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THE FISCAL SUSTAINABILITY FORECASTING MODEL IN THE MEMBER STATES OF THE EUROPEAN UNION

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Abstract. This paper develops an integrated methodological framework for classifying and forecasting fiscal sustainability among the 27 Member States of the European Union, starting from a fundamental economic question: how can EU Member States' fiscal sustainability be reliably assessed and predicted in a context marked by repeated macroeconomic shocks and institutional heterogeneity? An integrated model for forecasting fiscal sustainability in the European Union is proposed, built upon a well-defined economic hypothesis: fiscal sustainability can be captured by a composite index derived from statistically validated fiscal and macroeconomic indicators. Our approach addresses a major gap in the economic literature, where forecasting models often fail to integrate institutional constraints and policy relevance. By combining advanced statistical techniques and macroeconomic scenario simulation – a Composite Fiscal Sustainability Index (CFSI) is constructed and its predictive performance evaluated under three alternative economic scenarios. The model achieves an overall accuracy of 85.19%, demonstrating strong discriminatory power and the ability to provide early warning signals of fiscal profile transitions. Positioned at the intersection of research on fiscal rules, public debt dynamics, and fiscal stress indicators, this study contributes both a methodological innovation – through an integrated and reproducible forecasting framework – and policy-relevant insights for enhancing fiscal governance within the European Union.

Keywords: fiscal sustainability, forecasting, cluster analysis, Composite Fiscal Sustainability Index, European Union.

JEL Classification: H63, H68, E62, C53.

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1. Introduction

1.1. Conceptual background of fiscal sustainability

Fiscal sustainability is the ability of a state to maintain its applied fiscal policies without entering into an unsustainable public debt spiral in the medium and long term, which would represent a burden for future generations. In operational terms, fiscal sustainability assumes that public debt does not grow uncontrollably, in the absence of discretionary fiscal adjustments, and that the government has the capacity to meet its payment obligations without resorting to constraints through various fiscal instruments, such as government expenditures and revenues.

In the empirical literature, sustainability is analyzed both from a deterministic perspective and revealed through the public debt dynamics equation, and from a behavioral perspective revealed by assessing the probability that a state will retain its capacity to implement fiscal policies congruent with the economic context (Blanchard et al., 1990; Burnside, 2005). However, existing fiscal sustainability indices either rely exclusively on public debt dynamics or ignore institutional dimensions (European Commission, 2023). Our approach fills this gap by integrating financial, structural, and institutional indicators into a unified forecasting framework.

The European economic context of the last two decades has been marked by the sovereign debt crisis, the COVID-19 pandemic, as well as the war in Ukraine, emphasizing the need to use various robust tools for monitoring and forecasting fiscal sustainability. EU fiscal rules impose a debt sustainability requirement on national governments, in the sense that, whenever the debt level exceeds 60% of GDP, fiscal policy must ensure that the public debt ratio follows a downward path at least until the end of an adjustment period lasting between four and seven years (Darvas et al., 2025). Fiscal expansion policies used as ways of economic recovery and the flexibility of European fiscal rules came as direct answers to questions regarding the trajectory of the budgetary positions of the European Union member states, but without touching the full dimension of this problem (Beetsma et al., 2022). Even though common fiscal rules apply, EU member states experience different developments in public debt and budget deficits. This raises a fundamental question: why do countries with similar levels of debt face different fiscal risks? Understanding these differences is essential for reforming European fiscal rules and preventing fiscal crises.

In this context, it was necessary to develop a model that is capable of anticipating transitions between sustainable, vulnerable and unsustainable fiscal profiles, using a rigorous selection of economic indicators, as well as statistically validated classification methods and techniques.

1.2. Original contributions of the paper

This paper brings a series of original contributions to the field of fiscal sustainability modeling and forecasting, proposing a complete methodological framework that combines expert-based classification, cluster analysis, stepwise analysis, Linear Discriminant Analysis (LDA) and scenario forecasting, insufficiently explored previously in the specialized literature.

First, the reaserch advances the concept of fiscal sustainability by moving beyond analyses that rely exclusively on public debt dynamics or deterministic rules. While the empirical literature typically examines sustainability either from a debt-dynamics perspective or from a behavioral fiscal reaction framework, existing fiscal sustainability indices often neglect institutional and structural dimensions. This paper fills this gap by integrating financial, structural, cyclical, and institutional indicators into a unified and operational forecasting framework.

Second, the paper proposes a novel methodological approach that use of an expert-based classification and its calibration based on cluster analysis. In this sense, the paper starts from an expert-based classification of the 27 European Union member states into three categories of fiscal sustainability (sustainable, vulnerable, unsustainable), built on the basis of specialized literature, fundamental macroeconomic indicators and analytical judgment. By using the hierarchical cluster method (Ward) and a rigorous selection of indicators, the paper manages to reconstruct a trichotomous structure of fiscal sustainability based on historical data. The results obtained through cluster analysis were compared with the expert-based classification, ensuring methodological convergence and providing a robust foundation for forecasting fiscal sustainability.

Third, a key contribution consists in the construction of a synthetic fiscal sustainability score through linear discriminant analysis, termed the Composite Fiscal Sustainability Index (CFSI), which allows for an objective classification of states according to their fiscal position. This score was calibrated on the cluster classification and then applied to historical (2000Q1–2024Q3) and forecasted (2024Q4–2026Q3) data, providing a robust fiscal scoring solution comparable over time and across states.

Fourth, the research aims to establish thresholds through optimization using a search grid method (Hastie et al., 2009, chap. 7; Kuhn & Johnson, 2013, chap. 6; Hellwig, 2021). This method maximized accuracy relative to the cluster reference and offers decisional transparency and superior performance compared to conventional methods (Balassone & Franco, 2000; European Commission, 2006; Berti et al., 2012).

Fifth, innovative element of the paper is the application of the autoregressive AR (1) model to forecast data over an 8-quarter period for the baseline scenario, as well as the creation of two alternative scenarios (optimistic and pessimistic). These aimed to anticipate the migration of states between fiscal clusters depending on the evolution of fundamental indicators. This scenario framework provides a valuable tool for decision-makers and institutions in assessing conditional future fiscal risks.

The central idea of this paper is that fiscal sustainability – defined as a state's ability to maintain public finances without requiring disruptive adjustments – is determined not only by debt or deficit levels, but also by a multidimensional interaction of structural, cyclical, institutional, and financial indicators. Building on the literature on the intertemporal budget constraint and the fiscal reaction function (Bohn, 1998; Escolano, 2010; Lee et al., 2023), we posit that this multidimensionality can be synthesized into a single latent construct: the Composite Fiscal Sustainability Index (CFSI). Based on this premise, the entire methodological framework was structured around four research hypotheses. The first hypothesis allows the validation of the theoretical basis by comparison with empirical results, the second hypothesis contributes to testing the methodological performance of the model, the third hypothesis allows the identification of key variables in the classification process, and the fourth hypothesis contributes to validating the predictive value and sensitivity of the model to economic shocks, as follows:

H1: *The classification of European Union member states into three fiscal sustainability groups through cluster analysis is significantly correlated with the expert-based classification;*

H2: *Fiscal indicators associated with the cost of financing have a significant contribution to the discrimination among fiscal sustainability groups compared to structural, institutional or cyclical indicators;*

H3: *The linear discriminant analysis model, calibrated on cluster classification, generates a CFSI score that allows a classification of the European Union member states with an accuracy greater than 80%;*

H4: *Applying the CFSI score to forecast data in three macroeconomic scenarios (optimistic, baseline, pessimistic) leads to the movement of states between clusters, with a higher probability of migration towards unsustainable groups in the pessimistic scenario.*

Formally, we test whether a statistically derived score – based on selected macro-fiscal variables (such as interest burden, public debt, government expenditure, etc.) – can replicate or even improve fiscal risk classifications. We argue that a high CFSI score correlates with fiscal unsustainability, while a low or negative score corresponds to sustainable profiles. The novelty of our approach lies in embedding the CFSI within an institutional context, enabling it to forecast cluster migration in response to different macroeconomic shocks – an essential feature absent from standard fiscal sustainability models (thus, traditional approaches that analyze sustainability only through the lens of public debt are overcome). We further hypothesize that countries in the "vulnerable" cluster exhibit greater sensitivity to economic shocks (e.g., through discretionary fiscal policies), a proposition tested empirically through scenario analysis. This hypothesis builds on the asymmetry of fiscal multipliers and the nonlinear effects described in the literature (Blanchard, 2019; Shaheen & Turner, 2020).

Considering these aspects, the paper was structured as follows: the second section includes a literature review that encompasses the empirical foundation of this analysis; the third section includes the research methodology that defines the main statistical methods and techniques that underlie the construction of the fiscal sustainability model; the fifth section includes the results of the analysis, such as the equation underlying the calculation of the CFSI discriminant score, the cutoff limits, and the scenario-based forecasts; and the sixth section is dedicated to the conclusions.

2. Literature review

The economic literature on fiscal sustainability encompasses both deterministic and probabilistic approaches; however, few studies manage to operationalize sustainability within a predictive model that is adaptable to scenario analysis. Most empirical works focus on retrospective validations of fiscal stress (e.g., through unit root tests or cointegration of debt and primary balance), offering limited predictive utility for policy design. Our paper seeks to fill this gap by proposing a forward-looking, empirically validated methodology that enables ex-ante forecasting of fiscal transitions. In doing so, we contribute to the development of a framework that integrates fiscal rules, sovereign risk, and policy design into sustainability indicators. As a result, a very important aspect to highlight and which is defining for this research niche is related to the contemporary specialized literature whose models dedicated to forecasting fiscal sustainability are relatively limited, the existing approaches present a significant methodological diversity and do not converge towards a unitary or generally accepted analytical framework. This is also reflected in the inherent difficulty with which decision-makers shape fiscal policies and which are influenced by economic, political and social factors difficult to anticipate through classical statistical models. Most existing studies focus primarily on fiscal sustainability from the perspective of public debt, emphasizing either the identification of fiscal shocks through fiscal multipliers or the ex-post evaluation of fiscal measures, while failing to provide robust econometric models for ex-ante forecasting. Thus, identifying a solid and coherent literature in order to determine a strong argumentative foundation in forecasting fiscal sustainability remains a challenge, further justifying the need to develop such a model that combines econometric rigor with the inclusion of the characteristics of a complete transnational environment. Although the specialized literature does not provide a direct precedent for the proposed econometric model, it can constitute a relevant methodological foundation, facilitating the choice of appropriate estimation techniques and also constituting a valuable theoretical framework by providing elements related to the assessment of the fiscal position and national and interstate socio-economic dynamics, considering the existing common European framework.

A broad conceptual framework for analyzing public debt and fiscal dynamics was provided by Escolano (2010), who proposed a practical approach to assessing medium-run fiscal sustainability, including the cyclical adjustment of budget balances and the implications of economic growth on debt. These theoretical principles underlie numerous institutional applications. An important research direction is represented by the development of early warning indicators. A relevant example was provided by Berti et al. (2012), who constructed a composite index of fiscal stress for the member states of the European Union, using optimized thresholds and macro-fiscal indicators. In a similar vein, Röhn et al. (2015) presented the OECD findings on fiscal vulnerabilities, developing an early warning framework grounded in robust empirical evidence.

