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Stochastic Debt Sustainability Analysis in Romania in the Context of the War in Ukraine

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Abstract: Public debt is determined by borrowings undertaken by a government to finance its short- or long-term financial needs and to ensure that macroeconomic objectives are met within budgetary constraints. In Romania, public debt has been on an upward trajectory, a trend that has been further exacerbated in recent years by the COVID-19 pandemic. Additionally, a significant non-economic event influencing Romania's public debt is the war in Ukraine. To analyze this, a stochastic debt sustainability analysis was conducted, incorporating the unique characteristics of Romania's emerging market into the research methodology. The projections focused on achieving satisfactory results by following two lines of research. The first direction involved developing four scenarios to assess the risks presented by macroeconomic shocks. Particular emphasis was placed on an unusual negative shock, specifically the war in Ukraine, with forecasts indicating that the debt-to-GDP ratio could reach 102% by 2026. However, if policymakers implement discretionary measures, this level could be contained below 88%. The second direction of research aimed to establish the maximum safe limit of public debt for Romania, which was determined to be 70%. This threshold would allow the emerging economy to manage a reasonable level of risk without requiring excessive fiscal efforts to maintain long-term stability.

Keywords: public debt; fan chart; snowball effect; System GMM; VAR model

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1. Introduction

The onset of the conflict in Ukraine marks a significant moment in the 21st century, impacting the global social, economic, and political landscape. This situation has particularly influenced emerging states in Eastern Europe, which can make them more susceptible to economic challenges. In this context, the geopolitical dynamics in the region contribute to the economic uncertainties faced by these states, both directly and indirectly. The consequences of this conflict are anticipated to be felt in the medium to long term, as the situation involves not just an economic crisis but also other aspects, such as adjustments in budgetary planning with increased allocations to the defense sector and the expansion of strategic services.

This paper aims to perform a stochastic debt sustainability analysis (SDSA) in Romania in the context of a shock caused by the war in Ukraine, serving as a research method for future analysis in calculating the level and risk limit of public debt in exceptional conditions. Two general objectives were considered to obtain satisfactory results. The first objective was to predict the level of public debt over five years, taking into account the economic implications of the war in Ukraine. An inescapable repercussion is given by the possible interruption of the energy and gas supply, a fact that is observed in the impossibility of the European states to look for alternative sources in the short run. The increase in the price of a barrel of oil led to the emergence of an inflationary phenomenon that began to manifest itself in Romania shortly after the start of the war, and a reduction in economic expansion became immediately visible. The phenomenon is amplified by the need of the Romanian

state to increase defense spending, which involves either a rescheduling of the public budget for money from certain sectors to be reallocated to military spending or the creation of additional borrowings to support these current needs. Taking these aspects into account, the debt-to-GDP ratio will have an acute and upward trend, and a forecast of its level could provide indispensable information to decision makers for the use of those fiscal instruments to ensure the damping of the shocks produced by this war. The second objective involved setting risk limits for public debt. In Romania, as in all Member States of the European Union, a maximum public debt level was set at 60% of GDP. This limit, together with a set of other criteria, was recommended by the Maastricht Treaty (Protocol on the Excessive Deficit Procedure 1992), which entered into force on 1 November 1993 and aims to maintain price stability and, consequently, the sustainable growth of the economy. However, this general maximum level of indebtedness could not be considered when setting risk limits. The reasons behind this statement are determined by the characteristics of existing markets in the European Union. For Romania as an emerging market, a debt-to-GDP ratio of 60% could indicate an economic imbalance; for another state with a developed economy, like Germany or France, this level can only be a reference element in maintaining economic balance and not a risk limit. The maximum level of indebtedness should be calculated individually, differing from one state to another, as socio-economic conditions and those involving a fiscal policy are not uniform, even if the states are part of the same union.

In this regard, a stochastic debt sustainability analysis was developed. This implies the establishment of two econometric models that allow obtaining 1000 trajectories for each of the macroeconomic and non-fiscal determinants to include them in the debit–deficit stock–flow identity equation. Thus, the vector autoregressive (VAR) model allowed the forecasting of non-fiscal determinants (real output growth, real domestic interest rate, real foreign interest rate, and real effective exchange rate), and the Generalized Method of Moments (GMM) was used to forecast primary balance. Based on these estimates, four detailed scenarios were made in the form of fan charts to assess the sustainability of public debt in the period of 2022–2026. The first scenario is the baseline one and is aimed at determining the level of public debt in the existing conditions. The second scenario marked the effects of eliminating the output gap to identify the type of fiscal policy applied in Romania. The third scenario considered the implications of the government in mitigating the effects of the war, and the last scenario involved the use of the public balance targeted by the European Commission to validate the results obtained.

In order to obtain conclusive research results, this paper was based on four hypotheses as follows:

H1: *The level of public debt will more than double in 2026 compared to 2021 due to the shocks caused by the war in Ukraine.*

H2: *The snowball effect greatly amplifies the debt-to-GDP ratio.*

H3: *The risk limit of public debt in Romania is less than or equal to 80%.*

H4: *Fiscal policies consistent with the current economic situation could stabilize the debt-to-GDP ratio.*

The hypotheses formulated in this study are based on the findings of previous research. Thus, studies by Alvarez-Plata and Brück (2008) have shown that major geopolitical shocks, such as armed conflicts, can lead to rising debt arrears and deteriorating creditor relations. Also, Hayashi et al. (2022) believe that the war in Ukraine significantly complicates the ability of emerging market governments to pay their debts to external creditors, fueling fears of possible crises that could destabilize markets and weaken the global economic recovery. This research supports hypothesis H1. The snowball effect in the context of public debt refers to the phenomenon whereby the public debt grows at an accelerated rate due to the costs related to compound interests. Thus, when the interest on the public

debt is higher than the rate of economic growth, the debt accumulates at an exponential rate, even in the absence of primary deficits. This happens because governments have to borrow extra to pay the interest, which leads to a continuous increase in the stock of debt. In the current situation, the war in Ukraine has caused interest rates and inflation to rise, which puts additional pressure on emerging economies. These states need to borrow extra to meet unexpected expenses, such as increasing the defense budget and managing the energy crisis. In the case of Romania, the increase in oil prices and the interruption of natural gas supply led to inflation and a reduction in economic expansion. To support these additional costs and to stabilize the economy, the government had to take out additional loans. Thus, increased interest rates and the need for additional financing led to an exponential accumulation of public debt, generating the snowball effect. Della Posta (2019) and Rădulescu (2012) demonstrated that the snowball effect significantly amplifies the debt/GDP ratio, thus supporting hypothesis H2. In addition, the research carried out by Daniel et al. (2003) suggests that the risk limits for public debt vary considerably between emerging and developed countries, supporting hypothesis H3, according to which the risk limit of public debt in Romania must be less than and equal to 80%, while the average rate of public debt in emerging markets exceeds that of industrial countries. Finally, the present study aims to examine whether the application of appropriate fiscal policies can stabilize the debt-to-GDP ratio, as suggested by Adam (2011), thereby strengthening hypothesis H4.

For a more explicit presentation of the research, this paper was structured in seven sections. Section 2 includes a review of the empirical literature; Section 3 details the debt–deficit stock–flow identity equation based on which 1000 debt projections were obtained; Section 4 is dedicated to research methodology and includes two subsections that define the econometric models used; Section 5 reveals the results of the research, Section 6 is dedicated to discussions; and Section 7 contains the findings and conclusions resulting from the analysis.

2. Literature Review

The analysis of public debt sustainability has become an intensely debated topic, a determining factor being represented by the economic crises that took place, as well as by the COVID-19 pandemic. Pamies and Reut (2020) highlighted the importance of conducting a stochastic debt sustainability analysis, as this is an indispensable element in fiscal risk management. In addition, they state that SDSA provides the information needed to investigate a wide range of economic phenomena, from fiscal and economic policy to macroeconomic surveillance. Due to the significant events of recent years, analyses have been developed to describe the extent of the risks due to economic conditions and applied policies. The most recognized work is the one written by Celasun et al. (2006), which based on the fan chart approach, captured the behavior of the primary surplus and the risks associated with achieving fiscal sustainability in emerging market countries. Two econometric methods were proposed in the paper, namely, VAR and System GMM, which would contribute to predicting public debt and obtaining possible trajectories. Medeiros (2012) similarly analyzed a stochastic simulation of public debt using the VAR model and a panel of the fiscal reaction function (FRF) for fifteen European Union Member States under four regimes.

Zdravković (2014) used two econometric methods to project the debt-to-GDP ratio over two years. He stated that the use of the VAR model provided similar forecasts compared to those made by the IMF, and the projections based on the AR (1) approach overestimated the debt-to-GDP ratio. Tielens et al. (2014) analyzed three selected Member States (Greece, Ireland, and Portugal) using three key elements in the methodology: (a) a baseline scenario (incorporating the traditional recursive debt equation), (b) the analysis of the non-fiscal determinants based on the VAR model, and (c) the fiscal reaction function. Also, based on three steps similar to those detailed above, Výškrabka (2016) made a stochastic forecast of public debt in Slovakia, an emerging state of the European Union. The results showed a declining trajectory of debt under the influence of interest rates, the primary deficit, and

GDP growth. Fournier and Fall (2017) highlighted the non-linear and unstable nature of debt sustainability, showing that market interest rates react non-linearly to debt growth. Multiple equilibria are possible, and the absence of a solution indicates unsustainable fiscal behavior under the observed macroeconomic conditions. They considered that the debt limit is influenced by the state's fiscal and monetary policy, financial market conditions, and economic growth prospects. Checherita-Westphal et al. (2022) showed that, in the context of the war in Ukraine and economic pressures, fiscal policy in emerging EU states faces significant challenges. The increased public debt, accentuated by the support needed to counter the impact of the conflict and support the economic recovery, needs to be carefully managed in the face of monetary policy normalization and increased inflationary pressures. These challenges are amplified by the growing energy crisis and the deterioration of the economic and inflationary outlook, reflected in the volatility of financial markets and the structural and fiscal vulnerabilities specific to each country.

