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Article

Approaches to Prognosing the European Economic Crisis Through a New Economic–Financial Risk Sensitivity Model

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Abstract: This paper presents a novel approach to prognosing European economic crises through the development of an economic–financial risk sensitivity model. The model integrates key macroeconomic indicators such as government deficit (NETGDP), GINI coefficient, social protection expenditure (ExSocP), unemployment rate (UNE), research and development spending (RDGDP), and tax structures (TXSwoSC), assessing their role in predicting economic vulnerability across European countries. By applying the Kruskal–Wallis non-parametric test on data from 324 observations across multiple countries, significant differences were identified in the distribution of these variables. The results show that government policies related to social protection, R&D, and taxation play an important role in a country’s resilience to economic shocks. On the other hand, indicators such as income inequality and unemployment exhibit less variation, reflecting global economic conditions. The model provides a comprehensive risk assessment framework, allowing for the early detection of potential economic crises and guiding policy adjustments to mitigate risks. This methodology offers valuable insights into the sensitivity of European economies to financial disruptions, emphasizing the importance of fiscal policies and social expenditure in maintaining economic stability.

Keywords: economic crisis; risk sensitivity model; Kruskal–Wallis test; European economies; macroeconomic indicators; fiscal policy

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1. Introduction

The global economy has experienced multiple economic and financial crises over the years, each with different levels of impact on countries and regions. In the European context, economic crises have often been triggered by specific factors at both macroeconomic and structural levels, exposing latent vulnerabilities in national economies (Alessi et al., 2020; Ionescu et al., 2024). For instance, the sovereign debt crisis highlighted significant weaknesses in fiscal and monetary coordination within the euro area, exacerbating disparities among Member States (Petrakos et al., 2024; Schilin, 2024).

One of the most recent crises, the 2008 financial crisis, highlighted the lack of preparedness of many EU Member States to cope with major economic shocks. This situation compelled numerous countries to adopt comprehensive structural reforms and reassess their economic policies in order to enhance resilience and better prepare for potential future crises. Research shows that these measures often focused on improving fiscal discipline, strengthening financial regulations, and promoting social and economic stability through

targeted investments in public welfare and innovation (European Central Bank, 2024). Such reforms not only aimed to mitigate the immediate repercussions of economic shocks but also sought to address underlying vulnerabilities within national economies, ensuring greater preparedness for systemic risks (Armingeon et al., 2022; Goniewicz et al., 2023).

In recent decades, Europe has witnessed a significant intensification of economic and financial interconnectivity, driven by the expansion of trade, capital mobility, and coordinated policy frameworks among Member States. This deep integration has facilitated substantial opportunities for economic growth, enabling economies to capitalize on shared markets, efficient resource allocation, and technological diffusion (Qin et al., 2023; Sánchez-García et al., 2024). However, alongside these benefits, the interconnected nature of European economies has amplified systemic vulnerabilities, as disruptions in one country can rapidly propagate across borders, transforming localized economic shocks into regional or even global crises (Gardes-Landolfini et al., 2024).

Empirical studies underline that the interconnectedness of financial systems increases the likelihood of contagion effects during periods of instability, as demonstrated during the sovereign debt crisis and subsequent financial turmoil (European Central Bank, 2023). While the integration of markets and policies has contributed to economic convergence in certain aspects, it has also exposed disparities in fiscal and economic resilience across Member States, further accentuating the risks of collective downturns during periods of external or internal shocks (European Commission, 2022).

The dual-edged nature of integration highlights the importance of coordinated policy responses and robust economic governance mechanisms to manage interdependencies effectively and mitigate potential vulnerabilities.

Thus, economic dependence between Member States means that a crisis in one country spreads rapidly to other economies, turning a local problem into a regional crisis. A good example is the sovereign debt crisis in the euro area, which severely affected southern European countries, demonstrating how interdependent European economies are. Lacking sufficient fiscal buffers, countries such as Greece and Italy faced prolonged recessions (Alessandri et al., 2022; Theodoropoulou, 2022; Miró et al., 2024).

In this context, the ability to forecast economic crises is essential to the prevention of major economic collapses. But forecasting crises is not an easy task, as it requires a deep understanding of economic and financial dynamics and how various macroeconomic variables interact (Cicarelli et al., 2024). Advanced econometric models, such as those integrating nonlinear dynamics, have shown promise in improving forecasting accuracy (Huang et al., 2024).

The studies in the literature (European Commission, 2023; Huynh & Uebelmesser, 2024) have shown that identifying the early signs of a crisis can help governments and financial institutions to take corrective action before the situation deteriorates significantly. Early warning indicators, including income inequality and research and development (R&D) investment levels, provide important insights into a country's economic vulnerabilities.

This research aims to address the following questions: Which economic indicators are most critical for forecasting economic crises in Europe? Are there significant disparities among European economies in their sensitivity to economic and financial risks? How do fiscal policies and public expenditures shape the economic vulnerability of EU Member States? These questions define the analytical framework and guide the study in providing evidence-based insights through relevant data and statistical analyses.

In line with the research questions, the following study objectives were set:

O1—The first objective of the research is to develop a model of sensitivity to economic and financial risks, which will allow the early identification of potential economic crises in Europe. This model integrates key macroeconomic indicators such as government

deficits, income inequality, and unemployment rates in order to analyze how these factors contribute to the vulnerability of European economies. In this sense, the main objective is to provide a useful tool to help policymakers implement appropriate preventive measures.

O2—Another objective is to assess the differences between European economies in their exposure to economic and financial risks. By using the Kruskal–Wallis test, the research aims to identify significant cross-country variations in the economic and social variables analyzed, which can reveal which countries are more vulnerable to crises and why. Thus, the objective is to gain a thorough understanding of the factors driving economic disparities in Europe.

O3—This research aims to explore the role of fiscal and public expenditure policies in mitigating economic risks. Particular emphasis is placed on investments in social protection and R&D, as these areas are considered essential for maintaining economic stability. A central objective is therefore to assess how national policies can influence the resilience of an economy to external and domestic shocks.

O4—The fourth objective is to provide policy recommendations based on research findings. These policies aim to increase economic resilience through structural reforms and coordination at the European level. The answers to the research questions can guide future policies, helping to create a more stable economic framework better able to face global challenges.

In recent years, researchers ([Vrontos et al., 2021](#); [Foroni et al., 2022](#); [Xu et al., 2023](#); [Lu et al., 2024](#)) have tried to develop more accurate models for forecasting economic crises using various econometric and statistical techniques. Economic and financial risk sensitivity models are among the most effective tools in this respect, as they allow for the identification of the key factors that can trigger a crisis. These models integrate macroeconomic and social indicators to assess the vulnerability of economies to systemic risks. The economic and financial risk sensitivity model proposed in this study focuses on analyzing several key indicators that have a direct impact on a country's economic stability. These indicators include the government deficit, income inequality, the unemployment rate, social protection expenditure, R&D investment, and tax structure. By analyzing these variables, the model aims to provide an overview of the capacity of European economies to cope with future crises. We appreciate that one of the major challenges in developing the model is the variability of the economic and political context across EU Member States. For example, southern European countries such as Greece, Italy, and Spain were more severely affected by the debt crisis of 2010–2012 compared to northern European countries due to differences in fiscal and social policies. This disparity underlines the need to adapt forecasting models to country specificities. In addition, economic and financial risks are often amplified by external factors, such as geopolitical shocks or global crises like the COVID-19 pandemic. The pandemic has highlighted how vulnerable European economies are to external shocks and demonstrated the importance of resilient economic systems. Economic risk sensitivity models must also take into account the impact of external factors that can amplify domestic crises. Another important issue is the role of fiscal and monetary policies in crisis prevention and management. Our study examines how public spending and taxation policies contribute to increasing or decreasing economic vulnerability. For example, countries that invest more in social protection and R&D tend to be better prepared to cope with economic shocks. Finally, the proposed model provides valuable insight into how European economies may be affected by future economic crises and how more effective policies can be put in place to prevent such situations. The results of the study underline the need for structural reforms and closer coordination between Member States to increase the resilience of European economies.