In terms of quantitative analysis applied to historical data, Beetsma et al. (2018) use extensive historical evidence to assess public debt sustainability in Europe, integrating shocks, discretionary fiscal policies and macroeconomic volatility. Afonso and Jalles (2017) also used panel regressions to test fiscal sustainability in advanced economies, revealing a clear interdependence between public debt, economic growth and risk premia.

A significant recent contribution was provided by Hellwig (2021), who applied machine learning techniques to predict sovereign fiscal stress in the European Union, showing that machine learning-based models can improve predictive ability over classical models. At the same time, Darvas and Welslau (2023) highlighted the importance of the Recovery and Resilience Mechanism (RRF) as a tool to strengthen fiscal capacity in the post-pandemic European Union, providing a relevant institutional framework for scenario calibrations. The European Commission (2021) has also integrated these perspectives into a coherent European fiscal governance strategy, promoting the use of synthetic scores and comparable assessment frameworks across countries. Complementarily, the European Court of Auditors (2023) has drawn attention to the performance risks of RRFs, underscoring the need for robust assessments and transparent fiscal monitoring methodologies.

A series of studies that represent the foundation for estimating fiscal sustainability in the European Union member states have as a reference element the analyses based on the evaluation of fiscal shocks obtained through the impulse-response function as cumulative, integral or impact fiscal multiplier and peak fiscal multiplier. The use of these studies is justified and relevant from two perspectives. First, fiscal multipliers are generally accepted as a measure of the efficiency of fiscal policy, reflecting the intensity with which a shock to government expenditure or revenue influences economic growth. Since fiscal sustainability involves maintaining a balance between the dynamics of public debt and the capacity of economy to generate revenues in the short and long-run, understanding these multiplicative effects is essential to anticipate the consequences of fiscal policies and, implicitly, to create a complex forecasting model that captures the fiscal characteristics of this transnational environment, in this case, all the member states of the European Union. Secondly, these studies that focus on the estimation and analysis of fiscal multipliers contribute to observing the relationship between applied fiscal policies and fundamental macroeconomic variables (GDP, government expenditure and revenues, investments), a relationship that can constitute the foundation of a robust model for forecasting fiscal sustainability. Derkacz (2020) analyzed fiscal multipliers in six developed countries of the European Union, including the effects of exogenous fiscal policy factors, namely the COVID-19 pandemic. The results were obtained by developing a Keynesian model and revealed that all the countries under analysis presented an imbalance in the economic structure in the face of such an event, presenting an increased risk of instability. This study highlights the importance of including in the analyses the specific characteristics of such periods with the prevalence of socio-economic elements, as it allows obtaining results that reflect the real behavior of states under the action of the applied fiscal policies. On the other hand, Szymańska (2022) conducted a study of fiscal policy in three Baltic states using a structural vector autoregressive (SVAR) model, covering only the period 2002Q1–2019Q4. However, it was found that the use of discretionary fiscal policy instruments is an important factor in stimulating economic activity, and the obtained fiscal multipliers indicate the limited effect of government expenditure on the economy of the Baltic states compared to net taxes. Similar approaches are also found in studies conducted by Deleidi (2022), Krajewski and Szymańska (2019), Grdović Gnip (2017), and Kasselaki and Tagkalakis (2016). Shaheen and Turner (2020), using a threshold vector autoregressive (TVAR) model for the United Kingdom, analyzed the effects of fiscal policy on gross domestic product. The authors found that government expenditure has a positive, almost insignificant, effect on gross domestic product in "normal" periods, and in "boom" periods this effect disappears, becoming negative. This analysis was carried out to observe the economic shocks produced by taxation. Thus, in "normal" periods this has a positive effect, and in "boom" periods a strong negative effect was recorded. Haug et al. (2019) estimated the sustainability of fiscal policy in Poland using the structural vector autoregressive (SVAR) model. By analyzing the obtained fiscal multipliers, with a particular focus on the government expenditure multiplier, the importance of combining fiscal and monetary policy directives was highlighted. Thus, the resulting fiscal multipliers were significantly higher than those reported in previous studies, which were close to zero when fiscal policy was not combined with monetary policy. Szymańska (2018) investigated the impact of fiscal policy on economic growth in six Central and Eastern European countries that are not part of the euro area. By applying the structural vector autoregressive (SVAR) model, it was found that government spending has a positive effect on gross domestic product in each country under analysis. In the case of government revenue, the impact was negative in each country, with differences subsequently observed in the time horizon analyzed. On the other hand, Michail et al. (2017) analyze the size and impact of fiscal policies in five countries in the euro area by using the factorial augmented vector autoregressive (FAVAR) model, highlighting the importance of fiscal policies and how their inappropriate application can have negative effects on the economy in both the short and long-run. Other studies that evaluated fiscal policies implemented in European Union member states through the lens of fiscal multipliers and were considered relevant for this analysis include those conducted by Pikhart (2019), Boubaker et al. (2018), Kameník et al. (2018), Alloza et al. (2019), and Mirdala and Kameník (2017).

Moreover, articles that directly address the issue of fiscal sustainability were considered essential for the empirical foundation of this study, as they provide both theoretical and methodological insights into how fiscal policies contribute to achieving this sustainability in the short and long-run. First, these studies contribute to the conceptual definition of fiscal sustainability and the indicators used, while also determining the extent to which fiscal policies converge towards achieving this objective. In the development of this forecasting model, such elements are indispensable as they allow the formulation of realistic and concrete hypotheses. Secondly, empirical analyses in the field of fiscal sustainability offer relevant quantitative methods, such as stationarity tests, cointegration analyses, causality tests or other estimation models that can be adapted and used in the construction of the fiscal sustainability forecasting model. In this context, Brady and Magazzino (2018) analyzed fiscal sustainability both at the level of the 28 European Union states and at the level of the euro area by estimating the relationships between variables in the short and long-run. In a similar context, determined by the imbalances existing at the level of the European Union member states, Barbier-Gauchard et al. (2021) analyzed the effect of national fiscal rules on fiscal discipline using the Global Financial Performance Index (GFPI). It was found that fiscal rules have a major effect on fiscal discipline, and the latter is directly related to the ability of government to maintain fiscal sustainability. Arčabić (2018) assessed fiscal sustainability in the European Union member states using a policy response function. Thus, the coefficients of this function, valuable insights were obtained regarding the sustainability of the fiscal policies implemented in the countries included in the analysis. A similar approach is also found in the research carried out by Ramos-Herrera and Sosvilla-Rivero (2020). Zahariev et al. (2021) also captures the effects of the COVID-19 pandemic on fiscal sustainability. These exceptional events, also considered exogenous shocks, have drawn the attention of Capati and Celi (2023), who analyze in their study how such events could contribute to a reorganization of fiscal governance in the European Union. Also, in the last decade, the issues related to the establishment of a European Fiscal Union and the way in which the imposed directives could eliminate a number of existing fiscal risks, contributing to economic growth, have been increasingly debated. This topic was the objective of the research carried out by Pench (2024), Mileusnic (2021), Cottarelli (2016), Fuest and Peichl (2012).

Although these studies are predominantly oriented towards the evaluation of ex-post effects, the characteristics and methodological elements found in them and the results regarding the dynamic relationships between fiscal and macroeconomic variables contribute to defining the structure of the fiscal sustainability forecasting model, while ensuring its logical continuity and scientific validity. In summary, while numerous studies explore debt sustainability and fiscal rules, very few provide an integrated, empirically validated tool for ex-ante forecasting. This methodological gap motivates the development of the CFSI model.

3. Research methodology

3.1. Empirical derivation of fiscal profiles of the member states: calibration through expert-based classification and cluster analysis

The first step in developing the fiscal sustainability forecasting model was the identification of three fiscal profiles used to classify states as sustainable, vulnerable, or unsustainable. As an initial stage, an expert-based classification of the 27 European Union member states was carried out. This classification played a conceptual role, serving as a theoretical anchor for identifying the specific characteristics of each fiscal profile, and is presented in Table 1. This classification was made based on the specialized literature and qualitative judgments regarding the history of budgetary consolidation and exposure to external shocks (aspects regarding public debt, budget deficits, implementation of fiscal reforms and compliance with European fiscal rules, interest rates).

Table 1. Expert-based classification of European Union member states (source: authors' own calculations)

Code	Expert-based classification
0 – states with a sustainable fiscal profile	Austria, Bulgaria, Denmark, Estonia, Finland, Germany, Luxembourg, Netherlands, Sweden
1 – states with a vulnerable profile	Belgium, Czech Republic, France, Hungary, Latvia, Lithuania, Malta, Poland, Romania, Slovenia
2 – states with an unsustainable profile	Croatia, Cyprus, Greece, Ireland, Italy, Portugal, Slovakia, Spain

However, the methodological aim was not to impose this classification, but to empirically validate or challenge its structure through an approach based exclusively on historical data. At this stage, a linear discriminant analysis was performed. In order to develop the analysis, a categorical variable was constructed that reflects the level of fiscal sustainability of each European Union member state, based on the expert-based judgment mentioned above. Each state was assigned to one of three numerically coded groups as follows: 0 – states with a sustainable fiscal profile, 1 – states with a vulnerable profile and 2 – states with an unsustainable profile. This variable was used only in training the discriminant analysis model to obtain the functions LDA_1 and LDA_2 in order to collect the characteristics of the fiscal profiles and not to impose a final classification.

Subsequently, a selection of variables used in this analysis was made, this being based on the empirical literature on fiscal sustainability, as well as on fiscal risk at the level of the European Union member states. In order to build fiscal profiles, in particular, clusters related to them, six variables were chosen that were considered relevant both in the neoclassical theoretical framework of public debt dynamics captured in the works written by Blanchard et al. (1990) and Bohn (1998), and in the empirical analyses carried out by European institutions such as Berti et al. (2012), Escolano (2010) and the European Commission (2022). The choice of these variables also aimed to capture two defining dimensions for determining fiscal sustainability. Thus, they targeted the structural sustainability as well as the cyclical vulnerability of public finances. Table 2 presents the six synthesized variables that underlie the discriminant analysis, as well as their relevance in capturing the dominant economic and

Table 2. Synthesized variables defining the fiscal profiles of the 27 European Union member states (source: authors' own calculations)

Synthesized variable	Relevance
Average budget deficit (% of GDP)	Expression of structural fiscal imbalance
Difference between interest rate and real economic growth rate (*r–g*)	Expression of public debt dynamics, in line with the standard fiscal sustainability equation (r > g indicates additional pressure)
Interest burden (% of government revenues)	Reflects the cost of public debt servicing and the vulnerability to interest rate increases
Growth rate of public debt (% of GDP)	Captures the direction and speed of fiscal adjustment
Average output gap	Captures the cyclical position of the economy and the countercyclical or procyclical orientation of fiscal policy
Budget deficit volatility (standard deviation)	Reflects the instability of budgetary decisions and the risk of fiscal uncertainty

fiscal characteristics. All these variables are comparable across countries and are sensitive to the fiscal policies applied and the macroeconomic context, being frequently used in early warning models and fiscal classifications, such as the one carried out by Cerovic et al. (2018).