Berti (2013) proposed a simpler model for assessing the sustainability of public debt based on existing data at the level of the Member States of the European Union. In this paper, the dynamics of public debt were based on the variance–covariance matrix of historical shocks using a "central scenario" for which the European Commission DG ECFIN's Autumn 2012 forecasts were used, and shocks were applied around it. Moreover, the methods of annualization of non-fiscal determinants were an integral part of this analysis. Based on this model, Cuerpo and Ramos (2015) assessed the level of public debt in Spain, which seems to be largely sustainable in the baseline scenario, which involved strict compliance with the European Union budget as well as national rules. A different analysis method was used by Goedl and Zwick (2018). Thus, the assessment of the stochastic debt sustainability analysis was based on the Markov chain model, as well as on various Bayesian techniques that allowed the incorporation of information from other countries in the estimate. For an explicit representation of the results, the fan chart approach was used to show the distribution of the debt-to-GDP ratio over a specific time horizon and with randomly chosen data.

In the context of the epidemiological situation, Khalladi (2022) conducted a stochastic analysis of public debt to assess the impact of shocks caused by the COVID-19 pandemic in Tunisia. The results revealed that the strong reaction of the government to public debt is leading to a vehement decrease in its rate. According to those mentioned by Della Posta et al. (2022), even a strong economic shock could be mitigated if appropriate economic policies are applied, referring to the impact on public debt sustainability. The shock caused by the COVID-19 pandemic was also the subject of the paper written by Cohen-Setton and Oikawa (2022). They presented the trajectory of public debt in Japan after the COVID-19 pandemic, taking into account several scenarios, including the consolidation plan. Dumitrescu and Hândoreanu (2022) projected the evolution of public debt in Romania in the period of 2021–2030, considering the shock generated by the COVID-19 pandemic as a main risk factor. The obtained results reveal the need for fiscal consolidation according to the current plan for 2021–2024 so that the level of public debt does not exceed the limits that determine the occurrence of a risk.

In this direction of research, the literature is quite limited, as studies that reveal stochastic analyses of public debt based on the fan chart approach are found in a very small number. However, other research methods were established to study this economic phenomenon. A more theoretical approach was taken by Mehrotra and Sergeyev (2021), who argue that the primary balance has a direct link with public debt; more precisely, public debt is only sustainable if there is a primary surplus that grows linearly with it. The threshold of public debt sustainability will differ from one state to another, taking as the main feature, according to this study, the level of primary surplus. Also, Ghosh et al. (2013) suggest that the primary balance is determined by a cubic polynomial function of previous debt levels. Della Posta (2021) established a model by which it determined an area of primary surplus to eliminate the risks related to the level of public debt. In addition to the primary balance, non-fiscal determinants were used in this research to produce the

snowball effect. The importance of the interest rate as an element of the snowball effect in analyzing the dynamics of public debt was presented in a paper also written by Della Posta (2019) by which it can constrain the primary balance if a higher maximum threshold is imposed. Blanchard (2019) analyzed the costs involved in public debt when the interest rate is low, stating that an interest rate lower than the long-term growth rate is more of a historical norm than an exception. The idea that economic growth higher than interest costs is sufficient to ensure financial stability is contradicted by Casalin et al. (2019). They demonstrate that public debt can become unstable if the difference between economic growth and interest costs falls below a certain critical threshold. Their study based on historical data from the USA supports this hypothesis, highlighting the risks associated with public debts, even in countries with relatively low risk, especially in situations where tax collection systems are not modern and efficient.

This review of the scientific literature is the foundation and direction for a comprehensive stochastic analysis to determine the trajectories of public debt in Romania as a result of the shock caused by the war in Ukraine. To date, no study or method has been developed to tolerate the effects of such exceptional events.

3. Debt–Deficit Stock–Flow Identity

In the European Union, the amount of public debt varies significantly between Member States, reflecting different fiscal policies, diverse economies, and varying levels of development. According to recent data, the Member States with the highest levels of public debt to GDP include Greece (207% in 2020; 195% in 2021, 172.7% in 2022), Italy (155% in 2020; 147.1% in 2021, 140% in 2022), and Portugal (134.9% in 2020; 124.55% in 2021, 112.4% in 2022) with significant percentages, while states with lower debt include Estonia (18.6% in 2020; 17.8% in 2021, 18.57% in 2022), Luxembourg (24.6% in 2020; 24.5% in 2021, 24.7% in 2022), and Bulgaria (24.67% in 2020; 23.9% in 2021, 22.6% in 2022). Romania recorded average values in the same interval (46.7% in 2020; 48.5% in 2021, 47.5% in 2022). Public debt in Romania generally had an upward trend but with strong markings due to economic and social phenomena that have manifested themselves over the years. Figure 1 shows the historical debt model in the period of 2000Q1–2021Q4. The bars highlighted in gray define the two moments that influenced the transition of the Romanian economy to periods of prosperity. These periods are often accompanied by increased public debts due to higher government spending on infrastructure and social programs, cheaper borrowing costs, political incentives, investment in future projects, expansionary fiscal policies, and heightened public demand for improved services. It can be seen that both the financial crisis that started in the third quarter of 2008 and the COVID-19 pandemic were two situations that significantly changed the level of public debt. If, until 2008, the debt-to-GDP ratio remained below a limit of 25%, reaching the lowest historical value of the analyzed period of 10.5% in the third quarter of 2008, with the manifestation of the economic crisis, public debt had a trend ascending and acute. Even after the disappearance of the recession in the fourth quarter of 2010, the effects continued to manifest themselves, the public debt gradually continuing its evolution, reaching a maximum value of 39.20% in the fourth quarter of 2014. The Romanian economy was going through a period of stability and recovery until 2020. Starting with the first quarter of 2020, the debt-to-GDP ratio follows a pattern similar to that of the recession. Thus, the consequences of the COVID-19 pandemic are immediately felt at the level of public debt, which reaches a level of 37.40%, and at the end of the analyzed period, respectively, the fourth quarter of 2021, a level of 48.80%.

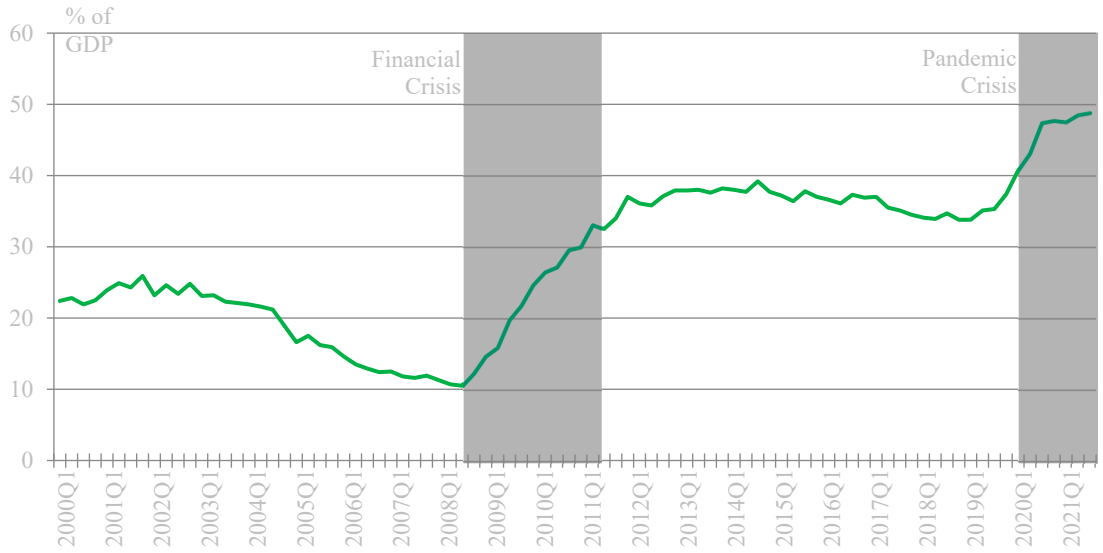

Figure 1. Historical pattern of debt in Romania (% of GDP). Source: own data processing.

