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Debt limit, fiscal space and fiscal fatigue in the Central and Eastern European countries of EU

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**ROMANIAN ACADEMY
NATIONAL INSTITUTE FOR ECONOMIC
RESEARCH**

WORKING PAPERS

***DEBT LIMIT, FISCAL SPACE AND FISCAL FATIGUE IN
THE CENTRAL AND EASTERN EUROPEAN COUNTRIES OF EU***

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DEBT LIMIT, FISCAL SPACE AND FISCAL FATIGUE IN THE CENTRAL AND EASTERN EUROPEAN COUNTRIES OF EU¹

AUREL IANCU²
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Abstract: *This study analyzes the correlation between the primary budget balance and the public debt over the last two decades, for a panel of 12 countries from Central and Eastern Europe, in order to assess their debt sustainability, the level of debt at which fiscal fatigue may occur, as well as the degree of risk of fiscal fatigue, depending on the past and future evolution of public debt. First, using estimates of the cubic fiscal reaction function and two variants (quadratic / linear) of the financing cost function, we determined the equilibrium level of public debt as percentage of GDP, the "fiscal fatigue" point and the debt limit, for the whole panel and for each country. Second, by using the common (from panel regressions) and country-specific coefficients, and public debt projection for 10 and 5 years, we evaluated the level of risk for fiscal fatigue, in relation to the future evolution of public debt and other financial indicators.*

Keywords: *primary balance, public debt, fiscal space, fiscal policy*

JEL: *H61, H62, H63, H68, E62*

1. Introduction

One of the nightmares of any country's government "sinking" in public debt is to ensure the fiscal leeway for meeting the sovereign debt service. This is the fiscal space, defined as the difference between the public debt limit - calculated to avoid the country to enter insolvency - and the actual sovereign debt stock. The higher the actual public debt, the lower and tighter the distance between the two mentioned quantities, a distance inside which using different combinations of fiscal policies becomes more and more difficult. The outcome of insufficient fiscal space is the explosion of debt, manifested by the inability of governments to roll over sovereign debt and make the payments as they fall due.

In recent decades, most EU member countries have experienced an explosive increase in public debt, thus endangering the economic and financial stability of the entire economic system. The increase in public debt-to-GDP ratio during the last two decades is presented for two groups of EU members (12 EU countries from Central and Eastern Europe³ - CEE-12, and the initial 11 members of Eurozone⁴ - Euro-11) in Fig. 1a, 1b, respectively. The evolution of this ratio for individual countries belonging to CEE-12 and Euro-11 groups is given, respectively, in Annexes 1a and 1b.

The evolution of public debt share in GDP for CEE-12 countries, compared to that of Euro-11 countries, leads to the following observations:

- a) after a slight decrease by 2.5 percentage points (pp.) during the 2000-2008 expansion period, in the following period, 2009-2021 (of recession, recovery and expansion), the CEE-12 countries experienced a rise in debt by 21.3 pp. Within this group, there are several countries with sustained public debt dynamics. Among them, Romania stands out through an increase from a relatively low level of 11% in 2007-2008, to a relatively high

¹ This is an English version of paper *Limita datoriei, spațiul fiscal și riscul oboselii fiscale în țările Europei Centrale și de Est ale UE*, Studii Economice 221215, Institutul Național de Cercetări Economice, <http://www.studii-economice.ro/2022/seince221215.pdf>.

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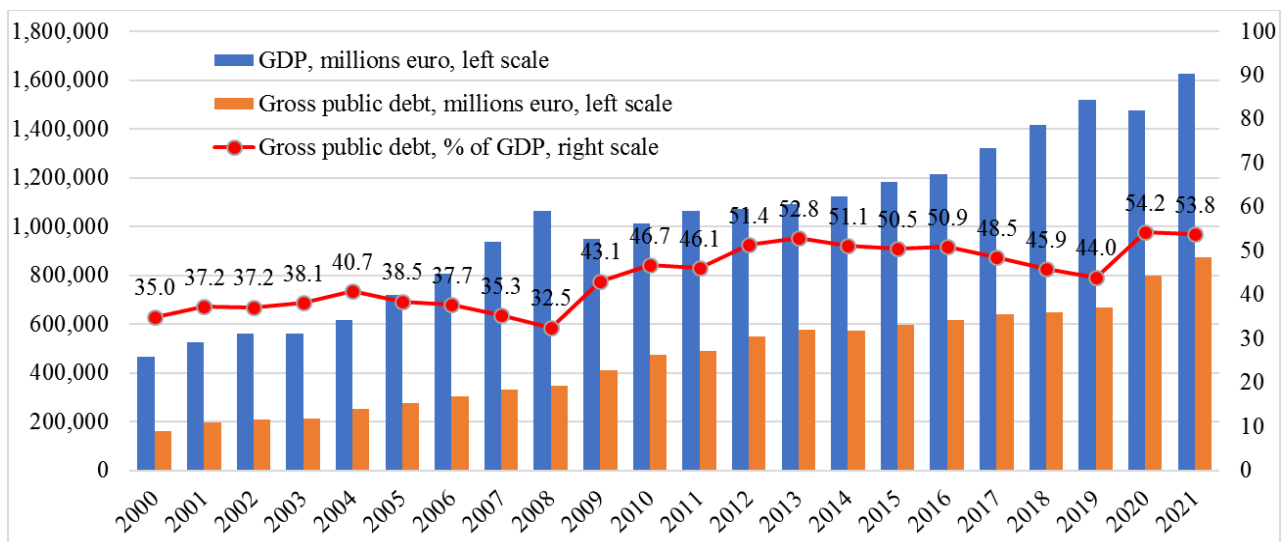
³ Bulgaria, Croatia, Czechia, Cyprus, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia, Slovenia.

⁴ Austria, Belgium, Finland, France, Germany, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain.

level of 48.6% in 2021; thus, by 37.6 pp. At the opposite pole we find Bulgaria, which, from a dramatic decrease in public debt-to-GDP ratio from 70.5% in 2000 to 13% in 2008, in the subsequent period, until 2021, the debt level reached 25.1%; thus, an increase by only 12.1 percentage points. In other CEE-12 countries, such as Poland and Hungary, although in 2000 the level of debt was higher, the increases, alternating with decreases, were lower.

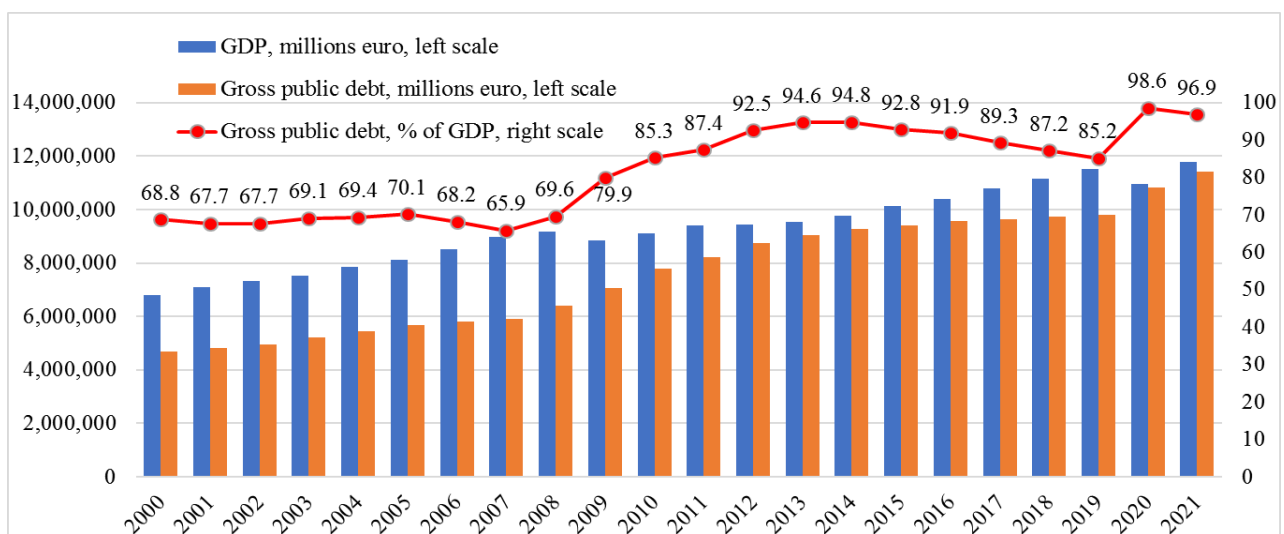
- b) the group of Euro-11 countries, compared to the group of CEE-12 countries, is characterized not only by a higher level of public debt, but also by its more pronounced dynamics. The difference between the average debt of Euro-11 countries and that of CEE-12 countries, as a share of GDP, increases from 33.8 pp in 2000, to 37.1 pp in 2008 and 43.1 pp in 2021. In some developed countries belonging to the Euro-11 group, the value of public debt stock significantly exceeds the value of GDP, in 2021: Italy (150.8%), Portugal (127.4%), Spain (118.4%), France (112.5%).

Figure 1a
Public debt-to-GDP ratio (%), CEE-12 average



Source: Eurostat, authors' calculations.

Figure 1b
Public debt-to-GDP ratio (%), Euro-11 average



Source: Eurostat, authors' calculations.

A normal question that many authors ask is the following: how much can public debt increase under circumstances of ensuring sustainability? High debt means high interest costs, as well as high risks of shocks in times of recession when incomes contract, interest rates rise and the need for unemployment payments and demand/supply stimulation is higher. All these may escape from government control when debt exceeds a certain limit and the fiscal space runs out when signals of the so-called "fiscal fatigue" show up, and/or the risk of fiscal fatigue are not taken into account.

It is considered that by a moderate increase in public debt, however, its sustainability may be ensured by the fact that debt itself, its level and structure, through the effects produced in the economy, cause economic growth, as well as increases in the primary fiscal balance. This process is described by applying the fiscal reaction function (FRF), which we present and use in this study to determine the debt limit and fiscal space, to estimate the level of debt at which fiscal fatigue can occur, as well as to assess the degree of risk of fiscal fatigue, depending on the past and future evolution of public debt.

Next, in this study, we present: the empirical literature regarding the contributions made in this field (Section 2); the data and methodology used (Section 3); the analysis of the statistical series, the calculation of the fiscal reaction function on variants, results and comments (Section 4); the determination of fiscal thresholds (optimal level of debt, fiscal fatigue, debt limit and fiscal space) on the entire CEE group, according to the developed and improved Ghosh methodology (Section 5); the assessment of fiscal fatigue degree of risk (Section 6); and the conclusions (Section 7).

2. Empirical literature

The intense growth of public debt in recent decades, at national and global level, and the economic-financial crisis of 2008-2009 determined development and publication of numerous studies on the topic of public debt sustainability, from a fiscal point of view. These studies form an important chapter of public finance, in which the fundamental role is played by the fiscal reaction function (FRF), which measures the variation of government budget balance to the change (increase / decrease) in public debt, under the circumstances of budgetary constraints. Bohn (1998, 2008) is the one who inaugurated this model, in order to define and test public debt sustainability.

Based on the correlation between primary budget balance and public debt, under the circumstances of intertemporal budgetary constraints, Bohn believes that a significant and positive coefficient, representing the reaction of primary balance to public debt, is sufficient to ensure the sustainability of the sovereign debt. The sustainability criterion used by Bohn, based on the positive reaction of primary balance to the growth of lagged debt, under the budgetary constraint, is called by Ghosh *et al.* as poor sustainability, as it accepts a permanent increase in debt (Ghosh *et al.*, 2013, p. 5).

Bohn was engrossed in the idea of ensuring a permanent primary balance surplus, given the increase in debt and government policy adjustments when the surplus could not be provided by market mechanisms. Ghosh *et al.*, seeing the massive and sudden increase in public debt and the brink of insolvency reached by some countries with large sovereign debts, introduced in the analysis of debt sustainability (i) new concepts regarding the debt limit, fiscal fatigue and fiscal space, and (ii) as an explanatory tool, the graphical representation of the relationship between the key indicators - primary balance (pb) and debt interest $(r-g)*d$ -, as well as the non-linear fiscal reaction function (quadratic and cubic).

In these developments, Ghosh *et al.* take into account the role of interest rates, because they carry the risk of a sudden increase as debt approaches the limit; hence, the risk of default (Ghosh *et al.*, 2013, p. 26). These new concepts, deciphered and brought to the measurement phases, have broadened the perspective of approaching, evaluating and explaining the sustainability of public debt, enriching the set of tools for measuring and analyzing the relationship of fiscal balance to public debt carried out within the framework of financial and institutional constraints.

Many studies on sovereign debt sustainability, later published, are inscribed in the concepts and methodology of Ghosh *et al.* These studies bring significant clarifications, developments and extensions using panels of various country groups, and individual countries. For example, Ganiko *et*

al. (2016), in the analysis of debt limit, fiscal fatigue and fiscal space in the emerging economies, states that when the budget balance responds positively but downwards to debt growth, the occurrence of fiscal fatigue is noticed. Also, Ganiko *et al.* estimates the cost of debt as a driver of the evolution of public debt (along with the primary budget balance), and the public debt level as an important determinant of this cost.

Regarding the calculation of the sovereign debt cost, the authors take into account the shortcomings currently practiced: either in the case of historical interest rates, where the reactions of the financial market to high levels of future interest rates are ignored, or in the case of long-term bonds (10 years), where some countries often issue these debt securities for shorter terms.

The studies that address the sustainability of public debt use, as a central model, the fiscal reaction function (FRF) in increasingly complex variants, in order to correctly estimate both the size of intensity of the relationship between primary balance and sovereign debt - expressed by the FRF coefficient of public debt - as well as a series of thresholds (fiscal fatigue, debt limit, fiscal space), determined by the constraints of different economic and institutional factors sensitive to the size of public debt.

In the context of ensuring sufficient conditions for sovereign debt sustainability and integrating the fiscal reaction function into financial market reactions, Ghosh *et al.* (2013), Fournier and Fall (2015), Berti *et al.* (2016) support the idea that debt ratio must not only be positive, but also large enough to create a surplus of primary balance that at least offsets the increase in debt of low-indebted countries, and exceeds the increase in debt for highly indebted countries.

Through a summary analysis of some articles that estimate the reaction functions, a great diversity is observed regarding the size of the coefficients of public debt, estimated for individual countries, groups of countries, time periods and cycle phases. Annex 2 contains examples of FRF coefficients of public debt which vary according to the cycle phase (expansion or recession), the structure and development level of the countries, the fiscal policy carried out by governments, and the applied methodology. Some authors estimate that the normal value of the FRF coefficients of sovereign debt lies in the range of 0.01-0.10 (Berti *et al.*, 2016; Checherita-Westphal and Zdarek, 2017).

Concerned with dealing more accurately with the relationships between primary balance and public debt, the empirical research has switched to using the polynomial (quadratic and cubic) FRF of Ghosh *et al.*, to highlight the threshold occurrence - Ganiko *et al.* (2016), Fournier and Fall (2015), Legrenzi and Milas (2013). A more recent concern of empirical research is solving the problems of national economy / economic and fiscal policies heterogeneity, long time data series and their character - stationary or non-stationary, etc., in the case of panels with large groups of countries or for individual countries, with statistical time series and long-term projected scenarios, as well as in the case of using different methodologies.

Exposing to critical analyses the results of linear and non-linear FRF and the validation of fiscal fatigue occurrence in the case of panels with large groups of countries and long time periods, some authors - Berti *et al.* (2016), Checherita-Westphal and Ždarek (2017), Mauro *et al.* (2013), Plödt and Reicher (2015), Everaert, Jansen (2018), Di Iorio and Fachin (2021) - revised some assumptions and methodologies, which changed some results and conclusions. For instance, in the econometric approach of using long time series, Berti *et al.* (2016, p. 9) find that few studies take into account the stationarity issue, especially for FRFs applied at country level. Stationarity tests (unit root, I(1)) ADF, PP, KPSS were applied to all data series of the EU developed countries in the FRF model used by the mentioned authors.

The Di Iorio and Fachin (2021) study presents an assessment of linear and non-linear FRF performed for 22 developed economies (panel) and each component country, over long-time horizons (1961-2019 and 1961-2007). Using appropriate time series and cubic model estimation and testing techniques, the authors reached the following results: for the period 1961-2019, out of the total of 22 countries, FRFs were estimated for only 6, of which only one cubic FRF (for Germany) and 5 linear FRF (for the other 5 countries); for the period 1961-2007, from the same total of 22 countries, FRFs were estimated for 10 countries, of which one cubic FRF (Italy) and 9 linear FRFs for the other countries. The authors mention that, after 2008, the probability of using the fiscal reaction function to assess the sustainability of sovereign debt, at country-level, decreased.

