THE DYNAMICS OF FISCAL SUSTAINABILITY IN THE CONTEXT OF GREEN TRANSITION

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Abstract

The transition toward sustainable economic development and climate neutrality has intensified the importance of understanding the relationship between fiscal sustainability and green transition dynamics within European economies. In the context of the European Green Deal, REPowerEU strategy, and increasing fiscal pressures generated by economic instability, public debt expansion, and environmental transition costs, governments are required to balance environmental objectives with long-term fiscal stability. The present study investigates the impact of renewable energy consumption, environmental taxation, government expenditure, and macroeconomic performance on fiscal sustainability in selected European economies, namely Bulgaria, Germany, Hungary, Poland, and Romania, during the 2015–2024 period. The research employs a comparative econometric framework based on Ordinary Least Squares (OLS) regression models estimated separately for each country using annual data collected from Eurostat databases. The empirical findings indicate that renewable energy consumption and environmental taxation exert heterogeneous effects on government fiscal balance across the analysed economies. Romania and Hungary display comparatively stronger relationships between renewable energy transition and fiscal sustainability, while Germany and Romania record more significant effects associated with environmental taxation mechanisms. Government expenditure and real GDP per capita emerge as important determinants of fiscal balance dynamics, confirming the strong interdependence between macroeconomic performance, fiscal capacity, and environmental transition policies. The econometric results also reveal substantial differences among the analysed countries regarding public indebtedness, renewable energy integration, and fiscal resilience. The study contributes to the literature on sustainable public finance by integrating fiscal, environmental, and macroeconomic variables into a unified comparative framework capable of capturing the interaction between green transition policies and fiscal sustainability. The findings underline the necessity of adopting differentiated and country-specific fiscal strategies capable of supporting environmental transition objectives while maintaining long-term

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macroeconomic stability and public finance sustainability within the European Union context.

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JEL Classification
H63; Q56; R11.

1. Introduction

The transition toward sustainable economic development has become one of the main strategic priorities within the European Union, particularly in the context of climate change, environmental degradation, energy security concerns, and increasing fiscal vulnerabilities. The implementation of the European Green Deal (European Commission, 2023), the REPowerEU strategy (European Commission, 2024), and the European Union's climate neutrality objectives for 2050 have intensified the need for European economies to accelerate renewable energy adoption, strengthen environmental taxation systems, and redesign fiscal policies capable of supporting sustainable growth while maintaining macroeconomic stability. At the same time, the economic consequences of the COVID-19 crisis, persistent inflationary pressures, geopolitical instability, and rising public expenditure have intensified concerns regarding long-term fiscal sustainability across European economies.

Recent literature increasingly emphasizes the close relationship between fiscal sustainability, environmental transition dynamics, and sustainable development objectives. Studies highlight that renewable energy expansion, green investment, and environmental taxation may influence public finance stability through their effects on economic growth, public revenues, energy dependence, and investment requirements (Ahmad et al., 2025; Raihan & Sarker, 2026). At the same time, the literature argues that green transition policies may generate substantial fiscal pressures in the short term due to infrastructure modernization costs, public subsidies, and financing requirements associated with environmental transformation programs (Ma & Jiang, 2025; Radzewicz-Bak et al., 2024).

Environmental taxation has become an increasingly important instrument within European fiscal policy frameworks, being promoted as a mechanism capable of simultaneously supporting environmental sustainability and generating additional public revenues. According to the European Commission (European Commission, 2025b), green taxation policies contribute to reducing environmentally harmful activities while improving the efficiency of public revenue systems. However, several studies underline that the effectiveness of environmental taxation depends on fiscal governance quality, administrative capacity, and the degree of integration of sustainability objectives into national fiscal strategies (Kalaš et al., 2025; Nguyen & Ho, 2025).

The specialised literature also highlights the important relationship between government expenditure, economic development, and fiscal sustainability. Persistent fiscal deficits and rising public debt may reduce governments' fiscal flexibility and limit their capacity

to finance green transition policies, particularly in economies characterized by lower income levels and structural vulnerabilities (Gonon et al., 2026; Mutai et al., 2026). Conversely, stronger macroeconomic performance and higher GDP per capita levels improve public revenue generation capacity and strengthen fiscal resilience, facilitating the financing of environmental transition programs and sustainable development policies (Meinhold et al., 2026; OECD, 2026a).

Although numerous studies examine fiscal sustainability and the green transition separately, relatively few empirical studies investigate the combined effects of renewable energy consumption, environmental taxation, and government expenditure on fiscal sustainability within a comparative European framework. Furthermore, the comparative dynamics among Bulgaria, Germany, Hungary, Poland, and Romania remain insufficiently explored despite the substantial differences existing between these economies regarding economic development, public indebtedness, renewable energy integration, and fiscal capacity.

The novelty of the present study derives from the integration of fiscal, environmental, and macroeconomic indicators into a unified econometric framework designed to evaluate the impact of green transition dynamics on government fiscal balance within selected European economies during the 2015–2024 period. Unlike traditional approaches focused primarily on debt sustainability or fiscal deficits, the study explicitly incorporates renewable energy consumption and environmental taxation as central determinants of fiscal sustainability. In addition, the country-level comparative analysis allows the identification of heterogeneous fiscal adjustment mechanisms and differentiated responses to green transition policies across the analysed economies.

The main objective of the research is to investigate the extent to which renewable energy transition, environmental taxation, government expenditure, and macroeconomic performance influence fiscal sustainability dynamics in Bulgaria, Germany, Hungary, Poland, and Romania. At the same time, the study aims to identify differences in fiscal adjustment patterns associated with green transition implementation across economies characterized by distinct levels of economic development and fiscal resilience.

To achieve these objectives, the study addresses the following research questions:

RQ1: To what extent do renewable energy consumption and environmental taxation influence government fiscal balance within the analysed European economies?

RQ2: How do government expenditure and macroeconomic development affect fiscal sustainability dynamics in the context of green economic transition?

To answer these research questions, the study employs a comparative econometric analysis based on Ordinary Least Squares (OLS) regression models estimated separately for each country using annual data collected from Eurostat for the 2015–2024 period. The research contributes to the growing literature on sustainable public finance by emphasizing the increasing interdependence between environmental transition policies and fiscal sustainability within the European Union. At the same time, the findings provide relevant policy implications regarding the design of balanced fiscal and environmental strategies capable of supporting both green transition objectives and long-term macroeconomic stability.

2. Review of the scientific literature

The growing complexity of sustainable development policies within the European Union has led to numerous studies focusing on the interplay between the green transition and fiscal sustainability. In recent years, researchers have increasingly emphasized that climate neutrality goals, the transition to renewable energy, and environmental fiscal reforms have substantial implications not only for environmental performance but also for macroeconomic stability, public finance structures, and long-term fiscal resilience (Hardi et al., 2026; Karbalaei Aghababaei et al., 2025). Consequently, fiscal sustainability is increasingly analysed through broader multidimensional approaches that integrate environmental, economic, and institutional determinants (Boitan, 2023; Georgescu et al., 2025; Sun et al., 2024).

The specialised literature highlights that the transition toward low-carbon economic systems requires significant structural transformations involving energy systems, industrial production, public infrastructure, and fiscal governance mechanisms (Park et al., 2025; Shen et al., 2025). Renewable energy expansion, environmental taxation, and green public investment programs are frequently identified as central instruments supporting sustainable economic transition and climate policy implementation (O. R. Lobonț et al., 2025; OECD, 2025a). At the same time, these policies may generate important fiscal consequences through their influence on public revenues, government expenditure, debt dynamics, and economic competitiveness.

A significant stream of research focuses on the relationship between the renewable energy transition and sustainable economic development, emphasizing the role of green investments in stimulating innovation, energy security, technological modernization, and long-term economic resilience (Nauman et al., 2024; Wen et al., 2025). Another important research direction investigates the fiscal implications of environmental taxation and green fiscal reforms, particularly regarding their capacity to generate public revenues while discouraging environmentally harmful activities. Additionally, numerous studies analyse the influence of public expenditure, public debt, and macroeconomic performance on fiscal sustainability and governments' capacity to support environmental transition objectives (Baret & Menuet, 2024; Ciaffi et al., 2024).

Despite the expansion of the literature on sustainable public finance and green transition, existing empirical evidence remains relatively fragmented. Most studies analyse fiscal sustainability, renewable energy policies, or environmental taxation separately, while comparatively limited research integrates fiscal, environmental, and macroeconomic variables into unified analytical frameworks. Furthermore, the comparative dynamics among European economies characterized by heterogeneous levels of development, fiscal capacity, and renewable energy integration remain insufficiently explored within the specialized literature.

2.1. Fiscal sustainability and macroeconomic stability

Fiscal sustainability represents one of the central concepts within public finance literature and is generally associated with governments' ability to maintain stable public finances without generating excessive debt accumulation or persistent macroeconomic imbalances. According to Baret and Menuet (Baret & Menuet, 2024), fiscal sustainability depends on the capacity of governments to finance public expenditure

while preserving debt trajectories compatible with long-term economic growth and fiscal stability.