In order to have a clearer picture of the intensity of these crises that have affected both the economy and social life, an analysis of public debt dynamics indicators was performed. Figure 2 includes two quadrants related to the two significant moments in the Romanian economy. The area highlighted in light green includes chain dynamics indices, which indicate the relative change in public debt from one year to another, more precisely, $i_{t/t-1}$. It can be said that the 2008 recession forced decision makers to use more borrowed capital to rebalance the economy. In this sense, the percentage change from one year to another was highlighted by calculating the rate of chain dynamic rhythm, $r_{t/t-1}$. This index allowed the exact determination of the borrowed capital needs from these two periods of crisis. In just two quarters of the recession, more precisely, in the first quarter of 2009, public debt increased by 19.51% compared to the previous quarter, reaching a peak of 24.53% in the third quarter of 2009. The situation was different in the case of the epidemiological situation, as the public debt had a maximum dynamic rate of only 9.98% in the last quarter of 2020. The analysis of these dynamics indicators is not illusory and without a practical purpose because they characterize the behaviors of decision makers in Romania in times of extreme crisis, on the one hand, the economic crisis, and on the other hand, the sanitary crisis. In both cases, they made short-term decisions, noting that during the 2008 crisis, the economy of Romania did not have a stable plan to achieve sustainability. This was due both to the late transition to the market economy and the incipient accession to the European Union. However, Romania was at that time under the general economic safeguard clause, as well as the one on the Internal Market, which allowed the state to receive support in the first three years after accession in certain sectors of the economy.

Based on the dynamics indices, the average rhythm of dynamics of public debt was calculated, and their calculation formulas can be found in Appendix A.1. The results revealed that the public debt during the recession changed on average by 10.71% from one year to another and during the pandemic by only 4.13%. These percentage changes tolerate the bias of conclusions in two directions. The first aims to observe an evolution of the Romanian economy that has become able to cope with the economic shocks produced. This presupposes that decision makers have focused on the application of fiscal policies consistent with the objectives of achieving economic sustainability, which has improved the response of the market to a shock. All that are mentioned are found in the way the Romanian economy coped with the sanitary crisis related to the COVID-19 pandemic and refer to the widespread and severe public health emergency caused by the rapid transmission of the coronavirus, resulting in significant illness, mortality, overwhelming healthcare systems, disruptions to daily life, and necessitating extensive public health interventions and measures to control its spread. The second direction assumes that the

intensity of the shock caused by the COVID-19 pandemic was much lower than in the case of the economic crisis.

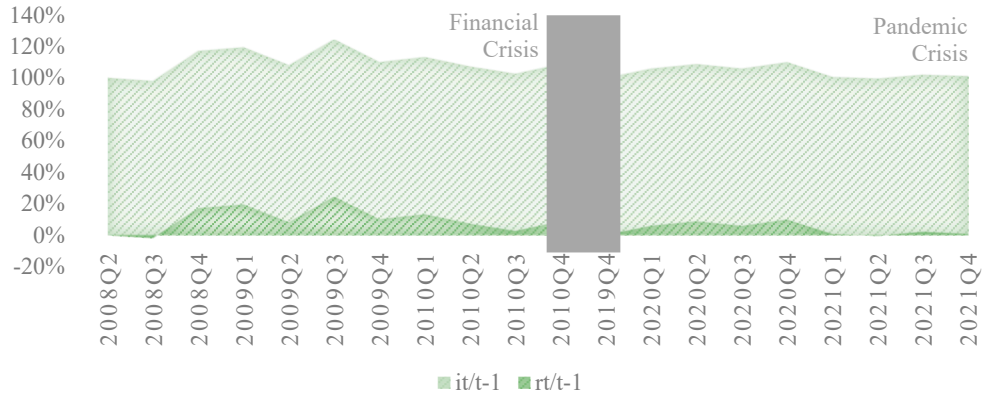

Figure 2. Dynamics indices of public debt. Source: own data processing.

The economy of Romania was destabilized by two shocks that had a divergent specificity, the strictly financial crisis of 2008 and the sanitary crisis of 2020, which had severe repercussions on economic growth. A third problem that requires an imperative analysis is the one related to the effects that will manifest when a new shock, different from the two previously mentioned, affects the Romanian economy, in this case, the Russian invasion of Ukraine. Romania faced the adversities created by the economic and epidemiological shock, and now, most recently, the war. This diversification of shocks will once again make the Romanian government face a new situation, which will test the ability of these decision makers to make use of fiscal instruments to mitigate imbalances with long-run influence. Unfortunately, for Romania, history does not repeat itself. Since the fall of the communist regime, which meant 22 years, this state has faced two different major crises, and now the influences of a war on the border with Romania are being felt. According to the Maastricht Treaty, in addition to a budget deficit limit of 3% of GDP, Romania, like any Member State of the European Union, should maintain a maximum public debt level of 60% of GDP should to ensure price stability and economic sustainability.

Given that the Romanian economy still faces a high public debt-to-GDP ratio and in the last period analyzed, more precisely a percentage of 48.8% in the fourth quarter of 2021, the current context of the war will be able to make public debt exceed the maximum limit set by the treaty and reach new historical values. In this context, there will be questions about the admissible public debt limit for an economy like Romania, as well as its projected level in the context of the war in Ukraine. The European Commission's (2021) forecast for 2022 was a debt-to-GDP ratio of 63.6%, and by 2026, of 95.7%. It should be taken into consideration that these forecasts were made under normal economic conditions and that there could be a risk that the percentage of public debt would double in 2026 compared to 2022 in such exceptional situations.

The SDSA framework helps to establish public debt trajectories over five years, which will determine their sustainability in Romania, as well as the related risk limit. Thus, the analysis started from the law of general motion of the evolution of public debt over time as follows:

$$DBT_t = (1 + I_t)DBT_{t-1} - PB_t + S_t \quad (1)$$

where DBT_t represents the public debt at the end of year t, I_t represents the nominal interest rate, PB_t is the primary balance, and S_t is the stock–flow adjustments. The stochastic analysis of public debt will be further conducted using the debt–deficit stock–flow identity equation, if it is assumed that $S_t = 0$, as follows:

$$dbt_t = dbt_{t-1} + (yg_t + fir_t + dir_t + er_t) - pb_t \quad (2)$$

where yg_t represents the real GDP growth rate, fir_t is the real foreign interest rate, dir_t is the real domestic interest rate, and er_t is the real effective exchange rate. In this equation yg_t, dir_t, fir_t, and er_t represent the snowball effect and in the current conditions in Romania, which should contribute more to a reduction in public debt than the primary balance. However, this hypothesis can only be validated after completing the analysis.

Public debt projections for the period of 2022–2026, taking into account the implications of the war in Ukraine, will be made using Equation (2). The SDSA framework will continue to be used to predict the elements of this equation. Thus, in order to predict the non-fiscal determinants, the VAR model was taken into account, and in order to predict the primary balance, FRF was used based on the System GMM model.

4. Research Methodology

The development of robust econometric models requires, as the first step in this analysis, the application of different methods from seasonal adjustment to the expression of values in real terms. To ensure the accuracy and relevance of the results, it was necessary to apply advanced data fitting and forecasting methods. The choice of these methods was not arbitrary but was based on their ability to address the specificities and challenges of the Romanian economy in the analyzed period (2000–2021). The first step in data processing was to remove seasonal fluctuations to obtain more stable and relevant time series. Thus, the Unobserved Components Model (UCM) was used to eliminate seasonal fluctuations. It decomposes time series into trends, seasonal and cyclical components, and leads to obtaining results similar to those achieved by the TRAMO-SEATS procedure but with increased flexibility in dealing with seasonal variations specific to the Romanian economy. Other data adjustment procedures were the expression of economic indicators in real terms using the GDP deflator and the consumer price index, as well as logarithms. This approach allows a more accurate comparison of economic values over different time periods, eliminating the effects of inflation and other distortions. Moreover, the fiscal response function (FRF) required the use of the output gap and the government expenditures gap. To determine these variables, the Hodrick–Prescott filter was used, taking into account the smoothing parameter λ equal to 6.25. The value of this parameter was recommended for annual data by Ravn and Uhlig (2002). In order not to lose the essence of this study and to be able to follow the whole data processing procedure, they were analytically structured in Appendix A.2. This section required the structuring of the research methodology in two main parts, as the analysis requires the forecasting of fiscal indicators using two econometric models, an aspect that will be further motivated. The first part is dedicated to the VAR model, which was developed using quarterly data from 2000Q1 to 2021Q4 and involves the forecasting of non-fiscal determinants. This model was chosen due to its ability to capture the dynamic interdependencies between economic variables. In the context of our analysis, the VAR model was used to forecast real GDP growth, the real domestic interest rate, the real foreign interest rate, and the real effective exchange rate. The choice of this model brings novelty through its specific application to the Romanian economic context and the integration of relevant variables for evaluating the sustainability of public debt. The Two-Step System GMM model served to estimate the fiscal reaction function by which the primary balance was forecast and required the use of annual data from 2000 to 2021. The choice of the GMM model was motivated by its ability to deal with endogeneity problems and to provide robust estimates of the economic parameters. Based on these, a stochastic debt sustainability analysis was performed. This stochastic nature of the analysis is given by the shocks that must be applied to the forecast values to obtain the distribution percentiles but also the probabilities in which the public debt could reach certain specific values for a forecast period of five years. This innovative approach allows for assessing the risks associated with public debt in a more dynamic and realistic way, reflecting the uncertainties and economic variability in the current context.