These results question the use of the FRF model as a general tool for assessing the sustainability of public debt, especially at the level of individual countries. Such doubt, the mentioned authors argue, might only be removed when long-term stationary and non-stationary time series are considered and tested, also when the economies and economic / fiscal policies of the panel countries are generally homogeneous across periods, and the cyclicities of the variables have a synchronous character.

For stationarity analysis, the authors propose, as a first operation, the graphical representations of time series used in the FRF evaluations, and the second operation of stationarity testing (AF, PP, KPSS, etc.). Among the valid solutions seen by Di Iorio and Fachin (2021) would be the following: accepting the use of time series in the FRF model only after testing them, synchronizing their evolution with the cyclicity of the economies, as well as ensuring the homogeneity of the economies included in the panel, together with using appropriate techniques for estimating and testing nonlinear FRF (quadratic and cubic). The mentioned authors state that estimating the polynomial FRF with non-stationary variables requires a set of new econometric tools, developed by Wagner (2015) and Wagner and Hong (2016) - see Di Iorio and Fochin (2021).

3. Data and methodology

For the present empirical research on the primary balance - sovereign debt relationship and its sustainability, a group of 12 EU countries from Central and Eastern Europe (CEE-12) was chosen, considering that they have been less analyzed in this respect and they have certain common characteristics: they are small and medium-sized economies, have a certain economic, social and institutional homogeneity, and all are emerging economies, although some of them are OECD members and/or belong to the euro area.

Since the requirement of econometric modeling is to have as many observations as possible, and since for these countries the data available for most of the indicators start in 2000, we opted for using quarterly data, although they present certain inconveniences. To express the dynamics, values of current quarters are related to the same quarter of the previous years, in order to avoid seasonality. Data sources, both for the key and control variables, are the Eurostat and AMECO databases.

In the introduction, it was stated that the main objective of this study is to correctly estimate the debt limit and fiscal space, and to assess the degree of risk for fiscal fatigue, as an effect of excessive increase in public debt, a phenomenon that can escape the governments' control. This approach employs as its main instruments the *fiscal reaction function* (FRF) and the public debt *financing cost function* (FCF), whose components we describe in the next section, along with the indicators used in the analyses.

3.1. The fiscal reaction function (FRF)

The FRF is the main instrument with which the objective mentioned above is achieved. The use of this function was first proposed by Bohn, in a simple linear form:

$$pb_t = \beta d_{t-1} + \varepsilon, \quad (1)$$

which expresses the relationship between the two key variables: pb_t – the primary budget balance-to-GDP ratio, as a dependent variable; d_{t-1} – first lag of debt-to-GDP, as a determinant; β – the reaction coefficient of primary balance to the change of public debt (debt coefficient). The term ε depends on other factors called control variables.

The FRF model has been further developed, including different variables for responding to different requirements and characteristics of the economic, social and political processes that can produce effects with constant, increasing or decreasing values on primary balance. On this basis, alongside the linear model, the nonlinear (quadratic and cubic) model was developed and applied.

In the current study, we use both types of models, with the following panel specifications:

The linear model

$$pb_{i,t} = c_i + \beta_1 d_{i,t-1} + \beta_2 GAP_{i,t} + \beta_3 INF_{i,t} + \delta_i + \varepsilon_{i,t} \quad (2)$$

where: i - country; t - period; c - constant; $\beta_1, \beta_2 \dots$ - coefficients; pb – primary balance-to-GDP (%); d – public debt-to-GDP (%); GAP - output gap = $(GDP - \text{potential GDP}) / \text{potential GDP}$ (%); INF - inflation; δ_i – unobserved country specific effect; ε_{it} - regression error (assuming error autocorrelation: $\varepsilon = \sigma_1 + \sigma_2 * \varepsilon_{t-1} + \sigma_3 * \varepsilon_{t-2} + \dots$).

We calculated the primary balance (pb) based on quarterly seasonally adjusted budget balance (% in GDP), provided by Eurostat, from which we removed the interest paid. Public debt (% of annual GDP) was calculated by dividing quarterly gross public debt (quarter-end stock) by seasonally adjusted quarterly GDP multiplied by 4, both expressed in national currency, provided by Eurostat. The quarterly GAP was calculated by smoothing the annual data, provided by AMECO, using the HP filter. For inflation, the quarterly GDP deflator was used, expressed as percentage change as compared to the same quarter of the previous year, provided by Eurostat.

The nonlinear model (polynomial - quadratic / cubic)

The non-linear model involves the primary balance reaction to public debt dynamics, in the form of a 3rd degree polynomial, following Ghosh *et al.* (2013):

$$pb_{i,t} = c_i + \beta_1 d_{i,t-1}^3 + \beta_2 d_{i,t-1}^2 + \beta_3 d_{i,t-1} + \beta_4 GAP_{i,t} + \beta_5 INF_{i,t} + \delta_i + \varepsilon_{i,t} \quad (3)$$

with the same elements as in the previous model. In addition, the polynomial function is included, using debt ratio as follows: $d_{i,t-1}^3, d_{i,t-1}^2, d_{i,t-1}$.

For the non-linear FRF model, the methodological details and the economic significance of inflection and intersection points between the curves of primary balance and financing cost of debt are described in Annex 3.

Using the linear FRF model, along with the non-linear FRF model, has the following justifications: on the one hand, the sample also includes countries with relatively low debt-to-GDP ratios, and on the other hand, the following practical benefits appear, for both models: 1) using the non-linear FRF when approximating the fiscal fatigue threshold and determining the public debt limit; 2) using the linear FRF to determine the average debt coefficient, and this, in turn, to approximate the degree of risk for fiscal fatigue.

Given the availability of quarterly data series that provide a sufficient amount of information, it becomes possible to use the linear and non-linear FRF model also at country level. In this way, country-specific coefficients can also be calculated to approximate the degree of risk of fiscal fatigue in each country.

3.2. The public debt financing cost function (FCF)

The debt financing cost (fc_t) represents, according to the model of Ghosh *et al.* (2013), the difference between the nominal interest rate on public debt (r_t) and the nominal GDP growth rate (g_t), multiplied by debt (d_t), as % of GDP:

$$fc_t = (r_t - g_t) * d_t \quad (4)$$

For g_t we used the quarterly nominal GDP growth rate, compared to the same quarter of the previous year, provided by Eurostat. As for the interest rate, we compute it as a weighted average of the effective nominal interest (re), paid for debt service, and the long-term nominal interest rate (rl) on government bonds, following the approach of Ganiko *et al.* (2016, p. 8):

$$r_t = a * re_t + (1-a) * rl_t \quad (5)$$

where:

$a = 1$, if $D_t \leq D_0$ (when debt stock D_t declines from the initial level D_0 , effective interest rate is used);

$a = D_0 / D_t$, if $D_t > D_0$ (when debt stock increases, the weight of the newly created debt is applied to the long-term interest).

The effective interest (re) was calculated by dividing quarterly interest payments to the public debt stock at the end of previous quarter, both expressed in national currency, provided by Eurostat. Long-term interest (rl) was calculated as the quarterly average of the monthly interest on 10-year government bonds, provided by the European Central Bank.

The debt financing cost function (FCF) is increasing in relation to the public debt ratio (d), and can be approached in a linear or non-linear (quadratic) version:

$$fc_{i,t} = c_i + \beta_1 d_{i,t-1} + \beta_2 d_{i,t-1}^2 + \beta_3 GAP_{i,t} + \beta_4 INF_{i,t} + \delta_i + \varepsilon_{i,t} \quad (6)$$

where the variables are those described in equation (2).

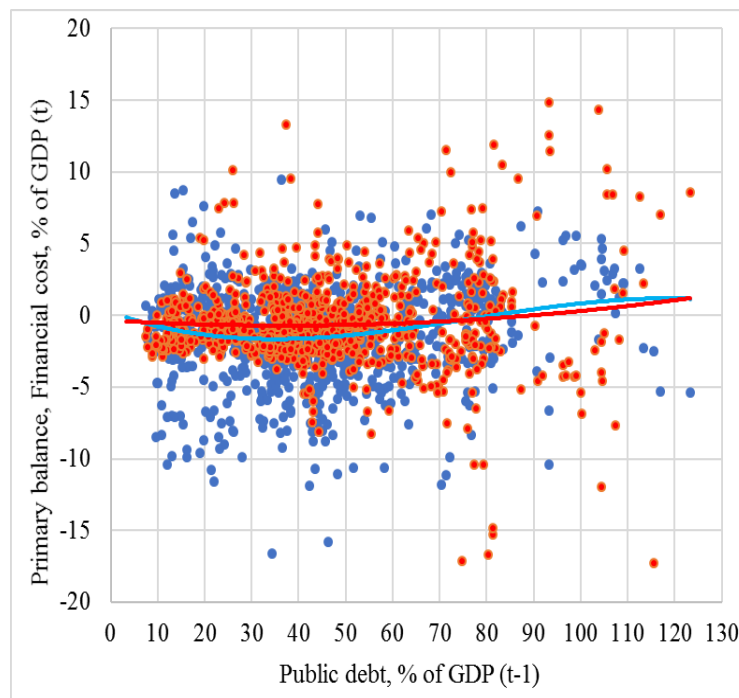
4. Determining the fiscal reaction and financing cost functions

4.1. Correlation between primary balance and public debt. Graphical analysis

In Figure 2 we present a first graphical estimation, at panel level, of the nonlinear FRF (marked blue) and FCF (marked red) curves. We removed Estonia from the ECE-12 group, because of data unavailability for long term interest rate and, implicitly, missing FCF estimations. We used a 3rd degree polynomial trend for FRF, and 2nd degree for FCF, respectively, plotted using Excel. We removed 3 extreme values of primary balance series, which exceeded $\pm 20\%$ of GDP. Time periods for which the two functions were calculated are 2000.Q2 - 2021.Q4 for FRF, and 2001.Q1 - 2021.Q4 for FCF, respectively.

Figure 2

Fiscal reaction function¹ (FRF) and financing cost function² (FCF), for the CEE-11 panel



Note: ¹ blue line; ² red line.

Source: Authors' calculations, based on Eurostat data.

In the case of FRF we assumed a cubic shape, with an initial decrease, a subsequent increase leading to a maximum point d_{\max} ("fiscal fatigue" threshold), after which another decrease follows. Regarding FCF, an upward trend is observed, which intersects FRF in 3 points, the second representing the optimal (equilibrium) debt (d^*), while the third is the debt limit (\bar{d}), as we detailed in the methodological Annex 3.

4.2. Estimation of fiscal reaction function (FRF)

Based on data used in Figure 2, we compiled a panel of CEE-11 countries, for which we estimated the FRF coefficients according to relations (2) and (3) described in the previous section. In Annex 4 we presented a brief statistical analysis of the used data series.

Panel analyses imply the assumption of homogeneity in terms of coefficients, an assumption which, as a rule, is not verified for a group of countries. Constant term heterogeneity is provided by country fixed effects, which allows for country specific values. As for nonlinear trend slopes, the problem is more complex. Public debt values for each individual country cover only a segment of the entire range of values recorded by all countries. As a result, the FRF and FCF functions of each country represent only fragments of the two panel trends, drawn in Figure 2. Each segment of a non-linear curve, corresponding to a country, may have a positive or negative slope, depending on its location within the entire panel trend. Thus, nonlinear trends do not necessarily require slope heterogeneity, as would happen in the linear function case, and does not impede a panel analysis approach. Likewise, in the absence of a panel that covers the entire range of public debt values, the FRF and FCF functions cannot be drawn in their entirety, but only a segment of them, corresponding to a single country. In this case, it is impossible to determine the intersection points corresponding to the optimal debt or debt limit, the fiscal space, etc., an approach that constitutes precisely the objective of this study.

Another econometric issue is that of stationarity in time series. Tests for stationarity included in Annex 5 show that, among the considered variables, only public debt series (d) is non-stationary, the others being stationary (according to most of the tests performed⁵), including the dependent variable (pb). A study by Noriega and Ventosa-Santaulària (2006, p. 7) concludes that such a situation, in which only one of the variables is non-stationary, cannot lead to an apparent regression ("spurious regression" - Granger and Newbold, 1974). As a result, we consider allowing the use of public debt series without stationarity transformations such as differencing, which would prevent us to estimate the debt critical points.

In Table 1 we included the results of panel estimations, using country fixed effects to deal with differences caused by time-invariant country-specific factors. At the same time, we assumed a second-order serial correlation, based on correlograms, introducing AR(1) and AR(2) terms. Since we found that the two control variables in levels lead to considerable distortions in estimations (for coefficients and significance levels of public debt), probably induced by multicollinearity, we opted for their inclusion as time differences (ΔGAP , ΔINF).

The first 3 columns of Table 1 present regression estimates where, in addition to public debt, we add each additional factor, to test their relevance. Public debt coefficients are significant both in the short form of the equation (column 1) and also when the other factors are introduced, which shows that the cubic form of the function is correctly chosen. The results for the quadratic FRF are significantly weaker, which is why we do not present them.

Regarding the control factors, only ΔGAP coefficient is significant and positive, which shows that a higher increase in output gap leads to a higher primary balance, indicating a countercyclical fiscal policy. At the same time, it is observed that in the last equation (4), introduction of ΔINF in addition to ΔGAP does not increase the coefficient of determination R^2_{aj} , as compared to equation (2). For this reason, we chose the estimations from equation (2) to determine the intersection points between FRF and FCF, in the next section.

⁵ Levin, Lin & Chu t; Breitung t-stat; Im, Pesaran and Shin W-stat; ADF - Fisher Chi-square; PP - Fisher Chi-square.

Table 1

Cubic FRF estimations for the CEE-11 panel

Dependent variable: pb_t				
Factors:	(1)	(2)	(3)	(4)
d_{t-1}^3	$-1.93 \cdot 10^{-5}^{**}$ (0.000)	$-2.15 \cdot 10^{-5}^{**}$ (0.000)	$-1.98 \cdot 10^{-5}^{**}$ (0.000)	$-2.18 \cdot 10^{-5}^{**}$ (0.000)
d_{t-1}^2	0.003** (0.002)	0.004** (0.002)	0.004** (0.002)	0.004** (0.002)
d_{t-1}	-0.158* (0.108)	-0.184* (0.104)	-0.166* (0.108)	-0.189** (0.095)
ΔGAP_t	-	0.416*** (0.227)	-	0.399*** (0.143)
ΔINF_t	-	-	0.049 (0.040)	0.042 (0.033)
C	0.249 (2.160)	0.815 (2.053)	0.405 (2.157)	0.926 (1.624)
AR(1)	0.427	0.412	0.423	0.410
AR(2)	0.268	0.269	0.273	0.272
R^2_{aj}	0.426	0.432	0.427	0.432
S.E.	2.435	2.429	2.433	2.428
Countries	11	11	11	11
Observations	926	922	926	922

Notes: ***, **, * - significant coefficient for a threshold of 1%, 5%, 10% respectively; standard error σ in brackets; unbalanced panel estimated by OLS with fixed effects, period 2000.Q4-2021.Q4.

Source: Authors' calculations, based on Eurostat and AMECO data.

In Table 2 we presented the estimations of FRF in linear form, for the entire CEE-12 group; the coefficients of the linear function will be used in the assessment of the risk degree for fiscal fatigue, in Section 5. A generally positive correlation is observed between public debt and primary balance, which confirms the tendency of fiscal contraction (austerity) as public debt increases. The GAP and INF factors are significantly and positively correlated with the primary balance.

Table 2

Linear FRF estimations for the CEE-12 panel

Dependent variable: pb_t				
Factors:	(1)	(2)	(3)	(4)
d_{t-1}	0.015 (0.016)	0.071*** (0.015)	0.028* (0.016)	0.072*** (0.015)
GAP_t	-	0.502*** (0.051)	-	0.476*** (0.054)
INF_t	-	-	0.155*** (0.037)	0.050 (0.037)
C	-1.785** (0.738)	-4.180*** (0.658)	-2.890*** (0.749)	-4.424*** (0.680)
AR(1)	0.433	0.373	0.414	0.371
AR(2)	0.252	0.259	0.257	0.260
R^2_{aj}	0.413	0.463	0.423	0.464
S.E.	2.452	2.347	2.431	2.346
Countries	12	12	12	12
Observations	993	991	993	991

Notes: ***, **, * - significant coefficient for a threshold of 1%, 5%, 10% respectively; standard error σ in brackets; unbalanced panel estimated by OLS with fixed effects, period 2001.Q1-2021.Q4.

Source: Authors' calculations, based on Eurostat and AMECO data.

4.3. Estimation of financing cost function (FCF)

In Table 3 we present the results of the estimation of financing cost function (FCF), both in the non linear variant - increasing 2nd degree polynomial (equations 1-3) - and linear (equations 4-6). As in the case of the FRF, we used panel regressions with country fixed effects.