In order to reflect different episodes of systemic fiscal stress, the analysis covered two distinct periods. The first period is 2008Q1–2013Q4 and corresponds to the global financial economic and the sovereign debt crisis in the European Union, being marked by austerity measures and forced fiscal adjustments. The second period is 2020Q1–2024Q3 and is associated with both the COVID-19 pandemic and the war in Ukraine, reflecting an expansionary fiscal regime, with relevant implications for the trajectory of public debt, as presented in the paper written by Dobrotă and Vodă (2024) and Južnik Rotar (2025), generating additional fiscal pressures on public budgets by increasing defense spending, aspects found in the paper written by the European Commission (2024). The period 2020Q1–2024Q3 is considered an exceptional fiscal regime, combining post-pandemic support measures with responses to a large-scale geopolitical shock. Separating the two periods provides a solid basis for assessing the fiscal behavior and capacity of European Union member states to respond to major external shocks.

Thus, using the categorical variable and the six synthesized variables, calculated separately for each fiscal period, linear discriminant analysis was conducted to obtain the scores of the two functions LDA_1 and LDA_2 that maximize the separation between the three expert-based groups. Each observation (state) is projected into the two-dimensional plane defined by these functions, as follows:

$$LDA_1 = a_1x_1 + a_2x_2 + \ldots + a_{12}x_{12} + c; \quad (1)$$

$$LDA_2 = b_1x_1 + b_2x_2 + \ldots + b_{12}x_{12} + d, \quad (2)$$

where, x_i are the synthesized variables, a_i and b_i are the coefficients estimated by *LDA*, and c and d are the constants.

These scores were used to perform agglomerative hierarchical cluster analysis, which has the ability to incorporate the characteristics of fiscal profiles. This approach allowed for obtaining an empirical structure of states, independent of expert-based assumptions.

In order to validate the fiscal profiles derived from the discriminant analysis, the Ward's linkage method and Euclidean distance as proximity metric were used in the agglomerative hierarchical cluster analysis. This combination is also found in the work written by Everitt et al. (2011) for grouping entities based on continuous scores, such as those resulting from *LDA*.

The analysis was applied to the scores obtained from the two functions (LDA_1 and LDA_2), resulting in a two-dimensional space of states, in which the measure of similarity was calculated using:

$$d(x,y)=\sqrt{(x_1-y_1)^2+(x_2-y_2)^2}, \tag{3}$$

where, x and y represent pairs of European Union member states expressed in the coordinates of the *LDA* space.

The Ward method aims to minimize the increase in intracluster variance at each aggregation step by selecting the pair of clusters A and B that minimizes the following objective function:

$$\Delta E(A,B)=\frac{|A||B|}{|A|+|B|}\left\|\bar{x}_A-\bar{x}_B\right\|^2, \tag{4}$$

where, $|A|$ and $|B|$ represent the dimensions of the cluster, $\bar{x}_A$ and $\bar{x}_B$ are the mean vectors of the clusters, and $\|\cdot\|^2$ indicates the square of the Euclidean norm.

This method was chosen for its properties of producing compact, balanced and well-separated clusters, essential criteria for obtaining a fiscal-relevant classification.

Following the application of this method, a hierarchical dendrogram was obtained that allowed the identification of three distinct groups of member states, comparable to the predefined expert-based classification, as can be seen in Figure 1. The states in the green cluster belong to the sustainable fiscal profile, the states in the yellow cluster belong to the vulnerable fiscal profile, and the states in the red cluster belong to the unsustainable fiscal profile.

The degree of overlap between the two classifications was assessed using the ARI (Adjusted Rand Index) based on the equation:

$$\text{Rand Index}(RI)=\frac{a+b}{a+b+c+d}=\frac{a+b}{\binom{n}{2}}, \tag{5}$$

where, n is the total number of observations (states), a is the number of pairs classified in the same group in both classifications, b is the number of pairs classified in different groups in both classifications, and c and d are the number of mismatches. Adjusted Rand Index adjusts Rand Index as follows:

$$ARI=\frac{RI-RI_{expected}}{RI_{\max}-RI_{expected}}, \tag{6}$$

where, RI is the raw rand, $RI_{expected}$ highlights the match expected by chance, and $RI_{\max}$ presents the perfect match. The result obtained can receive values between –1 and 1, where a value equal to 1 represents that the similarities between the classifications are identical, if the result is equal to 0 the classification is random, and a result equal to –1 indicates the existence of contradictory classifications.

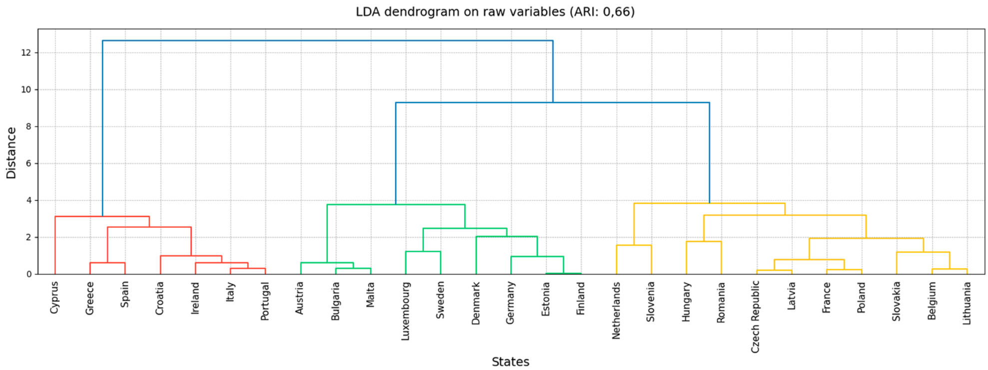


Figure 1. LDA dendogram (ARI: 0.66) (source: authors' own calculations)

Thus, a value of 0.66 was obtained, indicating a significant structural coherence between the expert-based model and the data-derived classification. This result empirically validates the ability of the model to distinguish relevant fiscal profiles without subjective intervention.

In conclusion, the successive use of expert-based classification and automatic clustering allows for the convergence between theoretical reasoning and empirical validation, avoiding both subjective arbitrariness and the risk that the analysis ignores the institutional and historical context of each state.

3.2. Stepwise analysis for the selection of fiscal indicators

After establishing the three clusters using expert-based reasoning, followed by cluster analysis to eliminate subjective arbitrariness and establish a classification based on historical data, the second stage preceding the estimation of the fiscal sustainability forecasting model continued.

This stage corresponds to the identification and selection of variables that will contribute to determining the fiscal sustainability forecasting model. Thus, the variables were not chosen randomly. A set of 22 indicators were considered relevant, constituting the subject of a meta-analysis carried out by Vodă (2022). To reach these results, the meta-analysis involved the evaluation of a set of 2.643 articles that analyze fiscal policies and fiscal sustainability at the level of the European Union member states, allowing the inclusion in the analysis of a set of 33 articles from which 22 indicators relevant to this topic were identified. Furthermore, this analysis has been extended by including seven additional indicators, chosen to cover dimensions often invoked in the empirical literature on fiscal risks and fiscal sustainability. This extension is based on the need to capture the structural and dynamic nuances of the fiscal position of the European Union member states. The first dimension is related to the budgetary sustainability of public debt, an aspect found in the works written by Escolano (2010), Mauro et al. (2015) and Blanchard (2019). The second dimension provides for the capture of fiscal risk and market perception based on indicators proposed by the European Commission (2020), International Monetary Fund [IMF] (2016), as well as Afonso and Rault (2010). The third dimension is related to the economic and demographic structure explained by the works written by the European Commission (2018), Mauro (2011) and Organisation for Economic Co-operation and Development [OECD] (2019). The last dimension taken into account when completing the set of relevant indicators is related to the cyclicality of fiscal policies and macroeconomic implications, aspects mentioned by Bénétrix and Lane (2013), European Commission (2022) and Bornhorst et al. (2011). The inclusion of the seven indicators allows for a superior calibration of the analyses carried out, by integrating dimensions that were partially neglected in the selection of the 22 indicators. The complete table with the 29 indicators is found in Appendix and also includes the calculation method, the adjustment procedures applied, the full name and the database from which they were extracted, as well as other relevant details. All 29 indicators were extracted or calculated, as the case may be, for each member state of the European Union, covering the available quarterly data from the period 2000Q1–2024Q3.

Before identifying the relevant indicators for forecasting the fiscal sustainability model through stepwise analysis, the existence of strong correlations between them, which could influence the robustness of the analysis, was checked. Thus, four variables were eliminated at a correlation coefficient $p \geq 0.80$ (FCE – final consumption expenditure, POUT – private production and OUT – output). A correlation that exceeded the established threshold was also identified between public revenues and expenditures. Given that in the literature such as Alesina and Ardagna (2010), government expenditures are frequently used as a proxy for fiscal expansion or budgetary expansion, they were retained in the analysis to the detriment of government revenues. Moreover, they are less dependent on the economic cycle than government revenues, also having a more predictable and stable behavior over time, directly reflecting structural pressures on the budget. Although no significant correlations were identified, based on economic and statistical reasoning, IMP – imports and EXP – exports were also eliminated, as they are component elements in the calculation of EB – external balance.

Thus, the variables retained in the analysis were standardized using their mean and standard deviation. Each variable x_j was transformed into a standardized score z_j using the equation:

$$z_{ij} = \frac{x_{ij} - \overline{x}_j}{\sigma_j}, \tag{7}$$

where, z_{ij} represents the standardized value of observation i for variable j, x_{ij} is the raw value, $\overline{x}_j$ is the mean of variable x_j, and σ_j is the standard deviation of variable x_j.

This procedure was applied individually for all variables retained in the analysis, across the entire set of available observations, namely for all 27 Member States and for all quarters. Standardisation was essential because the stepwise procedure relies on the comparison of F-values which are sensitive to the magnitude of the variables. Without this step, variables with higher variation would have had an artificial advantage in the selection process.

To identify the most relevant explanatory indicators of fiscal sustainability among the European Union member states, a Forward: Stepwise automatic variable selection procedure was applied. This process started from an initial empty model (without predictors) and iteratively added the variable with the strongest statistical association with the dependent variable established in the cluster analysis and evaluated by the F-test. After each addition, the procedure checked whether the variables already introduced retained their statistical significance, also allowing their elimination if they became insignificant. The selection was based on the statistical thresholds F-to-enter = 1.5, respectively F-to-remove = 1.0. The F-test was calculated at each step using the following equation:

$$F = \frac{\frac{R_{new}^2 - R_{previous}^2}{k}}{\frac{1 - R_{new}^2}{n - p - 1}}, \quad (8)$$

where, R_{new}^2 represents the coefficient of determination of the model after including a new variable, $R_{previous}^2$ is the coefficient of determination of the previous model, k represents the number of newly added variables (usually a single variable), n is the total number of observations, and p is the number of variables already included in the model. The Forward: Stepwise procedure continued until no more variables were identified that met the entry or removal criteria.

From an initial set of 29 indicators, seven significant predictors were selected, which will constitute the basis for the forecasting of the fiscal sustainability model, depending on the related profile. These standardized indicators are: INTBUR (interest burden), ER (employment rate), PD (public debt), DEF (deficit), GE (government expenditure), SPRD (10-year bond yield spread compared to Germany) and SFRI (standardised fiscal rule index) (European Commission, n.d.). Table 3 contains information regarding the equality tests of group means. Wilks's Lambda is statistically significant for most variables, and a lower value indicates that they discriminate better between groups. The F-statistic shows the significance of the difference between means, more precisely whether the mean of a variable differs significantly between the groups predefined by cluster analysis. Thus, a high value for the F-statistic suggests that the mean of the variable is very different between the groups, and the variable can be chosen for discrimination. Also, the $p - value$ indicates the level of their statistical significance. These results support the validity of including these indicators in the discriminant analysis model, as each contributes significantly to the separation of groups of European Union member states according to the fiscal profile.