The first step in the research methodology aims at calculating the variance–covariance matrix based on historical data and then its decomposition based on Cholesky factorization as follows:

$$A = L \times U = \begin{bmatrix} A_{yg,yg} & A_{yg,fir} & A_{yg,dir} & A_{yg,er} & A_{yg,pb} \\ A_{fir,yg} & A_{fir,fir} & A_{fir,dir} & A_{fir,er} & A_{fir,pb} \\ A_{dir,yg} & A_{dir,fir} & A_{dir,dir} & A_{dir,er} & A_{dir,pb} \\ A_{er,yg} & A_{er,fir} & A_{er,dir} & A_{er,er} & A_{er,pb} \\ A_{pb,yg} & A_{pb,fir} & A_{pb,dir} & A_{pb,er} & A_{pb,pb} \end{bmatrix} = \tag{3}$$

$$= \begin{bmatrix} L_{yg,yg} & 0 & 0 & 0 & 0 \\ L_{fir,yg} & L_{fir,fir} & 0 & 0 & 0 \\ L_{dir,yg} & L_{dir,fir} & L_{dir,dir} & 0 & 0 \\ L_{er,yg} & L_{er,fir} & L_{er,dir} & L_{er,er} & 0 \\ L_{pb,yg} & L_{pb,fir} & L_{pb,dir} & L_{pb,er} & L_{pb,pb} \end{bmatrix} \begin{bmatrix} U_{yg,yg} & U_{fir,yg} & U_{dir,yg} & U_{er,yg} & U_{pb,yg} \\ 0 & U_{fir,fir} & U_{dir,fir} & U_{er,fir} & U_{pb,fir} \\ 0 & 0 & U_{dir,dir} & U_{er,dir} & U_{pb,dir} \\ 0 & 0 & 0 & U_{er,er} & U_{pb,er} \\ 0 & 0 & 0 & 0 & U_{pb,pb} \end{bmatrix}$$

where A represents a square matrix, L represents the lower triangular matrix, and U is the upper triangular matrix. Thus, the Cholesky decomposition of the variance–covariance matrix showed how these stochastic shocks, normally distributed and standard deviation σ, $\varepsilon \sim N(0, \sigma 2)$, were obtained both in the case of non-fiscal determinants and the case of the primary balance. Some studies, such as those written by Khalladi (2022) or Eller and Urvová (2012), use the Cholesky factorization matrix obtained from the VAR model. To obtain stochastic shocks related to non-fiscal determinants and to obtain the shocks of the primary balance, the model related to the estimation of the fiscal reaction function was used. The shocks obtained in the case of the SDSA framework by different methods could eliminate the redundancy of the information related to the studied economic phenomenon. As previously explained, this paper presents a different approach to obtaining economic shocks. The two econometric models were only used to predict the constituent elements of the debt–deficit stock–flow identity equation, and economic shocks were obtained using a single matrix calculated based on the Cholesky decomposition to capture the influences and interdependence between non-fiscal determinants and primary balance.

4.1. VAR Model for Forecasting Non-Fiscal Determinants

In order to predict the non-fiscal determinants, the vector autoregressive model in level was used in the analysis. Enders (2008, p. 301) states that "the main argument against differencing is that it "throws away" information concerning the comovement of the data (such as the possibility of cointegrating relationships)". This analysis intends to keep as much of the information about the non-fiscal determinants as possible, without altering them to be able to make as indisputable forecasts as possible. The VAR model of non-fiscal determinants in Romania will have the following form:

$$Y_t = \gamma_0 + \sum_{k=1}^{p} \gamma_k Y_{t-k} + \xi_t \tag{4}$$

where Y_t is an nx1 matrix containing the non-fiscal determinants that are entered in Equation (2); more precisely, $Y_t = \begin{bmatrix} yg_t \\ fir_t \\ dir_t \\ er_t \end{bmatrix}$, γ_0 is a vector of constant parameters, γ_k is a vector of coefficients, $k = 1, \ldots, p$ represents the number of lags, and ξ_t is a vector of well-behaver error term that is normally distributed and has a zero mean that also contains the variance–covariance matrix Ω.

The variables were evaluated to determine the existence of a unit root by applying the augmented Dickey–Fuller test and the Phillips–Perron test, respectively. As mentioned above, this model was developed in level, and due to the characteristics of the variables, they were stationary in level. It should be noted that the variables *dir* and *er* were tested by

eliminating the trend with a number of five lags; the detailed results of this procedure can be found in Appendix A.3.

The first step in building this econometric model is to determine the optimal number of lags. According to the data presented in Table 1, all lag order selection criteria chose to use a single lag in the development of the model.

Table 1. Lag order selection criteria.

lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	−450.984				0.46279	10.58100	10.62700	106.95200
1	−158.783	584.400	16	0.000	0.00075 *	4.15773 *	4.38745 *	4.72851 *
2	−145.620	26.326 *	16	0.050	0.00081	422.37100	463.71900	525.11100

* is the best value for lag order selection criteria. Source: own data processing.

Using the lag specified by the selection criteria, the model must be dynamically stable. Figure 3 shows the inverse roots of the autoregressive characteristic polynomial (AR). Since they are positioned inside the unit circle, it can be confirmed that the developed VAR model is statistically stable.

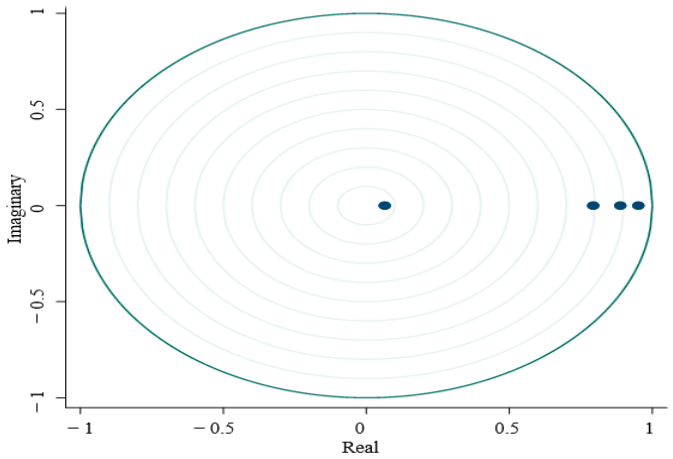

Figure 3. The inverse roots of the autoregressive characteristic polynomial (AR). Source: own data processing.

Another diagnostic test that had to be applied before proceeding with the effective analysis was the Lagrange Multiplier test for autocorrelation. The null hypothesis implies the lack of autocorrelation at the selected lag. According to Table 2, since $p > 0.05$, the null hypothesis failed to be rejected, which strengthens the assumptions related to the stability of the model and the forecasting of non-fiscal determinants.

Table 2. LM test for autocorrelation.

lag	chi2	df	Prob > chi2
1	207.478	16	0.18841
2	174.985	16	0.35407

Source: own data processing.

In this stage of public debt analysis, the forecast of non-fiscal determinants for the period of 2022Q1–2026Q4 was obtained. The data were annualized and together with the related stochastic shocks, 1000 projections were obtained for each determinant.

4.2. System GMM Model for Primary Balance Forecasting through the FRF

The last stage of the SDSA methodology involves estimating the fiscal response function that aims to assess the response of the primary balance (% of GDP) to various macroeconomic indicators. The usefulness of this function is given by the fact that it can represent an efficient tool for the Romanian government to control the level of the primary balance to maintain an optimal debt-to-GDP ratio. The fiscal reaction function used in this analysis has the following form:

$$pb_{i,t} = \alpha_0 + \alpha_1 pb_{i,t-1} + a_2 dbt_{i,t-1} + \alpha_3 ygap_{i,t} + X_{i,t}\beta + \eta_i + \varepsilon_{i,t} \quad (5)$$

where α_i represents the coefficients of endogenous variables, $pb_{i,t-1}$ is the lagged primary balance-to-GDP ratio, $dbt_{i,t-1}$ is the lagged public debt-to-GDP ratio, $ygap_{i,t}$ represents the output gap, $X_{i,t}$ is a vector of control variables, β is a vector of coefficients, η_i an unobserved country fixed effect, and $\varepsilon_{i,t}$ represents the error term, which is normally distributed, and the standard deviation is σ, $\varepsilon \sim N(0, \sigma^2)$. In the estimation of the primary balance, the inflation rate, government expenditure gap, and trade openness were used as instruments.

As the FRF requires the use of annual data and the existing databases do not provide information for a long time, the Two-Step System GMM model was applied, which is a dynamic estimator system for the use of panel data. This model eliminates the problems related to endogeneity and heterogeneity and uses instrumental variable estimation, and it is based on the works written by Holtz-Eakin et al. (1988), Arellano and Bond (1991), Arellano and Bover (1995), and especially the study developed by Blundell and Bond (1998). Thus, the FRF was estimated based on a panel containing all 27 Member States of the European Union for a period of 22 years (2000–2021). In the selection and inclusion of these states, the aspects related to the policies and regulations regarding the common market prevail. Membership in the European Union, together with other features, is a set of characteristics that have been included in the model to define this common framework that influences each national economy. In this sense, the specificities related to the level of public debt in Romania can be identified, taking into account a common economic framework, in this case, the elements that require unitary applicability in the European space.

The result of the detailed estimation of the baseline scenario can be found in Table 3. As can be seen, all coefficients are statistically representative. The coefficient of the primary balance indicates a persistent behavior, as a 1% increase in its value in the current year will cause a change of 0.39% in the following year. Derisory variations were identified at the level of public debt because, when it increases by 1%, the primary balance will change by 0.07%. Specifically, if the public debt increases from 40% to 41% in the current year and the deficit has a percentage of −4%, it will decrease in the following year to 4.07%. The output gap also has a positive value, indicating that European Union Member States generally apply a countercyclical fiscal policy. Eyraud et al. (2017) mentioned that the measurement of discretionary fiscal policy is performed through the output gap coefficient. A negative coefficient implies the existence of a procyclical fiscal policy, a positive coefficient implies a countercyclical fiscal policy, and a statistically insignificant coefficient would suggest that the applied fiscal policy is acyclic. Overall, the output gap seems to have the greatest influence on the primary balance. This statement is argued by the value of the coefficient, which implies a current change of 1.07% of the primary balance in the context of a current variation of 1% of the output gap. However, the output gap should be considered with some caution, as to determine the type of fiscal policy applied at the level of a state, a particular analysis is required to highlight the specific characteristics of the market under study, which could signal procyclical or even acyclic valences. What can certainly be concluded is related to the very strong influence of the output gap on the primary balance. As a result of these aspects, the output gap could be used as a tool in the application of discretionary fiscal policies to control the primary balance and, implicitly, the public debt.