Table 3

FCF estimations for the CEE-11 panel

Dependent variable: fc_t						
Factors:	(1)	(2)	(3)	(4)	(5)	(6)
d_{t-1}^2	1.24*10 ⁻⁴ *** (0.000)	4.17*10 ⁻⁶ (0.000)	1.28*10 ⁻⁴ *** (0.000)	-	-	-
d_{t-1}	-	-	-	0.011* (0.007)	-0.003 (0.007)	0.012* (0.007)
ΔGAP_t	-1.346*** (0.117)	-	-1.250*** (0.119)	-1.339*** (0.118)	-	-1.244*** (0.119)
ΔINF_t	-	-0.283*** (0.048)	-0.181*** (0.047)	-	-0.282*** (0.048)	-0.182*** (0.047)
c	-0.880*** (0.184)	-0.575*** (0.191)	-0.889*** (0.182)	-1.086*** (0.339)	-0.440 (0.350)	-1.123*** (0.336)
$R^2_{aj.}$	0.139	0.045	0.153	0.137	0.045	0.151
S.E.	2.858	3.009	2.835	2.860	3.009	2.837
Countries	11	11	11	11	11	11
Observations	876	876	876	876	876	876

Notes: ***, **, * - significant coefficient for a threshold of 1%, 5%, 10% respectively; standard error σ in brackets; unbalanced panel estimated by OLS with fixed effects, period 2001.Q1-2021.Q4.

Source: Authors' calculations, based on Eurostat and AMECO data.

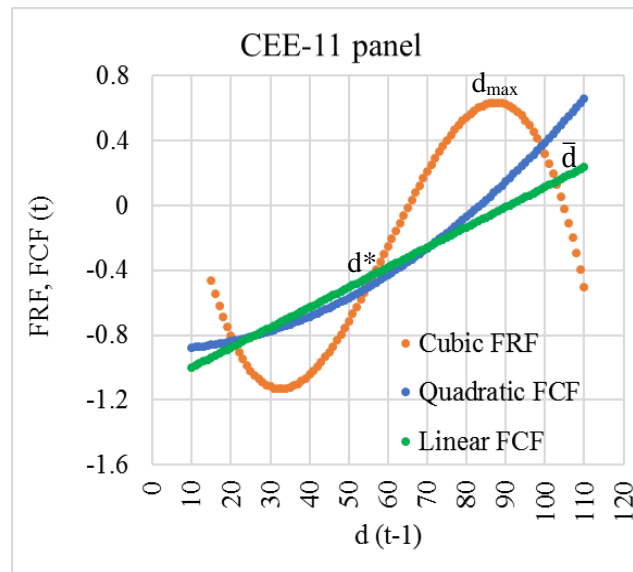
The interest rate used in the FCF calculation represents, as mentioned in the methodological section, a weighted average between the effective interest (paid for debt service) and the long-term interest. Using only the long-term interest rate for the FCF calculation leads to roughly similar results, which is why we omit their presentation.

Public debt coefficients are positive, which confirms a rise in financing cost as indebtedness increases, and significant - except for equations (2) and (4). ΔGAP and ΔINF coefficients are significant and negative, which shows a lower cost of financing as gap change increases (expansionary phases) and inflation change is higher. Based on significance tests and coefficients $R^2_{aj.}$, we chose equation (3) for the quadratic version and (6) for the linear version, respectively, to be used in estimating the intersection points between FRF and FCF (in the next section).

5. Determination and interpretation of critical points on FRF and FCF trends, in relation to the level of public debt ratio

As we detailed in Annex 3, the equilibrium debt (d^*) and debt limit (\bar{d}) represent the intersections of the two curves, FRF and FCF, while fiscal fatigue (d_{max}) is the maximum inflection point of FRF. To obtain FRF / FCF, and determine these intersection points, we estimated the evolution of their trends in relation to the level of public debt, d (from 10 to 110 % of GDP), using debt coefficients estimated in the previous section (variant 2 of Table 1 - for FRF, and variants 3 and 6 from Table 3 - for FCF, respectively). In Figure 3 we present the estimates of the two curves for the entire CEE-11 panel, and in Figure 4 we used the results of fixed-effects regressions to draw these curves for each country. The FRF function is considered in cubic form, while the FCF curve is presented in both polynomial (quadratic) and linear versions.

Figure 3
FRF and FCF estimates for the CEE-11 panel



Source: Authors' calculations (estimates from Table 1 and 3), based on Eurostat and AMECO data.

We can identify an equilibrium point (d^*) around 55% of GDP in the quadratic FCF version, and of 56% in the linear FCF version, respectively. The fiscal function shows an increase with a ceiling (fiscal fatigue - d_{\max}) around a maximum point of 87% of GDP, followed by a decrease and a new point of intersection with FCF, which represents the debt limit (\bar{d}), amounting to 99% for the quadratic FCF and 103% for the linear FCF.

In Figure 4 we presented the results for each country in the CEE-11 group, while in Table 4 we summarized the results regarding the FRF and FCF intersection points for each country. One may see that, for some of them, the two curves are spaced apart and do not intersect, either locally or only at the debt limit point (\bar{d}).

For example, in the case of Bulgaria and Cyprus, FRF takes higher values as compared to the other countries, which reveals higher levels of primary balance for the same levels of public debt. This is also confirmed by the fact that the two countries are the only ones that register positive averages of primary balance for the analyzed period, as we can see in Annex 4. Moreover, in the case of Bulgaria, a relatively low cost of financing appears. As a result, FRF lies above FCF, and the first two intersection points do not appear, but only the third one, (\bar{d}). Similar is the case of Lithuania, where the optimum debt (d^*) appears only in the linear variant of FCF, and is very low.

On the other hand, in the case of Croatia, FRF takes relatively low values, while FCF registers relatively high values, which leads to the location of FRF below FCF, without any intersection point between the two curves.

Romania displays a significantly lower FRF curve, which reveals a relative expansionary (or loose) fiscal policy, and a slightly lower FCF (financing cost), relative to the CEE-11 average. These result in relative higher d^* (65% / 66% of GDP) and relative lower \bar{d} points (93% / 98% of GDP).

Figure 4
FRF and FCF estimates for the CEE-11 countries

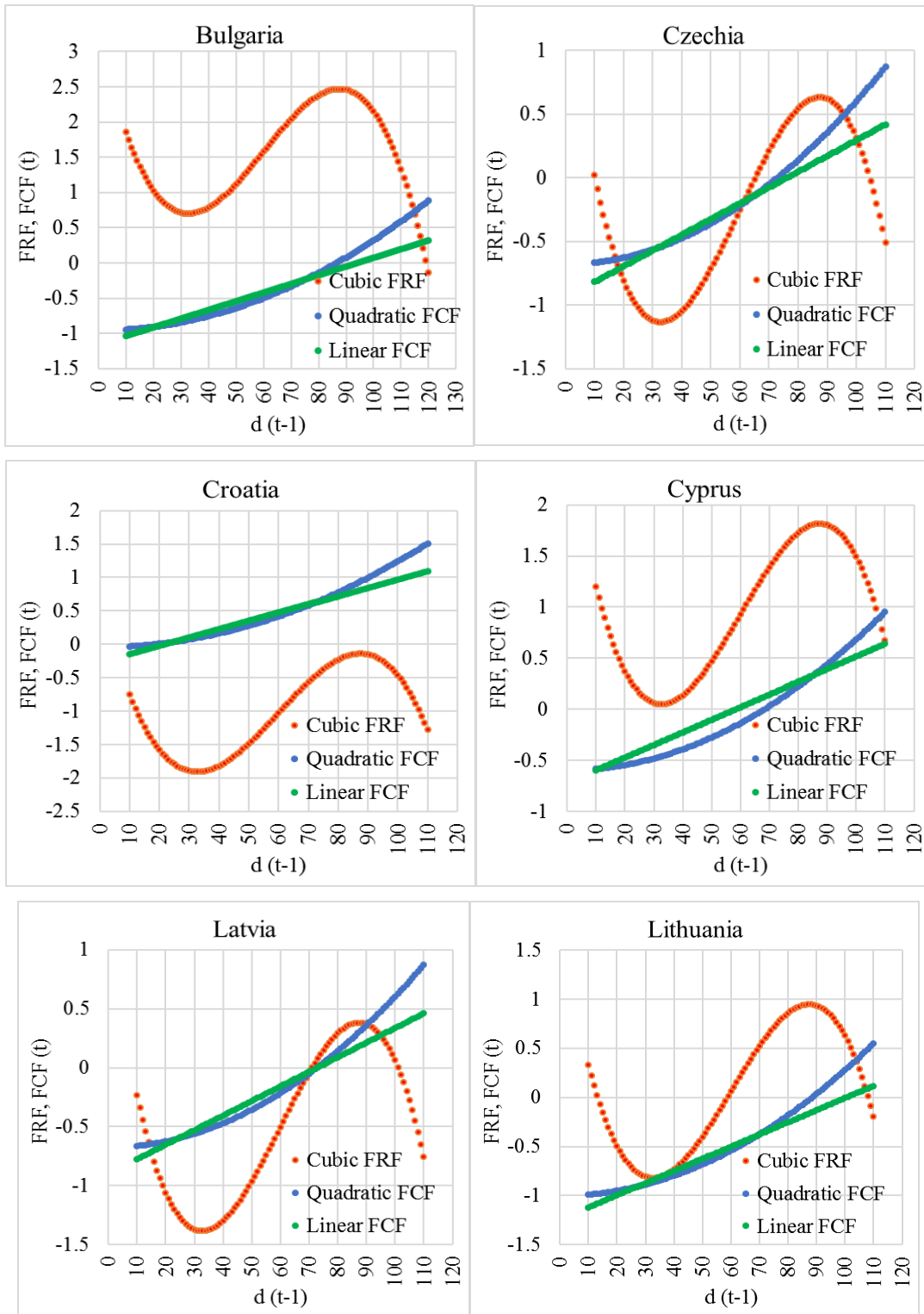
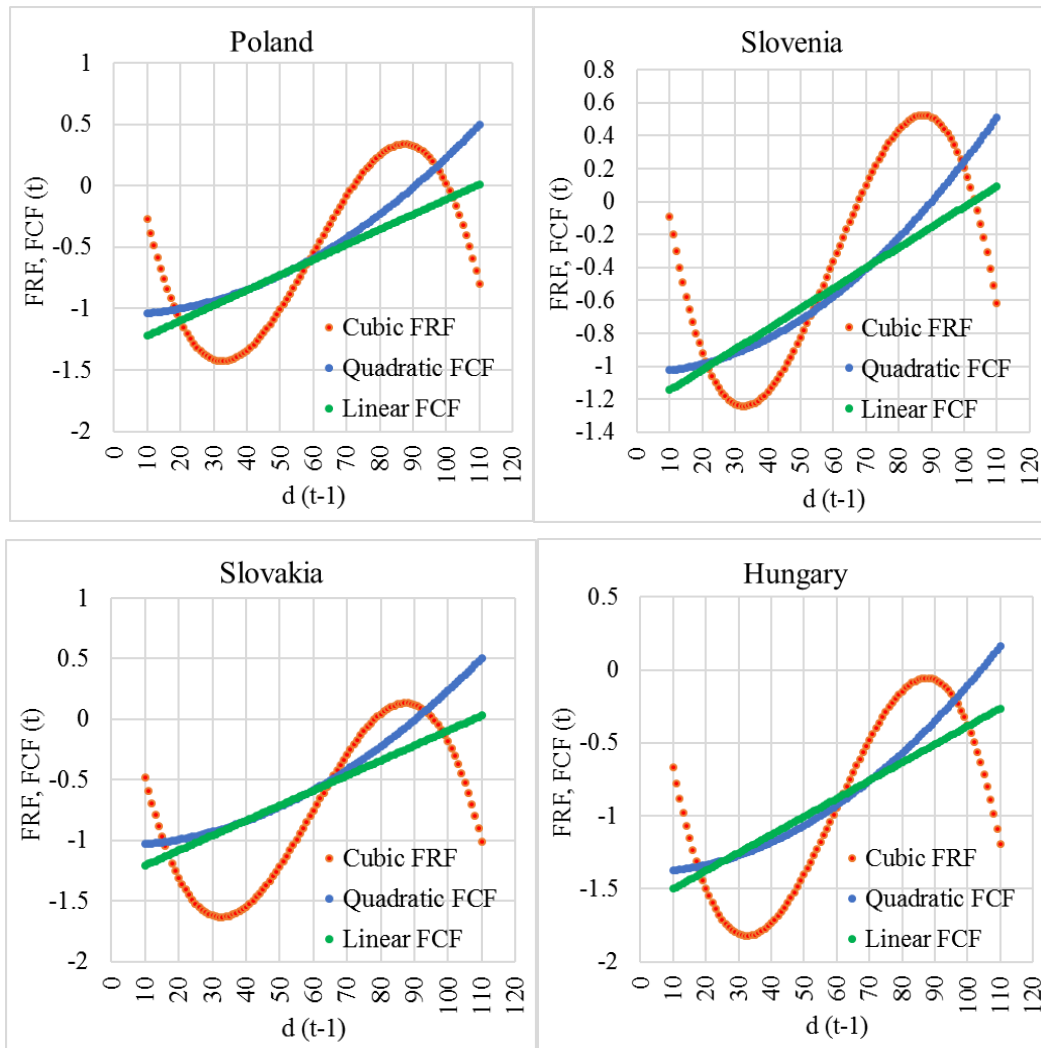


Figure 4 (continuation)



Source: Authors' calculations (estimates from Table 1 and 3), based on Eurostat and AMECO data.

Table 4 summarizes the values of intersection points d^* and \bar{d} , along with the amplitudes of fiscal space (FS), calculated as the difference between debt limit (\bar{d}) and the actual (2021) values of debt (d). As for d^* , except for the extremely low value of Lithuania (FRF far above FCF), figures lay between 53% and 70% of GDP, and are roughly equal between the two variants of FCF (quadratic and linear). It should be noted that, in 2021, Hungary and Slovenia register debt values above the optimal d^* , Slovakia being also quite close to this threshold.

Regarding \bar{d} , more significant differences appear between the two variants. The values lie in the 93-115% range for the quadratic FCF version, and 95-118% in the linear version, respectively. The linear FCF can be considered as the "optimistic" variant, in the sense that debt limits \bar{d} are more distant and, consequently, the fiscal space (the distance to the actual debt) is higher. The actual fiscal space (FS), calculated using estimated debt limit and actual debt in 2021, registers very low values in the case of Cyprus, which constitutes a warning signal for public debt sustainability. Romania records above-average fiscal space values, in both variants: 44% and 49% of GDP, respectively.

Table 4

Estimation of optimum debt (d^*), debt limit (\bar{d}) and fiscal space (FS), CEE-11 country level

Countries	Actual d Year 2021	<i>a. quadratic FCF</i>			<i>b. linear FCF</i>		
		d^*	\bar{d}	FS ¹	d^*	\bar{d}	FS ¹
Bulgaria	25.1	-	115	89.9	-	118	92.9
Czechia	43.3	61	96	52.7	61	100	56.7
Croatia	79.9	-	-	-	-	-	-
Cyprus	103.6	-	108	4.4	-	110	6.4
Latvia	44.8	70	90	45.2	70	95	50.2
Lithuania	44.3	-	104	59.7	38	107	62.7
Hungary	74.5	60	96	21.5	62	100	25.5
Poland	53.4	59	97	43.6	58	102	48.6
Romania	48.6	65	93	44.4	66	98	49.4
Slovenia	74.7	53	100	25.3	55	103	28.3
Slovakia	63.1	65	93	29.9	65	99	35.9
Panel	59.6 ²	55	99	39.4	56	103	43.4

Notes: ¹ FS = \bar{d} – actual d; ² CEE-11 arithmetic average.

Source: Authors' calculations (estimates from Table 1 and 3), based on Eurostat and AMECO data.

The optimal (equilibrium) points, illustrated in Table 4, are related to the sign of the marginal effect (changes) of public debt on primary balance, in the absence and presence of fiscal fatigue. In principle, in the economy, initially, positive changes prevail. Following to the first signals of fiscal fatigue, changes become negative. The point where this downturn occurs is considered and defined as the optimal debt, d^* .

6. The risk for fiscal fatigue assessment

As shown above, in the analyses of the relationship between primary balance and public debt, especially when using nonlinear FRF, the most controversial issue is the quantitative assessment of fiscal fatigue at country level, although theoretically it seemed to be fully clarified. Faced with failures to obtain conclusive results at country level using cubic FRFs, some authors propose different ways out of the deadlock, ranging from in-depth testing of time series to the adoption of new methodologies or new approaches. Among them, for example, Checherita-Westphal and Ždarek come up with a new approach to fiscal fatigue, consisting in assessing the degree of risk for its occurrence and development, according to the primary fiscal balance and indebtedness level illustrated by data series and simulated (projected) series for the next period. The mentioned authors return to using the linear FRF to determine the average debt ratios and, implicitly, to assess the comparison indicator called the maximum adjusted primary balance (pb_{\max}).