The robust results of the forward: Stepwise analysis allowed the continuation of the discriminant analysis and implicitly the predefinition and creation of a model that would allow the forecasting of fiscal sustainability in the 27 member states of the European Union.

Table 3. Tests of equality of group means (source: authors' own calculations)

Variables	Wilks's Lambda	F	Sig.
$INTBUR_z$	0.707	402.528	0.000*
ER_z	0.823	208.651	0.000*
PD_z	0.825	205.698	0.000*
DEF_z	0.869	145.958	0.000*
GE_z	0.891	118.286	0.000*
$SPRD_z$	0.911	94.702	0.000*
$SFRI_z$	0.975	25.326	0.000*

Note: *p < 0.01, **p < 0.05, ***p < 0.10, z provides the property of standardized variables.

While our methodological pipeline incorporates algorithmic techniques such as linear discriminant analysis and clustering – which may be considered "black-box" models – the economic rationale for each step is explicitly defined. Variable selection is grounded in fiscal theory and existing policy frameworks (e.g., the SGP criteria, debt sustainability frameworks), and all thresholds and weights are optimized through transparent grid search methods. Moreover, we compare model outputs with expert-based classifications and known fiscal behaviors, ensuring interpretability and policy relevance.

3.3. Discriminant analysis

3.3.1. Estimation of the discriminant function LD_1

To build a robust model for estimating fiscal sustainability, linear discriminant analysis was applied with the three groups predefined by cluster analysis: sustainable (0), vulnerable (1) and unsustainable (2). This coding was necessary for the further use of the dependent categorical variable and necessary for outlining the fiscal profile. The seven standardized variables (with their respective mean and standard deviation) and selected by the Forward: Stepwise method were also included in the analysis. Since the database presented some missing values for short periods of time, these were imputed with the mean of each indicator.

Thus, the linear discriminant analysis used to forecast fiscal sustainability in the European Union member states and essential for identifying their fiscal profiles across three categories (sustainable, vulnerable and unsustainable), was constructed using a discriminant function of the following form:

$$LD_{1i} = \sum_{j=1}^{p} w_j \cdot z_{ij} + b, \tag{9}$$

where, LD_{1i} is the discriminant score for observation (state) i, w_j is the coefficient associated with variable j resulting from the linear discriminant analysis model (canonical coefficient), p is the total number of fiscal indicators used, and b is the intercept.

However, considering the application of the standardization procedure to eliminate the influence of dominant variables and bring them to a comparable scale, by transforming them into z-scores (mean 0 and standard deviation 1), the mean vector of the standardized variables received the value zero, which led to a zero intercept term in the equation LD_1, as follows:

$$b = -\bar{Z}^{\top} \cdot W = 0, \tag{10}$$

where, b is the intercept term in the LD_1 equation, $\bar{Z}$ is the mean vector of standardized variables for all observations, W is the vector of LD_1 coefficients for standardized variables and $\top$ represents the transpose of the vector and transforms the column vector into the row vector to allow for the scalar product.

In a standardized space, the intercept takes the value 0 because the mean of the standardized values is 0, then:

$$b = -0^{\top} \cdot W = 0. \tag{11}$$

This implies that the LD_1 score reduceds to a simple scalar product between the standardized input vector and the coefficient vector:

$$LD_{1i} = Z_i^{\top} \cdot W, \tag{12}$$

where, Z_i represents the vector of standardized values for observation i.

The fiscal sustainability forecasting model becomes, in this sense, more robust and portable because it is no longer necessary to use the adjustment term (intercept).

The LD_1 model, calibrated on the seven standardized variables (INTBUR, ER, PD, DEF, GE, SPRD, SFRI), is statistically significant and robust. All variables contribute significantly to the separation of groups, and the first discriminant function (LD_1) explains most of the variation. The results of the Eigenvalue and canonical correlation tests in Table 4 indicate a high classification power between sustainable, vulnerable and unsustainable fiscal profiles. Specifically, the Eigenvalue explains 93.80% of the total variation, and the canonical correlation of 96.90% indicates a strong correlation between LD_1 scores and cluster membership, indicating a high discrimination power between the identified profiles.

Table 4. Eigenvalues (source: authors' own calculations)

Function	Eigenvalue	% Variance	Cumulative %	Canonical correlation
LD_1	0.938	93.799	93.799	0.969

The Wilks's Lambda test for this function has a value of 0.062, indicating a statistically significant difference between the groups. The associated chi-square value is 7415.671, with 14 degrees of freedom, and $p - value < 0.001$, which allowed the rejection of the null hypothesis and the conclusion that the discriminant function significantly separates the three groups, as can be seen in Table 5.

Table 5. Wilks's Lambda test (source: authors' own calculations)

Test	Wilks's Lambda	Chi-square	df	Sig.
LD_1 to LD_1	0.062	7415.671	14.000	0.000

3.3.2. Cutoffs

In order to assign a functionality to the discriminant function resulting from the applied model, which was transformed into a forecasting and classification tool applicable to the 27 member states of the European Union, it was necessary to establish decision thresholds (cutoffs) on the LD_1 score scale. Since LD_1 is a continuous variable, and the target classification is trichotomous (sustainable, vulnerable and unsustainable), the delimitation of the thresholds c_1 and c_2 was achieved through a search grid procedure, designed to maximize the classification accuracy across the three clusters. For each combination of thresholds (c_1 and c_2), the LD_1 scores were transformed into three classes using the rule:

$$Cluster_i = \begin{cases} 0, \text{if } LD_{1i} \le c_1 \left(sustainable\right) \\ 1, \text{if } c_1 < LD_{1i} \le c_2 \left(vulnerable\right), \\ 2, \text{if } LD_{1i} > c_2 \left(unsustainable\right) \end{cases} \tag{13}$$

where, c_1 and c_2 represent the values obtained for the separation thresholds between clusters.

The set of possible values for c_1 and c_2 was generated by regular sampling within the empirical range of LD_1 scores:

$$c_1 \in \left[\min\left(LD_1\right), \max\left(LD_1\right)\right],\ c_2 \in \left[c_1 + \delta, \max\left(LD_1\right)\right], \tag{14}$$

where, δ is the minimum separation step between thresholds, ensuring $c_2 > c_1$.

For each combination (c_1 and c_2), the classification rule was applied and the results were compared with the cluster labeling. Thus, in order to evaluate each combination, the overall classification accuracy was calculated based on the equation:

$$Accuracy = \frac{1}{N}\sum_{i=1}^{N} 1\left(\widehat{y_i} = y_i^{cluster}\right), \tag{15}$$

N is the total number of member states (N = 27), $\widehat{y_i}$ represents the estimated class for state i, $y_i^{cluster}$ cluster is the reference cluster class, and $1(\cdot)$ is the indicator function that returns 1 if the prediction is correct, 0 otherwise. The values that maximized the overall accuracy were:

$$c_1 = -0.45,\ c_2 = 0.59. \tag{16}$$

This combination generated an overall correct classification rate of 85.19%, which validates the robustness of the optimal search cutoff method. This method of establishing cutoffs is more rigorous from a mathematical and statistical point of view, allowing its reproduction with greater ease. The applied method also maximized the compatibility between cluster and automatic classification, providing a solid basis for extending the classification to forecast scenarios.

4. The AR(1) autoregressive forecasting model

In order to test the fiscal sustainability forecasting model, the variables were projected over a period of eight quarters, namely for the period 2024Q4–2026Q3. This projection was made based on the autoregressive AR(1) model, which is appropriate in the context in which the continuity of the fiscal regime is assumed and which, from a statistical point of view, admits that the future value of a variable depends linearly on its own value in the previous period, plus a random term:

$$x_t = \alpha + \rho \cdot x_{t-1} + \varepsilon_t,\ \varepsilon_t \sim N\left(0, \sigma^2\right), \tag{17}$$

where, x_t is the value of the variable in period t, α is the intercept of the model, ρ is the first-order autocorrelation coefficient, x_{t-1} is the value of the variable in the previous period (t – 1), ε_t represents the random error in period t and $N\left(0, \sigma^2\right)$ is the normal error distribution with mean 0 and constant variance σ^2.

Starting from the last observed value x_t, the forecast values for eight future quarters (h = 1, ..., 8) are determined recursively:

$$\hat{x}_{T+h} = \alpha + \rho \cdot \hat{x}_{T+h-1}, \tag{18}$$

where, $\hat{x}_{T+h}$ is the forecasted value of the variable in quarter T + h, T is the time of the last available historical observation (2024Q3), h represents the forecast horizon (1 to 8 quarters).

This estimate constituted the baseline scenario reflecting a no-policy change hypothesis, serving as a benchmark for comparison with the alternative pessimistic and optimistic scenarios for each country i, indicator j and quarter $t \in \{1,\ldots,8\}$:

$$x_{ijt}^{scenario} = x_{ijt}^{baseline} + \frac{\Delta_j}{8} \cdot s_t, \quad (19)$$

where, Δ_j represents the total change and s_t is a linear distribution coefficient over quarters. Thus, the change is applied cumulatively, meaning it increases or decreases gradually in each quarter.

5. Empirical results

Following the application of a series of econometric and statistical analyses on the 27 member states of the European Union, a robust model for predicting fiscal sustainability was developed. Thus, Linear Discriminant Analysis (LDA) was employed to construct a function that best separates the three fiscal profiles based on seven selected indicators: INTBUR (interest burden), ER (employment rate), PD (public debt), DEF (budget deficit), GE (government expenditure), SPRD (10-year bond yield spread relative to Germany), and SFRI (Standardised Fiscal Rule Index). The data were standardized with the mean and standard deviation presented in Table 6 by applying Eq. (7), being also useful for further analyses, applied outside the present sample.

Table 6. Mean and standard deviation for standardizing variables (source: authors' own calculations)

Variables (x_{ij})	Mean $(\overline{x}_j)$	Standard deviation (σ_j)
$INTBUR_z$	4.9079452	3.111029317
ER_z	65.712048	6.624583023
PD_z	230.46468	137.2395903
DEF_z	–2.527378	3.968193691
GE_z	44.388605	8.242207981
$SPRD_z$	1.3458517	1.849034300
$SFRI_z$	0.3626116	0.987004918

The entire process led to the derivation of a composite score, hereinafter referred to as the Composite Fiscal Sustainability Index, denoted as:

$$CFSI_{it} = \sum_{j=1}^{p} w_j \cdot \left(\frac{x_{ij} - \overline{x}_j}{\sigma_j} \right), \quad (20)$$

where, $CFSI_{it}$ represents the Composite Fiscal Sustainability Index for country i at time t, w_j represents the coefficients for each standardized indicator, as presented in Table 7, the expression $\frac{x_{ij} - \overline{x}_j}{\sigma_j}$ indicates the standardized value of indicator j for country i in period t based on the values in Table 6, and p is the total number of indicators included in the model.

In this sense, the coefficients from the eigenvector corresponding to the first function were extracted, as can be seen in Table 7.

Unlike existing models in the empirical literature, CFSI starts from a theoretically grounded (expert-based) fiscal classification and continues with a data-based (cluster-based) classification that it empirically validates through discriminant analysis (LDA). Thus, the model combines economic judgment with statistical rigor, avoiding both complete arbitrariness and overreliance on statistical classifications.