Table 3. Two-Step System GMM estimation results.

pb	Coef.	Corrected Std. Err.	z	P > z	[95% Conf. Interval]	
pb_L1	0.3919	0.0529	7.410	0.000	0.2882	0.4955
dbt_L1	0.0699	0.0331	2.110	0.035	0.0050	0.1347
ygap	1.0747	0.1254	8.570	0.000	0.8289	1.3205
cons	−4.4865	1.9114	−2.350	0.019	−8.2328	−0.7402

Source: own data processing.

To test the stability of the model, the Arellano–Bond test was applied to identify the existence of autocorrelation problems, and the results are presented in Table 4. Since the value is $p > 0.05$, the null hypothesis of the existence of the autocorrelation can be rejected.

Table 4. Arellano–Bond test.

Arellano–Bond for AR(1) in the first difference	z = −2.03	Pr > z = 0.043
Arellano–Bond for AR(2) in the first difference	z = −0.89	Pr > z = 0.375

Source: own data processing.

Moreover, to determine over-identifying restrictions in this econometric model, the Hansen test was applied, as can be seen in Table 5. In order to consider the stability of the model relevant, the statement of Roodman (2009) was taken into account, who claimed that "because of the risks, do not take comfort in a Hansen test *p*-value below 0.1. View higher values, such as 0.25, as potential signs of trouble." However, an upper limit of 0.30 is allowed.

Table 5. Hansen test.

Hansen test of overid	Restrictions: chi2(22) = 25.30	Prob > chi2 = 0.283

Source: own data processing.

Based on the Two-Step System GMM estimation, the primary balance was forecast for the period of 2022–2026. The values obtained together with the stochastic shocks contributed to the determination of 1000 trajectories of the public debt to evaluate its sustainability. By applying these methods, our study contributes to a deeper understanding of public debt dynamics and provides a robust framework for assessing its sustainability in the current economic conditions, marked by the uncertainties generated by the war in Ukraine and other global economic phenomena.

5. Empirical Results

The SDSA results are summarized in this section. In particular, the estimates obtained from the analysis of non-fiscal determinants (GDP growth, real domestic interest rate, real foreign interest rate, and real effective exchange rate) based on the VAR model and the estimates obtained from the analysis of the primary balance based on the FRF were included in debt–deficit stock–flow identity equation to obtain a forecast of the debt-to-GDP ratio for five years, as well as an establishment of the maximum safe debt limit up to which the Romanian economy should not bear additional costs.

Based on historical data, the Cholesky decomposition of the variance–covariance matrix was determined and thus, 1000 stochastic shocks were obtained for each variable in the model for each predicted year. Cholesky decomposition was calculated based on the matrix (3), which is crucial for generating the stochastic shocks used in the simulations, and its values are represented in Table 6. Each entry in the matrix shows the direct impact of the respective shock on the variables and helps in understanding how initial shocks are transmitted across different economic determinants, making it a vital component of the stochastic debt sustainability analysis. This decomposition ensures that the shocks are independent, enhancing the robustness of the simulations. The generated shocks, combined

with the forecasted values of the determinants of public debt, provide a reliable projection of the debt-to-GDP ratio and its evolution. The shocks obtained together with the forecasted values of the determinants of the public debt governed its evolution and the constitution of the fan chart-type representations.

Table 6. Cholesky decomposition matrix.

	yg	**fir**	**dir**	**er**	**pb**
yg	2.4134	0	0	0	0
fir	1.9297	1.8393	0	0	0
dir	1.8416	0.2149	8.0806	0	0
er	1.6555	0.4549	0.1994	1.4191	0
pb	2.7894	1.0609	0.9887	1.8790	0.3338

Source: own data processing.

For clearer concealment of the empirical results, this section has been structured in two parts. The subsection Public debt forecasting contains four scenarios based on which the level of public debt was predicted, taking into account the shocks caused by the war in Ukraine, and the subsection "Risk aversion" of public debt includes an analysis of the safe limit of public debt, assuming that the maximum level is not known or has not been imposed by any official document.

5.1. Public Debt Forecasting

The fan charts represented below include the statistical distribution of public debt trajectories, as well as the risks associated with its dynamics. The gray trajectory constitutes the evolution of the debt-to-GDP ratio based on historical data until 2021. The darkest shade of green summarizes the median of the trajectories, the darker cone indicates a probability of 50%, and the lightest cone has a probability of 90%.

Figure 4 represents the baseline scenario. The median projection of public debt rises from 58% in 2022 to 102% in 2026. This rapid growth rate, with a relative change of 10% annually, captures the shocks caused by both the COVID-19 pandemic and the war in Ukraine. Thus, the primary balance is not used by the Romanian government as a tool to stabilize the growing evolution of public debt, taking into account the exceptional conditions of recent years. The highest primary balance to GDP ratio of 0.27% was reached in 2005, and the lowest of 11.76% was in 2021. This trend is expected to have an adverse effect on the debt-to-GDP ratio. However, the snowball effect, in the current conditions in Romania, contributes to the same extent to the increase in the public debt as the primary balance. Similar results were published by the European Commission in the Debt Sustainability Monitor 2020, with the debt-to-GDP ratio having a value of 63.6% in 2022 with an upward direction until 2026, when it is expected to reach a level of 95.7%. It should be specified again that these analyses were performed under normal economic conditions, without assessing the effects of possible economic or other shocks. In this direction, according to the results of this analysis, the distribution of public debt indicates a high probability that it will reach values close to 70% in 2022, and by 2026, its ratio to GDP will double compared to the Maastricht Treaty proposals, more precisely exceeding 140%, which are worrying results compared to the forecasts of the European Commission. These percentages indicate a serious alteration of the solvency of the Romanian economy, which should impose on the decision makers the bringing in the political agent as a fundamental problem, the aspects related to the level of borrowed capital, and its destination. It is advisable, as a first step in limiting the sharp increase in public debt, to assess the revenue and expenditure budget, as it is reflected directly in the level of the primary balance, which strongly influences the level of public debt. The second step is related to the analysis of the repercussions of the snowball effect constituted by the cumulation of non-fiscal determinants, as their total influence doubles the increasing incidence of public debt.

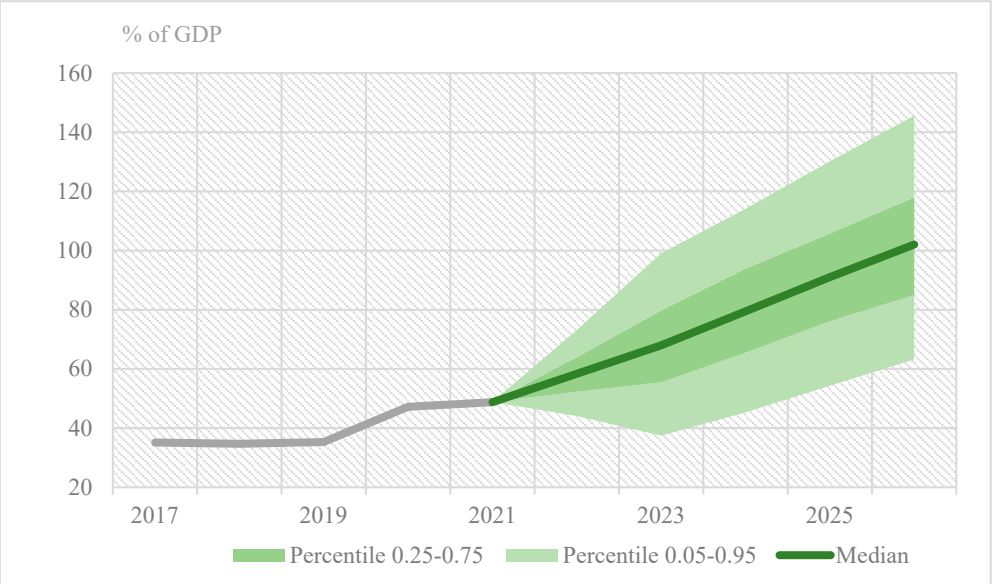

Figure 4. Stochastic debt projection—baseline scenario. Source: own data processing.

The second scenario is stylized in Figure 5, eliminating the output gap effects to observe the trajectory of public debt when there is an acyclic behavior in the economy. In the first year of forecasting, the level of public debt remains unchanged from the baseline scenario. Only in the last year was there an increase of 2% compared to 2026 in the first scenario, failing to reject hypothesis H1. In Romania, the primary balance reacts to an almost imperceptible extent to the business cycle. Although this aspect contradicts the results observed in the Two-Step System GMM analysis where the output gap coefficient had a value of 1.0747, it must be borne in mind that the analysis was carried out by including all Member States of the European Union in the panel. In this way, the coefficient indicates a cumulative economic phenomenon, and when performing this individual analysis, Romania manifests a behavior with acyclic valences. These results contribute to the overall representation of the state of affairs of the Romanian economy and allow decision makers to take action in the direction in which the snowball effect could be reduced. In the case of this scenario, too, the importance of mitigating the cumulative influences of these non-fiscal determinants is demonstrated.