6.1. Methodology and data used

In order to assess the risk for fiscal fatigue in the CEE-12 countries, we follow the methodology of Checherita-Westphal and Ždarek, 2017. In addition, we determine and use the specific and significant coefficients for the analyzed countries, and highlight the fourth degree of fiscal fatigue risk.

The assessment of fiscal fatigue degree in these countries is based on time series regarding the primary budget balance (% of GDP) and the gross public debt (% of GDP), as well as the country-specific, linear FRF coefficients.

Data series address two periods of time: statistical (historical), and forecasted or simulated. To simplify calculations and eliminate fluctuations, time series are expressed as average values over 10-year periods.

As main elements and calculation tools, we use:

- The coefficients (β) of debt from the linear FRF, determined: i) for the entire CEE-12 panel; ii) for each country;
- The debt difference between the projected average level and the statistical average level (% of GDP):

$$\Delta d = d_{pr} - d \quad (7)$$

- The addition to the primary balance (considered an intermediate indicator), obtained from the two calculation elements mentioned:

$$\beta * \Delta d \quad (8)$$

On the basis of these calculation elements, the comparison indicator is constructed:

- The maximum adjusted primary balance pb_{max} resulting from summing the primary balance with the addition to the primary balance:

$$pb_{max} = pb + \beta * \Delta d. \quad (9)$$

After comparing the three indicators mentioned above, a country can qualify into one of the following four degrees of risk:

$$\text{LR (low risk):} \quad pb > pb_{pr} < pb_{max} \quad (10)$$

$$\text{MR (medium risk):} \quad pb < pb_{pr} < pb_{max} \quad (11)$$

$$\text{HR (high risk):} \quad pb > pb_{pr} > pb_{max} \quad (12)$$

$$\text{VHR (very high risk):} \quad pb < pb_{pr} > pb_{max} \quad (13)$$

The degree of risk – low, medium, high or very high – is defined according to the position of primary balance in the statistical period (pb) and the adjusted maximum primary balance (pb_{max}) in relation to the reference indicator – the projected primary balance or simulated (pb_{pr}).

As a result of the comparisons made on the size of each indicator in relation to the other two, the degree of country exposure to the risk of fiscal fatigue is assessed, according to relations (10) – (13). The classification of countries in different degrees of risk varies according to different factors: the time period, the size and evolution of fiscal balance and public debt, the coefficients of primary balance change relative to the variation in public debt.

6.2. Analysis of risk of fiscal fatigue

In our attempt to use the FRF at the level of each CEE country, we calculated the specific coefficients of linear FRF using time series for the Q1.2001-Q4.2021 period, which provides a sufficient number of observations. The calculation was performed in three variants, depending on the number of control variables, and the results were subjected to rigorous testing (Table 5).

According to the tests, in the first line of the table, which records the results of correlations between the key variables (primary balance and public debt) without control variables, significant coefficients were found only for two countries (Bulgaria and Hungary); in the second line, where GAP control variable is present, significant coefficients were identified for 5 countries (Bulgaria, the Czech Republic, Croatia, Lithuania and Hungary); in the third line where two control variables (GAP and INF) are attached, significant coefficients were found for 6 countries (Bulgaria, the Czech Republic, Croatia, Lithuania, Romania and Hungary).

When determining the fiscal fatigue risk categories into which countries may find themselves, we considered only the significant specific coefficients. In this case, the scope of this model is reduced to 6 countries. Table 6 presents the data for the periods 2012-2021 and 2022-2031 regarding the indicators used, their calculation method, as well as the results obtained based on the application of formulas (10) - (13). It should be noted that, according to the calculations, all 6 countries and their variants fall into the category of low risk for fiscal fatigue (column 9 of Table 6).

Table 5

Linear FRF - Country-level and panel common coefficients, in variants, Q1.2001-Q4.2021

Variants	Country-specific coefficients - OLS ¹												Panel OLS ²
	Bulgaria	Czechia	Cyprus	Croatia	Estonia	Latvia	Lithuania	Poland	Romania	Slovenia	Slovakia	Hungary	CEE-12 average
<i>1. Dependent: pb_t</i> <i>Factors: d_{t-1}, AR(1), AR(2)</i>	0.082 (***)	0.019 (-)	-0.047 (-)	0.035 (-)	-0.169 (-)	-0.060 (-)	0.064 (-)	0.064 (-)	-0.010 (-)	0.026 (-)	-0.001 (-)	0.127 (**)	0.015 (-)
<i>2. Dependent: pb_t</i> <i>Factors: d_{t-1}, GAP_t, AR(1), AR(2)</i>	0.157 (***)	0.282 (***)	0.014 (-)	0.108 (***)	-0.135 (-)	0.043 (-)	0.103 (*)	0.069 (-)	0.124 (-)	0.067 (-)	0.061 (-)	0.170 (**)	0.071 (***)
<i>3. Dependent: pb_t</i> <i>Factors: d_{t-1}, GAP_t, INF_t, AR(1), AR(2)</i>	0.150 (***)	0.278 (***)	0.026 (-)	0.110 (***)	-0.101 (-)	0.044 (-)	0.104 (*)	0.065 (-)	0.138 (*)	0.063 (-)	0.063 (-)	0.157 (**)	0.072 (***)

Notes: (***) , (**) , * , (-) - significant coefficient for a threshold of 1%, 5%, 15%, insignificant, respectively; ¹ Country-specific coefficients estimated by OLS, the number of observations may differ from one country to another; ² Unbalanced fixed-effects panel estimated by OLS, period Q1.2001-Q4.2021, CEE-12 countries.

Source: Authors' calculations, based on Eurostat data.

Table 6

**Degree of risk of fiscal fatigue for the CEE countries - Based on statistical series, EC projections (simulations) on public debt and primary budget balance,
and significant country-specific coefficients, linear FRF¹⁾
(2012-2021 and 2022-2031)**

Country	Variant ²⁾	Actual average 2012-2021		Projected average 2022-2031		Fiscal fatigue risk (adjustment with the significant specific coefficient, linear FRF)				
		Actual primary balance (pb)	Actual public debt (d)	Projected primary balance (pb _{pr})	Projected public debt (d _{pr})	Debt difference $\Delta d = d_{pr} - d$	Country- specific coefficients, linear FRF (β)	Addition to primary balance $\beta * \Delta d$ (col.5 * col.6)	Maximum adjusted primary balance, pb _{max} (col.1 + col.7)	Risk categories (comparison between pb, pb _{pr} and pb _{max})
A	0	1	2	3	4	5	6	7	8	9
Bulgaria	Var. 1	-1.04	23.1	-1.72	30.5	7.40	0.082	0.607	-0.433	LR
	Var. 2	-1.04	23.1	-1.72	30.5	7.40	0.157	1.162	0.122	LR
	Var. 3	-1.04	23.1	-1.72	30.5	7.40	0.150	1.110	0.070	LR
Czechia	Var. 2	0.00	37.6	-3.24	28.7	-8.90	0.282	-2.510	-2.510	LR
	Var. 3	0.00	37.6	-3.24	28.7	-8.90	0.278	-2.474	-2.474	LR
Croatia	Var. 2	-0.02	81.1	-1.11	75.4	-5.70	0.108	-0.616	-0.636	LR
	Var. 3	-0.02	81.1	-1.11	75.4	-5.70	0.110	-0.627	-0.647	LR
Lithuania	Var. 2	0.72	38.2	-0.9	41.5	3.30	0.103	0.340	1.060	LR
	Var. 3	0.72	38.2	-0.9	41.5	3.30	0.104	0.343	1.063	LR
Romania	Var. 3	-1.42	40.9	-3.92	60.6	19.70	0.138	2.719	1.299	LR
Hungary	Var. 1	0.74	73.6	-1.32	71.7	-1.90	0.127	-0.241	0.499	LR
	Var. 2	0.74	73.6	-1.32	71.7	-1.90	0.170	-0.323	0.417	LR
	Var. 3	0.74	73.6	-1.32	71.7	-1.90	0.157	-0.298	0.442	LR

Notes: ¹⁾ Only CEE countries with significant specific public debt ratios were considered; ²⁾ The variants are defined according to the consideration of control variables: variant 1 – the simple relationship between the key variables (primary balance and public debt) without control variables; variant 2 – debt variable accompanied by GAP variable; variant 3 - debt variable accompanied by GAP and INF variables.

Source: Authors' calculations, based on: EC, Eurostat database; Sustainability Report 2021, vol. 2; Country Analysis, Institutional Paper 171/ April 2022; EC, Debt Instability Monitor 2020, Institutional Paper 143, Feb. 2021; IMF, Fiscal Monitor Achieving More with Less, April 2017.

In addition to the above-presented analysis, in order to compare the results, we also consider variants: on the one hand, based on the use of average panel coefficients of linear FRF, for the period Q1.2001-Q4.2021; on the other hand, based on statistical series and 10-year / 5-year projections. In table 5, the average panel coefficients of linear FRF, in variants 2 and 3, were presented with the values: $\beta_2=0.071$ and $\beta_5=0.072$. They are used to calculate the maximum adjusted primary balance (sp_{max}) for both the 10-year and 5-year options.

Regarding the 10-year version (table from Annex 6), the comparison of the 3 relevant indicators (pb , pb_{pr} and pb_{max}) from formulas (10) – (13) leads to the conclusion that a number of 11 countries fall into the category of low risk, and only one country (Poland) finds itself in the situation of high risk for fiscal fatigue, in relation to the future evolution of public debt and other financial indicators.

Regarding the 5-year variant (table from Annex 7), with average FRF panel coefficients of 0.071 and 0.072, 11 countries fall into the low-risk category, while Poland is found in the very high-risk situation. However, if the insignificant difference between pb and pb_{pr} is taken into account, one may appreciate that Poland's degree of risk fits into both high and very high categories.

7. Conclusions

We analyzed in this study the correlation between government budget balance and public debt stock, for a group of 12 CEE countries, including Romania, over a period of approximately 21 years, in order to evaluate the debt limit and the fiscal space, to estimate the level of debt at which fiscal fatigue may occur, as well as for assessing the degree of risk for fiscal fatigue, depending on the past and future evolution of public debt.

In the first part of this approach, we estimated the fiscal reaction function (FRF) and the debt financing cost function (FCF), by variants (Tables 1-3), on the basis of which we determined the optimal debt, fiscal fatigue, debt limit and fiscal space for the entire CEE group. In the estimation of these points, we used a cubic shape FRF, and a linear and quadratic FCF, respectively.

At panel level, the estimates show an equilibrium (optimal) debt point (d^*) of 55% of GDP in the quadratic FCF version, and 56% in the linear FCF version, respectively, a ceiling point (accentuation of fiscal fatigue - d_{max}) around a maximum of 87%, followed by a debt limit point (\bar{d}) in the amount of 99%, and 103% of GDP, respectively. Calculating the differences between this limit and the actual debt level in 2021, the results reveal an average fiscal space of around 39-43% of GDP, for the CEE-11 group.

Romania displays a significantly lower FRF curve, which reveals a relative expansionary (or loose) fiscal policy, and a slightly lower FCF (financing cost), relative to the CEE-11 average. These result in higher d^* (65% and 66% of GDP, respectively) and lower \bar{d} points (93% / 98% of GDP). Romania's fiscal space values are above the group average, in both variants: 44% and 49% of GDP, respectively.

In the second part, using the coefficients of linear FRF, by country and for the entire panel, we assessed the degree of risk for fiscal fatigue. Depending on the location of projected average level of primary balance - related to primary balance from the statistical period and the adjusted maximum primary balance, all 6 countries with significant specific coefficients and their variants are found in the category of low risk of fiscal fatigue. Using the panel common coefficients, in the version of the 10 and 5-year projections, respectively, 11 of the analyzed countries reveal low risk of fiscal fatigue in relation to the future evolution of public debt and other financial indicators, and only one country (Poland) is found in a high or very high risk situation.