The literature emphasizes that persistent fiscal deficits and increasing public debt reduce fiscal flexibility, increase borrowing costs, and amplify macroeconomic vulnerabilities (Long et al., 2025; Mihai et al., 2025). Economies characterized by weak fiscal discipline often face difficulties in financing public investment, maintaining social protection systems, and responding to external economic shocks. Conversely, stronger macroeconomic performance and higher productivity levels improve governments' fiscal capacity through higher public revenues and greater economic resilience.

Recent studies argue that fiscal sustainability has become increasingly interconnected with structural transformation processes, including digitalization, demographic changes, climate policies, and green economic transition (Spilotro et al., 2026; Vărzaru et al., 2023). The implementation of sustainable development strategies requires substantial financial resources directed toward renewable energy infrastructure, technological modernization, environmental protection, and sustainable transport systems. Consequently, governments face increasing pressure to balance fiscal consolidation objectives with the financing requirements associated with environmental transition programs.

Within the European Union, fiscal sustainability is closely linked to sustainable development objectives and climate neutrality commitments. The European Green Deal recognises the necessity of integrating fiscal governance mechanisms into environmental transition strategies, emphasizing the importance of sustainable public finance systems capable of supporting ecological transformation without generating excessive fiscal imbalances (Heimberger, 2025; Seghini & Dees, 2025).

The literature further highlights that fiscal sustainability is strongly influenced by institutional quality, governance efficiency, and macroeconomic development. Countries characterized by stronger administrative capacity and diversified economic structures generally exhibit greater fiscal resilience and higher capacity to absorb the financial costs associated with green transition policies (Lobonț et al., 2025). In contrast, lower-income economies frequently face structural fiscal vulnerabilities due to weaker institutional frameworks, lower productivity levels, and higher dependence on external financing.

2.2. Renewable energy transition and sustainable economic development

Renewable energy transition represents one of the most important dimensions of sustainable economic transformation within contemporary European economies. The literature increasingly emphasizes that renewable energy expansion contributes to reducing greenhouse gas emissions, strengthening energy security, improving environmental sustainability, and supporting long-term economic resilience (Igliński et al., 2024; Tansuchat & Yosthongngam, 2026).

Several studies argue that investments in renewable energy infrastructure stimulate technological innovation, employment creation, industrial diversification, and economic competitiveness (B. Ma & Wang, 2025; Santos, 2025). Renewable energy systems are also associated with lower dependence on fossil fuel imports and reduced exposure to energy market volatility, thereby contributing to macroeconomic stability and

sustainable development objectives (Gniadkowska-Szymańska et al., 2025; Yadav, 2025).

The European Union has intensified renewable energy deployment through the European Green Deal and the REPowerEU strategy, particularly following the geopolitical and energy security challenges associated with external energy dependence. These policies emphasize the acceleration of renewable energy integration and the transition toward low-carbon economic systems capable of ensuring both environmental sustainability and long-term economic resilience (Kneebone et al., 2026; Taghizadeh-Hesary & Rasoulinezhad, 2025).

However, the literature also underlines that the renewable energy transition may generate substantial short-term fiscal pressures due to the high investment costs associated with energy infrastructure modernization, technological adaptation, public subsidies, and environmental support mechanisms (Dincă et al., 2025; T. Nguyen et al., 2025). Governments frequently finance renewable energy expansion through public expenditure programs, tax incentives, and investment schemes, increasing pressure on fiscal balances during the transition process (OECD, 2025b; Taghizadeh-Hesary & Rasoulinezhad, 2025).

The fiscal effects of renewable energy transition remain heterogeneous across economies and depend on factors such as institutional quality, investment capacity, technological development, and the maturity of national energy systems (Anser et al., 2026; Pinar, 2026). Countries characterized by stronger economic development and advanced renewable energy infrastructure often display greater capacity to finance environmental transition without generating substantial fiscal instability (IRENA, 2025; Nondo, 2026). In contrast, economies with lower fiscal capacity and higher dependence on conventional energy systems may experience greater fiscal pressures during the transition process.

Central and Eastern European economies face additional structural challenges regarding the renewable energy transition, including infrastructure gaps, limited investment capacity, and dependence on fossil fuel-based energy systems (Kułyk & Michałowska, 2025; Santa et al., 2025). These structural differences contribute to heterogeneous renewable energy trajectories and differentiated macroeconomic and fiscal outcomes across European countries.

2.3. Environmental taxation and green fiscal reforms

Environmental taxation has become an increasingly important component of sustainable fiscal policy frameworks within the European Union. The literature defines environmental taxes as fiscal instruments designed to discourage environmentally harmful activities while simultaneously generating public revenues capable of supporting sustainable development policies (Kalaš et al., 2025; Olasehinde-Williams, 2026).

Green taxation mechanisms, including energy taxes, carbon taxes, transport taxes, and pollution-related fiscal instruments, are increasingly promoted as efficient policy tools for internalising environmental externalities and supporting climate neutrality objectives. Several studies argue that environmental taxes contribute to fiscal sustainability by expanding public revenue structures while simultaneously encouraging

sustainable production and consumption patterns (Behera et al., 2025; Farooq et al., 2023).

The European Commission increasingly emphasizes the role of environmental taxation within green fiscal reforms and sustainable public finance strategies (European Commission, 2025b). Environmental taxes may contribute to improving fiscal efficiency, reducing dependence on traditional taxation systems, and financing environmental transition programs (Owusu Atuahene et al., 2025; Sen et al., 2025). At the same time, green taxation mechanisms may stimulate energy efficiency improvements, technological modernization, and renewable energy adoption.

Nevertheless, the effectiveness of environmental taxation depends significantly on institutional quality, administrative efficiency, governance capacity, and public acceptance. Several studies highlight that poorly designed environmental tax systems may generate negative social and economic effects, including reduced industrial competitiveness, inflationary pressures, and regressive distributional impacts, particularly within vulnerable economies (Bergougui & Ben-Salha, 2025; OECD, 2024).

The literature also indicates substantial differences between Western and Central-Eastern European economies regarding the implementation and effectiveness of environmental taxation systems (Amendola, 2025; Dmytrenko et al., 2024). Economies characterized by stronger institutional frameworks and diversified economic structures generally display greater capacity to integrate environmental taxation into broader fiscal and sustainability strategies. Conversely, structurally vulnerable economies may encounter difficulties in implementing efficient green taxation mechanisms due to lower fiscal capacity and higher energy dependence.

2.4. Government expenditure, public debt, and green transition financing

Government expenditure and public debt represent fundamental determinants of fiscal sustainability within both traditional and green economic policy frameworks. The literature emphasizes that expansionary fiscal policies and persistent budget deficits contribute directly to rising public indebtedness and reduced fiscal flexibility, potentially limiting governments' capacity to finance sustainable development objectives (Buthelezi, 2025; Mihai et al., 2025).

The transition toward sustainable economic systems requires substantial public investment in renewable energy infrastructure, environmental modernization, sustainable transport systems, green technologies, and climate adaptation measures. Consequently, governments increasingly allocate significant public expenditure toward environmental transition programs, generating important implications for fiscal sustainability (Long et al., 2024; Rehman et al., 2026).

Several studies argue that productive public expenditure directed toward green infrastructure and technological innovation may generate long-term positive effects on economic growth, environmental resilience, and macroeconomic stability (Teixeira, 2025; Van Trung et al., 2025). Investments in renewable energy systems, energy efficiency, and sustainable infrastructure may contribute to productivity growth, industrial modernization, and reduced environmental costs over the long term.

However, the literature also emphasizes that green transition financing generates considerable short-term fiscal pressures due to the large-scale investments and public support mechanisms required for environmental transformation (Fortea et al., 2026; Raihan & Sarker, 2026; Romaldi et al., 2024). Public debt dynamics therefore become increasingly relevant within the context of sustainable transition policies, particularly in economies characterized by persistent deficits, lower fiscal capacity, and structural vulnerabilities.

Within the European Union, fiscal sustainability and green transition financing became even more interconnected following the COVID-19 crisis and subsequent economic recovery programs (European Union, 2022; Tijanić & Kersan-Škabić, 2025). European recovery mechanisms intensified public expenditure and government borrowing in order to support economic stabilization and environmental transition objectives (European Commission, 2021; Sosvilla-Rivero et al., 2025). Consequently, governments are increasingly required to balance debt sustainability, fiscal consolidation, and sustainable development priorities.

The relationship between public debt, government expenditure, and fiscal sustainability also depends on macroeconomic development levels and institutional quality. Economies characterized by higher GDP per capita levels, stronger productivity, and more efficient governance structures generally display greater fiscal resilience and improved capacity to finance environmental transition without generating excessive macroeconomic instability.

2.5. Research gap and contribution of the study

Although the specialized literature extensively analyses fiscal sustainability, renewable energy transition, environmental taxation, and macroeconomic stability, existing empirical evidence remains relatively fragmented regarding the interaction between these dimensions within unified analytical frameworks. Most studies focus either on fiscal sustainability and public debt dynamics or on environmental transition and renewable energy policies separately, without explicitly integrating fiscal, environmental, and macroeconomic indicators into comparative econometric models.