The article presents a significant contribution to the field by introducing an innovative economic–financial risk sensitivity model that assesses European economies’ vulnerability to crises. This model stands out for its integration of specific macroeconomic indicators, such as government deficits, income inequality, and social protection expenditures, allowing for a comprehensive analysis tailored to the diverse structures of EU Member States. The findings underscore the importance of fiscal policies, social spending, and income distribution in shaping national resilience to economic shocks. By advancing the understanding of these dynamics, this research provides policymakers with a robust framework for crisis prediction and prevention. Furthermore, this study offers valuable policy recommendations, advocating for structural reforms and enhanced fiscal measures aimed at bolstering economic stability and resilience across Europe.

The research continues with a presentation of an extensive survey of the literature, after which the methodological chapter presents the variables analyzed, the working hypotheses, and concrete methodological aspects. Subsequently, the results of the research are presented in Section 4, along with the discussions based on the results obtained, and finally the authors present the relevant conclusions of the research.

2. Literature Review

In recent years, scholarship has placed particular emphasis on the development of predictive models to identify key drivers of economic vulnerabilities. Recent economic crises have underlined economic interdependence at the European level, highlighting how a crisis in one country can quickly turn into a regional problem. As European economies become increasingly integrated, the need for effective forecasting models capable of anticipating risks and providing policymakers with a framework for implementing preventive measures has grown. A number of studies have identified a wide range of macroeconomic, social, and structural indicators, such as government deficits, unemployment rates, and income inequality, as being relevant in assessing vulnerability to economic crises (Alessi et al., 2020; Ngouhouo & Nchofoung, 2022; Rezaei Soufi et al., 2022; Krawczyk et al., 2023). In addition, differences in tax policies and social protection structures across Europe have attracted the attention of researchers as significant factors in maintaining economic stability and preventing financial collapses. These differences stem from the varied ways in which Member States allocate resources and prioritize key areas for economic and social development (Crescenzi & Giua, 2020; Gura et al., 2023; Anselmi et al., 2024). For example, northern European countries such as Sweden, Denmark and Finland have adopted a progressive tax structure and made significant allocations to social protection, which has allowed them to build more resilient economies in the face of economic crises (Miró et al., 2024; Samans, 2024). These countries are investing heavily in providing a sound social protection framework to support citizens in times of economic hardship and to underpin domestic consumption, thereby contributing to macroeconomic stability.

On the other hand, southern European economies, such as Greece, Italy and Spain, have experienced difficulties in maintaining balanced fiscal structures and have been hit hard by previous financial crises, in particular due to high government deficits and limited public spending in critical areas (Bilbiie et al., 2021; Stockhammer & Novas Otero, 2023). These discrepancies underline the role of well-calibrated tax policies and social spending in ensuring a resilient economy, especially in the context of highly interconnected economies. At the same time, income inequality, as represented by the GINI coefficient, and the way it is managed through redistributive policies directly influences economic vulnerability (Franko, 2021; Vezzoli et al., 2023; Selim & Küçükçifçi, 2024). Countries with high levels of income inequality tend to experience greater economic instability and are more susceptible to financial crises as a significant share of the population is more

vulnerable to economic shocks (Bodea et al., 2021; Kohler & Stockhammer, 2022; Chisadza & Biyase, 2023; Paul, 2023).

Chen and Svirydzenka (2021) emphasized that financial cycles serve as pivotal early warning indicators of banking crises, highlighting how fluctuations in credit growth, asset prices, and leverage ratios can signal systemic vulnerabilities. Their study underscores the importance of integrating financial indicators into sensitivity analyses to strengthen early warning systems, enabling policymakers to address systemic risks proactively. This perspective aligns with the inclusion of FINLIAB (total financial sector liabilities, by instruments, consolidated) in our model, which reflects the leverage of and potential instability within the financial sector and its implications for economic resilience.

Thus, recent studies (Volz, 2022; Kopasker et al., 2024; Rahman & Pingali, 2024) highlight that the combination of a robust fiscal structure geared towards equity and inclusion and a well-developed social safety net can significantly reduce economic and social risks. Investments in social protection, such as health, education and social insurance, not only strengthen economic resilience, but also contribute to social cohesion by providing a more stable economic environment in the long run. In conclusion, differences in the fiscal and social policies of European countries are determining factors in the analysis of vulnerability to economic crises and underline the need for reforms tailored to the economic and social context of each country to ensure stability at the European level.

The recent economic crises have demonstrated the vulnerability of European economies and the need for effective forecasting tools to identify risks at an early stage. Economic crisis forecasting models are recognized for their role in anticipating economic vulnerabilities, providing policymakers with a framework for preventive intervention. Recent research (Aurino & Giunti, 2022; Casquilho-Martins & Belchior-Rocha, 2022; Nguyen et al., 2024) have highlighted the importance of indicators such as government deficits, unemployment, income inequality, and social protection spending, all of which have a significant impact on an economy's ability to cope with external shocks.

Also, according to specialized studies (Casabianca et al., 2022; Vogl, 2022; Willett, 2022; Cosma et al., 2023; Goutsmedt et al., 2024), the development of advanced techniques and complex econometric models allows for the identification of significant differences between European economies and clarifies the specific factors that contribute to crisis risk. These models integrate economic and social variables to generate relevant predictive scenarios tailored to the diversity of European economies and external influences such as geopolitical shocks. Current forecasting models thus not only support the anticipation of crises, but also the formulation of proactive economic policies tailored to the European context.

Predictive models have gained significant attention in the literature for their ability to anticipate economic downturns. Goodhead and Parle (2019) demonstrated the utility of factor-based approaches in predicting recessions within the euro area, emphasizing the ability of these models to distill complex macroeconomic dynamics into actionable insights. Their study highlights the importance of combining diverse economic indicators, such as GDP growth, inflation rates, and labor market trends, into a cohesive framework capable of identifying early signs of economic downturns. By leveraging factor models, the research underscores the value of dynamic and adaptable forecasting tools that can respond to the rapidly evolving economic environment, ultimately providing policymakers with a more precise mechanism for anticipating and mitigating crises.

Babecký et al. (2014) provided empirical evidence of the predictive power of integrating banking, debt, and currency crisis indicators, particularly for developed economies. Their study demonstrated that these indicators, when combined, offer robust early warning signals for systemic vulnerabilities. This approach underscores the critical importance of monitoring interdependencies between financial and macroeconomic variables to anticipate

crises effectively. In the European context, this methodology is highly relevant as it accounts for the interconnectedness of Member States' economies and their shared exposure to external shocks. By including these indicators in early warning models, policymakers can enhance their capacity to implement timely interventions to mitigate risks and stabilize economic systems.

Other studies (Ahmad & Zheng, 2023; Murdipi et al., 2023; Virjan et al., 2023; Vasin & Timokhina, 2024) highlight the importance of key macroeconomic indicators such as government deficits, unemployment rates, social protection spending, and R&D investment as predictors of the vulnerability of economies to crises. These indicators are used to assess an economy's ability to withstand external shocks and maintain long-term stability.