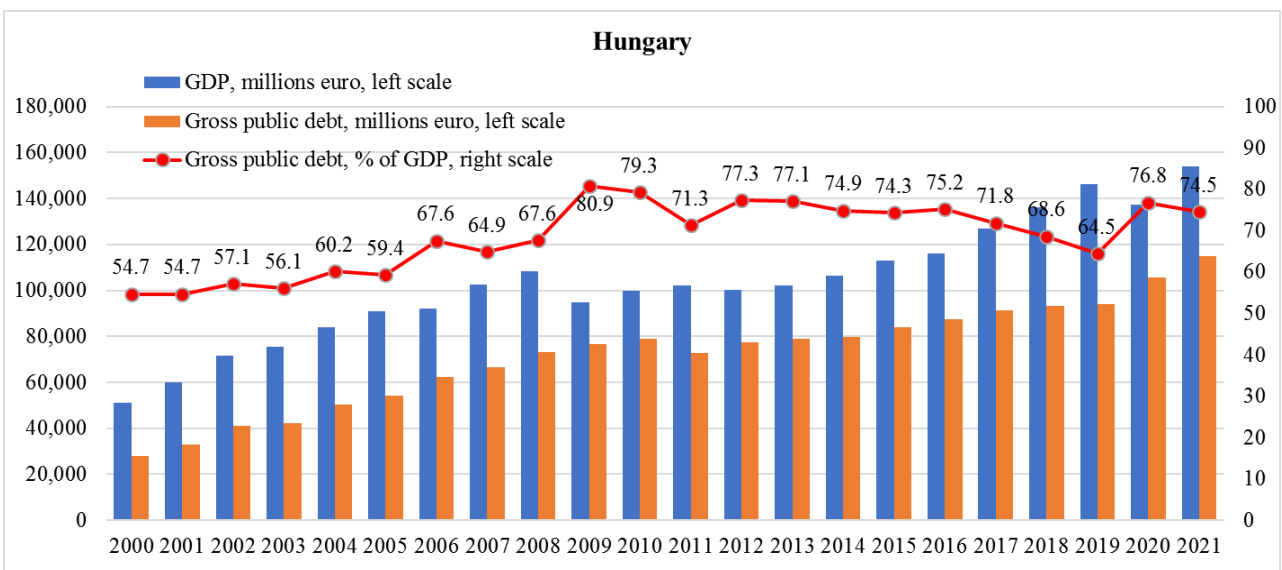
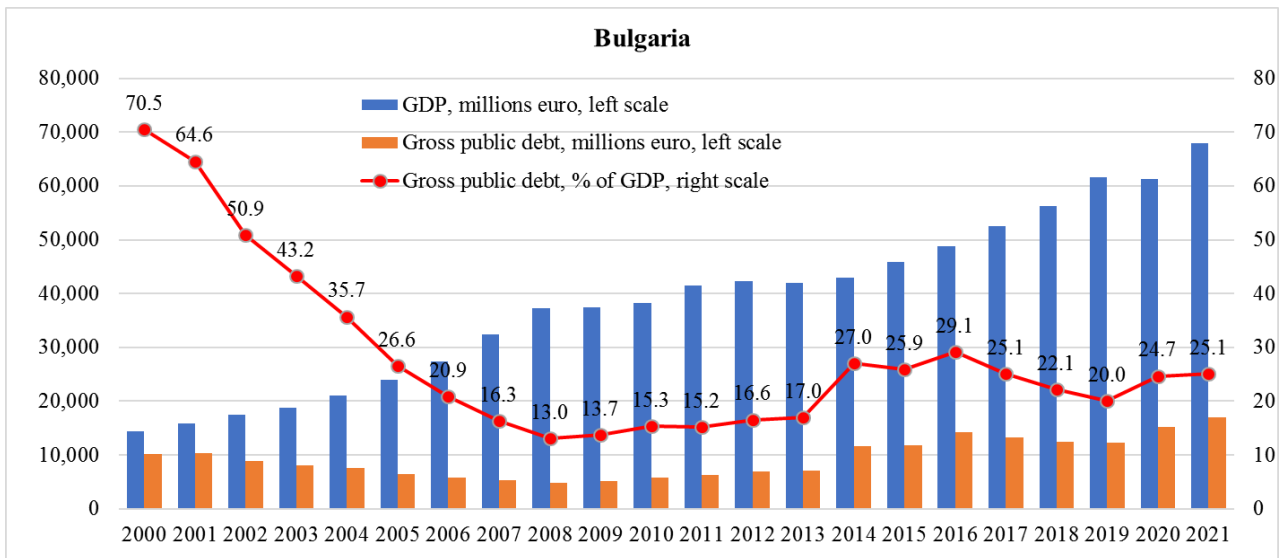
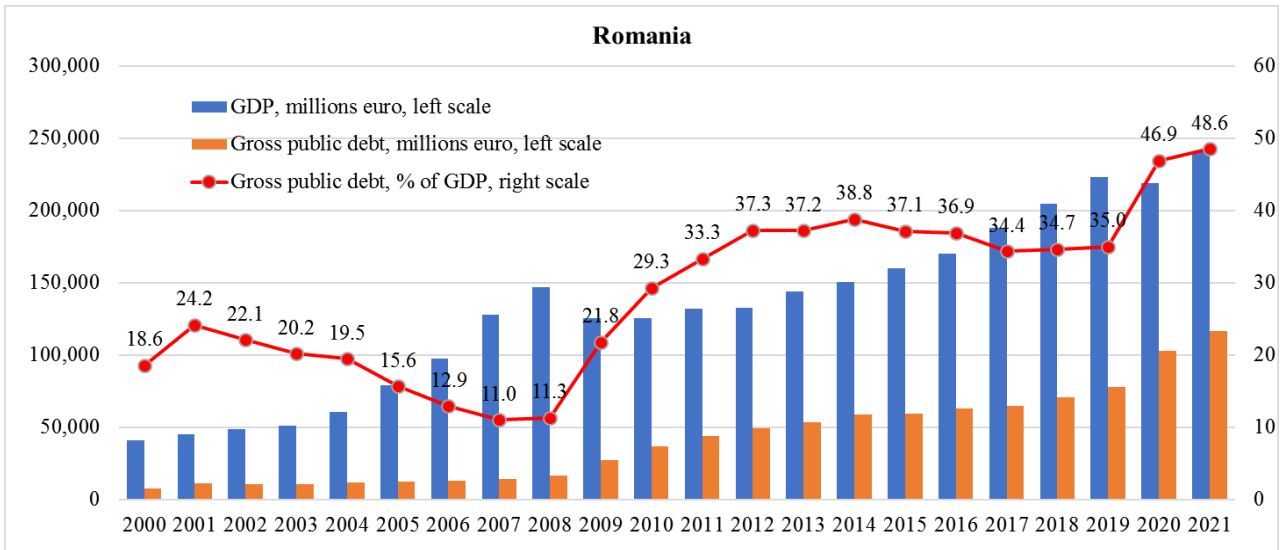
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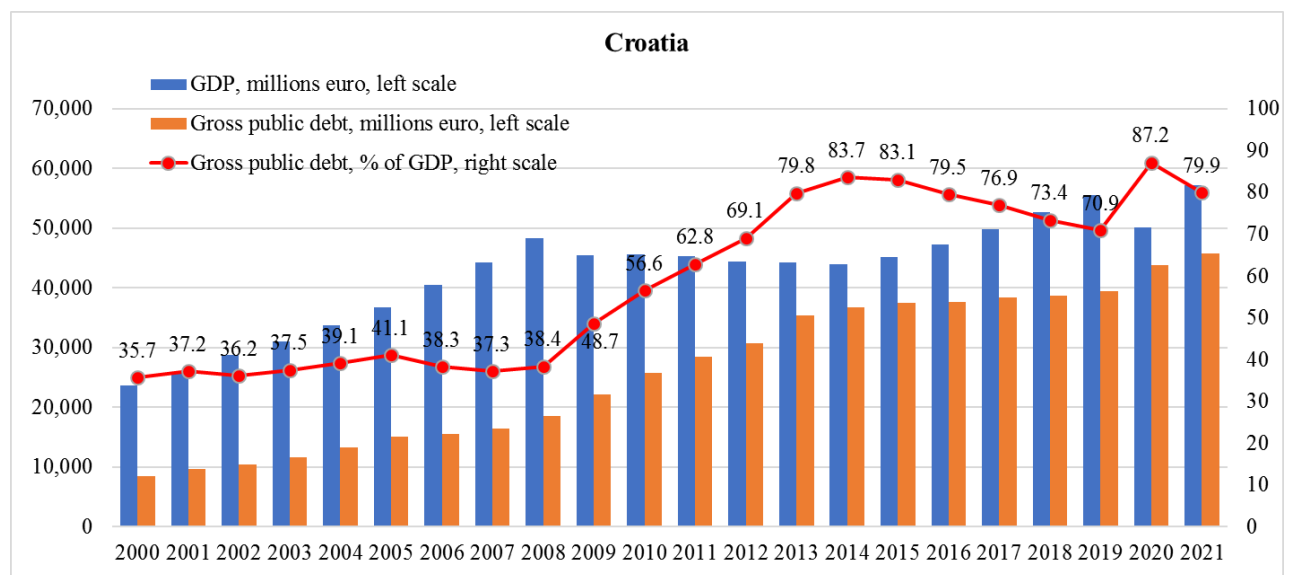
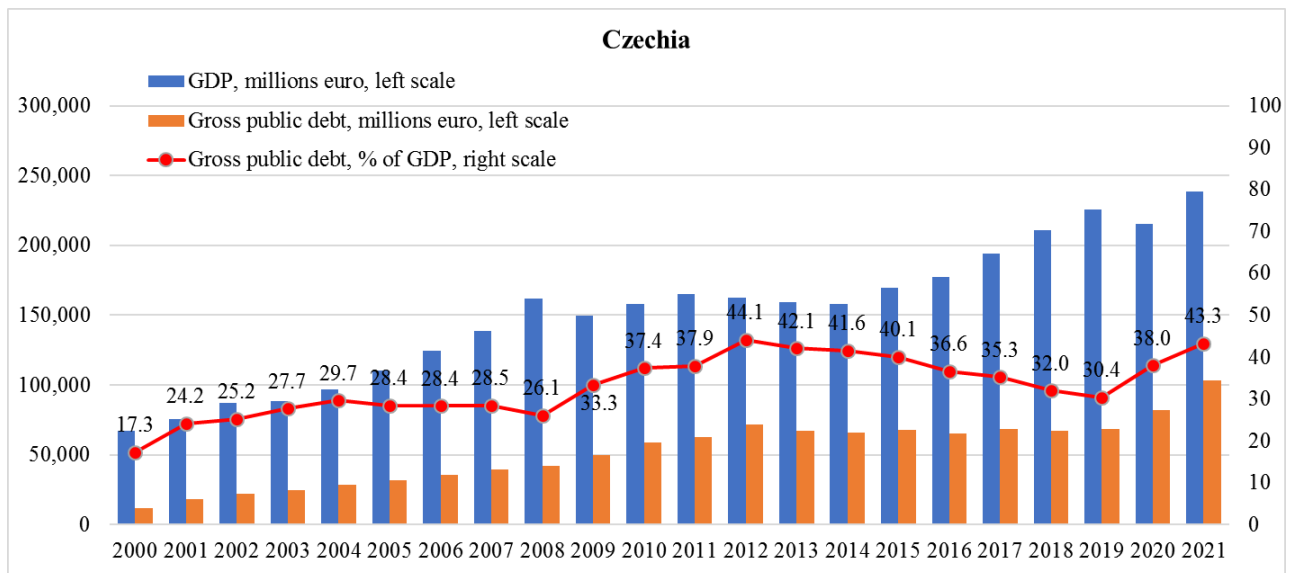
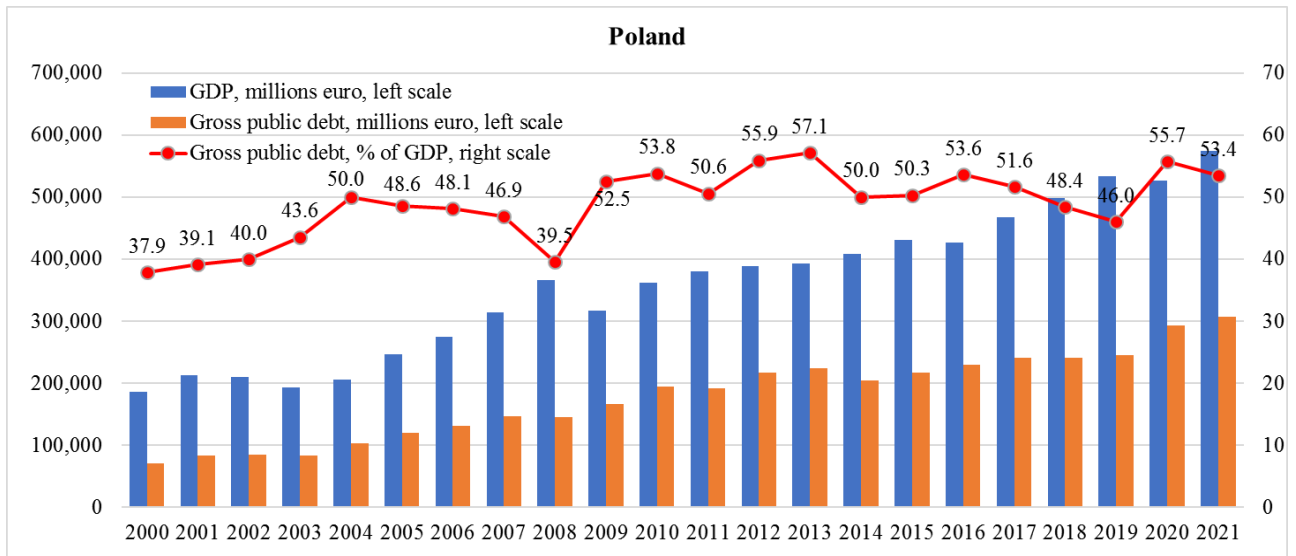
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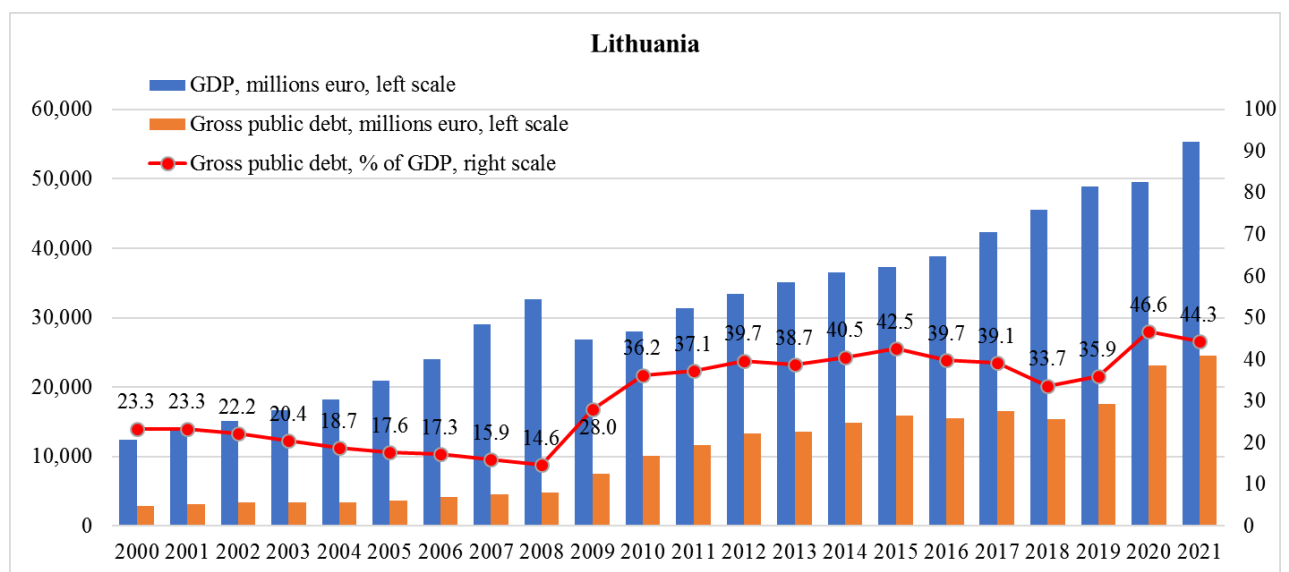
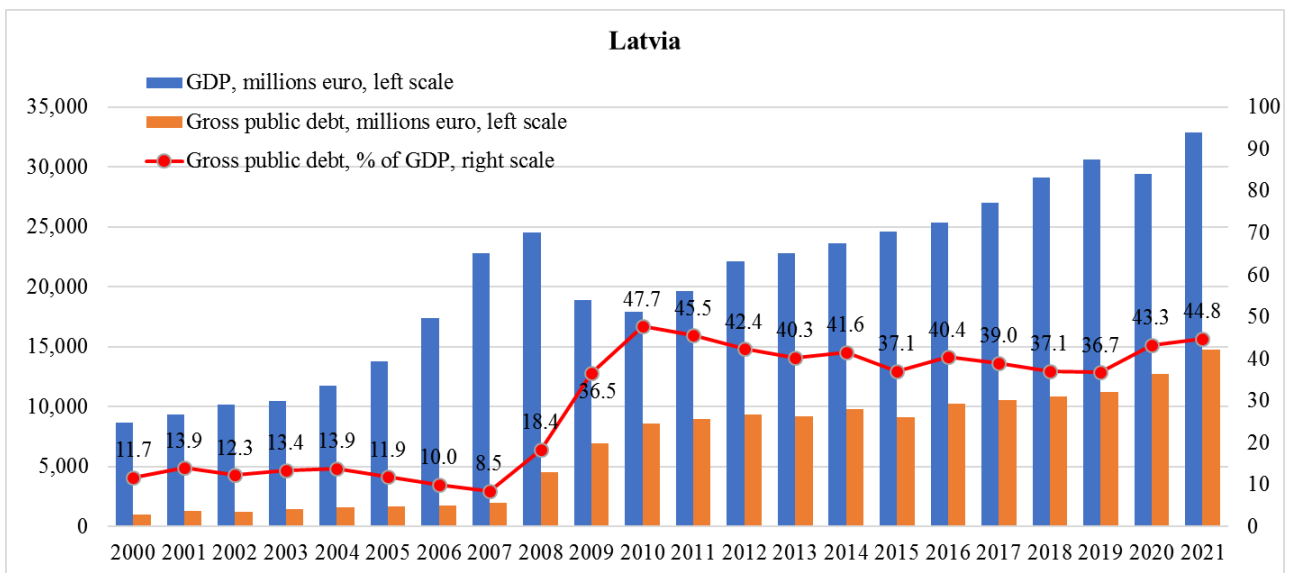
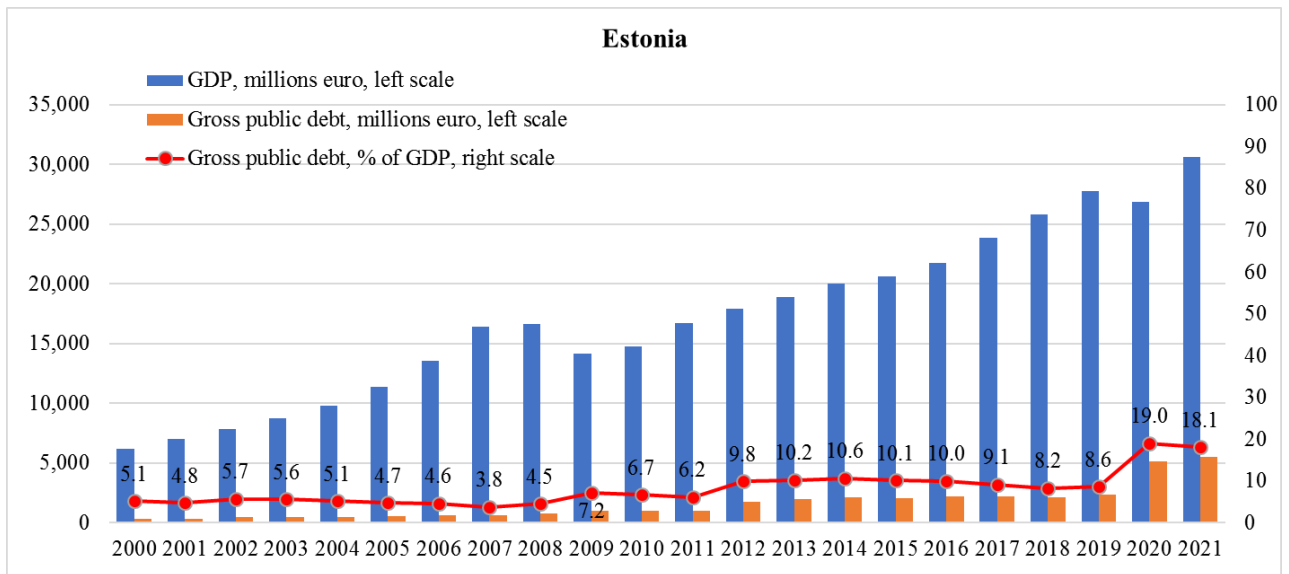
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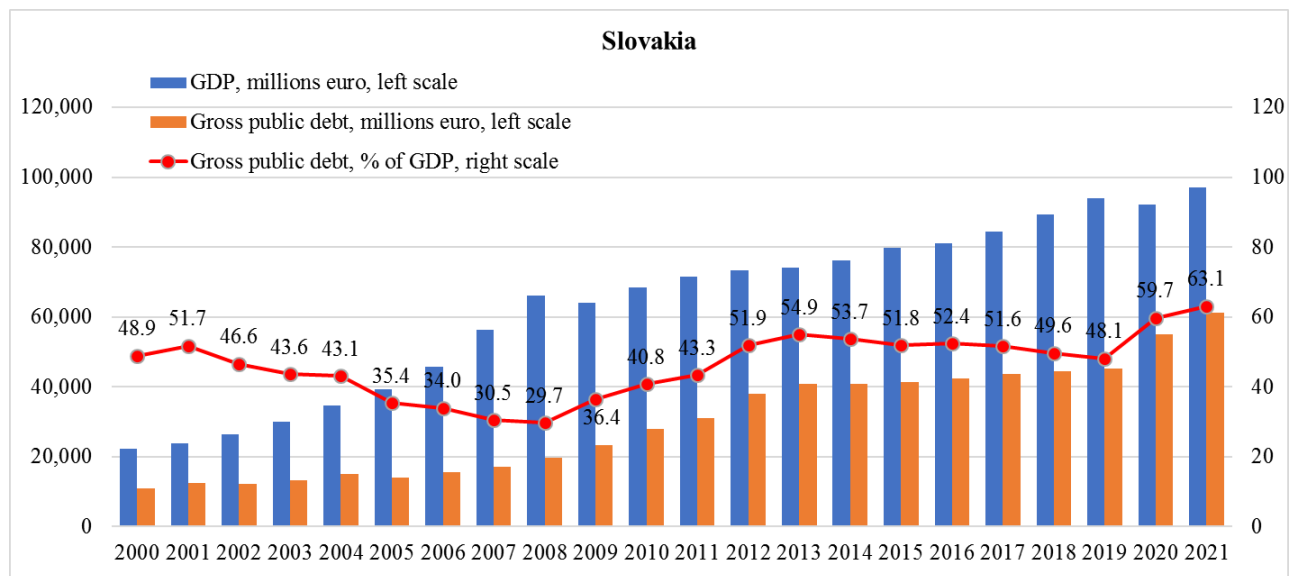
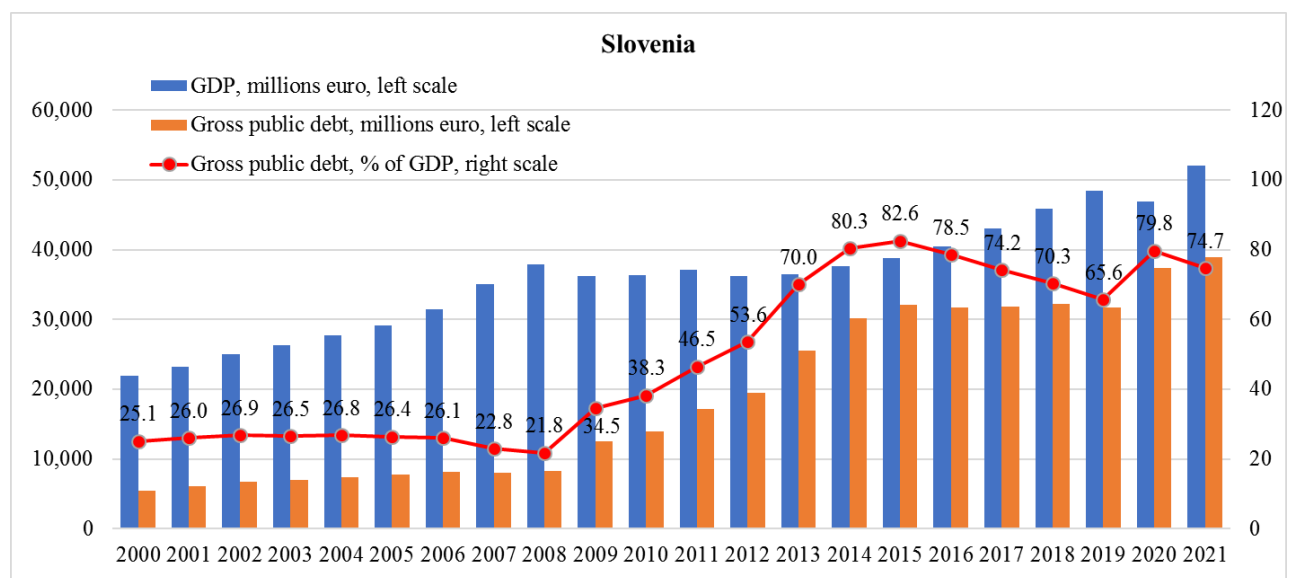
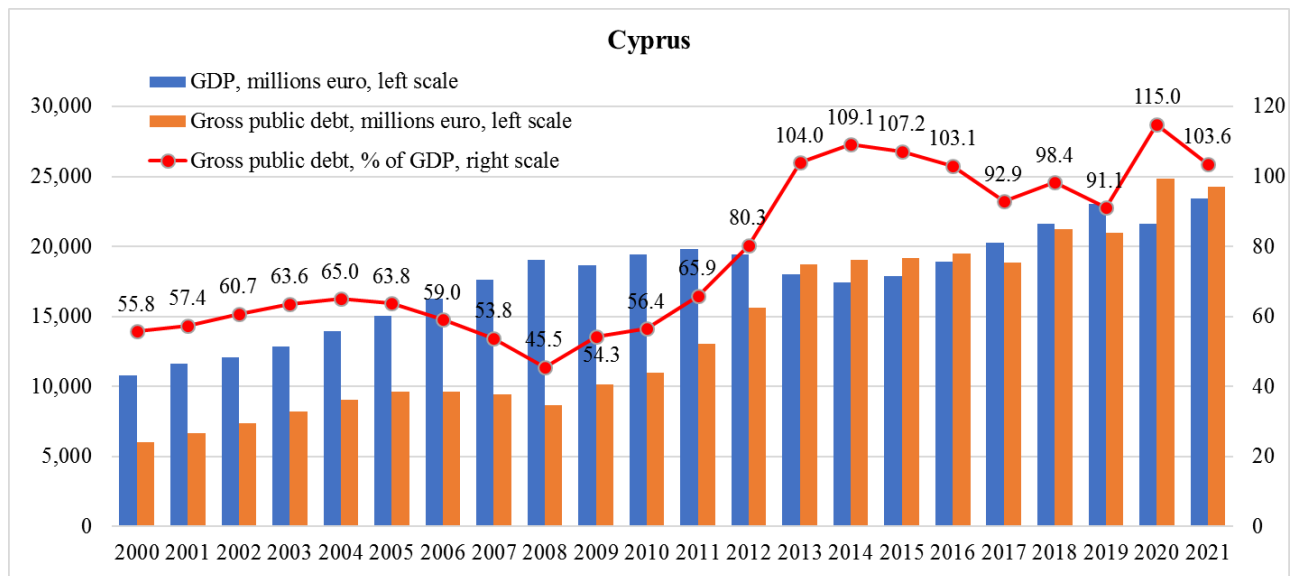
Annex 1a.