Furthermore, relatively limited empirical research investigates the combined influence of renewable energy consumption, environmental taxation, government expenditure, public debt, and macroeconomic performance on government fiscal balance within European economies characterized by heterogeneous levels of economic development and fiscal resilience. The comparative dynamics among Bulgaria, Germany, Hungary, Poland, and Romania remain particularly underexplored despite the substantial structural differences existing between these economies regarding renewable energy integration, environmental fiscal policies, public indebtedness, and institutional capacity.

The present study contributes to the literature by developing a comparative econometric framework capable of analysing the interaction between fiscal sustainability and green transition dynamics within selected European economies during the 2015–2024 period. By integrating renewable energy consumption, environmental taxation, government expenditure, public debt, and real GDP per capita into country-specific OLS regression models, the research provides a more comprehensive understanding of the fiscal

implications associated with sustainable economic transition and highlights the existence of heterogeneous fiscal adjustment mechanisms across the analysed economies.

3. Research methodology

The present study investigates the relationship between fiscal sustainability and green transition dynamics in selected European economies through a comparative econometric framework based on multiple linear regression analysis. The research aims to identify the extent to which renewable energy transition, environmental taxation, public debt, and government expenditure influence fiscal sustainability, measured through the government deficit/surplus indicator.

The empirical analysis was conducted for Bulgaria, Germany, Hungary, Poland, and Romania using annual data covering the period 2015–2024. The selection of the analysed economies reflects different levels of economic development, fiscal consolidation capacity, public indebtedness, and green transition implementation within the European context. All statistical data were collected from the Eurostat database to ensure methodological consistency, comparability, and reliability of indicators.

Table no. 1. Presentation of the analysed indicators

Indicator	Symbol	U.M.	Source
Government deficit/surplus	GovDef	% of GDP	Eurostat (Eurostat, 2026b)
General government gross debt	GrosDeb	% of GDP	Eurostat (Eurostat, 2026a)
Government expenditure	GovExp	% of GDP	Eurostat (Eurostat, 2026c)
Share of renewable energy in gross final energy consumption	RenEn	%	Eurostat (Eurostat, 2026f)
Share of environmental taxes in total tax revenues	EnvTax	%	Eurostat (Eurostat, 2026e)
Real GDP per capita	RGDP	Euro per capita	Eurostat (Eurostat, 2026d)

Source: Prepared by the authors

The selection of variables included in the econometric models is based on the specialized literature regarding fiscal sustainability, environmental transition, and macroeconomic stability. The indicators were chosen to capture both the fiscal dimension of public finance sustainability and the environmental dynamics associated with green transition policies implemented within European economies.

The dependent variable, government deficit/surplus as a percentage of GDP (GovDef), was selected because it represents one of the most relevant indicators used in the literature to evaluate fiscal sustainability and budgetary stability. Persistent fiscal deficits are frequently associated with increasing public debt, macroeconomic

imbalances, and reduced fiscal capacity to support long-term sustainable development policies.

General government gross debt (GrosDeb) was included because public indebtedness directly influences fiscal sustainability through debt servicing pressures and limitations on fiscal flexibility. Government expenditure (GovExp) was selected due to its direct impact on fiscal balances and its role in financing public investment, including green transition measures and environmental infrastructure.

The share of renewable energy in gross final energy consumption (RenEn) reflects the level of green transition implementation within each economy. The literature emphasizes that renewable energy expansion contributes to environmental sustainability and long-term economic resilience, although transition investments may generate short-term fiscal pressures. Environmental taxes (EnvTax) were included because green taxation mechanisms are increasingly considered important fiscal instruments for supporting sustainable development and generating additional public revenues while discouraging environmentally harmful activities.

Real GDP per capita (RGDP) was introduced as a macroeconomic control variable reflecting economic development and income levels. Economic growth is commonly associated in the literature with improved fiscal performance, higher public revenues, and stronger capacity to finance environmental and social policies.

All indicators were collected from Eurostat databases to ensure data comparability, methodological consistency, and statistical reliability across the analysed European economies and the 2015–2024 period.

The general form of the econometric model estimated in the study is the following:

$$GovDef_t = \alpha + \beta_1 RenEn_t + \beta_2 EnvTax_t + \beta_3 RGDP_t + \beta_4 GrosDeb_t + \beta_5 GovExp_t + \varepsilon_t \quad (1)$$

where:

$GovDef$ - government deficit/surplus;

$RenEn$ - share of renewable energy consumption;

$EnvTax$ - environmental taxes share;

$RGDP$ - real GDP per capita;

$GrosDeb$ - general government gross debt;

$GovExp$ - government expenditure;

ε_t - stochastic error term.

Based on the estimated regression coefficients obtained through the OLS econometric analysis, separate country-specific equations were formulated in order to capture the relationship between fiscal sustainability and green transition indicators within each analyzed European economy. The estimated models allow the identification of the direction and magnitude of the influence exerted by renewable energy consumption, environmental taxation, public debt, government expenditure, and economic development on government fiscal balances during the 2015–2024 period. The econometric equations corresponding to each country are presented below.

$$GovDef_{BG,t} = 49.651 - 0.058RenEn_{BG,t} + 0.079EnvTax_{BG,t} - 0.001RGDP_{BG,t} - 0.517GrosDeb_{BG,t} - 0.767GovExp_{BG,t} + \varepsilon_{BG,t} \quad (2)$$

$$GovDef_{DE,t} = -17.172 + 0.685RenEn_{DE,t} + 2.096EnvTax_{DE,t} + 0.001RGDP_{DE,t} + 0.080GrosDeb_{DE,t} - 1.050GovExp_{DE,t} + \varepsilon_{DE,t} \quad (3)$$

$$GovDef_{HU,t} = 77.431 + 0.375RenEn_{HU,t} - 2.119EnvTax_{HU,t} - 0.002RGDP_{HU,t} - 0.452GrosDeb_{HU,t} - 0.233GovExp_{HU,t} + \varepsilon_{HU,t} \quad (4)$$

$$GovDef_{PL,t} = 29.734 + 0.001RenEn_{PL,t} - 0.228EnvTax_{PL,t} + 0.001RGDP_{PL,t} - 0.035GrosDeb_{PL,t} - 0.829GovExp_{PL,t} + \varepsilon_{PL,t} \quad (5)$$

$$GovDef_{RO,t} = 4.035 + 0.829RenEn_{RO,t} + 0.392EnvTax_{RO,t} - 0.001RGDP_{RO,t} - 0.056GrosDeb_{RO,t} - 0.629GovExp_{RO,t} + \varepsilon_{RO,t} \quad (6)$$

Following the estimation of the country-specific econometric equations, the study formulates several research hypotheses in order to examine the relationship between fiscal sustainability and green transition indicators within the analysed European economies during the 2015–2024 period. The hypotheses are grounded in the existing literature on environmental taxation, renewable energy transition, public finance sustainability, and macroeconomic stability.

H1: The increase in the share of renewable energy consumption has a significant impact on government fiscal balance in European economies.

H2: Environmental taxation significantly influences fiscal sustainability by affecting government deficit dynamics.

H3: Government expenditure and real GDP per capita significantly influence government deficit/surplus dynamics within the context of green economic transition.

The methodological framework developed in this study combines comparative econometric analysis with fiscal and environmental sustainability indicators in order to evaluate the impact of green transition dynamics on government fiscal balance in selected European economies during the 2015–2024 period. The use of country-specific OLS regression models allows the identification of heterogeneous fiscal adjustment patterns and differences in the interaction between renewable energy transition, environmental taxation, public debt, and macroeconomic performance.

By integrating fiscal, environmental, and economic variables into a unified analytical framework, the research provides a comprehensive perspective on the challenges and opportunities generated by the transition toward sustainable economic systems within the European context. At the same time, the methodological approach contributes to the empirical literature on fiscal sustainability by emphasizing the growing importance of green transition policies in shaping public finance stability and long-term economic resilience.

4. Results and discussion

This section presents the empirical results obtained from the econometric analysis, beginning with the descriptive statistics of the variables included in the study, followed by the interpretation of the regression models estimated for each analysed European economy during the 2015–2024 period. The results provide a comparative perspective on the interaction between fiscal sustainability indicators, green transition dynamics, and macroeconomic performance within the selected countries.

Table 2 presents the descriptive statistics associated with the variables included in the econometric analysis, offering a preliminary overview of the fiscal, environmental, and macroeconomic characteristics of the analysed European economies. The descriptive indicators highlight significant variations among the selected countries in terms of fiscal sustainability, public indebtedness, government expenditure, renewable energy transition, environmental taxation, and economic development.