The third scenario considers the involvement of the government in public debt recovery by narrowing the effect of the negative primary balance. Thus, in 2022, the value of the primary balance estimated in the baseline scenario is taken into account, as it is impossible to plan and implement an economic recovery plan in the current year. In the coming years, a primary balance value of zero could be considered a realistic scenario given the consequences of Russia's restricted supply of energy and gas in response to the challenges of the Ukrainian war and political and economic conflict between nations. Figure 6 shows the effects of discretionary government involvement in counterbalancing public debt. Compared to the baseline scenario, public debt could be reduced by 14% in 2026 if the government implemented fiscal policies that raise awareness of the budget deficit, failing to reject hypothesis H2. However, these measures to curb the acute evolution of public debt are not enough, but they can contribute in part to mitigating the shocks of war. Annicchiarico et al. (2020) stated that governments can only partially control the primary balance sheet, as any fiscal intervention is also subject to uncertainty. He also argued that a simple linear rule of adjusting the primary balance to the government debt ratio could help maintain solvency, as long as it adjusts to the characteristics of the market under analysis.

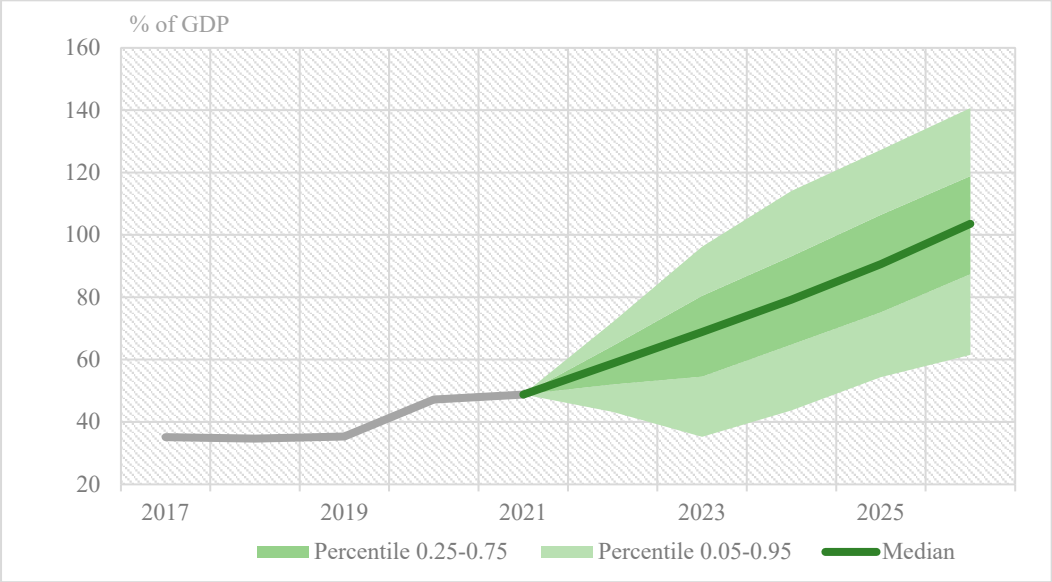

Figure 5. The response to output gap—second scenario. Source: own data processing.

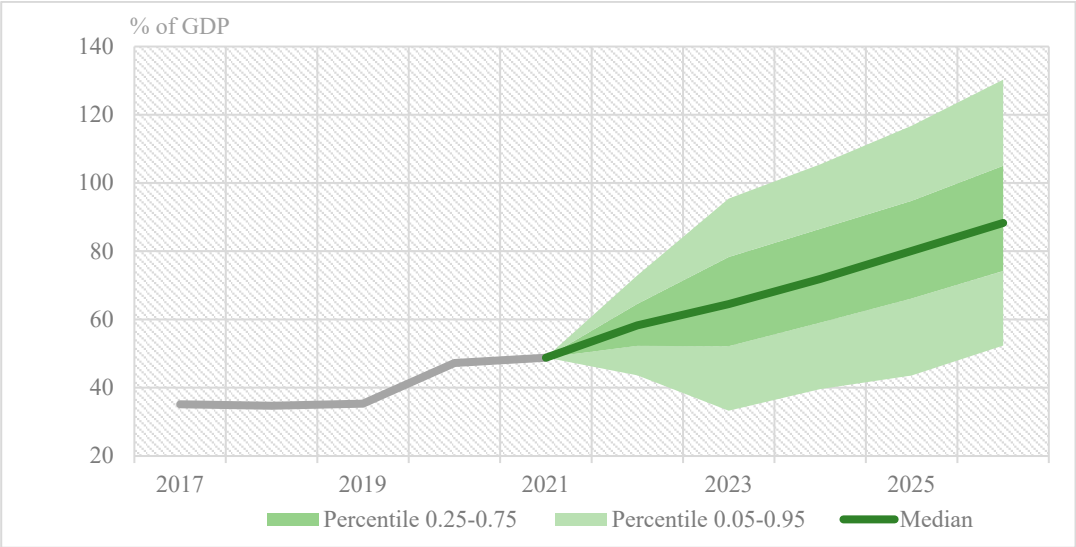

Figure 6. Targeted primary balance—third scenario. Source: own data processing.

Although, at such projected debt-to-GDP ratios, governments would be tempted to declare austerity, and these policies could still be avoided if, in the medium run, the focus of government expenditure was mainly on the investment sector. This would require the use of human capital and job creation, an increase in gross domestic product, and, as a chain reaction, the attainment of a safe debt limit.

The last scenario, represented in Figure 7, involved the use of the primary balance targeted by the European Commission, which was 10.2% for 2022, 9.5% for 2023, 8.9% for 2024, 8.4% for 2025, and −7.8% for 2026, respectively, and the remaining values of the non-fiscal determinants of those predicted in this study. The reason why only the values of the primary balance were replaced and used is related to the interdependence and the direct relationship between it and the public debt itself. Specifically, the primary balance can have an immediate effect on public debt, while non-fiscal determinants, taken individually, could not significantly influence its level. In the context of such a phenomenon, it should be specified that the public debt of Romania would reach, for the first time, this extreme threshold given by the median value of 130% in 2026. Under these forecasts, the probability that the debt-to-GDP ratio will reach 160% is quite high. In the case of this scenario, the

steep trajectory of the evolution of public debt in the period of 2022–2026 can also be observed. Although only the values of the primary balance were modified, the values of the public debt indicate the instability of the Romanian economy in the face of shocks, regardless of their nature. The results obtained should be a warning to decision makers, as a fiscal policy in line with the current situation could control the level of public debt and, in particular, ensure its sustainability.

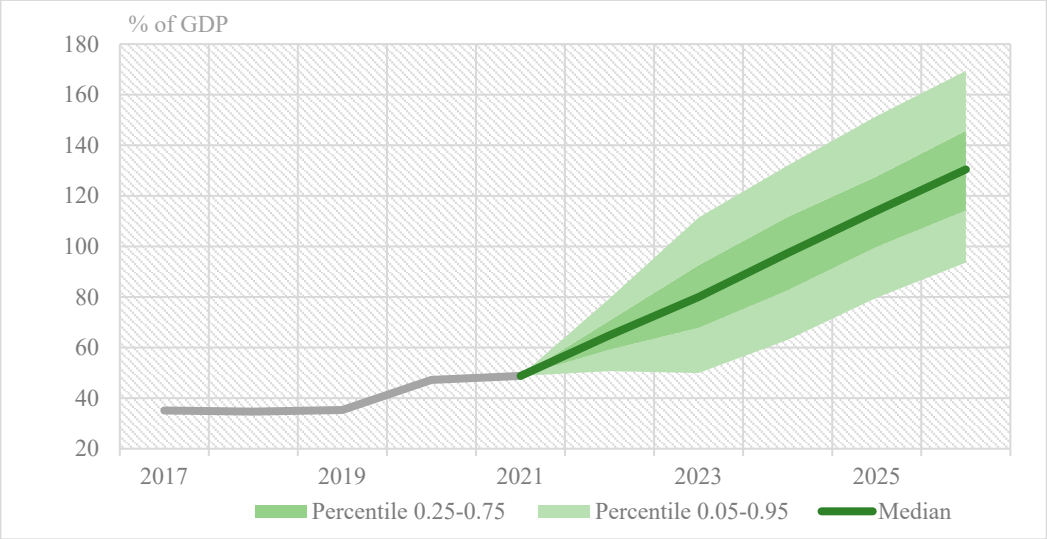

Figure 7. Forecasted primary balance—fourth scenario. Source: own data processing.

5.2. "Risk Aversion" of Public Debt

As was observed in the previous section, the debt-to-GDP ratio could reach up to 102% if only the median projection is taken into account, with the risk that this value will reach limits of over 140%. In these conditions, in which Romania suffered not only a social and political shock but also an economic one as a result of the war in Ukraine, questions will arise related to the "Risk aversion" of public debt. Specifically, when setting a maximum safe debt limit on the level of public debt at the budgetary level, there should be a plan that takes into account the measures that impose the lowest risks, regardless of the sector in which there is a penury of resources, and this is only supplemented by borrowed capital. The risk of a long-run economic imbalance is imminent in the context in which certain safety limits are not set. By the Maastricht Treaty, as it is already known, the debt-to-GDP ratio is set at a level of 60%, but in the case of a continuously developing economy like Romania, this limit could be changed, with the possibility for the limit to support a higher or even lower level of the debt-to-GDP ratio.