Government deficits are considered central predictors of economic crisis risk, as countries with large deficits and high public debt have limited resources to implement stabilizing measures in times of crisis. Some research (Cubeddu et al., 2023; Ekouala, 2023; Kasal, 2023; Zeqiraj et al., 2024) has highlighted that high levels of public debt are associated with an increased risk of economic collapse, as it indicates a dependence on external financing and exposes the economy to fluctuations in international financial markets. Budget deficits reflect financial imbalances that can lead to liquidity problems in the event of global or regional financial crises. Unemployment is another significant indicator, with both economic and social impacts. Studies (Adeosun et al., 2023; Chletsos & Sintos, 2023; Claveria & Sorić, 2023; Larch et al., 2024; Sinyor et al., 2024) show that high unemployment rates are correlated with a fall in domestic consumption and investment, which can aggravate economic downturns. Persistent unemployment also increases social tensions and governments are forced to allocate additional resources to support the affected population, limiting the capacity to invest in development (Çelikay, 2023; Miró et al., 2024; Ronaghi & Scorsone, 2024).

Spending on social protection plays a significant role in stabilizing economies in times of crisis by providing a minimum level of protection for household incomes. Countries that consistently invest in social programs, such as health and unemployment insurance, have demonstrated a greater ability to stabilize domestic demand and sustain consumption during economic downturns. Recent studies (Burchi et al., 2022; Romer & Romer, 2022; Goniewicz et al., 2023; Cuesta et al., 2024) suggest that such spending contributes not only to economic stability but also to social cohesion, thereby reducing long-term economic and social risks.

R&D investments are a cornerstone of economic resilience, contributing significantly to innovation and the capacity to adapt to systemic shocks. Countries that allocate substantial resources to research and innovation have demonstrated an increased capacity to adapt to global economic changes and seize new opportunities, thus reducing the potential impact of a crisis (Pal et al., 2024; Shi, 2024; Shi et al., 2024; van der Loos et al., 2024). Investment in R&D supports the transition to a knowledge- and innovation-based economy, enabling these economies to be more flexible and better prepared to react quickly to changes in the international economic environment.

The integration of these macroeconomic variables into a forecasting model helps to robustly assess economic vulnerabilities and formulate preventive economic policies. Thus, models using these indicators provide a clear picture of an economy's resilience to shocks and help to identify appropriate measures to reduce economic risks. According to other studies (Malla & Pathranarakul, 2022; Nguyen, 2022; Wang, 2023) it can be observed that tax policies and income inequality play a key role in shaping an economy's vulnerability to financial crises. The tax structure, including the level of direct and indirect taxes and any tax redistribution policies, directly influence economic stability, affecting the resources available for public investment, social protection, and economic adjustment to external

shocks. On the other hand, income inequality, usually measured by the GINI coefficient, contributes to amplifying economic and social tensions, reducing social cohesion and thus the resilience of the economy (Akarsu et al., 2024; Gaies, 2024; Sintos et al., 2024).

Fiscal policies are central to a country's economic management because they influence the distribution of resources and the structure of economic incentives. The recent literature (da Costa & Santos, 2023; Moshiri & Daneshmand, 2024; Wang & Liew, 2024) shows that a balanced tax structure, optimizing the ratio between direct (income and profit) and indirect (consumption) taxes, is important for maintaining economic stability. Countries with progressive tax policies tend to achieve a more equitable distribution of income, and this is associated with greater economic resilience to crises. Authors such as Szymborska (2024) and Zeytoon-Nejad (2024) have shown that progressive taxes not only reduce inequality but also support long-term stability, as higher tax resources allow governments to intervene effectively in recessions. Conversely, excessive reliance on indirect taxes can aggravate economic inequality, negatively affecting household consumption and making the economy vulnerable to fluctuations. These imbalances can exacerbate crisis risks, as a population more affected by indirect taxes has a reduced capacity to maintain consumption, leading to economic downturns in times of financial instability. In this sense, fiscal policy is becoming a key tool for economic stabilization, and various studies (Catalano et al., 2020; Brändle & Elsener, 2024; Canavire-Bacarreza et al., 2024) have shown that the implementation of a balanced tax structure, tailored to each country's economic specificities, can significantly reduce vulnerability to crises.

Recent studies, such as those conducted by Dafermos et al. (2023) and Stiglitz (2024), show that persistent economic inequality contributes to macroeconomic instability through its negative impact on aggregate demand and consumption, creating a downward spiral in the event of a recession. Economies with high level of inequality also tend to allocate fewer resources to social protection and investment in human capital, leading to a less adaptable labor force and reduced capacity to innovate. This contributes to increased vulnerability to economic crises and limits the prospects for long-term economic recovery. In this respect, some studies (Gunasinghe et al., 2021; Muinelo-Gallo & Miranda Lescano, 2022; Garcia & Lopez, 2024) have shown that redistributive policies, such as progressive taxes and the allocation of resources to social programs, are essential to mitigate inequality and support economic stability.

Tax policies and income inequality are two fundamental factors in assessing an economy's vulnerability to crises. The literature (de Jong & Ho, 2021; Vidal, 2021; Goniewicz et al., 2023; Ozili & Iorember, 2024) argues that balanced fiscal policies and measures to reduce inequality are essential to ensure long-term economic stability and to limit economic and social risks in the face of possible crises. These conclusions support the implementation of tailored fiscal and social strategies that minimize the impact of inequality and contribute to economic resilience to global financial challenges.

The need for benchmarking to understand the diverse sensitivity of European economies to economic and social risks is captured by a number of authors (Kourtiti et al., 2023; Kuc-Czarnecka et al., 2023; Anselmi et al., 2024; Lapietra et al., 2024; Nijkamp et al., 2024). Comparative studies use advanced statistical methods to examine variations between economies and to identify vulnerability factors specific to each EU Member State. In this context, non-parametric methods are valuable because they allow for the analysis of differences without assuming that there is a specific distribution of data. Groups of economies can be compared on the basis of economic and social factors such as unemployment rates, income inequality, and investment in social protection.

This approach highlights the structural and institutional differences between economies and is essential in the European context, where Member States have varied economic and

social structures. For example, research has shown that northern European countries with strong fiscal and social protection policies are less vulnerable to crises than southern European economies with larger fiscal deficits and higher unemployment rates (Marques & Hörisch, 2020; Ebbinghaus & Weishaupt, 2022; Branco et al., 2024). Benchmarking thus provides governments with concrete evidence to adjust their economic policies and reduce their sensitivity to crises by adapting to national specificities.

Social protection and investment in research and development (R&D) are recognized in the literature as pillars of economic resilience. Recent studies underline that countries that allocate a substantial part of their budget to social protection are better prepared to cope with economic downturns, as social assistance programs support household incomes and maintain aggregate demand in times of crisis (Kentikelenis & Stubbs, 2022; Muchhala & Guillem, 2022; World Bank Group, 2024). Well-developed social protection systems, such as those in Scandinavian countries, support social cohesion and ensure economic stability, thus contributing to greater resilience to external shocks.

In parallel, investment in research and innovation plays a fundamental role in the adaptability of the economy. Economies that invest consistently in R&D demonstrate a superior capacity to harness new technologies and adapt to rapid changes in the global environment. The literature emphasizes that innovation boosts productivity and allows economies to diversify, thus creating a buffer against economic shocks (Hynes et al., 2020; Xie et al., 2021; Saadaoui & Mokdadi, 2023; Yu et al., 2024). For example, in Germany and Finland, high levels of investment in research and development have contributed to a knowledge- and technology-based economy, increasing long-term stability (Löfsten et al., 2024; Sinani et al., 2024).

Risk sensitivity models that integrate economic and social variables are essential in forecasting economic risks, allowing governments and organizations to better anticipate crises (Dumitriu & Dragomir, 2021; DeMenno, 2023; Glette-Iversen et al., 2023; Reimann, 2024). Recent models not only incorporate traditional economic factors such as GDP and unemployment, but also social variables such as income inequality and social protection, providing a more complete picture of the economy's vulnerabilities (Bărbulescu et al., 2021; Melidis & Tzagkarakis, 2022; Remeikienė & Gasparyniene, 2023; Mishra et al., 2024). These forecasting models are used to analyze different scenarios and provide solutions tailored to the specifics of each economy.