Table no 2. Descriptive statistics

Indicator	Minimum	Maximum	Mean	Std. Deviation	Skewness	Kurtosis
GovDef	-9,30	2,20	-2,91	2,97	-0,24	-0,53
GrosDeb	20,10	78,70	51,19	17,90	-0,28	-1,13
GovExp	33,60	51,10	43,14	4,97	-0,20	-0,92
RenEn	11,06	25,76	18,56	4,29	0,11	-1,19
EnvTax	4,33	15,32	7,84	2,15	1,10	2,31
RGDP	6560	40710	16881,80	11722,60	1,38	0,18

Source: Prepared by the authors using SPSS

The government deficit/surplus indicator (GovDef) records an average value of −2.91% of GDP, indicating the predominance of fiscal deficits during the analysed period, with values ranging between −9.30% and 2.20%. General government gross debt (GrosDeb) exhibits a mean value of 51.19% of GDP, reflecting relatively high levels of public indebtedness and significant differences between the analysed economies. Government expenditure (GovExp) records an average value of 43.14% of GDP, confirming the important role of public sector intervention within the selected countries. At the same time, the share of renewable energy consumption (RenEn) presents an average value of 18.56%, highlighting the gradual implementation of green transition policies during the analysed period. Environmental taxes (EnvTax) register an average share of 7.84% of total tax revenues, emphasizing the increasing importance of green fiscal instruments within European economies. Real GDP per capita (RGDP) shows the highest variability, with values ranging from 6,560 to 40,710 euro per capita, reflecting substantial disparities in economic development among the analysed countries.

The descriptive statistics indicate significant heterogeneity regarding fiscal sustainability conditions, environmental transition progress, and macroeconomic performance across the selected European economies.

Figure 1 illustrates the evolution of the government deficit/surplus indicator across the analysed European economies during the 2015–2024 period, highlighting significant

differences in fiscal sustainability dynamics and budgetary adjustment capacity among countries.

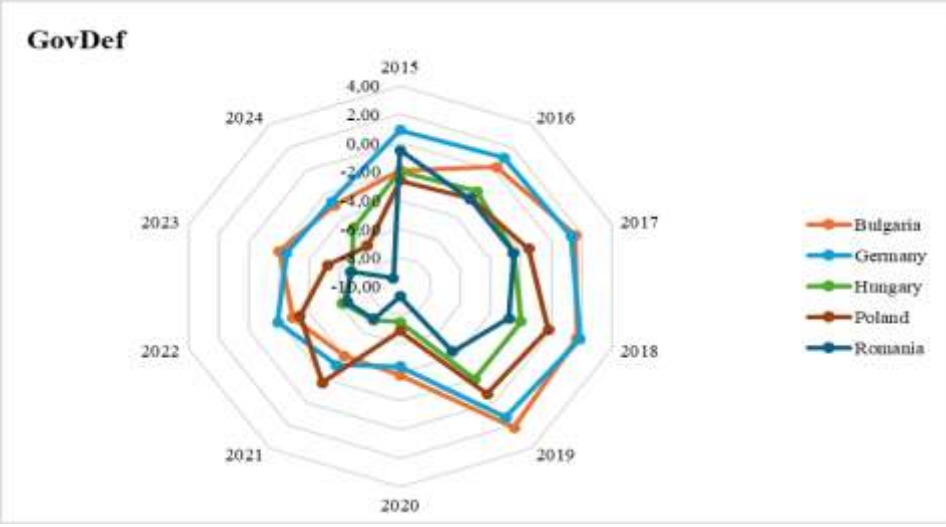


Figure no. 1: Evolution of Government Deficit/Surplus (GovDef)
Source: Prepared by the authors

The results reveal that most economies experienced persistent fiscal deficits throughout the analysed period, although the intensity and volatility of fiscal imbalances differed considerably.

Germany records comparatively more stable fiscal dynamics during the pre-pandemic period, including temporary fiscal surpluses, reflecting stronger fiscal discipline and higher budgetary resilience. In contrast, Romania and Hungary exhibit more persistent deficit levels, suggesting greater fiscal pressures and lower capacity for budgetary consolidation. Bulgaria and Poland display intermediate fiscal patterns, characterized by moderate fluctuations in fiscal balance over time. The figure also highlights the substantial deterioration of fiscal balances around the 2020 period, reflecting the economic and fiscal impact associated with the COVID-19 crisis, followed by gradual adjustment processes in the subsequent years.

Figure no. 2 illustrates the evolution of general government gross debt as a percentage of GDP in the analysed European economies during the 2015–2024 period, emphasizing significant differences in public indebtedness levels and fiscal sustainability conditions across countries.

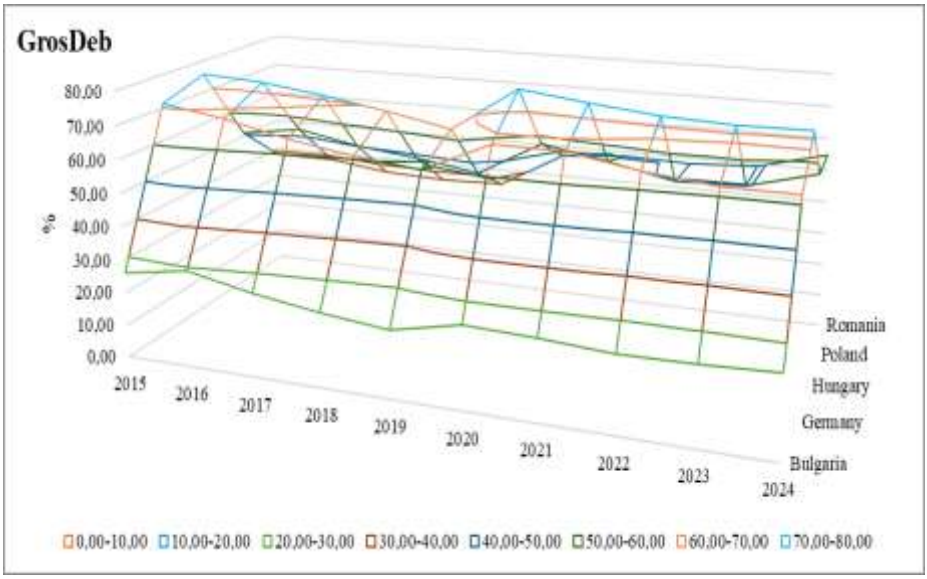


Figure no. 2: Evolution of General Government Gross Debt (GrosDeb)
Source: Prepared by the authors

The figure representation highlights both the persistence of high debt levels and the heterogeneous fiscal adjustment trajectories characterizing the selected economies. Germany records the highest levels of public debt during most of the analysed period, with values approaching or exceeding 70% of GDP, particularly in the years affected by the COVID-19 crisis and subsequent fiscal support measures. Hungary and Poland also display relatively elevated debt levels, although with moderate fluctuations over time. In contrast, Bulgaria maintains comparatively lower levels of public indebtedness throughout the analysed period, suggesting stronger fiscal stability and lower pressure on public finances. Romania exhibits a gradual upward trend in government debt, reflecting increasing fiscal deficits and expanding public expenditure pressures during the later years of the analysed interval. The figure 2 also highlights a visible increase in debt levels around the 2020–2021 period across most economies, reflecting the fiscal consequences of the pandemic crisis, economic recovery programs, and rising public financing needs.

Figure no. 3 presents the evolution of government expenditure as a percentage of GDP in the analysed European economies during the 2015–2024 period, highlighting differences in fiscal intervention intensity and public spending dynamics across countries.

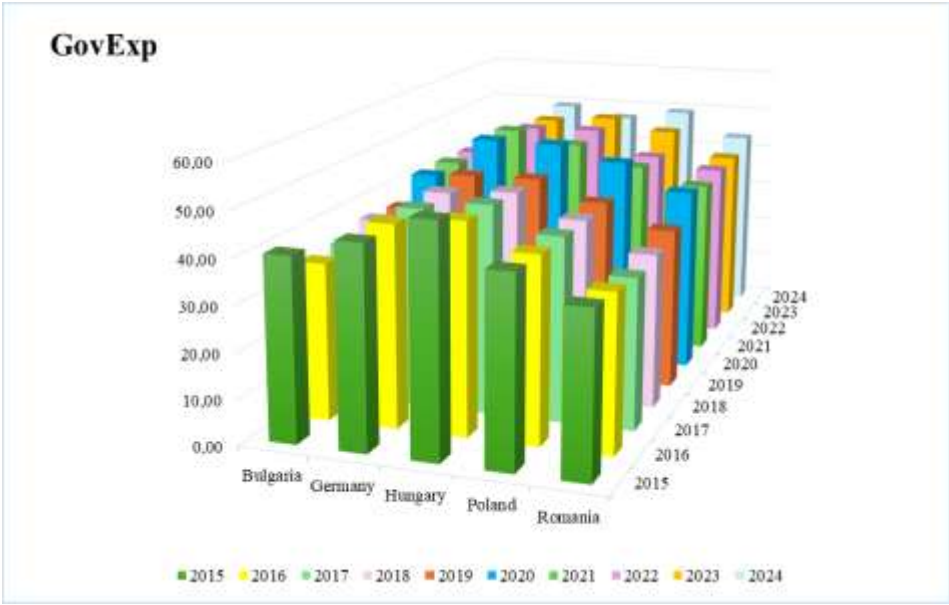


Figure no. 3: Evolution of Government Expenditure (GovExp)
Source: Prepared by the authors

The results indicate relatively high levels of government expenditure throughout the analysed interval, reflecting the important role of public authorities in supporting economic stability, social protection, and green transition policies. Hungary records the highest levels of government expenditure during most of the analysed period, suggesting a stronger degree of state intervention within the economy. Germany and Poland also display relatively elevated expenditure levels, particularly during the 2020–2021 period, reflecting the implementation of fiscal support measures associated with the COVID-19 crisis and economic recovery programs.