Taking these aspects into account, to establish the maximum safe debt limit, individual analysis is needed because the characteristics of each state related to economic, fiscal, political, and social particularities can influence this risk threshold. In order to determine this limit, the influence of the primary balance on public debt must be analyzed. In general, to maintain a maximum safe limit, the primary surplus is about 2% in developed countries and 4% in emerging countries. Although Romania is an emerging state, this percentage of the primary surplus cannot be used to obtain conclusive results. In this regard, an analysis of the primary balance was carried out to establish the maximum safe limit of the debt-to-GDP ratio. Figure 8 shows two fan charts related to the primary balance and public debt based on the fiscal reaction function and the distribution of economic shocks. The analysis showed that the primary balance must be below the 3% limit to stabilize the public debt. This limit was highlighted by a red transfer bar. At this percentage of the primary surplus, it can be seen in the second fan chart that the maximum safe debt limit is 70%, which would allow the Romanian economy to assume a sufficient amount of risk without

achieving too much fiscal effort to maintain long-run equilibrium. Upon observing the current results, H3 was not rejected.

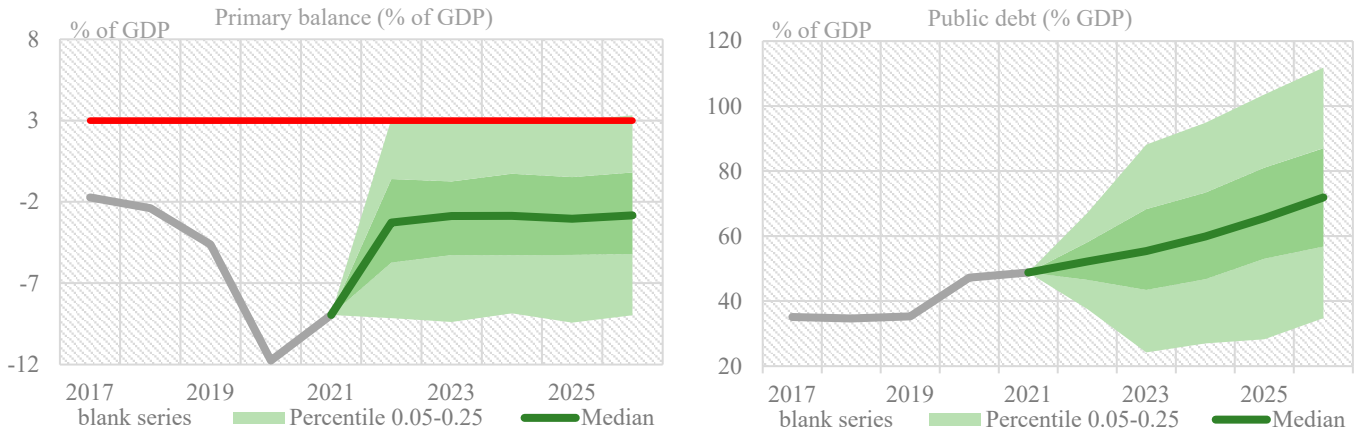

Figure 8. Maximum safe debt limit in Romania. Source: own data processing.

The primary balance and non-fiscal determinants equally influence the level of public debt. The government can make use of these indicators by applying fiscal policies to compensate for their individual influence. Thus, the maximum safe debt limit can be maintained if attention is paid to other elements that contribute to changing its level. Figure 9 was made to present the contribution of both the primary balance and the non-fiscal determinants in the period of 2000–2021, as well as for a forecast period of five years, highlighted by the light gray color. Until 2007 inclusive, the year in which Romania joined the European Union, the domestic interest rate had the highest share of all elements analyzed. According to the debt–deficit stock–flow identity equation, the domestic interest rate contributes to the multiplication of the snowball effect and implicitly to the increase in the public debt. The same situation is encountered in the case of the other elements, with the mention that their influence is not so strong. Starting with 2008, the situation changes significantly, and the foreign interest rate becomes the most significant element that contributes to the change in public debt. These observed behaviors support the acceptance of hypothesis H4. This economic phenomenon is directly related to the common market of the European Union, as Romania had become a full member at that time. However, the significant influence of the primary balance on the level of public debt can be observed. In 2009, the economic crisis favored a strong imbalance, as the primary deficit reached a level of −7.36% for the first time. The interdependence between it and the public debt can be seen in the graph presented. The low values of the primary deficit determined the high values of the public debt. The same situation was encountered in 2020, when the sanitary crisis again led to record low values of the primary deficit and, implicitly, an acute increase in public debt. In the forecast period, public debt remains on an upward trend. Although the budget deficit has lower values, the influence of the epidemiological situation in Romania and the shock of the Russian invasion of Ukraine affect the debt-to-GDP ratio, which exceeds the maximum safe limit by 32%.

Debrun et al. (2020) stated that there should be no room for complacency given that based on previous events in the economy, the costs of public debt "accidents" are very high, recommending close monitoring by decision makers. The solvency of the Romanian economy is currently threatened, especially by the war in Ukraine. The shocks produced by it require a careful assessment and the use of some instruments that determine the reaction of the economy to the applied fiscal policies. Otherwise, the repercussions generated by it could affect future generations, who will have to pay their current deficits or even bear a real amnesty.

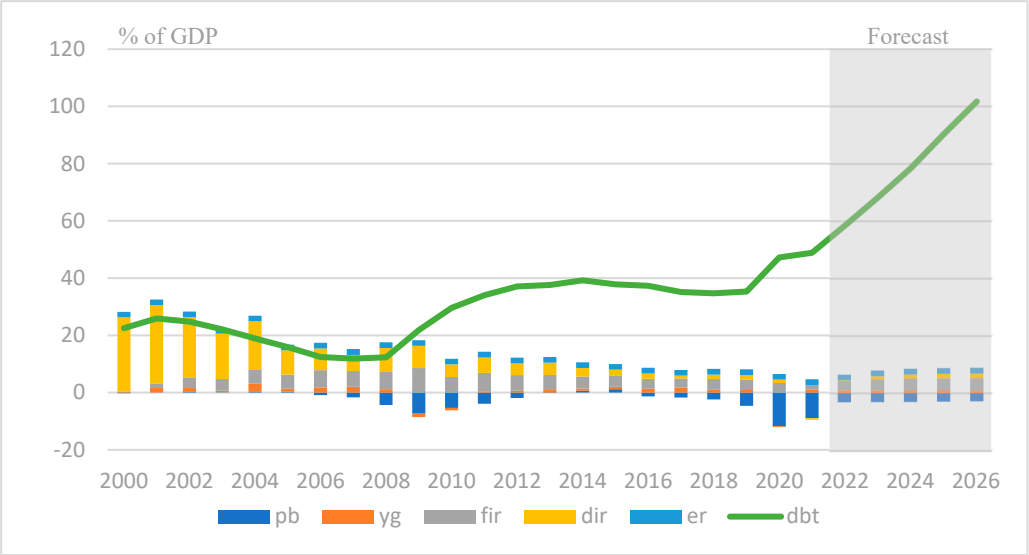

Figure 9. Contribution to change in debt. Source: own data processing.

6. Discussion

Although there is a vast amount of literature on the impact of geopolitical shocks on emerging economies, there are few studies that specifically analyze the effects of the war in Ukraine on public debt sustainability in Romania. This study aims to fill this gap by applying a stochastic analysis of debt sustainability under current conditions of uncertainty, a methodology that has not previously been applied in this specific context. This approach allows for a more nuanced assessment of economic risks and uncertainties, thus complementing the existing literature. Furthermore, our study will contribute to the understanding of how fiscal policies can mitigate the impact of these shocks on emerging economies. The results obtained in this research highlight the significant increase in the debt/GDP ratio in Romania, reaching a historical level of 102% in 2026, according to the base scenario, and 104% in an acyclical scenario. These projections underline the unsustainable nature of public debt evolution, confirming this study's first hypothesis that the level of public debt will more than double in 2026 compared to 2021.

Both Romania and the other states of the European Union have gone through two crises in the last 20 years, the nature of which was different. However, the first economic crisis in 2008 was to teach governments and other decision makers a lesson in terms of how they responded to the shocks produced. The high levels of public debt, as well as the negative percentages of economic growth represented by the gross domestic product, imposed the application of unprecedented fiscal measures to counterbalance the disequilibrium produced and ensure economic sustainability. Another shock felt strongly in the economy was given by the sanitary crisis that started in 2020. Again, neither Romania nor any other state was prepared to deal with such an exceptional event. Although the nature of this crisis was non-financial, its effects were also strongly felt at the economic level, as public debt, economic growth, and inflation reached defining values for a recession. Unfortunately, history has not repeated itself in the case of the modern world of the 21st century, and a new shock occurred almost two years after the pandemic. This time, the war in Ukraine amplified the existing imbalance.