In the European context, the literature highlights the effectiveness of these models in anticipating and reducing the impact of crises. For example, the integration of behavioral factors such as consumer and investor confidence has become an important component of risk sensitivity models (Venturini, 2022; Gric et al., 2023; Mushafiq et al., 2023). Research shows that behavioral factors can significantly influence how an economy responds to shocks (Shastri et al., 2022; Tolner et al., 2024; Yang, 2024). Thus, complex models that take into account both economic and social-behavioral variables are an important contribution to the literature, supporting the adoption of proactive economic policies that are better adapted to the changing socio-economic context.

This theoretical and empirical framework provided by the literature underlines the need for a risk sensitivity model that is tailored to the specificities of European economies, including a variety of key indicators. These contributions are fundamental to the construction of the proposed sensitivity model, which aims to provide a robust forecast of economic crises, thereby guiding public policies towards strengthening economic resilience.

3. Methodology

The methodology adopts a rigorous approach to analyzing economic and financial data through the application of a risk sensitivity model. This model serves as a predictive

framework for identifying potential economic crises in the European context. By integrating a comprehensive set of critical economic indicators, this model provides an in-depth assessment of vulnerability and resilience across Member States, enabling the identification of patterns and trends that contribute to systemic risks. The selected indicators are outlined as follows:

- NETGDP: GDP +/− general government deficit/surplus (as percentage of gross domestic product − GDP) (Eurostat, 2024d);
- GINI: GINI coefficient of equivalized disposable income − (scale from 0 to 100) (Eurostat, 2024c);
- ExSocP: expenditure on social protection − percentage of gross domestic product (% GDP) (Eurostat, 2024a);
- UNE: unemployment rate (%) (Eurostat, 2024h);
- RDGDP: gross domestic expenditure on R&D (% GDP) (Eurostat, 2024b);
- TXSwoSC: total taxes (excluding social contributions) as % of GDP (Eurostat, 2024f);
- GFK: gross fixed capital formation (% GDP) (Eurostat, 2024e);
- FINLIAB: total financial sector liabilities, by instruments, consolidated (% GDP) (Eurostat, 2024g).

The research hypotheses are based on the identification and assessment of key economic variables that may contribute to the forecasting of economic crises in the EU27 Member States. These are as follows:

Hypothesis 1. *Tests whether differences in EU countries' fiscal policies influence their ability to cope with an economic crisis. The distribution of the general government deficit (NETGDP) is not the same in all EU27 member states and influences vulnerability to economic risks differently.*

Hypothesis 2. *Explores the role of income inequality in amplifying economic vulnerabilities. The level of income inequality (GINI) varies significantly across the EU27 member countries and is a significant determinant of increased economic and social risk.*

Hypothesis 3. *Aims to test the link between investment in social protection and the ability to mitigate the impact of an economic crisis. Expenditure on social protection (ExSocP) is unevenly distributed across the EU27 and this influences the resilience of countries to economic crises.*

Hypothesis 4. *Focuses on testing the correlation between the unemployment rate and economic risks. The unemployment rate (UNE) is a significant predictor of economic and social risks, with significantly different distributions across EU27 Member States.*

Hypothesis 5. *Investigates the link between innovation, R&D investment and economic resilience. R&D expenditure (RDGDP) significantly influences an economy's ability to adapt to crises and is distributed differently across EU27 Member States.*

Hypothesis 6. *Tests the effect of tax policies on economic stability and sensitivity to financial risks. The total tax rate (TXSwoSC) and tax structure differ across EU27 countries and affect the sensitivity of these economies to economic crises.*

These hypotheses are formulated to guide the analysis and to test whether economic and social differences across EU member countries contribute to the variability in sensitivity to economic and financial crises.

To achieve the research objectives, the methodological steps are as follows: data collection was conducted during 2012–2023 for EU27 countries; data processing was performed;

the Kruskal–Wallis test was applied; the statistical results were interpreted; and the design of the risk sensitivity model was considered.

The period 2012–2023 is particularly relevant for this research as it captures a significant span of economic and financial dynamics that are critical for understanding risk sensitivity in the European Union. Following the global financial crisis of 2008–2009, the years immediately after 2012 marked a recovery phase, during which European economies implemented structural reforms and fiscal policies aimed at stabilizing financial markets and restoring growth. This period provides insights into how different economies within the EU responded to systemic shocks and adapted their fiscal and social policies. The chosen timeframe includes significant events such as the Eurozone debt crisis, the impacts of Brexit, and, most notably, the economic disruptions caused by the COVID-19 pandemic, starting in 2020. Each of these events presented unique challenges to economic resilience and exposed vulnerabilities in fiscal structures, financial systems, and social protection measures. By analyzing data from this period, this study can assess how these crises influenced variables like NETGDP, GINI, UNE, and others, providing a comprehensive view of economic risk sensitivity. The inclusion of the years leading up to 2023 captures the early impacts of post-pandemic recovery efforts and the challenges posed by inflationary pressures, supply chain disruptions, and geopolitical tensions, such as the Ukraine crisis. This period allows the study to evaluate the effectiveness of policy measures over time and to design a robust risk sensitivity model that reflects the lessons learned from this complex decade of economic transformations.

In the context of the economic–financial risk sensitivity model, a crisis is defined as a significant economic or financial disturbance that negatively impacts macroeconomic stability, such as disruptions in fiscal policies, rising unemployment, escalating income inequality, or underinvestment in critical sectors like R&D and social protection. The Kruskal–Wallis test is particularly suitable because it identifies statistically significant differences in the distribution of variables across EU countries. By using this non-parametric test, the study examines the variability of macroeconomic indicators—like NETGDP, GINI, ExSocP, UNE, RDGDP, GFK, FINLIAB and TXSwoSC—across different countries during the analyzed period. These differences highlight disparities in economic resilience and vulnerability to crises. By defining crises through these macroeconomic indicators and examining their distribution, the model leverages the Kruskal–Wallis test to uncover patterns of risk sensitivity. This approach aligns with the objective of forecasting economic crises by showing how disparities in these variables can amplify vulnerabilities, offering policymakers evidence-based insights for mitigating potential crises.

4. Result and Discussions

Economic and social data used in the model were taken from official statistical sources such as Eurostat and other international databases. The key variables that were selected reflected issues related to economic performance, income inequality, social protection, unemployment, research and development, health, and the tax system. The histogram distribution of the analyzed variables is presented in Figure 1.

Figure 1 shows the histogram distribution of the key variables used in the analysis of the EU27 economies for the period of 2012–2023, as these are central to the economic and financial risk sensitivity model. The variables analyzed, such as government deficit (NETGDP), unemployment rate (UNE), income inequality (GINI), social expenditure (ExSocP), and R&D expenditure (RDGDP), are key indicators in assessing the resilience of European economies to crises. The asymmetric distribution or outliers in NETGDP suggest that some countries (e.g., Romania and Bulgaria) are more vulnerable to crises due to large government deficits, while other countries manage to maintain fiscal stability. Also, the

GINI distribution indicates increased income inequality in some Member States, signaling an increased social risk, which may amplify the effects of an economic crisis.