Table 7. Coefficients of the LD_1 model for forecasting fiscal sustainability (source: authors' own calculations)

Variables	Coefficients (w_j)
$INTBUR_z$	–0.0779
ER_z	–0.0716
PD_z	1.3921
DEF_z	–0.5647
GE_z	–1.2807
$SPRD_z$	–0.0306
$SFRI_z$	–0.3446

In order to maximize the correct classification of states in the three fiscal profiles (0 – sustainable, 1 – vulnerable and 2 – unsustainable), it was necessary to establish decisional thresholds (cutoffs) on the LD_1 score scale by applying the search grid procedure, resulting in the optimal thresholds:

$$Cutoffs\begin{cases} CFSI_{it} \le -0.45 \rightarrow Cluster\ 0\left(sustainable\right) \\ -0.45 < CFSI_{it} \le 0.59 \rightarrow Cluster\ 1\left(vulnerable\right). \\ CFSI_{it} > 0.59\ Cluster\ 2\left(unsustainable\right) \end{cases} \quad (21)$$

Figure 2 shows the Kernel Density Estimation (KDE) distribution of the CSFI scores obtained from the linear discriminant analysis, segregated according to the cluster classification. This visualization allows for the assessment of the separability between groups and the empirical validation of the applied decision thresholds. This tripartite structure indicates that the derived CFSI score is an effective discriminator between the fiscal profiles of the European Union Member States.

As shown in Figure 3, a confusion matrix was then constructed to validate the overall accuracy of the model at the country level, confirming its reliability with an overall classification accuracy of 85.19%. In the case of Cluster 0, out of the nine states classified as sustainable according to the cluster classification, seven were correctly identified, one state was classified as vulnerable, and another as unsustainable. In the case of Cluster 1, 10 out of the 11 vulnerable states were correctly classified and one state was incorrectly assigned to the sustainable category. The situation is similar in the case of Cluster 2. Thus, six out of the seven unsustainable states were correctly identified, and one state was classified as vulnerable. It can be stated that there is no serious confusion between the extreme clusters (sustainable and unsustainable) and the errors are limited to natural transitions between classes.

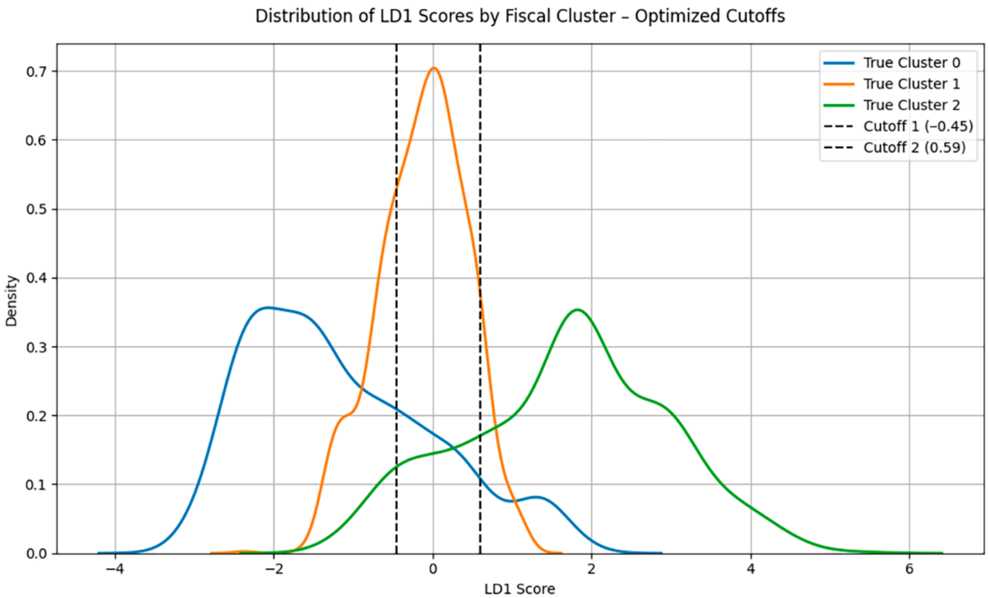


Figure 2. Distribution of CFSI scores by fiscal cluster – optimized cutoffs (source: authors' own calculations)

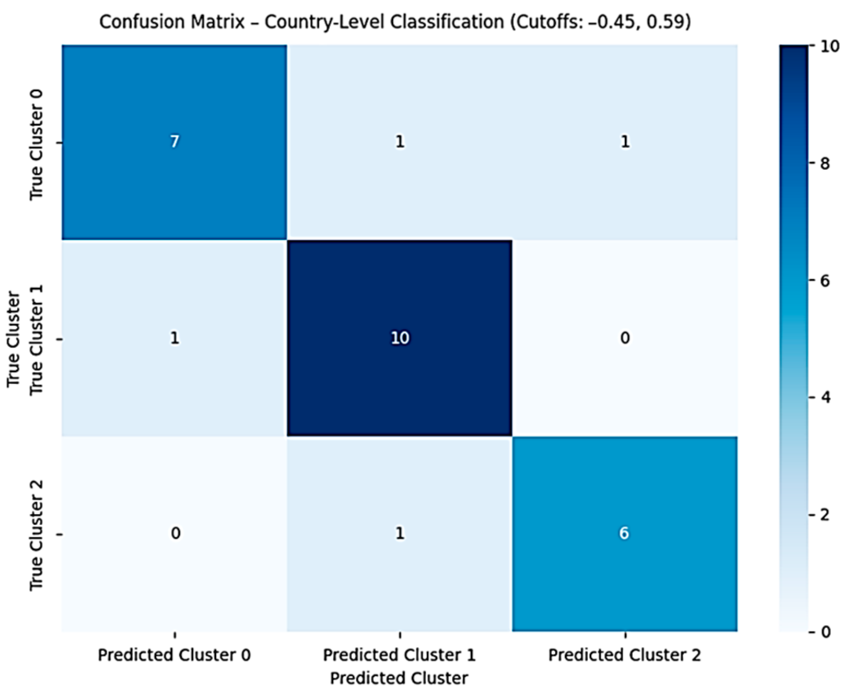
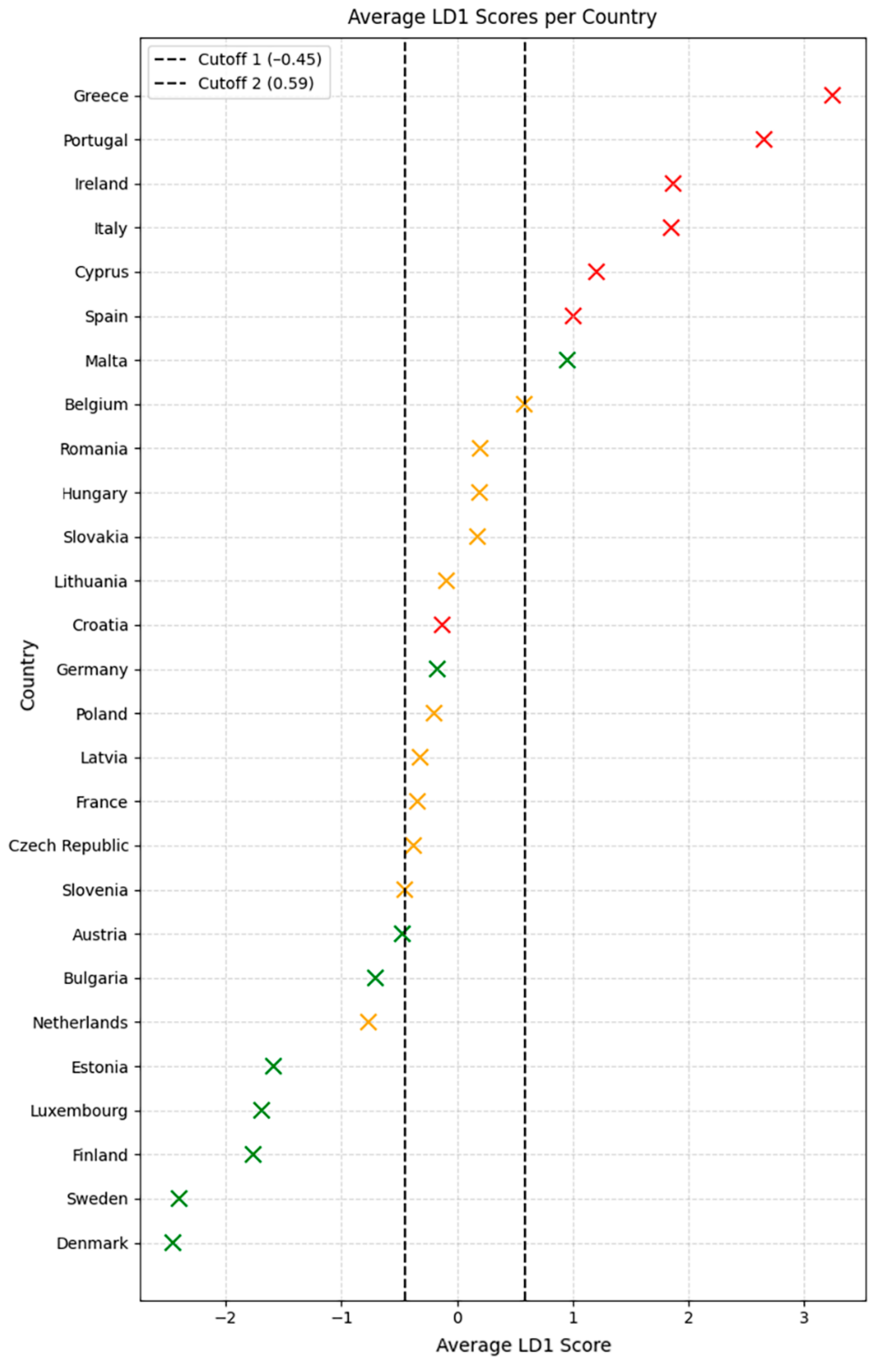


Figure 3. Confusion matrix – Country-level classification (cutoffs: –0.45 and 0.59) (source: authors' own calculations)

The classification obtained based on the CSFI scores can be considered robust, logical and well calibrated, with direct applications in risk analysis and fiscal policies.