Although World War II could be considered a precedent for both, directly and indirectly, involved states, previous experiences cannot be considered a benchmark in a world where respect for national sovereignty is the highest prerogative of a state. Koistinen (1973) highlights the implications of the war on the economy. The reorganization of the labor force to mobilize the industry in the military sphere represented important reforms in the economy at that time. These actions are not necessary at present, as the technologization of industry no longer requires a transfer of labor from one sector to another. However,

even during World War II, public debt in many states reached very high levels. Reinhart and Rogoff (2011) stated that this problem was solved mainly through financial repression. Although the scale of the war is significantly smaller than in World War II, its effects are strong enough to be felt around the world. We must be aware that there is a new type of war, waged not only at the military level, but also at the technological, computer, and economic level. These statements were also argued by Kammer et al. (2022), who described how the Russian invasion of Ukraine affected not only certain regions or states but also the whole world and was directly involved with the great powers of the world, such as the United States and China.

In such situations, economic theories that focus on explaining the effects and repercussions of wars must be taken into account. In general, economic theories are the foundation of decisions and analyses that must be conducted to assess a manifested phenomenon. The best-known theory is "military Keynesianism", which clarifies the mechanism of changing supply and demand in wartime. In a letter addressed to President Roosevelt, Keynes (1933) explained the importance of government expenditure, considering it the only secure means of rapidly increasing production, constituting the first step in the recovery technique. In his view, war is seen as, from an economic point of view, an event that creates huge industrial activity, and if government expenditure is financed by loans and not by taxing current income, society becomes stronger at the end of the conflict. The central idea of this theory is related to the application of fiscal policies to increase employment and government spending with the scope to stabilize fluctuations in the economic cycle and ensure sustainable economic growth. Custers (2010) argued that military Keynesianism works even where there seems to be no means of regulating the economic cycle. The effectiveness of this theory is also supported by Toporowski (2016), stating that military Keynesianism can help overcome many economic difficulties that do not affect only one state.

What must be taken into account is the fact that Romania is not directly involved in the war in Ukraine, but its effects strongly destabilize the economy. The substantiation of fiscal measures based on such economic theories could facilitate the process of stabilizing the economy. Problems related to the level of public debt can be solved if the extent and intensity with which fiscal and non-fiscal determinants act to change it are fully known. Only then could the fiscal measures be applied to prove their functionality. Although previous experiences, in this case, World War II, could help to solve current economic problems, the only aspect that can be taken into account is the allocation of government expenditure. In conclusion, this research not only fills an important gap in the existing literature but also provides a robust analytical framework for assessing and managing public debt sustainability in Romania in an economic context marked by uncertainties and major external shocks.

7. Conclusions

This research aimed to assess public debt in Romania in the medium term in the period of 2022–2026 in the context of the armed invasion of Ukraine, as well as to establish the maximum safe debt limit. In this sense, stochastic analysis of the assessment of public debt sustainability was developed based on two econometric models, as well as the debit–deficit stock–flow identity equation.

Observing the median projection, it can be seen that the evolution of the debt-to-GDP ratio in Romania is not sustainable. The first forecast in which the baseline scenario was estimated indicates a galloping increase in public debt, reaching a historical level of 102% in 2026. Similar results are obtained in the case of the second scenario in which the output gap effects were eliminated. Thus, in the case of an economy with an acyclic behavior, the public debt will reach a percentage of 104% by 2026, failing to reject accepting the first hypothesis (H1) of this study, according to which the level of public debt more than doubled in 2026 compared to 2021.

The only way this phenomenon can be mitigated is to force the primary balance to zero. In such circumstances, where the government would make use of such a fiscal

instrument, would allow a slower growth of public debt, namely, 58% in 2022, 65% in 2023, 72% in 2024, 80% in 2025, and 88% in 2026. However, attention should also be paid to the snowball effect, as the phenomenon is currently applied by its determinations, leading to the acceptance of the second hypothesis (H2). The last scenario took into account the level of the primary balance targeted by the European Commission. The results obtained require special attention to the level of public debt as, again, a demobilizing evolution of up to 130% is forecast. An important aspect to be taken into account by the Romanian government is related to the maximum debt-to-GDP ratio of 60% recommended by the Maastricht Treaty. This level is indicative of maintaining economic balance but does not include the characteristics of all markets in the European Union. In this way, it was necessary to determine the maximum safe debt limit in Romania. The analysis found that this limit is 70%, and to maintain it, the budget surplus should be kept around 3%. The results fail to reject the third hypothesis (H3) and the fourth hypothesis (H4), according to which the application of fiscal policies congruent with the current economic situation could stabilize the level of public debt.

The results of the SDSA analysis led to the immediate need to involve decision makers in the application of fiscal measures to limit the effect of the negative primary balance as a counter offensive to the shocks caused by the COVID-19 pandemic and, in particular, the imminent economic phenomena of the war in Ukraine. All these aspects can help decision makers in the implementation of the necessary measures to maintain economic and financial stability and the development of public debt management and economic stabilization strategies. Thus, it is recommended to reduce non-essential expenses and allocate resources towards priority sectors, namely, defense and energy security. In addition, increasing the efficiency of tax revenue collection can influence the mitigation of the increase in public debt. Considering the fact that the snowball effect can significantly amplify the public debt, it is recommended to refinance the debt at lower interest rates to reduce the total costs of the debt and establish a medium- and long-term debt management framework that includes clear objectives and risk mitigation measures.

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Conflicts of Interest: The authors declare no conflicts of interest.

Appendix A

Appendix A.1. Dynamics Indicators

Chain dynamics indices

$$i_{t/t-1} = \frac{y_t}{y_{t-1}} \times 100 \quad \text{(A1)}$$

Chain dynamic rhythm

$$r_{t/t-1\%} = (i_{t/t-1} - 1) \times 100 \quad \text{(A2)}$$

Average indices of dynamics

$$\bar{i} = \sqrt[n-1]{\prod_{t=2}^{n} i_{t/t-1}} \quad \text{(A3)}$$

Average rhythm of dynamics

$$\overline{r} = \overline{i} - 1 \quad \text{(A4)}$$

Appendix A.2. Variables Used in the Analysis

Table A1. Analytical list of variables used in the VAR model (quarterly data).

No.	Indicators	Code	Description and Calculation Method	Unit	The Process of Data Transformation	Source
1	Real GDP growth	yg	Quarterly GDP growth	% change	Seasonal adjustment (UCM procedure) Expression in real terms (deflated with GDP deflator, 2015 = 100)	Statistical Office of the European Union—Eurostat
2	Real foreign interest rate	fir	Long-term government bond yields—Maastricht definition (average)	%	Transformation of monthly data into quarterly data seasonal adjustment (UCM procedure) Expression in real terms (inflation rate adjustment)	Statistical Office of the European Union—Eurostat
3	Real domestic interest rate	dir	Financial, interest rates, monetary policy-related interest rate, percent per annum	%	Expression in real terms (inflation rate adjustment)	International Monetary Fund—International Financial Statistics (IMF-IFS)
4	Real effective exchange rate	er	Real effective exchange rate (deflator: consumer price index—27 trading partners—European Union from 2020)	Index	Difference of the log of the index	Statistical Office of the European Union—Eurostat

Source: own data processing.

Table A2. Analytical list of variables used in the Two-Step System GMM model.

No.	Indicators	Code	Description and Calculation Method	Unit	The Process of Data Transformation	Source
1	Primary balance	pb	Government surplus (+)/deficit (-)	% GDP	Net lending (+)/net borrowing (-) of the general government excluding interest, payable	Statistical Office of the European Union—Eurostat
2	Public debt	dbt	Gross consolidated debt of the general government	% GDP	-	Statistical Office of the European Union—Eurostat
3	Output gap	ygap	GDP deviation from its HP trend	% of potential GDP	Using the Hodrick–Prescott filter and taking into account the smoothing parameter λ equal to 6.25	Statistical Office of the European Union—Eurostat
4	Inflation rate	ir	Inflation, consumer prices	Annual %	-	International Monetary Fund—International Financial Statistics (IMF-IFS)
5	Government expenditure gap	gegap	Government expenditure deviation from its HP trend	% of potential government expenditure	Using the Hodrick–Prescott filter and taking into account the smoothing parameter λ equal to 6.25	Statistical Office of the European Union—Eurostat
6	Trade openness	to	Sum of the shares of exports and imports in GDP	% of GDP	exports + imports/real GDP*100	Statistical Office of the European Union—Eurostat

Source: own data processing.

Appendix A.3. The Results of the Stationarity Tests

Table A3. Augmented Dickey–Fuller and Phillips–Perron tests.

Test	Variables	Level				Prob. *
		t-Statistic	Critical Values			
			1%	5%	10%	
ADF	yg	−8.367	−3.528	−2.900	−2.585	0.0000
	fir	−3.519	−3.528	−2.900	−2.585	0.0075
	dir **	−3.295	−3.535	−2.904	−2.587	0.0151
	er **	−2.686	−3.545	−2.910	−2.590	0.0766
PP	yg	−8.391	−3.528	−2.900	−2.585	0.0000
	fir	−3.292	−3.528	−2.900	−2.585	0.0152
	dir **	−1.846	−3.528	−2.900	−2.585	0.3580
	er **	−2.203	−3.528	−2.900	−2.585	0.2050

Note: if $p > 0.01$, $p > 0.05$, or $p > 0.10$, the null hypothesis is accepted (there is a unit root); if $p < 0.01$, $p < 0.05$, or $p < 0.10$, the null hypothesis is rejected (there is no unit root or the variable is stationary). * MacKinnon approximate *p*-value for Z(t). ** No trend was included in the test equation. Source: own data processing.

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