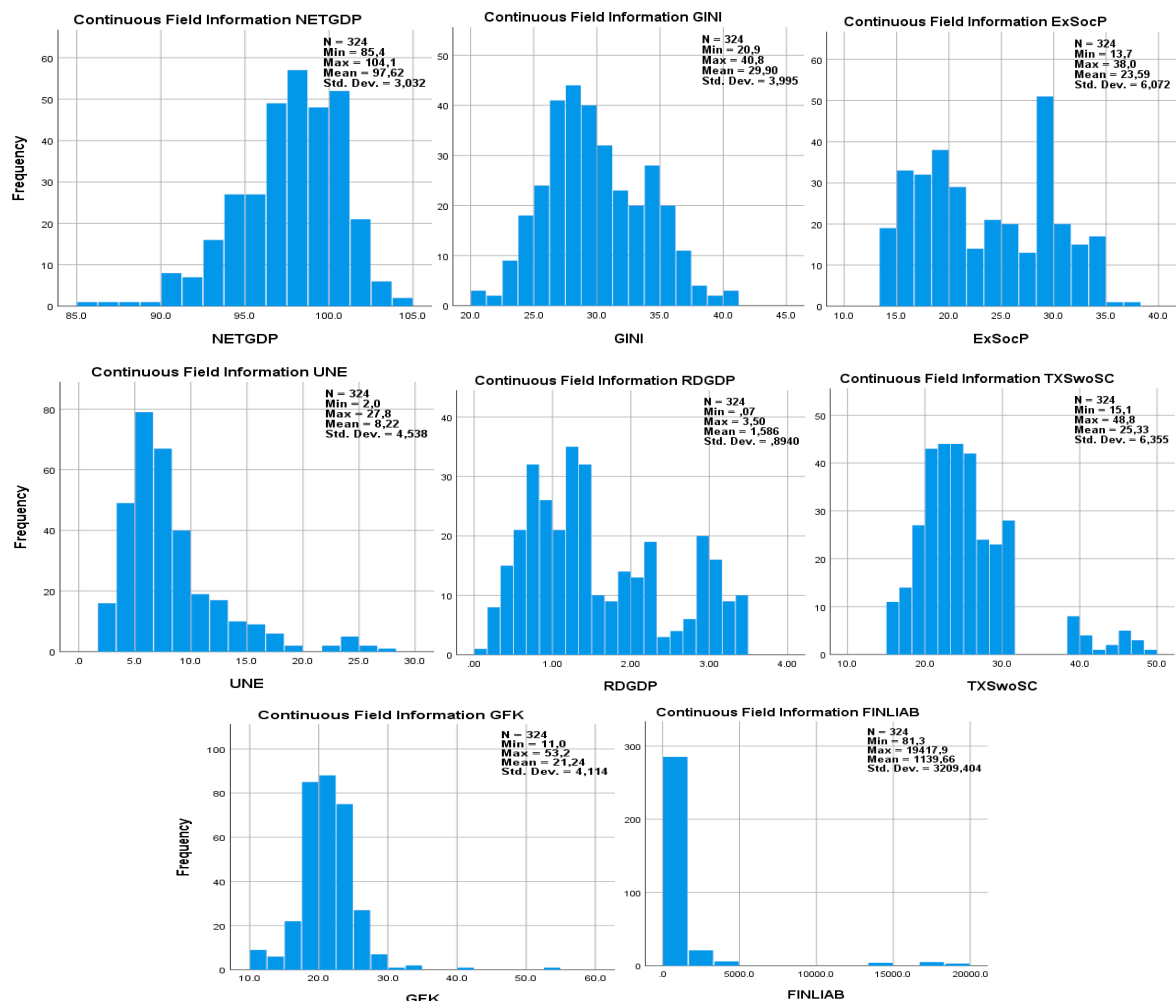


Figure 1. Histogram distribution of variables at EU27 level (2012–2023). Source: authors' projections using SPSS software 26 version.

In the context of the research, the distributions of these variables provide us with information about the level of exposure of each country to economic and financial risks. Thus, countries with a more even distribution of social spending (ExSocP) show a stronger commitment to the protection of citizens, which may make them more resilient to economic shocks. Another facet of the structural analysis relates to the RDGDP indicator, and so countries with large variations in R&D spending may be better prepared for innovation, but also more vulnerable to a possible crisis if investment is insufficient. This distributional analysis allows us to identify not only which countries are more prone to risks, but also common patterns across EU27 countries that contribute to the overall economic stability or vulnerability of the EU. The distribution of GFK, with a mean of 21.24% of GDP and a standard deviation of 4.114, indicates a relatively clustered investment pattern around the mean, with a few countries showing significantly higher values. These outliers might reflect economies with strong capital investment programs, essential for long-term growth and crisis resilience. However, countries with low GFK levels can face challenges in maintaining sustainable development and recovering from economic shocks. The uneven investment levels across Member States highlight disparities in economic capacity and the ability to mitigate crises through infrastructure investment and capital formation. In contrast, the

distribution of FINLIAB is highly skewed, with extreme outliers reaching up to 19417.9% of GDP and a standard deviation of 3209.404. This significant variability suggests that some financial sectors are disproportionately leveraged, exposing their economies to systemic financial risks. High financial liabilities, particularly in economies with limited fiscal buffers, signal vulnerability to external shocks and liquidity crises. Conversely, countries with lower levels of FINLIAB exhibit stronger financial stability, better positioning them to withstand economic turbulence. The stark contrast between highly leveraged and financially stable countries underscores the importance of monitoring and managing financial sector liabilities as a critical component of economic resilience and crisis prevention.

The analysis used the Independent-Samples Kruskal–Wallis test, applied on a sample of 324 observations (i.e., the information obtained for each variable for each EU27 Member State over the period of 2012–2023), to check whether the distribution of the indicators mentioned was the same in all the countries analyzed (Table 1).

Table 1. Independent-Samples Kruskal–Wallis test.

Independent-Samples Kruskal–Wallis Test	Across Country							
	NETGDP	GINI	ExSocP	UNE	RDGDP	TXSwoSC	GFK	FINLIAB
Total N	324	324	324	324	324	324	324	324
Test statistic	97.459 ^a	264.429 ^a	296.677 ^a	189.021 ^a	288.270 ^a	301.025 ^a	240.559 ^a	314.944 ^a
Degree of freedom	26	26	26	26	26	26	26	26
Asymptotic Sig. (2-sided test)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Source: the authors' calculations using SPSS software 26 version. a. The test statistic is adjusted for ties.

The results of the test showed that for all variables analyzed (NETGDP, GINI, ExSocP, UNE, RDGDP, TXSwoSC), the *p*-values (level of asymptotic significance) were very low (0.000), indicating that the distributions of the variables were different between the countries analyzed. Thus, the null hypothesis, suggesting that the variables were similarly distributed across countries, was rejected.

The correlations of the new macroeconomic–financial risk sensitivity model were projected and are presented in Table 2.

Table 2. Correlations.

Indicators	ExSocP	GINI	NETGDP	RDGDP	TXSwoSC	UNE
ExSocP	1.000	−0.301	−0.062	0.749	0.697	0.112
GINI	−0.301	1.000	−0.044	−0.485	−0.300	0.354
NETGDP	−0.062	−0.044	1.000	0.182	0.193	−0.337
RDGDP	0.749	−0.485	0.182	1.000	0.610	−0.303
TXSwoSC	0.697	−0.300	0.193	0.610	1.000	−0.066
UNE	0.112	0.354	−0.337	−0.303	−0.066	1.000

Source: the authors; calculations using SPSS software 26 version.

According to the data in Table 2, the correlation between GINI and other key variables is moderate, especially with UNE (0.354) and RDGDP (−0.485). These correlations indicate the existence of a link between income inequality and unemployment and R&D investment. GINI has a significant negative correlation with RDGDP, suggesting that countries with higher inequality invest less in R&D, thereby increasing economic risk. Thus, Hypothesis 2 is partially confirmed. Also, ExSocP has strong positive correlations with RDGDP (0.749) and TXSwoSC (0.697), indicating that countries that invest more in social protection

also tend to have higher levels of R&D investment and a stronger tax structure. These correlations show that social protection can help to increase economic resilience. Hypothesis 3 is confirmed.