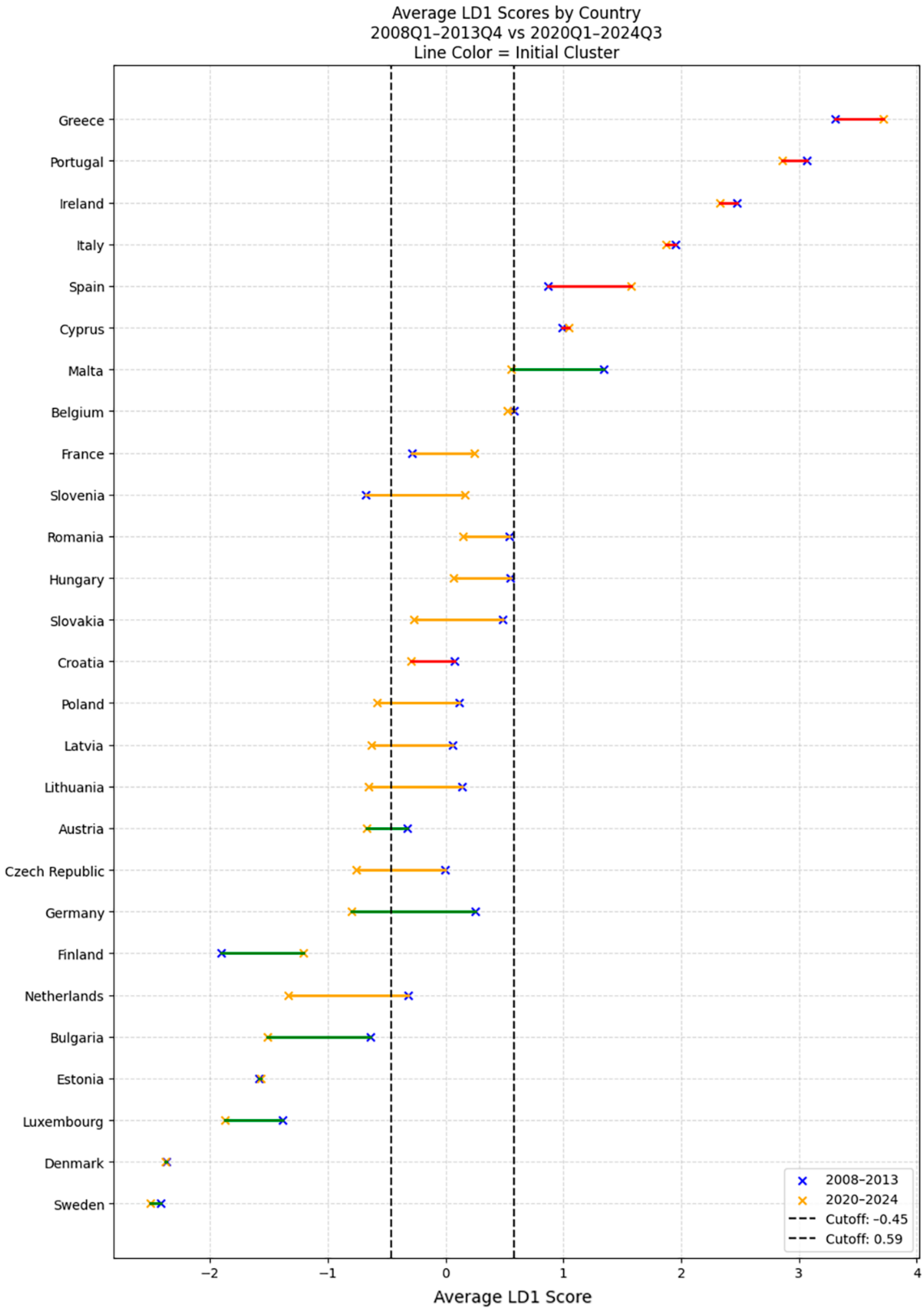
Figure 4 shows the average distribution of CFSI discriminant scores for each of the 27 European Union member states, sorted in descending order by estimated fiscal performance. Each state is positioned on the horizontal axis according to its average score, and the color of the marker corresponds to the fiscal cluster in which it was classified (green: Cluster 0 – fiscally sustainable, orange: Cluster 1 – fiscally vulnerable, red: Cluster 2 – fiscally unsustainable). The classification was performed according to the optimized thresholds identified in expression (20). Fiscally sustainable states, such as Denmark, Sweden, Finland, Luxembourg, Estonia, have negative CFSI score values, significantly below the –0.45 threshold, indicating fiscal robustness, budgetary stability and a low risk associated with fiscal imbalances. The intermediate (vulnerable) group includes states such as Romania, France, Slovenia or Belgium, whose positioning between the two thresholds signals a moderate fiscal vulnerability, requiring prudent fiscal consolidation measures. States classified as fiscally unsustainable, such as Greece, Portugal, Ireland, Italy, Cyprus, Spain, have CFSI scores above the upper threshold of 0.59, which reflects persistent budget deficits, high public debts and increased fiscal volatility during the periods under analysis. Moreover, the migration from one cluster to another explained by the confusion matrix can be observed through this graph. For instance, the Netherlands, which was classified in the cluster analysis as vulnerable, obtained a consistently negative CFSI score, which indicates a more robust fiscal position than the initial estimate. Croatia was classified as vulnerable, suggesting a relative improvement in its fiscal profile compared to the cluster-based classification. For Germany, the CFSI score indicates a slight deterioration in the fiscal profile, reflecting, in particular, recent budgetary pressures. In the case of Malta, the score close to 0 signals a moderate fiscal vulnerability, contrary to the initial assessment. This migration highlights the punctual discrepancies between expert-based judgment, cluster analysis and statistical assessment, underlining the role of quantitative models in calibrating fiscal policy decisions.

To capture the dynamics of fiscal sustainability over time, the model calibrated on historical data was applied to the average CFSI scores calculated for two distinct intervals: 2008Q1–2013Q4 and 2020Q1–2024Q3, as ahown in Figure 5. The aim was to identify structural changes in the fiscal profile of European Union member states and assess potential migrations between sustainability clusters, when crises due to applied fiscal policies occur (crisis and post-financial crisis), but also when there are exogenous crises (pandemic and post-pandemic period, but also the unstable geopolitical condition caused by the war in Ukraine). Thus, the position of the CFSI score in the period 2008Q1–2013Q4 is represented by the blue symbol, the position of the CFSI score in the period 2020Q1–2024Q3 is represented by the orange symbol, and the connecting line signals the direction and magnitude of the change, as well as the initial cluster to which each state belongs. As a general trend, it can be observed that most states have improved their fiscal position, which means that the CFSI score has decreased, more exactly, it can be observed a leftward shift along the graph axis. This evolution suggests a general trend of fiscal consolidation, which can be attributed, among others, to the post-crisis (post-2008) budgetary adjustment efforts, the reform conditionality under the Recovery and Resilience Mechanism (post-2020) established by Regulation (EU) 2021/241 (The European Parliament & The Council of the European Union, 2021) as well as to the progress in public debt management and fiscal transparency.



Note: symbol color represents the initial cluster (green: Cluster 0 – fiscally sustainable, orange: Cluster 1 – fiscally vulnerable, red: Cluster 2 – fiscally unsustainable).

Figure 4. Average CFSI scores per country (source: authors' own calculations)



Note: line color represents the initial cluster (green: Cluster 0 – fiscally sustainable, orange: Cluster 1 – fiscally vulnerable, red: Cluster 2 – fiscally unsustainable).

Figure 5. Average CFSI scores by country (2008Q1–2013Q4 vs 2020Q1–2024Q3) (source: authors' own calculations)

In this context, it is obviously that, beyond its strong discriminatory performance, the Composite Fiscal Sustainability Index (CFSI) provides valuable insights into the structural and dynamic changes in the fiscal profiles of European Union member states. The estimated coefficients of the linear discriminant function indicate that Public Debt (PD) and Government Expenditure (GE) are determinant factors of fiscal unsustainability, followed by the budget balance (DEF) and the abilities of fiscal institutions (SFRI). So, the fiscal vulnerability in the EU is primarily structural rather than cyclical, being influenced by the debt accumulation and rigid expenditure frameworks rather than short-term macroeconomic fluctuations. The cross-country distribution of average CFSI scores (Figure 4) reveals a clear stratification of fiscal regimes within the EU. Northern and small open economies such as Denmark, Sweden, Finland, Estonia and Luxembourg consistently exhibit strongly negative CFSI values, reflecting a combination of low interest burdens, prudent expenditure management and robust fiscal governance. On the contrary, countries including Greece, Italy, Portugal, Spain and Cyprus, are characterized by high public debt levels, recurrent deficits and elevated sovereign spreads, which translate into persistently positive CFSI scores and structural fiscal fragility. The dynamic comparison between the 2008Q1–2013Q4 and 2020Q1–2024Q3 periods (Figure 5) further deepens the analysis by capturing long-term adjustments in fiscal sustainability across successive crisis episodes. The general leftward shift of CFSI scores suggests that most EU member states have improved their fiscal positions over time, reflecting post-global-financial-crisis consolidation efforts, strengthened fiscal rules, and the conditionality embedded in the Recovery and Resilience Mechanism. However, this aggregate improvement masks substantial cross-country heterogeneity.

Countries previously located in the unsustainable cluster exhibit notable reductions in their CFSI scores, indicating successful fiscal adjustment and improved debt dynamics. By contrast, states such as Italy and Greece remain firmly within the unsustainable zone, underscoring the persistence of structural constraints despite favorable macroeconomic conditions or temporary policy support. In the fiscally vulnerable group, countries like Romania, Hungary, Poland and Belgium display high sensitivity to shocks, oscillating around the decision thresholds and having an elevated risk of downward reclassification under adverse conditions. Overall, the empirical findings demonstrate that fiscal sustainability in the European Union is not a static characteristic, but a process influenced by crisis, institutional reforms and macroeconomic conditions. The CFSI framework captures these dynamics effectively, enabling the identification of both consolidate fiscal regimes and latent vulnerabilities. This idea strengthens the policy relevance of the results, as it allows policymakers to distinguish between temporary fiscal stress and structural unsustainability, and to design targeted consolidation strategies accordingly.

To test the robustness of the model, as well as its ability to correctly classify the fiscal profile in the future, forecasts were generated over an eight-quarter horizon (2024Q4–2026Q3) for all 27 European Union member states, using three macroeconomic scenarios, namely the baseline, optimistic and pessimistic scenario. The baseline scenario determined based on the raw values estimated by the autoregressive AR(1) model applied individually to each indicator according to Eqs. (16)–(17). Macroeconomic scenarios, especially those used in fiscal sustainability analysis, are usually modeled based on shocks applied to key variables. In reality, not all variables change simultaneously or with the same amplitude within an economic cycle. Therefore, the alternative scenarios (optimistic and pessimistic) targeted those variables most susceptible to changes in the context of crisis or fiscal recovery, which also determined significant changes in the CFSI scores, as can be seen in Table 7 related to the linear discriminant analysis model coefficients. Table 8 presents the dominant indicators, as well as the related changes, necessary for building the alternative scenarios. The changes were applied over a horizon of eight quarters, respecting the variation limits according to Eq. (18), but also the applicability in economic reality. In the optimistic scenario, the adjustment of the main fiscal indicators was carried out in a favorable direction, keeping the values within realistic limits, while in the case of the pessimistic scenario, the adjustment in a negative direction revealed a fiscal deterioration of the same indicators.