Romania and Bulgaria exhibit comparatively lower government expenditure levels, although both economies experienced gradual increases in public spending during the later years of the analysed interval. The figure 3 also highlights a general upward trend in government expenditure across most countries around the pandemic period, emphasizing the expansionary fiscal policies adopted to mitigate economic and social disruptions.

Figure 4 illustrates the evolution of the share of renewable energy in gross final energy consumption within the analysed European economies during the 2015–2024 period, highlighting the gradual implementation of green transition policies and the increasing importance of sustainable energy systems across countries.

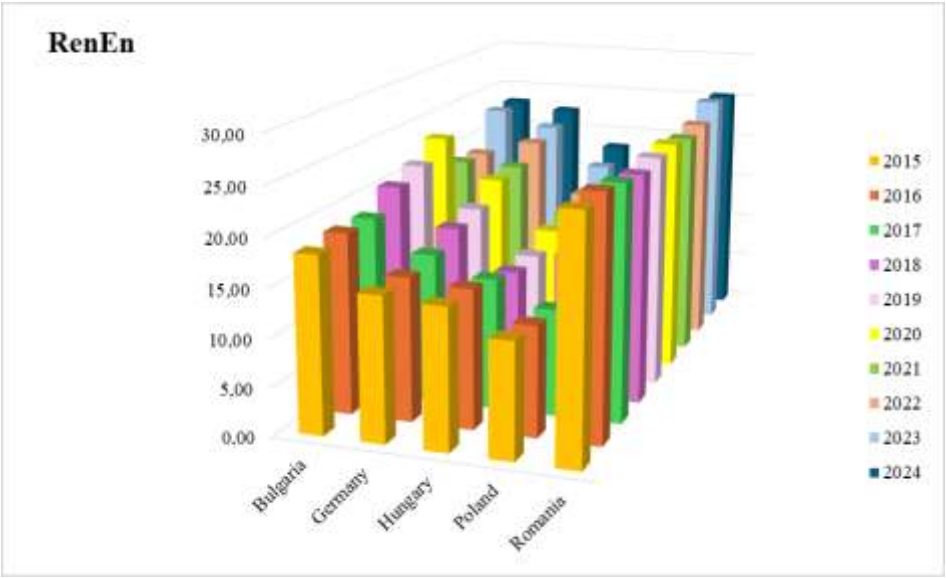


Figure no. 4: Evolution of Renewable Energy Share (RenEn)
Source: Prepared by the authors

The results indicate a general upward trend in renewable energy consumption throughout the analysed interval, reflecting the intensification of European environmental policies, investments in clean energy infrastructure, and the transition toward low-carbon economic models. Romania records the highest renewable energy shares among the analysed economies, with values approaching 30% in the later years of the period, suggesting a relatively advanced level of renewable energy integration within the national energy structure. Bulgaria and Hungary also display increasing renewable energy shares over time, although at more moderate levels compared to Romania. Germany and Poland register comparatively lower renewable energy shares during the analysed period, despite visible improvements in recent years associated with energy diversification strategies and environmental sustainability objectives. The figure also highlights a relatively continuous and stable increase in renewable energy adoption after 2020, emphasizing the acceleration of green transition measures within the European context. Overall, the results underline the existence of heterogeneous renewable energy transition trajectories among the analysed economies, reflecting differences in energy policies, investment capacity, natural resource availability, and environmental policy implementation.

Figure 5 presents the comparative evolution of environmental taxes as a share of total tax revenues within the analysed European economies during the 2015–2024 period, highlighting the increasing importance of green fiscal instruments in supporting environmental sustainability and fiscal transition policies.

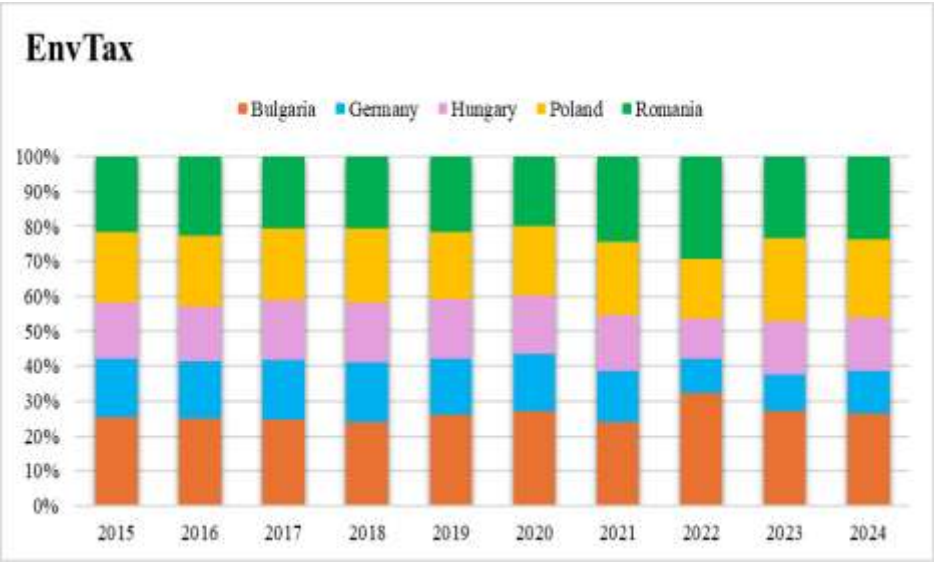


Figure no. 5: Evolution of Environmental Taxes (EnvTax)
Source: Prepared by the authors

The results reveal relatively stable but differentiated environmental taxation structures across the selected countries. Romania and Bulgaria record comparatively higher shares of environmental taxes during several years of the analysed period, reflecting a stronger reliance on green fiscal instruments within public revenue structures. Poland also maintains relatively consistent environmental tax shares, suggesting the continued importance of environmentally related taxation in supporting fiscal revenues. Germany and Hungary exhibit comparatively lower shares of environmental taxes in total tax revenues, although moderate increases can be observed during certain years, particularly after 2020. These developments may reflect the gradual adaptation of fiscal policies to European environmental objectives and the implementation of measures designed to support sustainable economic transition. The figure also highlights the persistence of environmental taxation throughout the entire analysed period, emphasizing its growing relevance within European fiscal systems. At the same time, the relatively moderate annual fluctuations suggest a certain degree of stability in the implementation of green taxation policies across the analysed economies.

Figure 6 illustrates the evolution of real GDP per capita in the analysed European economies during the 2015–2024 period, emphasizing substantial differences in economic development levels and income dynamics across countries.

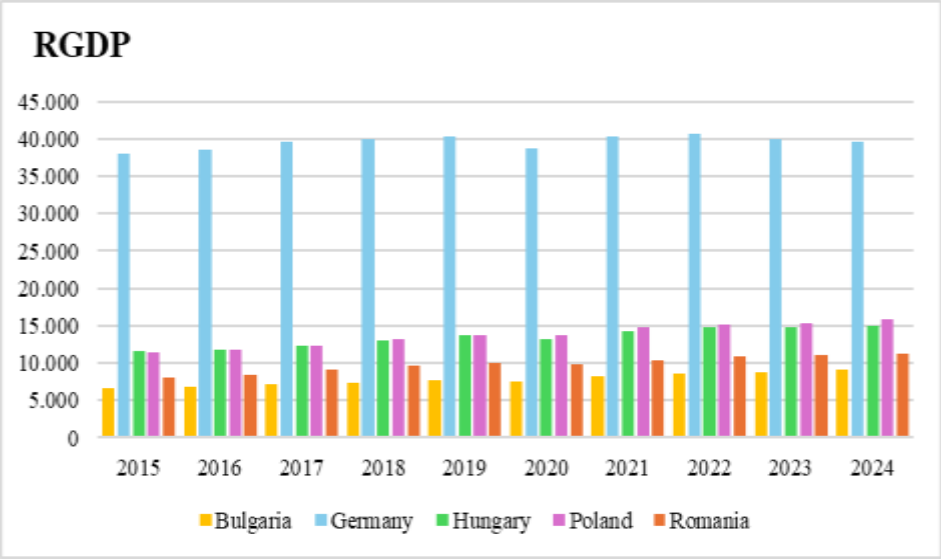


Figure no. 6: Evolution of Real GDP per Capita (RGDP)
Source: Prepared by the authors

The results reveal a general upward trend in GDP per capita for all analysed economies, reflecting economic growth processes and gradual improvements in macroeconomic performance during the analysed interval.

Germany records the highest levels of real GDP per capita throughout the entire period, with values approaching or exceeding 40,000 euro per capita, highlighting its strong economic performance, high productivity, and greater fiscal capacity. Poland and Hungary exhibit moderate but steadily increasing GDP per capita levels, reflecting economic convergence processes and improvements in economic competitiveness within the European context.