UNE is moderately correlated with GINI (0.354) and negatively correlated with RDGDP (−0.303) and NETGDP (−0.337), indicating the existence of a relationship between unemployment, income inequality, and development investment. These relationships emphasize that higher unemployment is associated with higher levels of inequality and lower research investment, amplifying economic risks. Hypothesis 4 is thus confirmed. RDGDP has strong positive correlations with ExSocP (0.749) and TXSwoSC (0.610), indicating that R&D investment is associated with a better tax structure and stronger social protection. These relationships support the fact that RDGDP is a significant factor in determining economic resilience. Hypothesis 5 is confirmed.

TXSwoSC is positively correlated with ExSocP (0.697) and RDGDP (0.610), indicating the existence of a link between a more robust tax structure and investment in social protection and research. These correlations confirm that the tax structure can contribute to increasing economic resilience, supporting Hypothesis 6.

The results of the Kruskal–Wallis test and the simulation model analysis show that variables such as spending on social protection, R&D, and the tax structure have a significant impact on economic resilience and are strong predictors of sensitivity to economic crises. In contrast, variables such as income inequality (GINI) play less of a role in predicting economic crises than expected. This partially confirms the research hypotheses and validates the model of sensitivity to economic and financial risks. GINI has a negative statistical score (−3.618) with a standardized test result of −0.095.

This result suggests that variations in income inequality across countries do not contribute significantly to differences in sensitivity to economic crises. However, income inequality is positively correlated with unemployment and negatively correlated with R&D spending, indicating that it may amplify certain economic risks indirectly. Hypothesis 2 is therefore partially validated, suggesting that income inequality has a weaker influence than expected. The Kruskal–Wallis test result for ExSocP is 18.152, with a standardized test statistic of 0.475. This score indicates a moderate variation in social protection expenditure across EU Member States, suggesting that investment in social protection plays a significant role in the resilience of economies to crises. This finding validates Hypothesis 3, which states that social protection expenditure plays an important role in increasing economic resilience. With a statistic score of −10.841 and a standardized test of −0.284, the results for the unemployment rate show significant cross-country variation, suggesting that unemployment is a key indicator in economic risk. The unemployment rate is positively correlated with income inequality and negatively correlated with R&D expenditure, emphasizing that high unemployment amplifies economic vulnerabilities.

Hypothesis 4 is confirmed, reinforcing the idea that unemployment is an important predictor of economic crises. The Kruskal–Wallis test for RDGDP yields a score of 18.865 and a test statistic of 0.493, reflecting the existence of significant variation across EU countries in R&D investment. This variation suggests that countries with higher levels of spending in this area are more economically resilient due to their ability to innovate and adapt to crises. Hypothesis 5 is validated, confirming that RDGDP contributes significantly to economic stability. With a score of 30.953 and a standardized test statistic of 0.809, this result shows that there is a high level of variation in the tax structure across EU countries. This suggests that tax policies, in particular total taxes (excluding social contributions), play an important role in determining the sensitivity to economic crises. Hypothesis 6 is confirmed, indicating that a sound tax structure can contribute to increasing economic resilience.

The validity of the was tested using the Kruskal–Wallis test of sample independence (Kruskal–Wallis); the results are presented in Table 3.

Table 3. Hypothesis test summary.

Null Hypothesis		Test	Sig.	Decision
1	The distribution of NETGDP is the same across categories of Country.	Independent-Samples Kruskal–Wallis test (H) $H = \frac{12}{N(N+1)} \cdot \sum \frac{R_k^2}{n_k} - 3(N + 1)$ where N is the sum of samples size, n_k is the size of k-th sample, and R_k is the total sum of ranks in the k-th sample (Hoffman, 2015)	0.000	Reject the null hypothesis.
2	The distribution of GINI is the same across categories of Country.		0.000	Reject the null hypothesis.
3	The distribution of ExSocP is the same across categories of Country.		0.000	Reject the null hypothesis.
4	The distribution of UNE is the same across categories of Country.		0.000	Reject the null hypothesis.
5	The distribution of RDGDP is the same across categories of Country.		0.000	Reject the null hypothesis.
6	The distribution of TXSwoSC is the same across categories of Country.		0.000	Reject the null hypothesis.
7	The distribution of GFK is the same across categories of Country.		0.000	Reject the null hypothesis.
8	The distribution of FINLIAB is the same across categories of Country.		0.000	Reject the null hypothesis.
Asymptotic significances are displayed. The significance level is 0.050.				

Source: the authors projections' using SPSS software 26 version.

The results in Table 3 provide a clear interpretation of how the macroeconomic variables NETGDP, GINI, ExSocP, UNE, RDGDP and TXSwoSC are distributed across the different EU27 countries and highlight the existence of significant differences between them. The Kruskal–Wallis test was applied for each variable, and the obtained asymptotic significances ($p = 0.000$) for all hypotheses allow us to reject the null hypothesis in each case. This indicates that the distributions of the variables analyzed are different across member countries, thus confirming the variability of economic and social conditions at the European level. The different distribution of the NETGDP reflects the different approaches to fiscal policies among Member States, which influences their ability to manage economic risks. Similarly, variations in the GINI distribution indicate substantial differences in income inequality, highlighting its impact on social and economic stability. Also, the results for ExSocP and UNE suggest that levels of social protection and unemployment rates are uneven across countries, which may amplify the vulnerability of some economies to economic crises. The results for RDGDP and TXSwoSC suggest that differences in R&D investment and tax structure are relevant for countries' ability to sustain economic growth and resilience to economic shocks. The fact that all the variables analyzed show different distributions across countries supports the idea that economic disparities across EU countries contribute significantly to sensitivity to economic risks. These results support the research objectives, highlighting the need for economy-specific policy approaches to ensure long-term stability.

According to the results of the simulation of lognormal distributions in Appendix A compared with the results of the concatenation of the sets of observations on pairs of data in the non-parametric Kruskal–Wallis test, it can be observed that variables such as social protection expenditure (ExSocP), research and development (RDGDP), tax levels (TXSwoSC), gross fixed capital formation (GFK), and total financial sector liabilities (FINLIAB) have a significant impact on the sensitivity of European economies to economic risks. These variables showed the largest differences across countries, indicating divergences in the

economic and social policies pursued by national governments. On the other hand, the income inequality indicator (GINI) showed less variation across countries, suggesting that these issues are influenced by more universal factors such as global economic conditions and the impact of past economic crises. Using the data obtained from the statistical tests, a risk sensitivity model was constructed to forecast future European economic crises by assessing the risks to which countries are exposed in relation to the economic and social factors analyzed. The model assesses how each country responds to economic shocks, based on their fiscal policies, social spending, and other relevant indicators, with the influence of each variable shown in Figure 2.

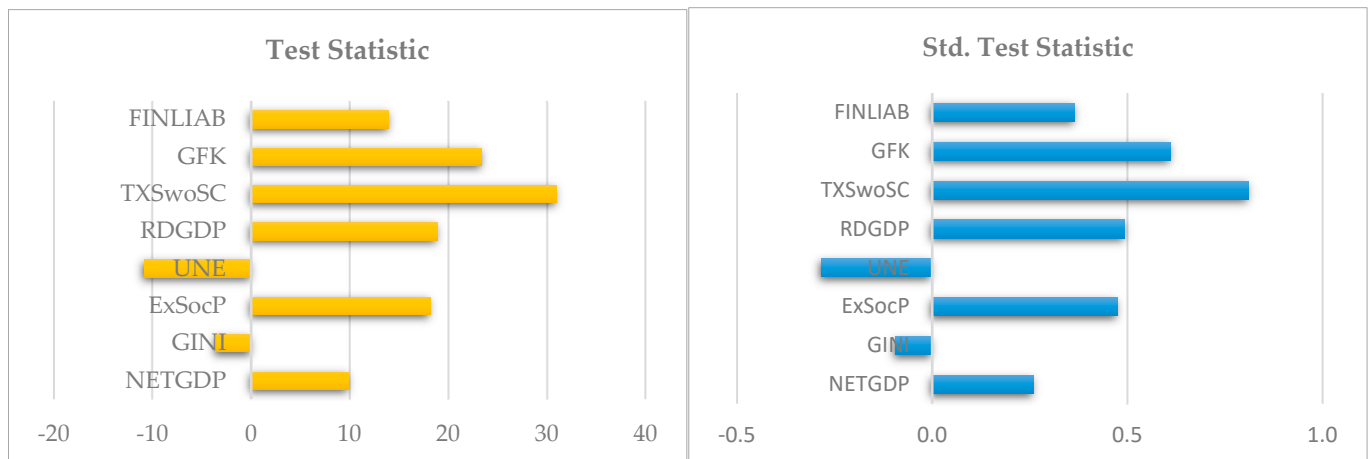


Figure 2. Graphical projections of statistical tests and standardized statistical tests using the means of comparisons on 351 data pairs (2012–2023). Source: the authors' projections using SPSS software version 26.