After applying the adjustments, the data were standardized with the values in Table 6 and the CFSI scores were subsequently calculated. Figure 6 presents the average distribution of the CFSI discriminant scores for the eight forecast quarters (2024Q4–2026Q3) for each of the 27 European Union member states according to the three scenarios. This scenario analysis allowed the identification of states whose fiscal position is robust (low-risk) versus those with a fragile profile (high-risk) in the face of probable future economic shocks. Most states, such as Denmark, Sweden, Finland, Estonia, Luxembourg, maintain a stable classification between scenarios, which indicates a robust fiscal profile and little sensitivity to variations in the macroeconomic context. Countries in the unsustainable cluster, such as Greece, Italy, Ireland, Spain and Portugal, remain consistently in this category regardless of the scenario, suggesting a structural and persistent fiscal risk. Migration between clusters is particularly noticeable in countries with a vulnerable profile, such as Romania and Poland. It can be seen that Romania migrates from the vulnerable cluster (1) in the optimistic scenario to the unsustainable cluster (2) in the baseline and pessimistic scenarios, signaling a heightened fiscal sensitivity. Poland remains sustainable in the optimistic scenario, but is reclassified as vulnerable in the other two scenarios. On the other hand, Austria is a case of context-dependent fiscal sustainability, maintaining a stable position under normal scenarios but becoming

Table 8. Construction of alternative scenarios (optimistic and pessimistic) – cumulative changes over the eight quarters (source: authors' own calculations)

Indicator	Optimistic scenario	Pessimistic scenario	Economic justification
DEF	decreases by 3.5 pp	increases by 3.5 pp	▪ Accelerated fiscal consolidation driven by economic growth (*optimistic scenario*); ▪ Fiscal relaxation / budgetary imbalances caused by recession (*pessimistic scenario*);
PD	decreases by 5 pp	increases by 5 pp	▪ Debt reduction through primary surpluses and GDP growth (*optimistic scenario*); ▪ Debt increase due to accumulating deficits and negative base effects (*pessimistic scenario*);
GE	decreases by 1.5 pp	increases by 1.5 pp	▪ Expenditure rationalization and budgetary efficiency (*optimistic scenario*); ▪ Pressure on government expenditure in a crisis context (*pessimistic scenario*).

vulnerable under adverse assumptions. This transition confirms the usefulness of scenario analysis in detecting latent risks. While Germany previously appeared marginally vulnerable (Figure 4), the updated scenario analysis highlights an improvement in the fiscal profile in all three scenarios, justifying its reclassification as sustainable over the period 2020Q1–2024Q3 (Figure 5). This evolution demonstrates the added value of the dynamic scenario approach compared to a static evaluation based on historical averages.

The multiple classification also based on scenarios confirms that the CFSI is a sensitive and predictive synthetic indicator, which responds coherently to changes in fundamental macroeconomic variables. It also highlights the need for proactive fiscal consolidation measures in countries approaching the unsustainability threshold in pessimistic scenarios, such as Romania.

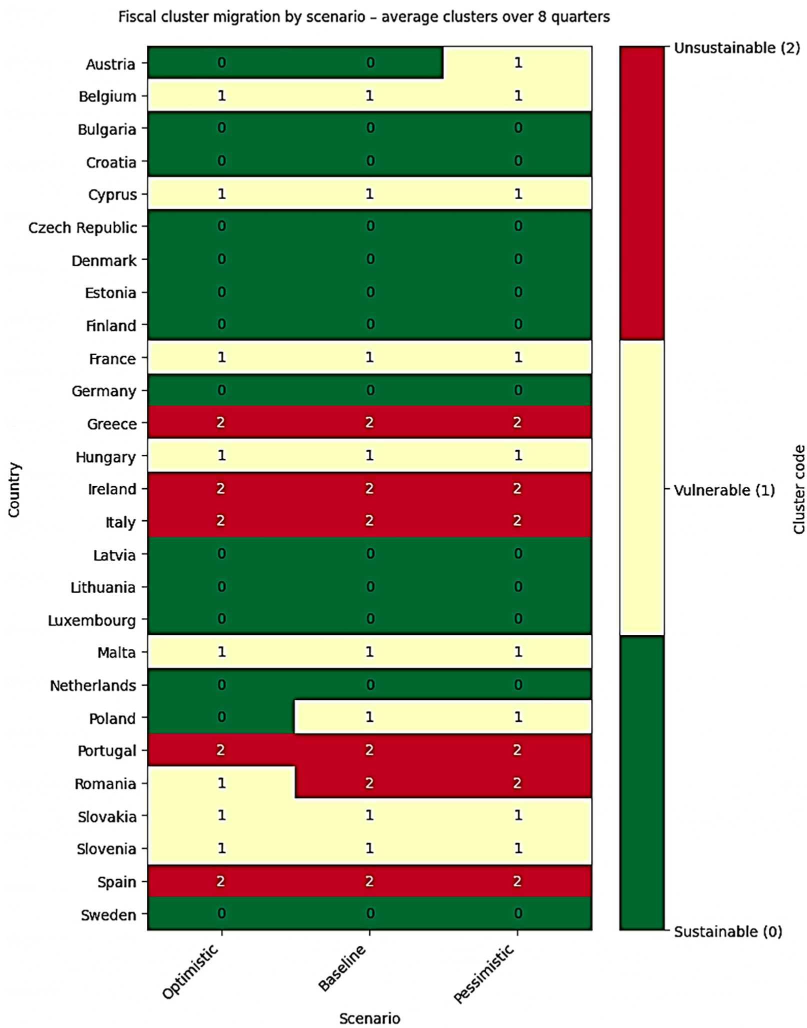


Figure 6. Heatmap for fiscal cluster migration by scenario – average clusters over eight quarters (2024Q4–2026Q3) (source: authors' own calculations)

6. Conclusions and personal considerations

The main objective of this paper was to build an empirical tool for classifying fiscal sustainability that would integrate the most relevant statistically selected economic indicators, is calibrated on historical data, allow application on forecasted data in order to anticipate future fiscal risk, and also provide a classification of states into three clusters: sustainable, vulnerable and unsustainable. The creation of such a model was necessary to respond to the urgent need to monitor and forecast fiscal sustainability in a European context deeply affected by successive shocks (sovereign debt crisis, COVID-19 pandemic and the war in Ukraine) that have amplified deficits, public debt and pressures on national budgets. In such an environment, a robust quantitative tool, based on data and alternative macroeconomic scenarios, becomes essential for anticipating fiscal risks and supporting evidence-based budgetary policymaking at both national and European levels.

The first step of this analysis was to perform the expert-based classification and cluster analysis in parallel to allow for the mutual validation of the fiscal profiles (sustainable, vulnerable and unsustainable), combining a theoretical foundation with an empirical approach. Obtaining an Adjusted Rand Index (ARI) of 0.66 indicated a significant convergence, which confirmed the existence of common classification cores between the two methods, justifying, at the same time, the use of cluster hierarchization as a benchmark for calibrating the LD_1 model. These results allowed the acceptance of the hypothesis H1 by which the trichotomous structure of fiscal sustainability has common points in the two approaches.

The second stage was defined by the selection of the 29 indicators related to the 27 member states and extracted for the period 2000Q1–2024Q3, using the Forward: Stepwise procedure. The tests of equality of group means were applied, so that Wilks's Lambda and the F-Statistic indicated the relevance of using in the analysis seven standardized indicators: INTBUR (interest burden), ER (employment rate), PD (public debt), DEF (deficit), GE (government expenditure), SPRD (10-year bond yield spread compared to Germany) and SFRI (standardised fiscal rule index). Also, $p - value < 0.001$ indicated the level of their statistical significance. Although the financing cost indicators have a significant influence, only INTBUR has a dominant role in discrimination, while SPRD is surpassed by ER, thus partially accepting hypothesis H2.

The third stage involved the actual development of the discriminant analysis. Thus, a function was obtained whose score was named Composite Fiscal Sustainability Index (CFSI), indicating an overall accuracy of 85.19%, a result that allows the acceptance of hypothesis H3. The results were also validated from a statistical point of view by applying the Eigenvalue and canonical correlation tests. Thus, the Eigenvalue test indicated that LD_1 explains 93.80% of the total variation, and the canonical correlation of 96.90% indicated a strong correlation between LD_1 scores and cluster membership. These tests revealed the high power of discrimination between the identified profiles.

The fourth stage required the establishment of classification thresholds (cutoffs) through the grid search procedure. This allowed the identification of the combination that maximized the overall accuracy of the model, avoiding the arbitrariness of the arithmetic mean between the scores. This optimized approach led to a more precise classification and better adapted to the real distribution of CFSI scores, strengthening the methodological validity of the model, aspects demonstrated by the score distribution graph and the confusion matrix, respectively.

To capture the dynamics of fiscal sustainability over time, the model calibrated on historical data was applied to the average CFSI scores calculated for two distinct intervals: 2008Q1–2013Q4 and 2020Q1–2024Q3. A general trend of improvement in the fiscal position of the member states was observed, reflected by the decrease in the CFSI score and its shift to the left on the graph axis. This evolution suggests that there is a gradual fiscal consolidation process, influenced by the adjustment measures implemented after the 2008 crisis, as well as by the progress made in public debt management and increasing fiscal transparency through fiscal policies applied in recent years.

The final stage of the analysis aimed to test the robustness of the model by generating forecasts over an 8-quarter horizon (2024Q4–2026Q3) for all 27 European Union member states, using three macroeconomic scenarios: baseline, optimistic, and pessimistic. The base scenario was determined based on the raw values estimated by the autoregressive AR(1) model applied individually to each indicator. The alternative scenarios (optimistic and pessimistic) targeted those variables most susceptible to changes in the context of crisis or fiscal recovery, which also determined significant changes in the CFSI scores. Thus, for DEF, PD and DE, the corresponding changes were applied depending on the scenario. In order to observe the migration of states between the three scenarios, a heatmap was created containing the average value of the CSFI scores in the eight forecasted quarters. Thus, it was possible to highlight the differences between states with sustainable, vulnerable and unsustainable fiscal profiles to economic shocks. Most northern and central European states maintain a stable classification between scenarios, while some southern European states remain constantly in the unsustainable cluster, reflecting a structural fiscal risk. Migration between clusters is frequent in the case of states with vulnerable fiscal profiles, such as Romania and Poland, suggesting sensitivity to the deterioration of the macroeconomic context, thus also accepting hypothesis H4.

Given the results presented, it can be stated that the model proposed in this paper provides a rigorous analytical framework for assessing and forecasting fiscal sustainability, being built on a reproducible and transparent methodology, applicable both in research and in public policy analysis. By integrating a synthetic score (CFSI), statistically calibrated and applicable to historical and scenario data, the model allows for a standardized classification of states according to their fiscal position, reflecting both current conditions and potential future developments. The model can function as an early warning tool, capable of anticipating the migration of countries between fiscal profiles (sustainable, vulnerable, unsustainable), thus enabling preventive interventions in the case of emerging fiscal risks. In addition, the proposed model also provides robust analytical support for decision-makers in the field of budgetary policy, as the CFSI synthetic score and the associated macroeconomic scenarios allow the assessment of the potential impact of various fiscal policy measures in an objective and comparable way. At the same time, the integration of this model into fiscal surveillance processes can contribute to compliance with the European Union requirements regarding the consolidated monitoring of fiscal sustainability. Moreover, the applicability of the model in analyzing the evolution of scores over time makes it a valuable tool for assessing the effectiveness of fiscal reforms and for supporting the decision-making process in contexts of economic uncertainty. By providing a standardized and transparent classification, the model can improve the communication of fiscal risks to both the general public and financial markets, thus contributing to strengthening budgetary discipline and confidence in fiscal policy. Last but not least, its utility extends to the field of sovereign solvency assessment, providing investors and rating agencies with a complementary analytical framework, based on objective economic data and criteria.