Public debt-to-GDP ratio (%) for the CEE-12 countries





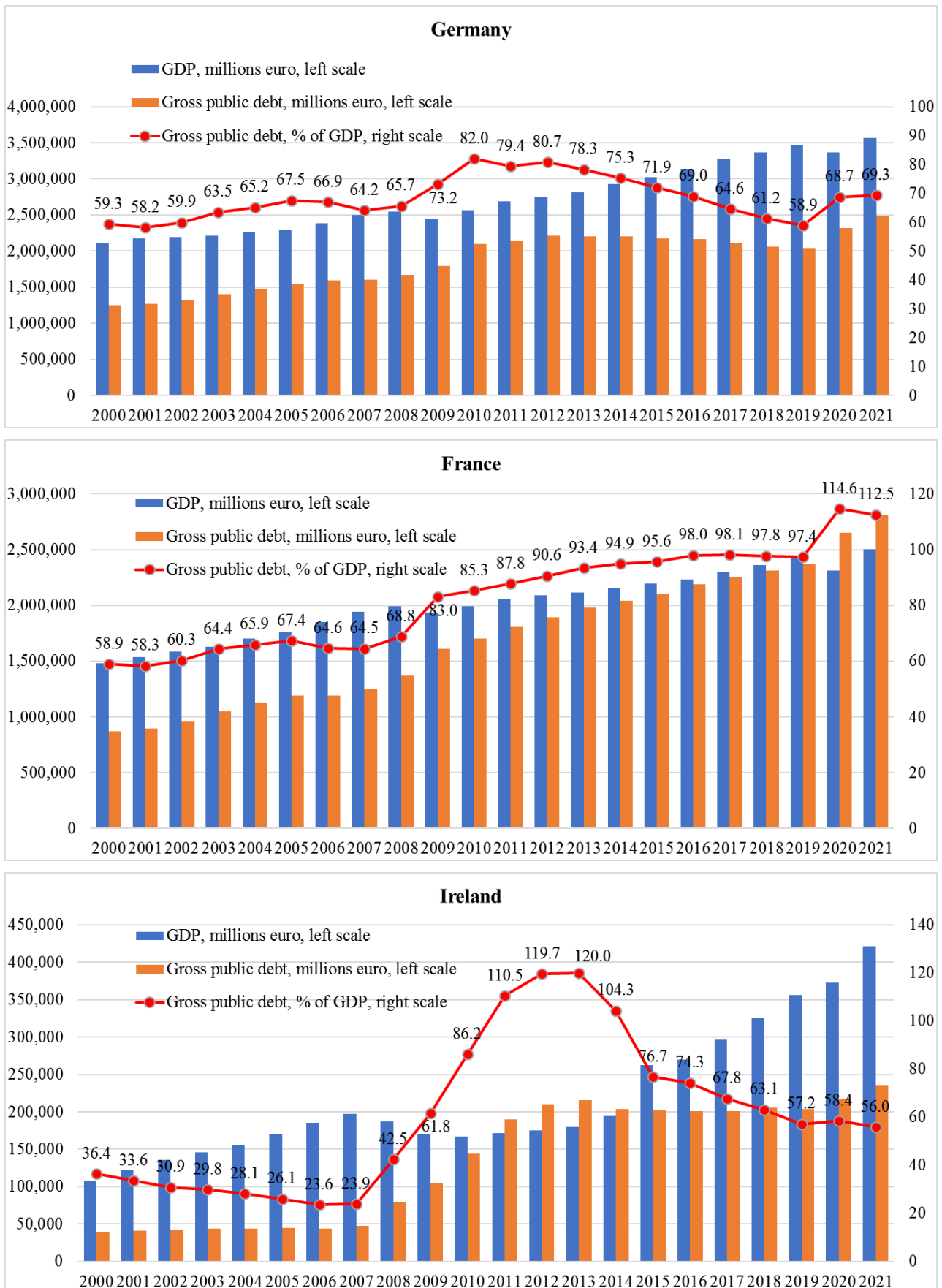


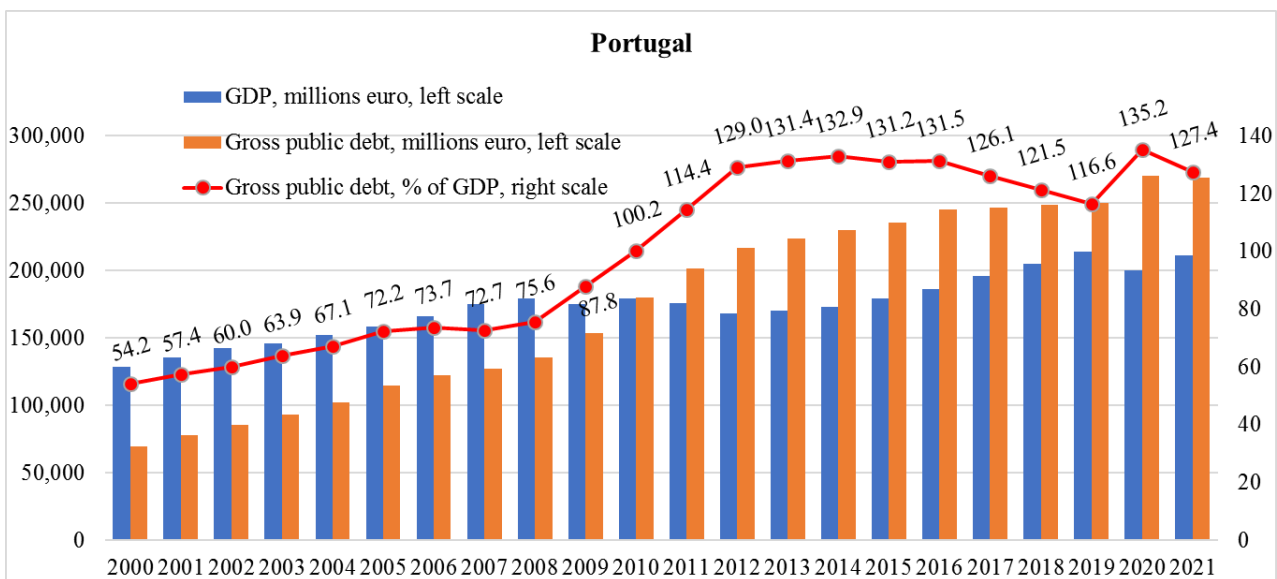
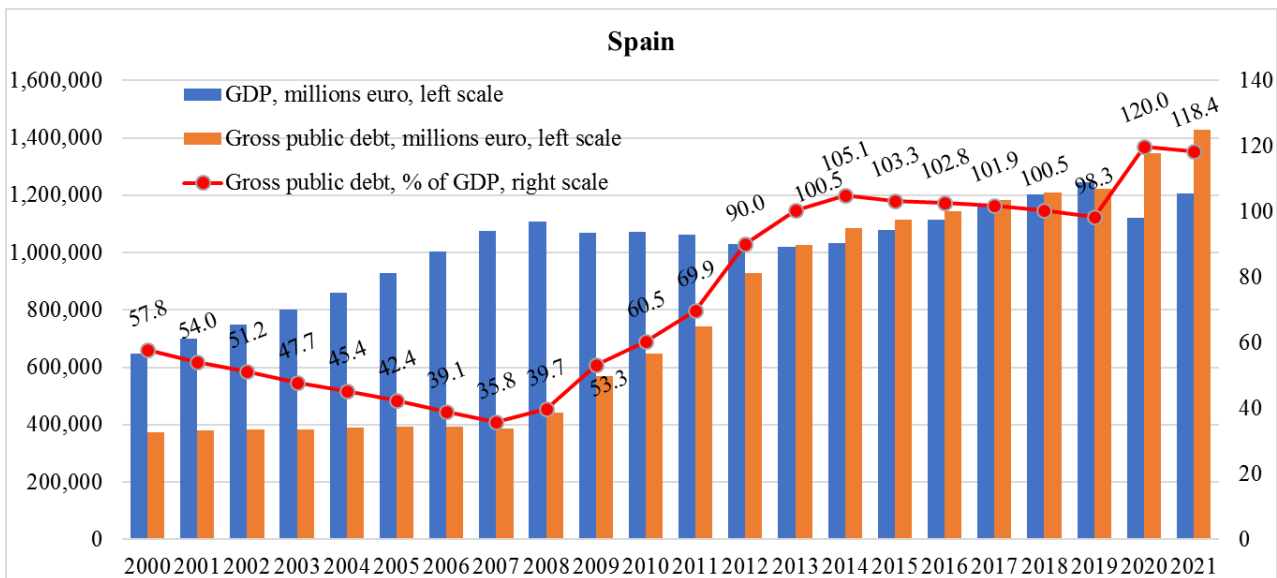
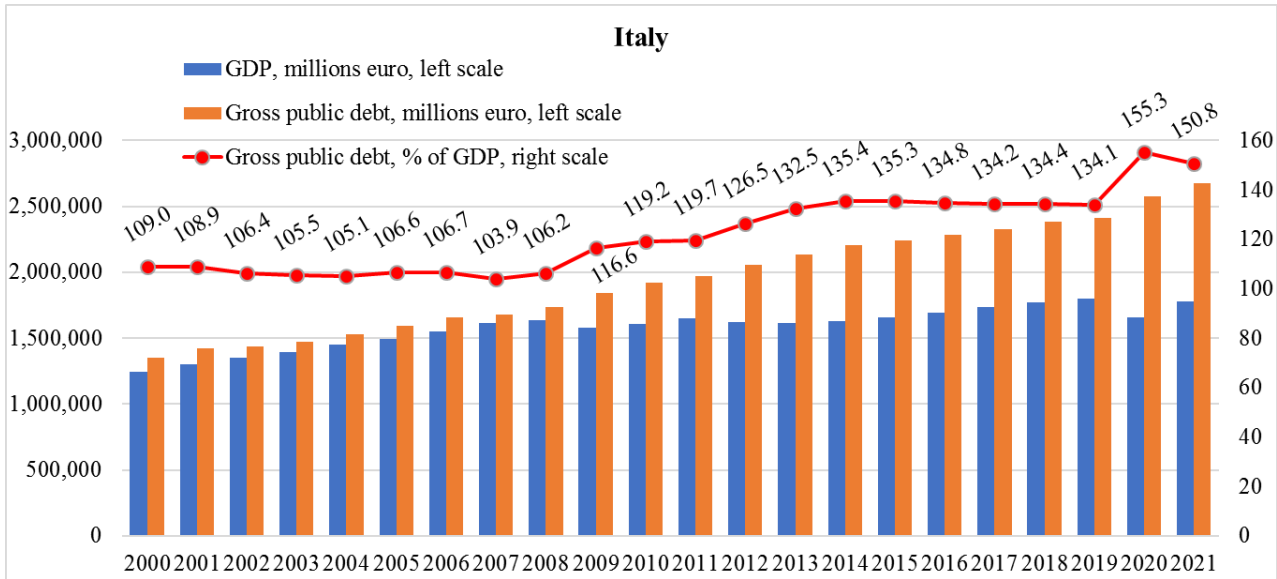