Romania also records a visible upward trajectory in GDP per capita during the analysed period, suggesting accelerated economic growth and increasing income levels, although remaining below the levels observed in more developed economies. Bulgaria maintains the lowest GDP per capita values among the selected countries, despite a gradual increase over time, indicating the persistence of development disparities within the analysed European region.

Table 3 presents the summary results of the econometric models estimated for the analysed European economies, highlighting the explanatory power, statistical validity, and overall robustness of the regression models developed to evaluate the relationship between fiscal sustainability and green transition indicators during the 2015–2024 period.

Table no. 3. Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin - Watson
					R Square Change	F Change	df 1	df 2	Sig. F Change	
Bulgaria	0.995	0. 990	0. 978	0.35826	0.990	80,098	5	4	0.001	2,525
Germany	0,994	0,988	0,974	0,37989	0,988	67,157	5	4	0,001	3,073
Hungary	0,996	0,991	0,980	0,34400	0,991	90,111	5	4	0,000	2,570
Poland	0,957	0,916	0,811	1,02501	0,916	8,704	5	4	0,028	2,747
Romania	0,961	0,924	0,829	1,26978	0,924	9,697	5	4	0,024	2,166
a. Predictors: (Constant), GovExp, EnvTax, RenEn, RGDP, GrosDeb										
b. Dependent Variable: GovDef										

Source: Prepared by the authors using SPSS

The results indicate very high correlation coefficients (R) for all estimated models, ranging between 0.957 in Poland and 0.996 in Hungary, suggesting a strong relationship between the dependent variable and the explanatory variables included in the analysis. Similarly, the coefficient of determination (R2) records very high values, varying from 0.916 in Poland to 0.991 in Hungary, indicating that the selected explanatory variables explain a substantial proportion of the variation in government deficit dynamics across the analysed economies. The adjusted R2 values remain relatively high for all countries, confirming the stability and explanatory relevance of the estimated models even after adjusting for the number of predictors included in the regressions. Hungary and Bulgaria exhibit the highest adjusted explanatory power, while Poland and Romania record comparatively lower but still statistically significant explanatory capacities. The standard error of the estimate remains relatively low across all models, suggesting good predictive accuracy and limited dispersion of residual values around the estimated regression lines. Bulgaria and Hungary register the lowest standard errors, indicating comparatively stronger model precision, whereas Romania records the highest standard error among the analysed economies. The ANOVA significance indicators further confirm the statistical validity of the models. The F-statistics are statistically significant for all countries, with significance levels below the conventional threshold of 5%, demonstrating that the independent variables collectively exert a statistically significant influence on fiscal balance dynamics. Hungary records the highest F-value (90.111), indicating the strongest overall explanatory capacity among the analysed models. The Durbin–Watson statistics range between 2.166 and 3.073, suggesting the absence of severe autocorrelation problems within the residuals of the estimated regressions. These values support the reliability and consistency of the OLS estimations employed in the study.

The results presented in Table 2 confirm the robustness and statistical relevance of the econometric models, indicating that renewable energy consumption, environmental taxation, public debt, government expenditure, and real GDP per capita represent important determinants of fiscal sustainability dynamics within the analysed European economies.

Table 4 presents the ANOVA results associated with the econometric models estimated for the analysed European economies, evaluating the overall statistical significance and explanatory validity of the regression models developed for the 2015–2024 period.

Table no. 4. Anova

Model		Sum of Squares	df	Mean Square	F	Sig.
Bulgaria	Regression	51,403	5	10,281	80,098	0,000
	Residual	0,513	4	0,128		
	Total	51,916	9			
Germany	Regression	48,459	5	9,692	67,157	0,001
	Residual	0,577	4	0,144		
	Total	49,036	9			
Hungary	Regression	53,316	5	10,663	90,111	0,000
	Residual	0,473	4	0,118		
	Total	53,789	9			
Poland	Regression	45,726	5	9,145	8,704	0,028
	Residual	4,203	4	1,051		
	Total	49,929	9			
Romania	Regression	78,172	5	15,634	9,697	0,024
	Residual	6,449	4	1,612		
	Total	84,621	9			
a. Dependent Variable: GovDef						
b. Predictors: (Constant), GovExp, EnvTax, RenEn, RGDP, GrosDeb						

Source: Prepared by the authors using SPSS

The results indicate that all estimated models are statistically significant, as reflected by the F-statistics and associated significance levels below the conventional threshold of 5%. These findings confirm that the explanatory variables included in the models, government expenditure, environmental taxes, renewable energy consumption, real GDP per capita, and general government gross debt, jointly exert a statistically significant influence on government deficit dynamics within the analysed economies.

Hungary records the highest F-statistic value (90.111), followed by Bulgaria (80.098) and Germany (67.157), indicating very strong overall explanatory capacities of the estimated models for these economies. Poland and Romania register comparatively lower F-values (8.704 and 9.697), although the models remain statistically significant, with significance levels of 0.028 and 0.024, respectively.

The regression sum of squares values are substantially higher than the residual sum of squares across all countries, suggesting that a significant proportion of the variation in fiscal balance is explained by the selected independent variables. At the same time, the relatively low residual mean square values indicate limited unexplained variation and support the adequacy of the estimated regression specifications.

The ANOVA results confirm the robustness and statistical relevance of the econometric models, emphasizing the important role of fiscal, environmental, and macroeconomic factors in shaping fiscal sustainability dynamics within the analysed European economies.

The empirical results obtained from the econometric analysis provide important evidence regarding the relationship between fiscal sustainability and green transition dynamics in Bulgaria, Germany, Hungary, Poland, and Romania during the 2015–2024 period. The findings confirm that fiscal balance dynamics are increasingly influenced by environmental transition indicators together with macroeconomic and fiscal determinants, although the magnitude and direction of these relationships differ across the analysed economies due to structural and institutional heterogeneity.

The first research hypothesis (H1), stating that the increase in the share of renewable energy consumption has a significant impact on government fiscal balance in European economies, is partially validated by the econometric estimations. The results indicate heterogeneous relationships between renewable energy consumption and fiscal sustainability across countries. Romania and Hungary record comparatively stronger positive effects associated with renewable energy expansion, suggesting that the transition toward sustainable energy systems may contribute to improved fiscal resilience through investment stimulation, energy diversification, and long-term economic modernization. Bulgaria also exhibits moderate effects linked to renewable energy consumption, while Germany and Poland display weaker relationships between renewable energy indicators and fiscal balance dynamics. These findings suggest that the fiscal implications of renewable energy transition remain dependent on country-specific factors such as investment capacity, energy policy implementation, infrastructure development, and the maturity of green transition strategies. The specialized literature emphasizes that renewable energy expansion may generate long-term environmental and macroeconomic benefits, although the financing requirements of green infrastructure and transition policies may simultaneously exert short-term fiscal pressures on public budgets (D'Orazio, 2025; Yıldırım et al., 2025).

The second hypothesis (H2), according to which environmental taxation significantly influences fiscal sustainability by affecting government deficit dynamics, is also partially validated. The econometric results reveal differentiated effects of environmental taxation among the analysed European economies. Germany and Romania exhibit relatively stronger positive relationships between environmental taxes and fiscal sustainability, indicating that green taxation mechanisms contribute to additional public revenues and support environmentally oriented fiscal reforms. In contrast, Hungary and Poland record weaker or less consistent effects, suggesting that the effectiveness of environmental taxation depends on the structure of national fiscal systems, the efficiency of tax collection mechanisms, and the stability of environmentally related tax bases. Bulgaria presents relatively moderate environmental tax effects, reflecting a more balanced interaction between fiscal and environmental policy instruments. These findings are consistent with the green fiscal policy literature, which highlights the increasing importance of environmental taxation in supporting sustainable public finance systems and facilitating ecological transition objectives within European economies (Hassan et al., 2025; Kalaš et al., 2025).

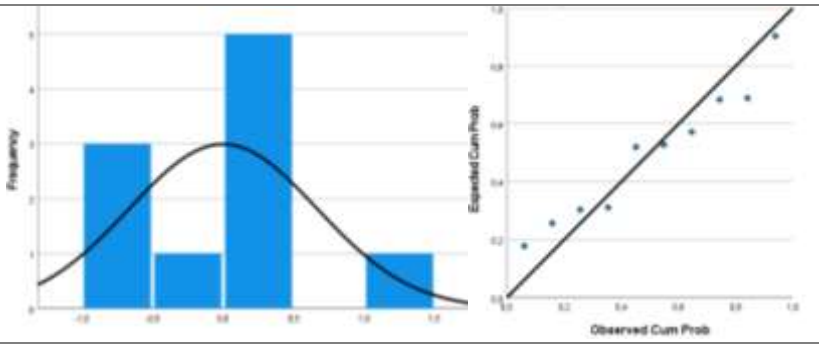
The third hypothesis (H3), stating that government expenditure and real GDP per capita significantly influence government deficit/surplus dynamics within the context of green economic transition, is validated by the empirical analysis. Government expenditure emerges as one of the most important determinants of fiscal balance across all analysed

economies, confirming the major role of fiscal intervention and public spending policies in shaping fiscal sustainability outcomes. Germany, Hungary, and Poland exhibit particularly strong expenditure-related effects, suggesting that fiscal expansion and public investment policies substantially influence budgetary stability. Romania and Bulgaria also display significant relationships between government expenditure and fiscal balance, although with comparatively lower intensities. Real GDP per capita significantly influences fiscal sustainability by reflecting differences in economic development, productivity, and fiscal capacity among the analysed countries. Germany records the highest levels of GDP per capita and comparatively stronger fiscal resilience, while Romania and Bulgaria exhibit lower income levels and greater fiscal vulnerabilities. Hungary and Poland demonstrate intermediate economic performance associated with gradual economic convergence processes within the European Union. These findings confirm the strong interdependence between economic growth, fiscal stability, and sustainable development emphasized in the macroeconomic literature, according to which higher income levels improve public revenue generation capacity, strengthen fiscal resilience, and increase governments' ability to finance green transition policies without generating excessive fiscal imbalances (European Commission, 2025a; OECD, 2026b).