The analysis of the results in Figure 2, which illustrates the graphical projections of the statistical tests and standardized statistical tests (obtained by pairwise comparisons of the variables NETGDP, GINI, ExSocP, UNE, RDGDP, GFK, FINLIAB, TXSwoSC and TXSRecv), highlights the significant differences between the distributions of the variables in the EU27 countries. Confirming Hypothesis 1, the results for NETGDP indicate that there is significant variation across countries in terms of government deficits. This supports the idea that different fiscal policies may affect the ability of states to manage economic risks, but the moderate value of the test statistic suggests that the influence of NETGDP on economic vulnerability is not as pronounced as that of other variables. Thus, Hypothesis 1 is partially confirmed, with government deficits playing a role in shaping the ability of states to withstand economic crises, but to a lesser extent than anticipated. Figure 2 reveals that income inequality (GINI) exhibits a significantly different distribution across the countries analyzed according to the adjusted test statistics. The positive correlations with unemployment and negative correlations with R&D expenditure emphasize the role of inequality in amplifying economic and social vulnerabilities, confirming Hypothesis 2. Similarly, for Hypothesis 3, the ExSocP variable shows a significantly different distribution across countries, indicating that investment in social protection has an influence.

The test values suggest that countries with higher social protection expenditures have a greater ability to mitigate the impact of crises, thus confirming the link between social investment and economic stability. For Hypothesis 4, the unemployment rate (UNE) shows marked differences across countries, and the association of this variable with income inequality and R&D spending confirms its role as a predictor of economic and social risks. At the same time, RDGDP and TXSwoSC exhibit significant distributions, supporting Hypothesis 5 and Hypothesis 6, which demonstrate that R&D investment and the tax

structure, respectively, play a key role in ensuring a resilient economy. In conclusion, Figure 2 validates most of the research hypotheses, highlighting that although each variable contributes to economic vulnerability to a different extent, key elements such as income inequality, social protection expenditure, unemployment, research, and the tax structure are determinants of sensitivity to economic crises in Europe. Through this model, using statistical data collected from different European countries and assessing key variables for detecting potential economic crises, the sensitivity of national economies to economic and social risks is demonstrated.

The methodology used in this study provides a comprehensive approach to forecasting European economic crises by applying a model based on key economic data. The model of sensitivity to financial and economic risks demonstrates the importance of variables such as government spending, income inequality, and R&D policies, showing that they are key to understanding the vulnerability of European economies to future crises.

The spectral analysis of the bidirectional influence presented in Figure 3 from the perspective of the model of sensitivity to economic and financial risks (O1) allows us to assess the periodicity and reciprocal influences of macroeconomic variables, such as the government deficit (NETGDP), on other key variables. The influence of the NETGDP on indicators such as income inequality (GINI) and the unemployment rate (UNE) is analyzed using spectral features such as spectral power and coherence in order to identify the moments when these correlations become stronger. The results suggest that the NETGDP, at certain periods, has a significant impact on the vulnerability of European economies, thus contributing to the early identification of potential economic crises. The assessment of differences across European economies in terms of exposure to economic and financial risks (O2) is supported by spectrographic analysis, which reveals the existence of significant cross-country variations in the periodicity of the influence of NETGDP on the variables analyzed.

The analysis of the graphs provides detailed insights into the interdependence between key economic variables and the NETGDP, highlighting their dynamics in the context of gain over time. The relationship between NETGDP and ExSocP shows how spending on social protection tends to increase during periods of economic downturn, generating significant fiscal pressure on government revenues. At the same time, the analysis of the relationship between NETGDP and GINI highlights the existence of close links between government revenues and economic inequality, where sudden variations in earnings signal social and economic imbalances, often associated with the onset of financial crises. On the other hand, the relationship between NETGDP and UNE highlights the sensitivity of government income to fluctuations in unemployment, especially during recessions. This suggests that an increase in unemployment can drastically reduce tax revenues, amplifying economic risks. R&D investment, as represented by RDGDP, has a low level of correlation with government revenues, which may signal long-term structural vulnerability, especially if these investments are insufficient to support economic recovery. Similarly, the relationship between NETGDP and taxes collected (TXSwoSC) reflects limited flexibility in the tax system, and decouplings in this relationship may be an early signal of a fiscal crisis. Last but not least, the analysis of the link between NETGDP and financial sector liabilities (FINLIAB) emphasizes the significant influence of financial instability on government revenues. Extreme swings in earnings suggest that rising financial liabilities may be an early indicator of the risk of a systemic crisis. Taken together, these relationships highlight the importance of an integrated analysis of economic factors, where volatility, decouplings, and unstable relationships between variables are key signals for early identification and the prevention of future financial crises.