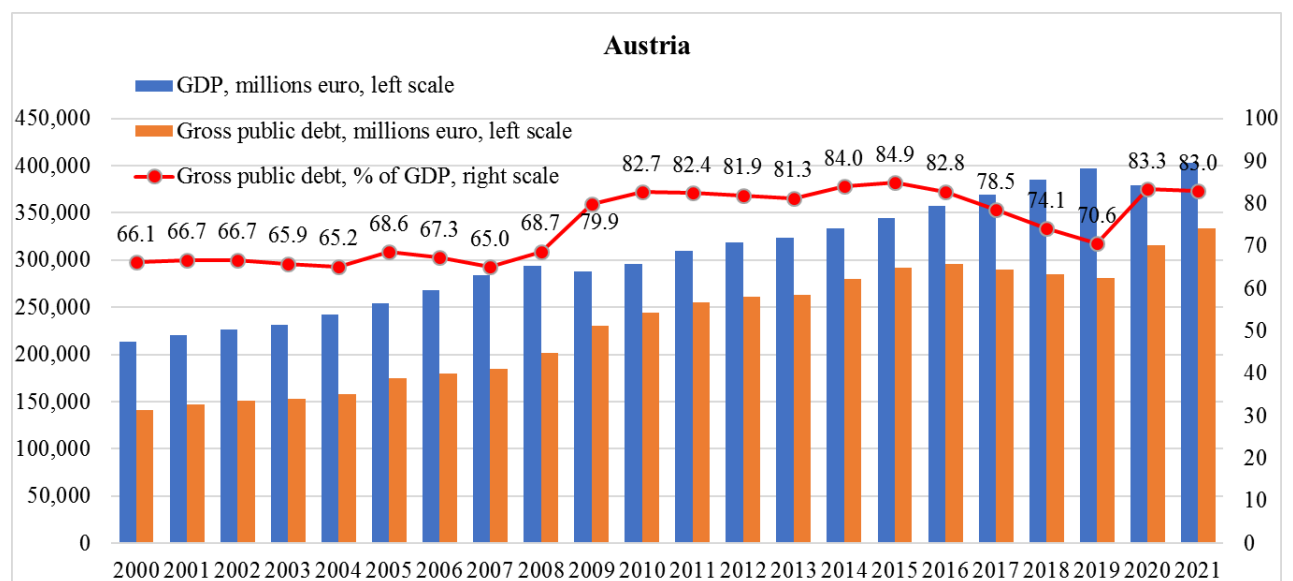
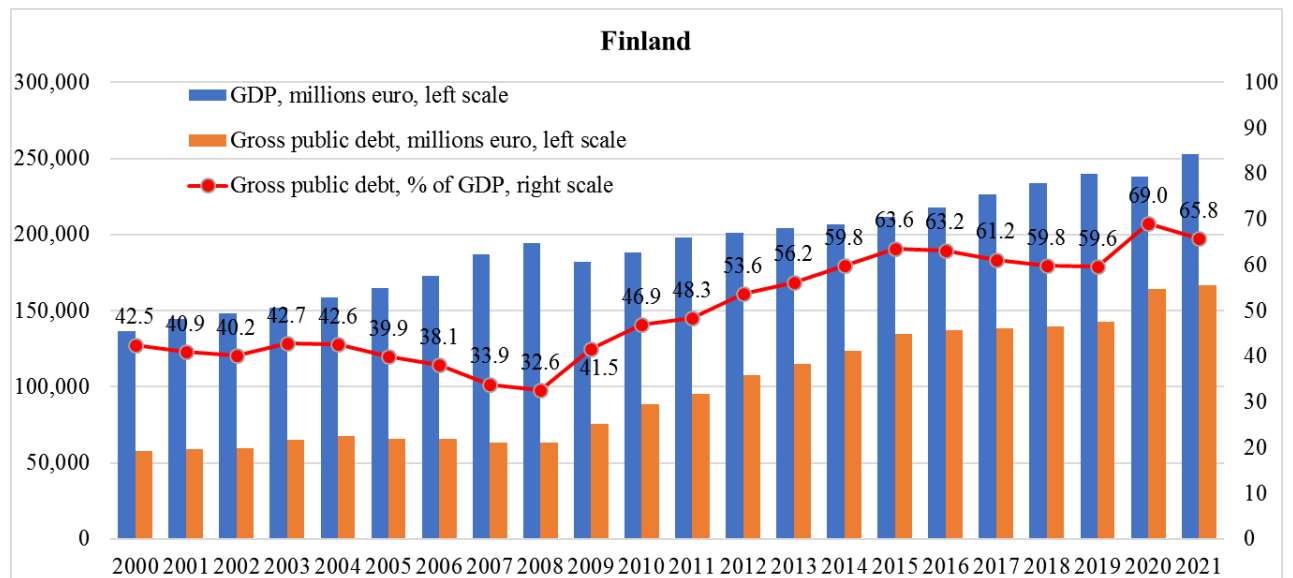
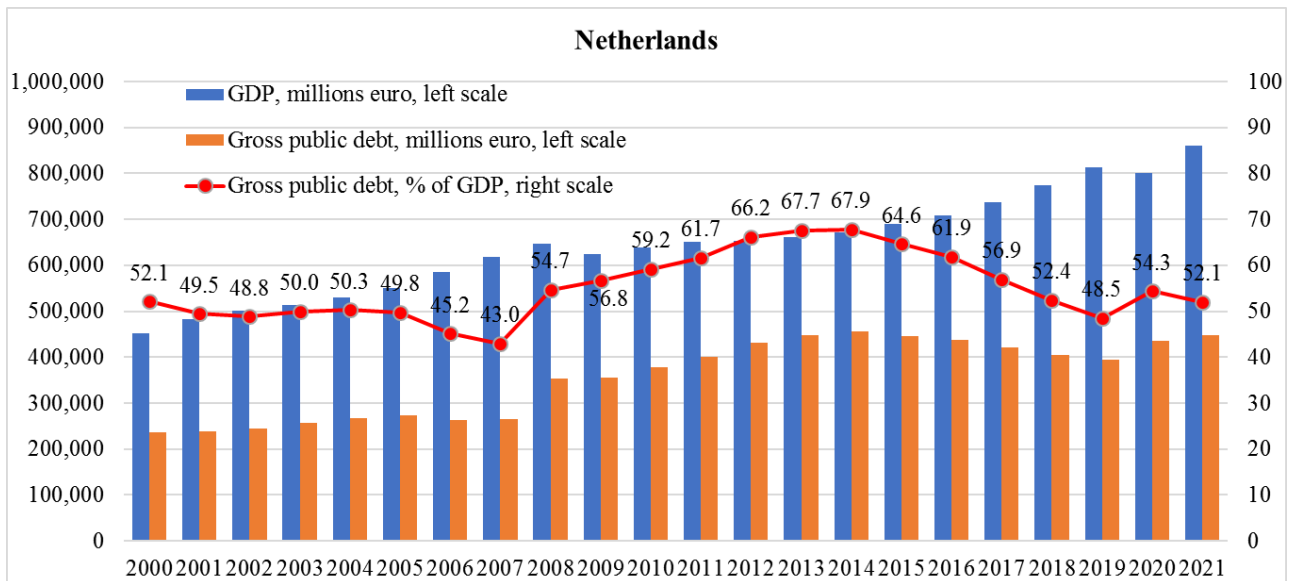
Source: Eurostat, authors' calculations.

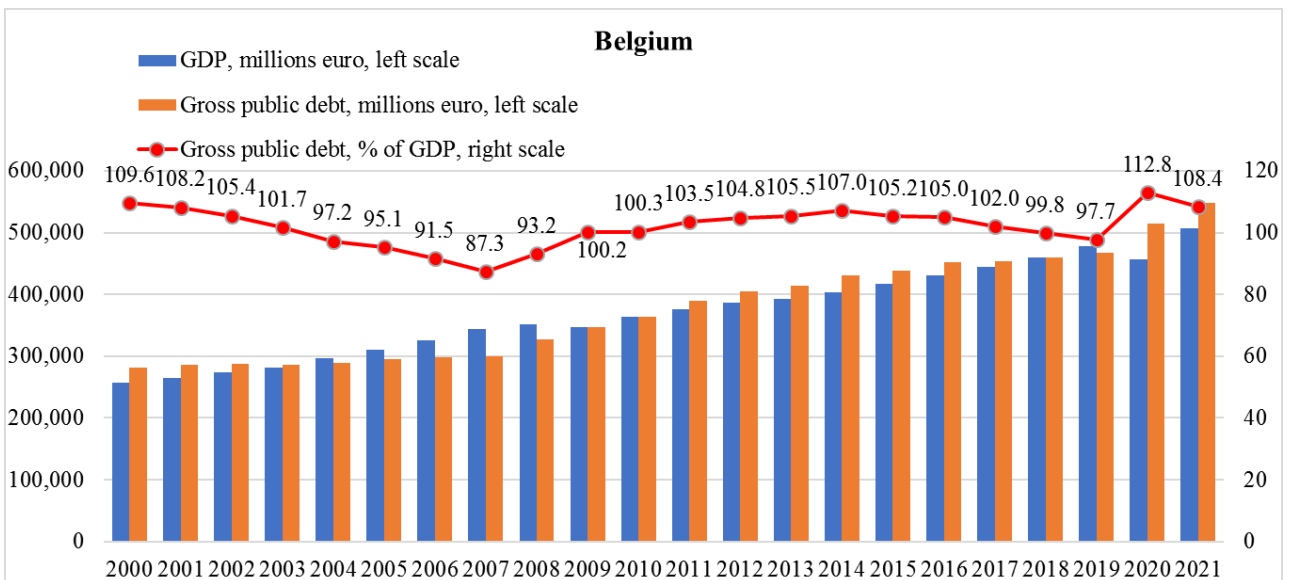
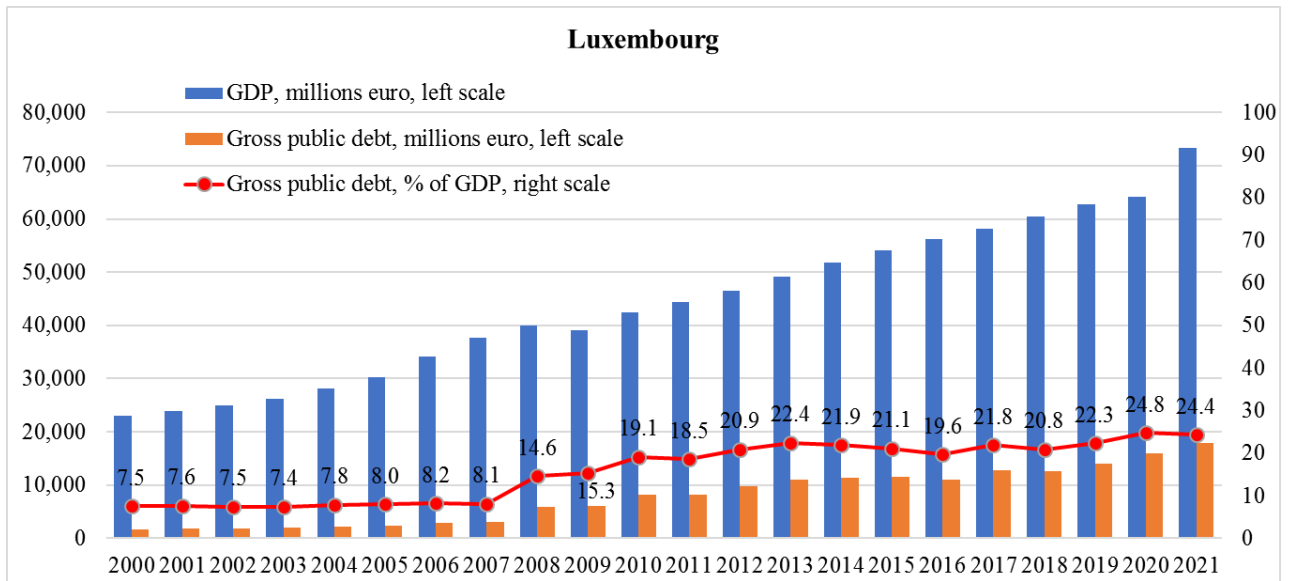
Annex 1b.

Public debt-to-GDP ratio (%) for the Euro-11 countries









Source: Eurostat, authors' calculations.

Annex 2.

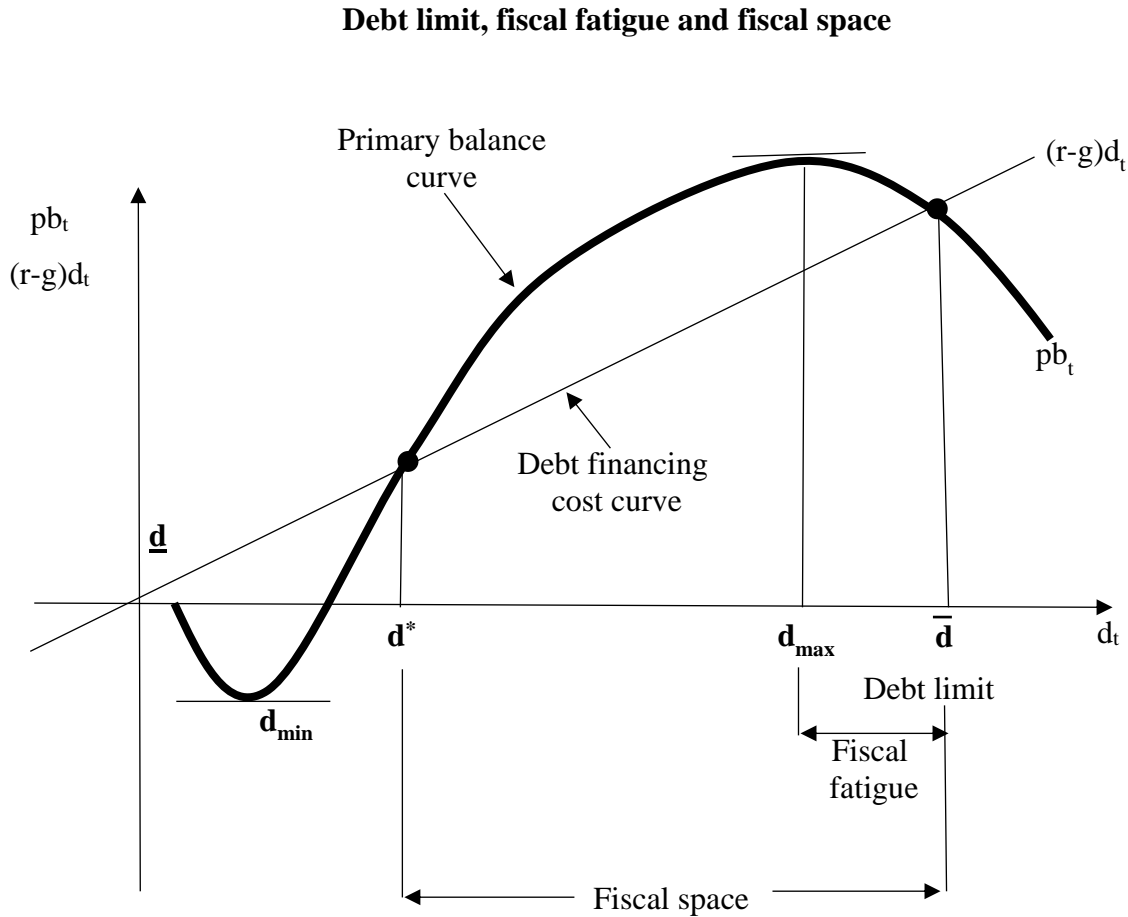
Sovereign debt FRF coefficients, calculated and presented in various studies

Studies and data series	Country group	Period	Public debt coefficients*
Baldi, Staehr (2016) quarterly data	Zona euro (panel, 19 countries)	2001-2008 2009-2014	0.023 0.087
	CEE (panel, 10 countries)	2001-2008 2009-2014	0.044 0.118
Schoder (2014) quarterly data	OECD (panel, 15 countries)	1980-1996	0.041
		1997-2010	0.011
Beti & Shiamtanis (2013) annual data	Eurozone (panel, 11 countries)	1970-2011	0.0727
Weichenrieder & Zimmer (2014) annual data	Eurozone (panel)	1970-2011	0.043-0.059
Debrun & Kinda (2013) annual data	Developed countries (panel, 28 countries)	1980-2010	0.035-0.040 (FE estimator)
	Emergent countries (panel, 26 countries)	1980-2010	0.032-0.037 (LSDVC estimator)
Cordes <i>et al.</i> (2015) annual data	Developed and emergent countries (panel, 57 countries)	1951-2013	-0.001-0.692
Checherita-Westphal & Ždarek (2017) annual data	Eurozone (panel 18 countries)	1970-2013	0.03-0.05 When the statistical series also includes the crisis period, the debt ratio increases by 0.008-0.019 pp
Fournier & Fall (2015) annual data	OECD (panel, 31 countries)	1985-2007 2008-2013	0.02 for debt level below 120 (% of GDP) 0.06 for debt level above 120 and below 170 (% of PIB) -0.10 for debt level above 170 (% of GDP)
Berti <i>et al.</i> (2016) annual data	Western European specific selected countries	1950-2013	-0.035-0.111 (whole period) 0.003-0.111 after crisis
	CEEC	1995-2013	0.0271-0.0663 (variation across estimators: OLS; FE; IVFE; NSDVC; ABGMM) 0.0643 0.052-0.0702 0.0663
	- (panel, total) - (panel, 12 countries) - (panel, 3 specific countries, including Romania)	1995-2013	
Akar (2019) quarterly data	Turkey	2001-2018	+ 0.125 (for low debt levels); - 0.056 (for high debt level, beyond the τ threshold)

* Increase/decrease in the primary budget balance for one percentage point increase in public debt (as % of GDP).

