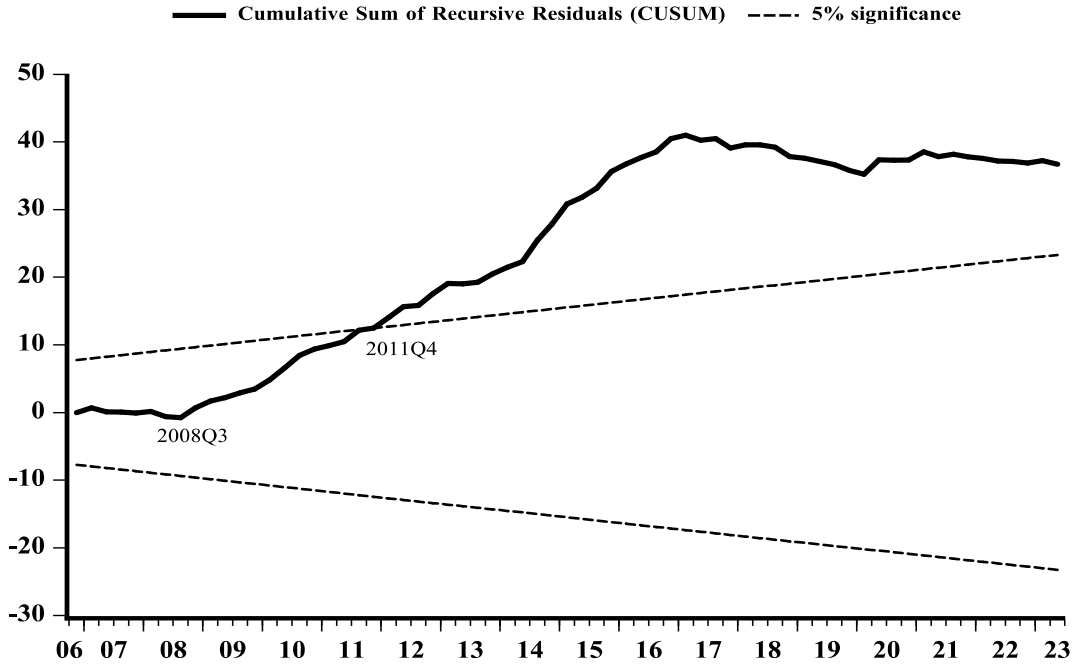

Figure 3. Cumulative Sum of Recursive Residuals (*y*-axis) with respect to time (*x*-axis) from SETAR (2, 1, 1) Model with 45% exogenous public debt/GDP Threshold.

Source: Author's calculations.

CONCLUSIONS

In this paper, the question was asked whether policymakers in Serbia complied with the 45% public debt-to-GDP limit between 2001Q1 and 2023Q2. The answer is that they did not. The paper finds little statistical evidence to support the claim that fiscal policy is more prudent when the public debt-to-GDP ratio is above the 45% threshold. Instead, fiscal policymakers in Serbia focused on targeting the 60% government debt ratio defined in the Maastricht fiscal criteria. One possible explanation for this focus on the 60% public debt threshold is that the European Commission, international financial institutions, rating agencies and foreign investors, who hold a significant share of Serbia's government debt, tend to use the widely known and generally accepted Maastricht fiscal criteria when assessing the fiscal position of a given economy in terms of its ability to repay maturing public debt.

However, Davoodi et al. (2022) report that deviations from the debt limits are very difficult to reverse. Given the recent findings of the OECD (2015) and Badia et al. (2022), which find that the probability of sovereign default increases when public debt exceeds 30-40% of GDP in emerging economies, it is clear that the past behavior of policymakers in Serbia does not contribute to the credibility of its fiscal institutions. Policymakers in Serbia should therefore make greater fiscal efforts to reduce the government debt-to-GDP ratio below the fiscal rule limit of 45%, while maintaining macroeconomic stability and promoting economic growth in line with OECD (2015) recommendations. Focusing on prudent debt targets below the 45% public debt limit would allow fiscal policymakers to assess uncertainties in a timely manner regarding adverse macroeconomic shocks and provide additional fiscal space for conducting counter-cyclical fiscal policy.

Given the evidence presented in this paper, it appears that the announced suspension of the general fiscal rules on public debt and the overall budget deficit until 2029 would further

undermine the credibility of fiscal institutions in Serbia. Although such a suspension was probably justified in the previous period due to the COVID-19 pandemic, in the current economic environment it is relatively difficult to find a solid economic justification for such behavior by the fiscal authorities (Fiscal Council, 2024). Fiscal authorities should therefore strive to comply with national fiscal limits by simultaneously 1) making efficient and prudent infrastructure investments that could have high multiplier effects in the medium to long term; 2) keeping the growth of public wages and pensions in line with the targets set in the special fiscal rules; and 3) restructure and/or privatize state-owned enterprises, which in the case of Serbia represent the largest fiscal risk and have cost taxpayers in Serbia on average around 1.9% of GDP annually over the last 10 years (Balaban and Grubisic, 2021).

Finally, the empirical analysis presented in this paper has at least two limitations. First, the study in question uses only a particular nonlinear framework, specifically the specification of the SETAR model, while the estimates of other nonlinear models, such as Markov regime-switching models, are not examined. Billio et al. (2013) show that a complementary use of SETAR and Markov regime-switching models allows for a more accurate and robust detection of turning points in the business cycle in the case of the Eurozone after 1970. In the context of the present work, Markov switching models could potentially be useful to identify the transition probabilities between states in which government debt/GDP expands and in which it collapses. Second, the present analysis does not use real-time fiscal data, so it essentially assesses the *ex-post* behavior of fiscal policymakers between 2001Q1 and 2023Q2. The creation of a real-time fiscal policy dataset in the case of Serbia, which would be an important policy contribution in itself (see Cimadomo, 2014, for an overview), would allow for more precise identification of fiscal shocks and an *ex-ante* assessment of fiscal policy decisions in Serbia.

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