In this context, the empirical results obtained from the research allow for the formulation of differentiated and targeted policy recommendations, adapted to the specific fiscal profile of each group of countries. For fiscally sustenabile states, the main policy priority should be the preservation of fiscal buffers through prudent expenditure management and countercyclical fiscal policies, ensuring sufficient room for maneuver in the event of future shocks. In this context, maintaining compliance with fiscal rules and strengthening automatic stabilizers remain essential to avoid procyclical fiscal behavior during periods of economic expansion. For countries classified as fiscally vulnerable, the results highlight the need for proactive and gradual fiscal consolidation strategies aimed at preventing migration toward the unsustainable cluster. Policy measures should focus to the level and structure of the public expenditure, targeting revenue collection efficiency, and enhancing the credibility of medium-term fiscal frameworks. The sensitivity of these countries to adverse macroeconomic scenarios, as revealed by the scenario analysis, suggests that fiscal policy should be closely coordinated with structural reforms that support potential growth and employment. In the case of fiscally unsustainable states, the persistently high CFSI scores point to structural fiscal imbalances that require comprehensive and sustained policy interventions. These include credible debt reduction strategies, expenditure rationalization, and the reinforcement of fiscal institutions, particularly fiscal rules. At the European level, the results support the role of enhanced fiscal surveillance mechanisms and conditional financial support instruments, such as those embedded in the EU's economic governance framework, to mitigate systemic fiscal risks and prevent spillover effects across member states. In conclusion, the findings suggest that fiscal sustainability policies should be designed in a differentiated manner, reflecting both the current fiscal position and the projected sensitivity to future shocks. The CFSI framework provides policymakers with an operational early-warning tool that can support timely and evidence-based fiscal decisions, contributing to the strengthening of fiscal discipline and long-term sustainability within the European Union.

The research conducted makes significant contributions in the field of fiscal sustainability forecasting, but also has several limitations determined by: dependence on data quality and availability (the model is based on quarterly historical series for a set of standardized macroeconomic indicators, which may influence the robustness of CFSI scores and the classification of states); the use of cluster analysis represented a solid reference point, but it was based on historical data (in reality, fiscal behavior of states may evolve in a more gradual and non-linear way than a fixed trichotomous structure suggests); in addition, the proposed model focuses primarily on economic variables (however, fiscal sustainability is also influenced by institutional factors such as the quality of governance, political stability, and the independence of fiscal authorities, which are not explicitly integrated). Given these limitations, future research may address issues related to extending this framework by integrating qualitative and institutional variables (such as governance efficiency and fiscal transparency scores), adapting the model for other geographical regions and developing a dynamic and probabilistic fiscal score. Additionally, testing the model against real-time fiscal shocks (e.g., sudden energy price increases) could enhance its predictive robustness.Thus, future studies may strengthen the practical utility of the model in supporting the formulation of sustainable fiscal policies in a European environment characterized by uncertainty and heightened fiscal pressures.

Despite these limitations, this study addresses an essential economic question at the intersection of fiscal policy, sovereign risk, and institutional governance: how can we anticipate fiscal unsustainability before it manifests in crisis? The proposed CFSI model answers this question with both statistical rigor and policy relevance, offering a replicable tool grounded in economic theory and applicable across diverse macroeconomic scenarios. As fiscal rules and governance frameworks evolve within the EU, such tools become vital for preemptive decision-making.

Authors contributions

G.D and A.D.V: conceptualization, methodology, software, formal analysis, validation, writing – review & editing, G.B., C.E.S. and I.M.C: visualization, validation, investigation, project administration; O.R.A and L.M.E: methodology, data curation, validation, resources, writing – review & editing.

Disclosure statement

No known competing financial interests or personal relationships.

Data availability statement

The authors confirm that the data supporting the findings of this study are available within the article.

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APPENDIX

Table A1. Analytical list of indicators (source: authors' own calculations)

No.	Indicators	Code	Description and calculation method	Unit	Data transformation process	Source
1	External balance	EB	External balance of goods and services External balance = exports-imports	% of real GDP	seasonal adjustment (TRAMO-SEATS procedure) expression in real terms (deflation with GDP deflator, 2020 = 100) standardization (mean and standard deviation)	
2	Government expenditure	GE	Total general government expenditure	% of real GDP	seasonal adjustment (TRAMO-SEATS procedure) expression in real terms (deflation with GDP deflator, 2020 = 100) standardization (mean and standard deviation)	Eurostat (n.d.)
3	Final consumption expenditure	FCE	Final consumption expenditure of general government	% of real GDP	seasonal adjustment (TRAMO-SEATS procedure) expression in real terms (deflation with GDP deflator, 2020 = 100) standardization (mean and standard deviation)	Eurostat (n.d.)
4	Private consumption	PC	Household and NPISH final consumption expenditure	% of real GDP	seasonal adjustment (TRAMO-SEATS procedure) expression in real terms (deflation with GDP deflator, 2020 = 100) standardization (mean and standard deviation)	Eurostat (n.d.)
5	Public debt	PD	Government consolidated gross debt	% of real GDP	seasonal adjustment (TRAMO-SEATS procedure) expression in real terms (deflation with GDP deflator, 2020 = 100) standardization (mean and standard deviation)	Eurostat (n.d.)

Continue of Table A1

No.	Indicators	Code	Description and calculation method	Unit	Data transformation process	Source
6	General government budget deficit	DEF	total general government revenue – total general government expenditure	% of real GDP	seasonal adjustment (TRAMO-SEATS procedure)	Eurostat (n.d.)
			surplus (+)/deficit (–)		expression in real terms (deflation with GDP deflator, 2020 = 100)	
					standardization (mean and standard deviation)	
7	GDP deflator	GDPDEF*	Price index (implicit deflator), 2020 = 100, euro	index		Eurostat (n.d.)
8	Exports	EXP	Exports of goods and services	% of real GDP	seasonal adjustment (TRAMO-SEATS procedure)	Eurostat (n.d.)
					expression in real terms (deflation with GDP deflator, 2020 = 100)	
					standardization (mean and standard deviation)	
9	Imports	IMP	Imports of goods and services	% of real GDP	seasonal adjustment (TRAMO-SEATS procedure)	Eurostat (n.d.)
					expression in real terms (deflation with GDP deflator, 2020 = 100)	
					standardization (mean and standard deviation)	
10	Taxes on income, revenue	IR	State budget revenues from personal income tax	% of real GDP	seasonal adjustment (TRAMO-SEATS procedure)	Eurostat (n.d.)
					expression in real terms (deflation with GDP deflator, 2020 = 100)	
					standardization (mean and standard deviation)	
11	Economic sentiment indicator	ESI	Compiled by the European Commission – Directorate-General for Economic and Financial Affairs (DG ECFIN)	index	compiled monthly and aggregated to quarterly frequency for analysis	Eurostat (n.d.)
					seasonal adjustment (TRAMO-SEATS procedure)	

Continue of Table A1

No.	Indicators	Code	Description and calculation method	Unit	Data transformation process	Source
12	Private investment	PRIVI	Gross fixed capital formation	% of real GDP	seasonal adjustment (TRAMO-SEATS procedure)	Eurostat (n.d.)
					expression in real terms (deflation with GDP deflator, 2020 = 100)	
					standardization (mean and standard deviation)	
13	Public investment	PUBI	Gross fixed capital formation (quarterly non-financial accounts for general government)	% of real GDP	seasonal adjustment (TRAMO-SEATS procedure)	Eurostat (n.d.)
					expression in real terms (deflation with GDP deflator, 2020 = 100)	
					standardization (mean and standard deviation)	
14	Output	OUT	Total value of goods and services produced over an accounting period	% of real GDP	seasonal adjustment (TRAMO-SEATS procedure)	Eurostat (n.d.)
					expression in real terms (deflation with GDP deflator, 2020 = 100)	
					standardization (mean and standard deviation)	
15	Output of the private sector	POUT	Private output = real gross domestic product – real final consumption expenditure – real public investment	% of real GDP	standardization (mean and standard deviation)	
16	Gross domestic product	GDP	Gross domestic product at market prices	percentage change on previous period	seasonal adjustment (TRAMO-SEATS procedure)	Eurostat (n.d.)
					expression in real terms (deflation with GDP deflator, 2020 = 100)	
					standardization (mean and standard deviation)	
17	Employment rate	ER	Employment rate (15–64 age group)	% of the active population	standardization (mean and standard deviation)	Eurostat (n.d.)

Continue of Table A1

No.	Indicators	Code	Description and calculation method	Unit	Data transformation process	Source
18	Exchange rate	EXR	Real effective exchange rate (deflator: consumer price index – 27 trading partners – European Union from 2020 – Index, 2020 = 100)	%	standardization (mean and standard deviation)	Eurostat (n.d.)
19	EMU convergence criterion bond yields	INTR	Long-term interest rates – Maastricht convergence criterion (residual maturity of approximately 10 years)	%	data for Estonia are available only from 2020Q2 onward, as there were no sovereign debt instruments prior to this period that met the definition of long-term interest rates for convergence purposes.	Eurostat (n.d.)
20	Inflation rate	INFR	Harmonised Index of Consumer Prices	% (annual rate of change)	inflation rate averaged over the quarter	Eurostat (n.d.)
					compiled monthly and aggregated to quarterly frequency for analysis	
					standardization (mean and standard deviation)	
21	Taxes on production and imports	TPI	This indicator is composed of taxes levied per unit of a good or service, value-added tax (VAT), as well as other taxes related to imports.	% of real GDP	seasonal adjustment (TRAMO-SEATS procedure)	Eurostat (n.d.)
					expression in real terms (deflation with GDP deflator, 2020 = 100)	
					standardization (mean and standard deviation)	
22	Social transfers	ST	Social benefits other than social transfers in kind and social transfers in kind – purchased market production, expenditure	% of real GDP	seasonal adjustment (TRAMO-SEATS procedure)	Eurostat (n.d.)
					expression in real terms (deflation with GDP deflator, 2020 = 100)	
					standardization (mean and standard deviation)	
23	Government revenue	GR	Total general government revenue	% of real GDP	seasonal adjustment (TRAMO-SEATS procedure)	Eurostat (n.d.)
					expression in real terms (deflation with GDP deflator, 2020 = 100)	
					standardization (mean and standard deviation)	

End of Table A1

No.	Indicators	Code	Description and calculation method	Unit	Data transformation process	Source
24	Output gap	OG	Output gap = (real GDP – potential GDP)/ potential GDP * 100	%	potential GDP estimated using the Hodrick–Prescott (HP) filter	
					standardization (mean and standard deviation)	
25	Interest	INTEX*	Interest, expenditure		seasonal adjustment (TRAMO-SEATS procedure)	Eurostat (n.d.)
					expression in real terms (deflation with GDP deflator, 2020 = 100)	
26	Interest burden	INTBUR	Interest burden = interest expenditure/ real government expenditure*100	% of real government revenues	standardization (mean and standard deviation)	
27	Population aged 65 and over	POP65	Share of population aged 65 and over	% of the active population	compiled annualy and aggregated to quarterly frequency for analysis	Eurostat (n.d.)
					standardization (mean and standard deviation)	
28	10-year bond yeld spread compared to Germany	SPRD	Sovereign bond spread vs. Germany = 10-year yield (country *i*) – 10-year yield (Germany)	pp	standardization (mean and standard deviation)	Eurostat (n.d.)
29	Standardised Fiscal Rule Index	SFRI		index	compiled annualy and aggregated to quarterly frequency for analysis	European Comm-ission (2023)
					standardization (mean and standard deviation)	
30	r-g	RG	Interest rate – real GDP growth (r-g)	pp	standardization (mean and standard deviation)	
31	Capital taxes	CTR	Capital taxes, revenue	% of real GDP	seasonal adjustment (TRAMO-SEATS procedure)	Eurostat (n.d.)
					expression in real terms (deflation with GDP deflator, 2020 = 100)	
					standardization (mean and standard deviation)	

Note: *indicators that were not used in the Forward: Stepwise selection procedure related to the development of the fiscal sustainability forecasting model.