Source: Berti *et al.* (2016), Checherita-Westphal & Zdarek (2017), and others.

The dynamic relationship between primary balance function and sovereign debt cost function; defining debt limit, fiscal space and fiscal fatigue



Source: Ghosh *et al.*, 2013; Robertson, Tambakis, 2016; Khalladi, 2019.

The graph depicts the dynamic relationship between the primary balance function and the public debt cost function, as debt ratio increase. The primary budget balance (pb_t), expressed as % of GDP, reacts to the increase/decrease in the lagged public debt (d_{t-1}), % of GDP, in the presence of significant control variables (X_tS):

$$pb_t = pb(d_{t-1}, X_tS) \quad (1)$$

Debt incurs costs. The higher the debt, the higher are its financing costs. The debt financing cost function (fc), in simplified form, is the difference between the interest rate (r) and the GDP growth rate (g), the difference multiplied by debt (d_t), as % of GDP⁶:

$$fc_t = (r_t - g_t)d_t \quad (2)$$

⁶ It is a component of the dynamic debt function: $\Delta d_t = (r-g)d_t - pb_t$.

Ganiko & Melgarejo (2016) use the financing cost function in the following formulation as $\Phi_t d_{t-1}$, where $\Phi_t = \frac{r_t - g_t}{1 + g_t}$. The financing cost function used in our study is explained in section 3.

In their dynamics, the relationships between the curves of functions pb_t and $(r-g)d_{t-1}$ described within the figure above, generate, highlight and order the notions and specific features of the processes, as follows:

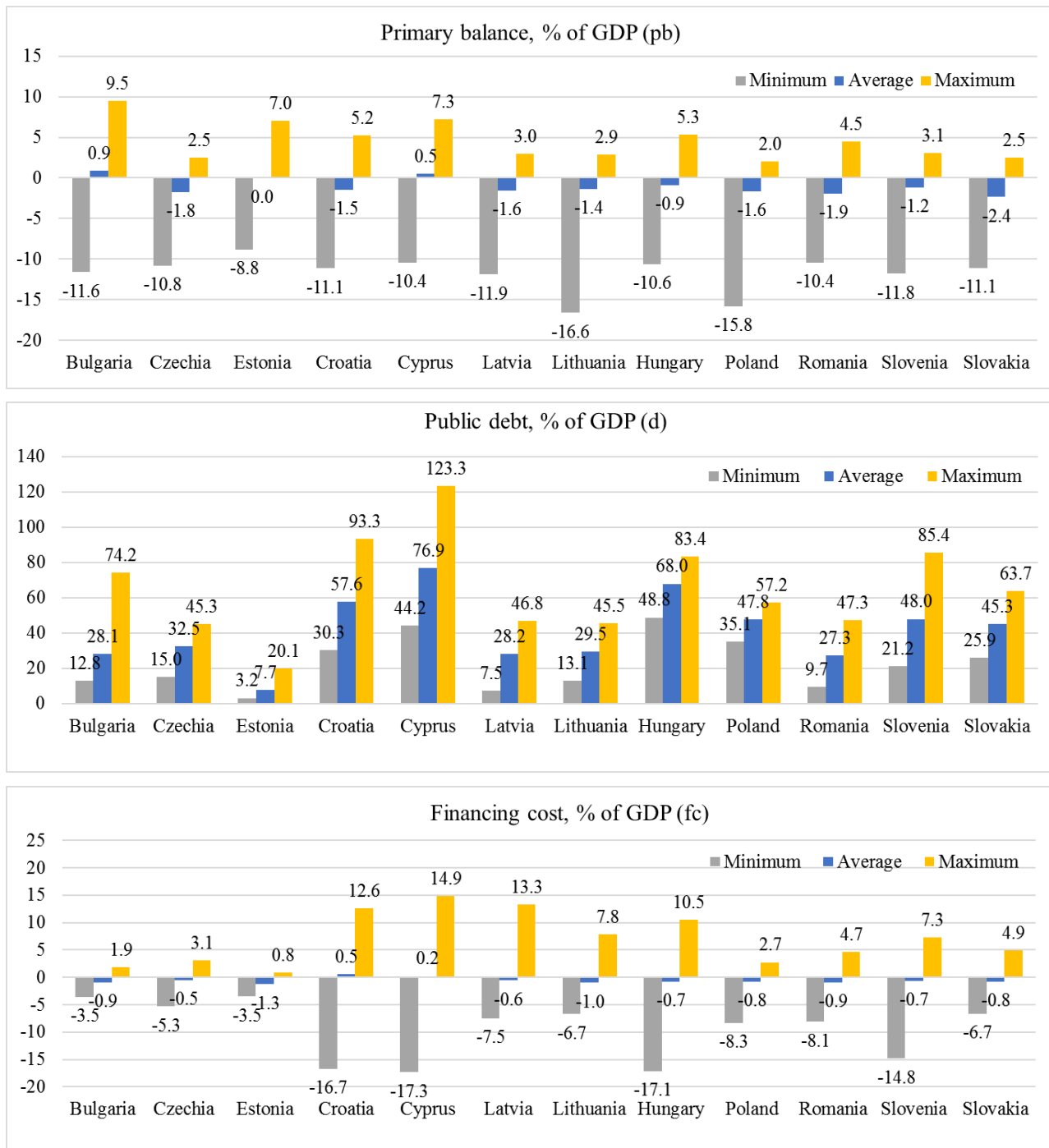
1. The analysis of dynamic relationship between the two functions (primary balance and cost of debt) - in relation to the size of debt - highlights the difference between financing cost of debt and primary budget balance, this representing debt variation:

$$\Delta d_t = (r-g)d_{t-1} - pb_t \quad (3)$$

Regarding this variation, when debt financing cost curve is above the primary balance curve, debt variation is positive ($\Delta d_t > 0$), and when debt financing cost curve is below the primary balance curve, debt variation is negative ($\Delta d_t < 0$) (Khalladi, 2019);

2. In the hypothesis of using non-linear (cubic-shaped) fiscal balance reaction function to the variation of public debt, a single inflection point denoted by d_{max} is produced, and the covariation of the two functions produces two long-term intersections, d^* and \bar{d} . Of these two points, the first is called **optimal debt** and the second, **debt limit**. The name optimal debt is justified because on the segment of the primary balance curve, $d_{min} - d^*$, the effect (yield) of debt is increasing, and on the segment $d^* - d_{max}$ of the same curve, the effect (yield) of debt is decreasing;
3. Between the two points d^* and \bar{d} , fiscal space is defined, mentioning that starting from d_{max} , the mechanisms for maneuvering government fiscal policies are getting jammed, in an accelerated manner;
4. From the inflection point d_{max} asserts, gradually stronger, the presence of fiscal fatigue characterized by the decrease, until total loss of government's ability to apply policies for increasing primary budget balance (by increasing taxes and/or reducing public spending), in response to debt increases above the threshold of affordability;
5. The intersection of primary balance function with debt financing cost function at point \bar{d} , called the debt limit, represents the explosive point called insolvency where neither rolling over the old debt, nor making new debts can be done.

Statistical analysis of data series



Source: Eurostat, authors' calculations.

Annex 5.

Stationarity tests

a. with constant included:

Method:	Variable:	pb		d		GAP		INF	
		t-statistic	probability	t-statistic	probability	t-statistic	probability	t-statistic	probability
Levin, Lin & Chu t		-3.74840	0.0001	-1.51131	0.0654	-1.87594	0.0303	-2.25701	0.0120
Im, Pesaran and Shin W-stat		-6.83360	0.0000	0.86002	0.8051	-4.23012	0.0000	-5.94836	0.0000
ADF - Fisher Chi-square		102.310	0.0000	24.4412	0.3245	57.0285	0.0001	79.9763	0.0000
PP - Fisher Chi-square		174.102	0.0000	20.1726	0.5722	32.2620	0.0730	107.325	0.0000

b. with constant and trend included:

Method:	Variable:	pb		d		GAP		INF	
		t-statistic	probability	t-statistic	probability	t-statistic	probability	t-statistic	probability
Levin, Lin & Chu t		-4.67612	0.0000	-1.27681	0.1008	-1.13376	0.1284	0.80551	0.7897
Breitung t-stat		-3.91598	0.0000	0.75743	0.7756	-4.81764	0.0000	-1.64243	0.0503
Im, Pesaran and Shin W-stat		-6.34452	0.0000	0.91692	0.8204	-2.39308	0.0084	-4.44630	0.0000
ADF - Fisher Chi-square		93.6902	0.0000	12.1537	0.9541	36.9777	0.0238	60.6526	0.0000
PP - Fisher Chi-square		144.989	0.0000	9.61466	0.9895	16.7682	0.7760	82.7819	0.0000

Source: authors' calculations.

Annex 6.

Assessment the degree of risk for fiscal fatigue in the CEE-12 countries, using EC projections (simulations) for public debt and primary budget balance, and the average linear FRF coefficients (two variants), 12-country panel

(2012-2021 and 2022-2031 periods)

(10 years)

Country	Actual average 2012-2021		Projected average 2022-2031		Risk for fiscal fatigue (adjustment with linear average FRF coefficients)						
	Actual primary balance (pb)	Actual public debt (d)	Projected primary balance (pb _{pr})	Projected debt (d _{pr})	Difference between debt levels $\Delta d = d_{pr} - d$	Linear FRF coefficient x debt difference (adjustment of primary balance) $\beta * \Delta d$ with coefficients:		Maximum adjusted primary balance sp_{max}		Risk categories (comparisons between actual, projected, and maximum adjusted pb) with average coefficients:	
						$(\beta_2=0.071)^*$	$(\beta_3=0.072)^*$	(col 1+col 6)	(col 1+col 6')	$(\beta_2=0.071)^*$	$(\beta_3=0.072)^*$
0	1	2	3	4	5	6	6'	7	7'	8	8'
Bulgaria	-1.04	23.1	-1.7	30.5	7.4	0.53	0.53	-0.51	-0.51	LR	LR
Czechia	0.00	37.6	-3.2	28.7	-8.9	-0.63	-0.64	-0.63	-0.64	LR	LR
Cyprus	1.31	100.8	0.0	87.0	-13.8	-0.98	-0.99	0.33	0.32	LR	LR
Croatia	-0.02	81.1	-1.1	75.4	-5.7	-0.40	-0.41	-0.42	-0.43	LR	LR
Estonia	-0.11	9.3	-1.7	23.0	13.7	0.97	0.99	0.86	0.88	LR	LR
Latvia	0.40	33.4	-1.5	48.7	15.3	1.09	1.10	1.49	1.50	LR	LR
Lithuania	0.72	38.2	-0.9	41.5	3.3	0.23	0.24	0.95	0.96	LR	LR
Poland	-0.98	53.2	-1.3	48.0	-5.2	-0.37	-0.37	-1.35	-1.35	HR	HR
Romania	-1.42	40.9	-3.9	60.6	19.7	1.40	1.42	-0.02	0.00	LR	LR
Slovakia	-0.44	51.1	-3.1	62.6	11.5	0.82	0.83	0.38	0.39	LR	LR
Slovenia	-1.27	75.5	-4.4	82.3	6.8	0.48	0.49	-0.79	-0.78	LR	LR
Hungary	0.74	73.6	-1.3	71.7	-1.9	-0.13	-0.14	0.61	0.60	LR	LR

* Linear FRF coefficient, 12-country panel from table 5 (variants 2 and 3), with country fixed effects.

Source: authors' calculations, based on data from: Eurostat Database; EC, Sustainability Report 2021, vol. 2, Country Analysis, Institutional Paper 171/ April 2022; EC, Debt Instability Monitor 2020, Institutional Paper 143, Febr. 2021; IMF, Fiscal Monitor Achieving More with Less, April 2017

Annex 7.

Assessment of the degree of risk for fiscal fatigue in the CEE-12 countries, using EC projections (simulations) for public debt and primary budget balance, and the average linear FRF coefficients (two variants), 12-country panel

(2017-2021 and 2022-2026 periods)

(5 years)

Țara	Actual average 2017-2021		Projected average 2022-2026		Risk for fiscal fatigue (adjustment with linear average FRF coefficients)						
	Country	Actual primary balance (pb)	Actual public debt (d)	Projected primary balance (pb _{pr})	Projected debt (d _{pr})	Linear FRF coefficient x debt difference (adjustment of primary balance) $\beta^* \Delta d$ with coefficients:		Maximum adjusted primary balance sp_{max}		Risk categories (comparisons between actual, projected, and maximum adjusted pb) with average coefficients:	
						$(\beta_2=0.071)^*$	$(\beta_3=0.072)^*$	(col 1+col 6)	(col 1+col 6')	$(\beta_2=0.071)^*$	$(\beta_3=0.072)^*$
0	1	2	3	4	5	6	6'	7	7'	8	8'
Bulgaria	-1.0	23.1	-1.54	27.7	4.6	0.33	0.33	-0.67	-0.67	LR	LR
Czechia	0.5	33.3	-3.06	34.9	1.6	0.11	0.12	0.61	0.62	LR	LR
Cyprus	2.4	100.8	0.36	91.3	-9.5	-0.67	-0.68	1.73	1.72	LR	LR
Croatia	1.1	80.0	-0.54	75.6	-4.4	-0.31	-0.32	0.79	0.78	LR	LR
Estonia	-0.2	8.6	-1.78	21.7	13.1	0.93	0.94	0.73	0.74	LR	LR
Latvia	0.3	30.8	-1.50	48.9	18.1	1.29	1.30	1.59	1.60	LR	LR
Lithuania	1.1	36.2	-0.86	43.4	7.2	0.51	0.52	1.61	1.62	LR	LR
Poland	-0.9	53.5	-0.88	48.5	-5.0	-0.36	-0.36	-1.26	-1.26	HR-VHR	HR-VHR
Romania	-2.2	42.7	-3.92	54.4	11.7	0.83	0.84	-1.37	-1.36	LR	LR
Slovakia	0.4	49.2	-2.34	59.4	10.2	0.72	0.73	1.12	1.13	LR	LR
Slovenia	0.6	77.5	-3.64	77.6	0.1	0.01	0.01	0.61	0.61	LR	LR
Hungary	-0.1	71.2	-1.64	74.5	3.3	0.23	0.24	0.13	0.14	LR	LR

* Linear FRF coefficient, 12-country panel from table 5 (variants 2 and 3), with country fixed effects.

Source: authors' calculations, based on data from: Eurostat Database; EC, Sustainability Report 2021, vol. 2, Country Analysis, Institutional Paper 171/ April 2022; EC, Debt Instability Monitor 2020, Institutional Paper 143, Febr. 2021; IMF, Fiscal Monitor Achieving More with Less, April 2017