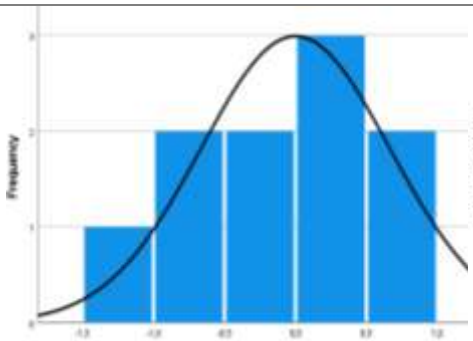
The empirical findings confirm that fiscal sustainability within the analysed European economies is increasingly shaped by the interaction between environmental transition dynamics, fiscal policy instruments, and macroeconomic performance. The results also underline the existence of heterogeneous adjustment mechanisms across countries, emphasizing the need for differentiated and country-specific fiscal strategies capable of balancing green transition objectives with long-term fiscal sustainability requirements.

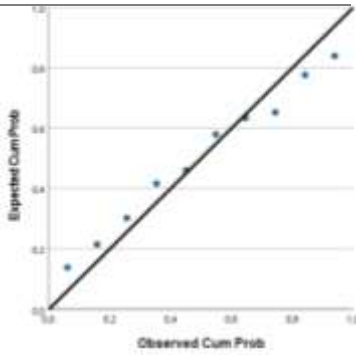
Figure 7 presents the histogram distributions and Normal P–P plots of the standardized residuals associated with the econometric models estimated for Bulgaria, Germany, Hungary, Poland, and Romania. These figures representations are used to evaluate the normality assumption of the regression residuals and to verify the adequacy and reliability of the estimated OLS models.

Bulgaria

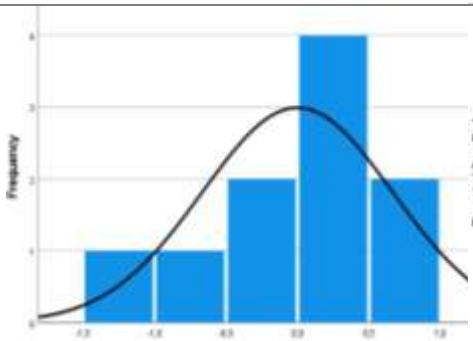


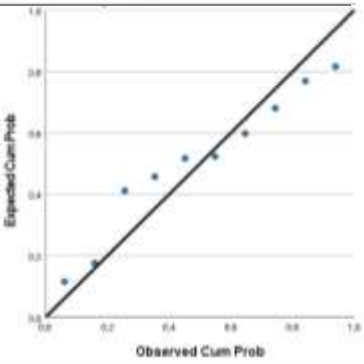
Germania



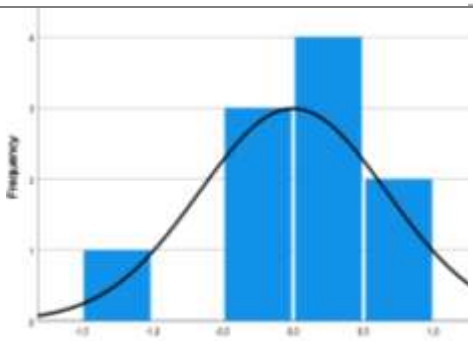


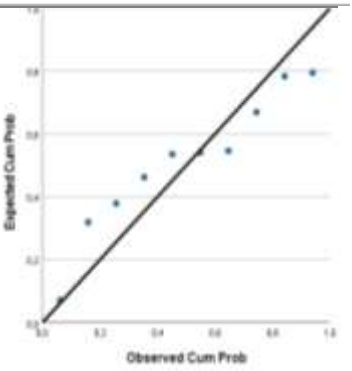
Hungary





Poland





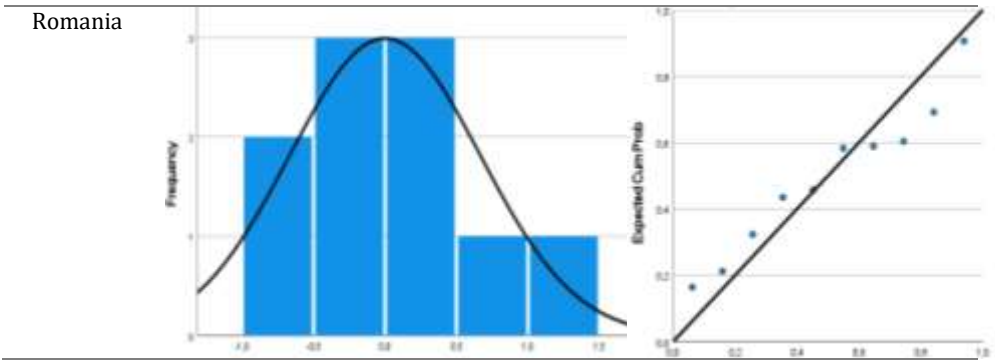


Figure no. 7: Histogram and Normal P–P Plot of regression standardized residuals for the estimated econometric models

Source: Prepared by the authors

The histograms indicate that the residuals are generally distributed around zero and approximately follow the bell-shaped form characteristic of a normal distribution. Although slight asymmetries and moderate deviations can be observed in some country models, the overall distributions remain relatively balanced, suggesting the absence of severe departures from normality. Bulgaria and Romania exhibit slightly wider residual dispersion, while Germany, Hungary, and Poland display comparatively more concentrated residual distributions around the mean value. The Normal P–P plots further support the validity of the normality assumption, as the observed cumulative probabilities are positioned relatively close to the diagonal reference line across all analysed economies. Minor deviations from the theoretical line are visible at the extremities of several distributions; however, these variations remain limited and do not indicate substantial violations of normality conditions.

The figure 7 analysis confirms that the residuals associated with the estimated econometric models are approximately normally distributed, supporting the statistical validity, consistency, and reliability of the OLS regression estimations employed in the study. These results strengthen the robustness of the empirical findings regarding the relationship between fiscal sustainability and green transition dynamics in the analysed European economies.

The empirical findings of the study provide important evidence regarding the interaction between fiscal sustainability and green transition dynamics within Bulgaria, Germany, Hungary, Poland, and Romania during the 2015–2024 period. The econometric estimations confirm that government fiscal balance is increasingly influenced by environmental transition indicators together with macroeconomic and fiscal variables, although the magnitude and direction of these relationships differ across the analysed economies due to structural, institutional, and development-related heterogeneity.

The results suggest that renewable energy transition exerts differentiated effects on fiscal sustainability across the analysed European economies. Romania and Hungary exhibit comparatively stronger relationships between renewable energy consumption and fiscal balance dynamics, indicating that the gradual expansion of renewable energy

systems may contribute to economic modernization, energy diversification, and improved fiscal resilience over the long term. Germany also benefits from advanced renewable energy integration, although the fiscal effects remain more balanced due to the complexity of its economic structure and the scale of public investment associated with green transition policies. Poland and Bulgaria display comparatively weaker relationships, reflecting differences in renewable energy infrastructure, energy dependence, and fiscal capacity to support large-scale environmental transition programs.

These findings are consistent with the objectives of the European Green Deal and the REPowerEU strategy, which emphasize the acceleration of renewable energy deployment, energy efficiency improvement, and the reduction of fossil fuel dependence across European Union member states. At the same time, the results indicate that green transition policies may generate substantial short-term fiscal pressures due to the need for public subsidies, infrastructure modernization, and investment in sustainable energy systems. Fiscal sustainability increasingly depends on governments' capacity to balance environmental transition objectives with prudent public finance management.

Environmental taxation also emerges as an important determinant of fiscal sustainability within the analysed economies. Germany and Romania display comparatively stronger positive relationships between environmental taxes and fiscal balance, suggesting that green fiscal instruments may contribute both to environmental policy objectives and to public revenue generation. These results support the European Union's growing emphasis on green taxation mechanisms within the framework of sustainable fiscal reforms and climate neutrality targets for 2050. Nevertheless, the weaker effects observed in Hungary and Poland indicate that the effectiveness of environmental taxation depends on national fiscal structures, administrative efficiency, and the capacity of governments to integrate environmental taxes into broader fiscal consolidation strategies.

The empirical analysis further confirms the important role of government expenditure and economic development in shaping fiscal sustainability outcomes. Higher government expenditure levels are associated with stronger fiscal pressures in several economies, particularly where fiscal deficits and public debt remain persistent. However, productive public expenditure directed toward renewable energy infrastructure, digitalization, innovation, and sustainable transport systems may generate long-term positive effects on economic resilience and environmental sustainability. Germany records comparatively stronger fiscal resilience due to higher GDP per capita levels and stronger economic capacity, while Romania and Bulgaria remain more vulnerable to fiscal imbalances due to lower income levels and more limited fiscal space. Hungary and Poland occupy intermediate positions characterized by gradual convergence toward European economic standards.

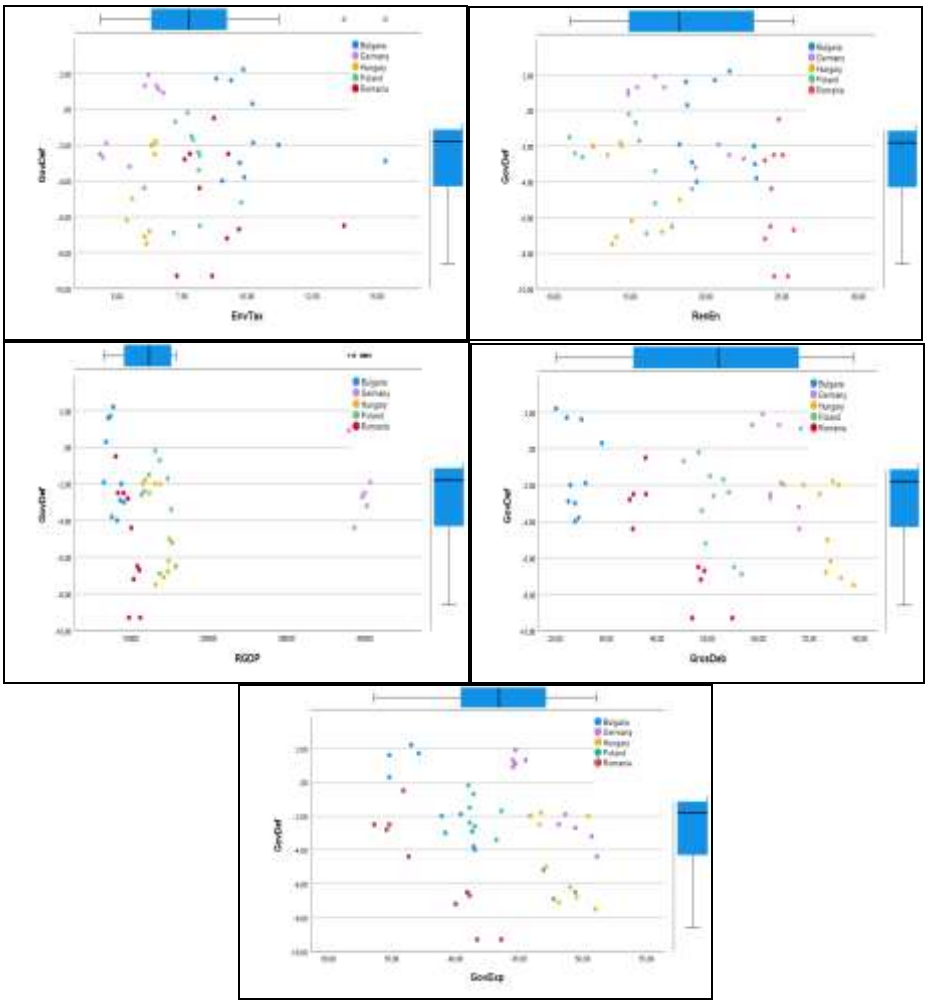


Figure no. 8: Scatterplot Relationships between Government Fiscal Balance and the Main Explanatory Variables

Source: Prepared by the authors

Figure no. 8 illustrates the relationships between government fiscal balance (GovDef) and the principal explanatory variables included in the econometric analysis, namely environmental taxes (EnvTax), renewable energy consumption (RenEn), real GDP per capita (RGDP), general government gross debt (GrosDeb), and government expenditure (GovExp). The figure 8 analysis highlights the existence of heterogeneous relationships among the analysed variables across Bulgaria, Germany, Hungary, Poland, and Romania. The scatterplots suggest moderate associations between fiscal balance and environmental transition indicators, particularly in the cases of renewable energy

consumption and environmental taxation. Countries characterized by higher renewable energy shares and stronger environmental tax systems tend to exhibit comparatively more stable fiscal balance dynamics, although these relationships remain non-uniform across economies. The relationship between government fiscal balance and public debt appears comparatively stronger, as higher debt levels are generally associated with larger fiscal deficits, particularly in Romania and Hungary. Similarly, government expenditure displays a visible association with fiscal balance deterioration, supporting the econometric findings regarding the importance of fiscal intervention and public spending dynamics in shaping fiscal sustainability outcomes. The scatterplot associated with real GDP per capita emphasizes the substantial development disparities among the analysed economies. Germany clearly records significantly higher income levels and comparatively stronger fiscal positions, while Romania and Bulgaria remain characterized by lower GDP per capita levels and comparatively greater fiscal vulnerabilities. Hungary and Poland occupy intermediate positions, reflecting gradual convergence processes within the European Union.

The discussion of the empirical results confirms that fiscal sustainability within the analysed European economies is increasingly shaped by the interaction between macroeconomic conditions, public finance structures, and green transition dynamics. The findings underline the necessity of adopting differentiated and country-specific fiscal strategies capable of balancing environmental transition objectives with long-term fiscal sustainability and macroeconomic stability requirements.

Conclusions

The present study investigated the relationship between fiscal sustainability and green transition dynamics in Bulgaria, Germany, Hungary, Poland, and Romania over the 2015–2024 period using a comparative econometric framework based on country-specific OLS regression models. The empirical findings show that fiscal sustainability is increasingly shaped by the interaction between environmental transition indicators, public finance conditions, and macroeconomic performance across the analysed European economies.

The results indicate that renewable energy consumption and environmental taxation have heterogeneous effects on government fiscal balances across countries. These differences reflect variations in economic development, fiscal capacity, energy structures, and the implementation of environmental policies. Economies characterized by stronger renewable energy integration and more developed green fiscal instruments tend to display comparatively more stable fiscal dynamics, although the fiscal consequences of the green transition remain strongly dependent on public investment requirements and the effectiveness of fiscal governance mechanisms.

Government expenditure and real GDP per capita also emerge as relevant determinants of fiscal sustainability. Higher levels of public expenditure are associated with greater fiscal pressures in several of the analysed economies, while stronger economic performance contributes to improved fiscal resilience and enhances governments' capacity to finance environmental transition policies. The findings also reveal substantial cross-country disparities in public indebtedness, renewable energy adoption, environmental taxation intensity, and macroeconomic development.

The main contribution of this study lies in the integration of fiscal, environmental, and macroeconomic dimensions within a unified comparative framework. By jointly considering renewable energy consumption, environmental taxation, government expenditure, public debt, and real GDP per capita, the analysis provides a broader perspective on the fiscal implications of the green transition. A second contribution is the country-specific comparative approach, which highlights the heterogeneous nature of fiscal adjustment mechanisms across economies with different structural and developmental characteristics. Finally, the study contributes to the literature on sustainable public finance by showing that green transition policies cannot be assessed independently of fiscal capacity and macroeconomic resilience. From a policy perspective, the findings underline the importance of designing differentiated fiscal strategies that support environmental transition objectives while preserving long-term budgetary stability.

The study is nevertheless subject to several limitations. First, the analysis covers only five European countries and a relatively short time horizon, which limits the generalizability of the findings to the entire European Union. Second, the use of country-specific OLS regression models may not fully capture dynamic relationships, potential endogeneity, or cross-country interdependencies between fiscal and environmental variables. Third, the analysis relies on a relatively limited set of indicators and does not explicitly incorporate other potentially relevant determinants such as energy prices, institutional quality, carbon emissions, green investment flows, or technological innovation. These limitations should therefore be considered when interpreting the empirical results.

Future research could extend the present analysis in several directions. A first avenue would be to enlarge the sample to include a broader group of European Union economies and a longer time, allowing for more robust cross-country comparisons. A second direction would involve the application of more advanced econometric techniques, including dynamic panel models, System GMM estimations, or spatial econometric approaches, to better address endogeneity, temporal dynamics, and cross-country spillover effects. Future studies could also examine the role of European Union funding mechanisms, energy security policies, carbon neutrality targets, and green technological innovation in shaping fiscal sustainability. In addition, further research could investigate the social and distributional effects of environmental taxation and renewable energy transition policies, particularly in economies characterized by greater fiscal vulnerability and structural development disparities.

The study confirms that fiscal sustainability and green transition dynamics are increasingly interconnected within European economies. The successful implementation of environmental transition policies requires not only substantial investment and institutional adaptation but also balanced fiscal strategies capable of supporting sustainable economic growth, environmental resilience, and long-term macroeconomic stability.

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