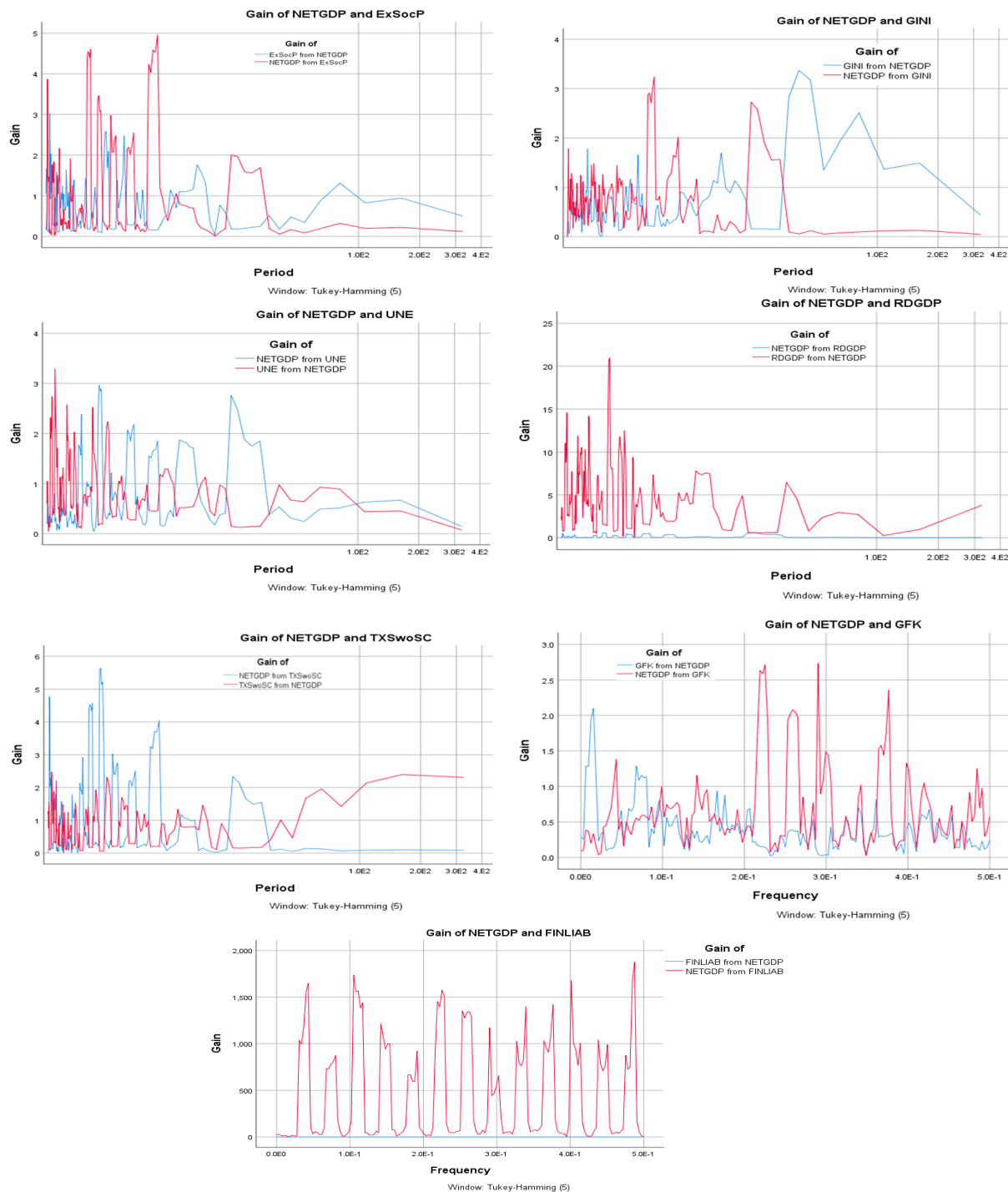


Figure 3. Results of spectral projections of the bidirectional influence of sensitivity variables (2012–2023). Source: the authors' projections using SPSS software 26 version.

These observations provide a deeper understanding of the factors that generate economic disparities in Europe and underline the specific vulnerabilities of some economies to crises. The role of fiscal policies and public spending in mitigating economic risks (O3) is clarified by spectrographic analysis of the variables ExSocP (social protection expenditure) and RDGDP (research and development expenditure) in relation to NETGDP. Figure 3 shows that, in times of economic crisis or instability, the influence of NETGDP on social spending and research investment increases. This suggests that fiscal policies oriented towards social protection and innovation can contribute to long-term economic stability by reducing the sensitivity of economies to external and domestic shocks. Thus, the spectral

analysis supports the conclusion that well-calibrated policies in these areas are key to maintaining high economic resilience in Europe.

The analysis of how different countries and time periods influence the macroeconomic indicators analyzed contributes to the identification of economic vulnerabilities and crisis forecasting. The analysis of the picture of budget deficit management at the European level is presented in Figure 4.

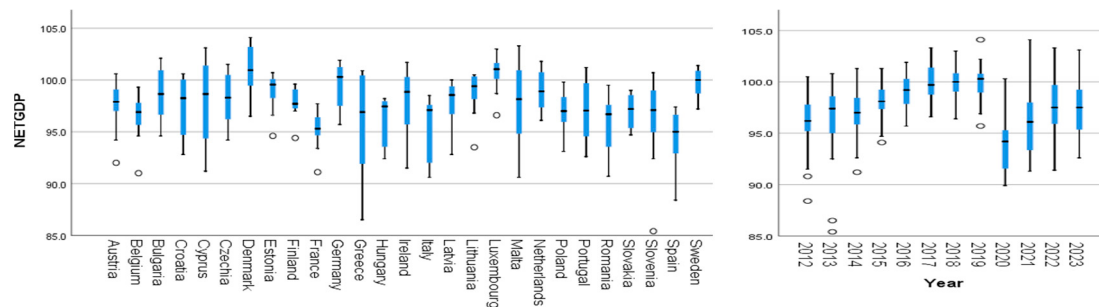


Figure 4. NETGDP Kruskal–Wallis diagram (across UE27 countries and across analyzed years). The circles (°) denote outliers that fall outside the interquartile range but are not considered extreme. They are located at a distance of 1.5 times the interquartile range from either the lower or upper limit of the boxplot. Source: the authors; projections using SPSS software 26 version.

Figure 4 highlights significant variations in the way budget deficits are managed across Europe. The NETGDP results across EU27 countries show notable differences in government deficit levels across European countries, suggesting that some economies are more exposed to economic risks due to fiscal imbalances. This cross-country variability reflects differences in fiscal policies and countries' capacity to cope with economic shocks, which supports the development of the economic risk sensitivity model proposed in the research. A forecast based on the distribution of the NETGDP variable in the context of the economic risk sensitivity model shows European countries with high government deficits as vulnerable to future economic crises. Thus, Greece, Italy, and Spain have consistently had deficits that are higher than the European average and have shown increasing deficit trends in recent years, with these economies being more exposed to the risks of financial instability in the context of external shocks, such as a global economic crisis or rising interest rates. The interpretation of this forecast confirms the assumption that government deficits are not evenly distributed across EU Member States and that high levels of NETGDP contribute to economic vulnerability.

The Kruskal–Wallis test showed significant differences in NETGDP across the countries analyzed, highlighting how fiscal divergences can amplify risks at the regional level. This forecast emphasizes that countries with large deficits require fiscal consolidation policies and economic stability measures to prevent the accumulation of risks. From a risk sensitivity model perspective, it emphasizes the importance of closely monitoring the evolution of the government deficit as an indicator of potential economic crises. With the help of this model, higher-risk countries can be identified, and specific preventive measures can be implemented to reduce exposure to economic shocks. We believe that understanding the distribution and trends in the NETGDP provides a solid basis for proactive economic interventions to mitigate the impact of crises and contribute to the long-term stability of European economies. The analysis supports the proposed sensitivity modeling approach, emphasizing the importance of monitoring both cross-country differences and time variations in budget deficits in order to forecast and mitigate the risks associated with economic crises in Europe.

Figure 5 presents the Independent-Samples Kruskal–Wallis analysis for the GINI coefficient, both across countries and over the years analyzed. It highlights the variations in income inequality in Europe in terms of economic and social stability. Differences between countries and temporal variations in the GINI coefficient suggest that economic inequality contributes to increased vulnerabilities and instability in Europe. The cross-country GINI distribution shows notable differences in income inequality across Member States, reflecting the different social and fiscal policies implemented. These discrepancies are associated with economic and social risks, as countries with high levels of inequality are often more vulnerable to economic stress and may experience greater economic instability. Our results support the hypothesis that income inequality amplifies economic risks, suggesting that countries with unequal income distribution should implement social and fiscal equity measures to mitigate risks. We project the risks resulting from the evolution of GINI over time: there is a trend towards stability in some countries, but an increase in inequality in others, suggesting the persistence of economic risk.

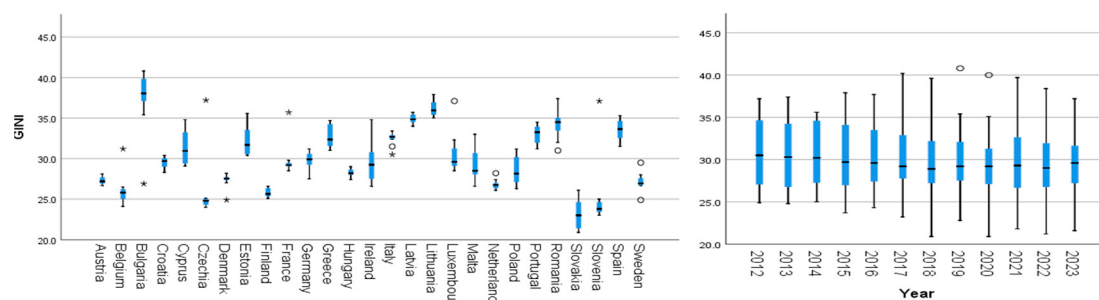


Figure 5. GINI Kruskal–Wallis diagram (across UE27 countries and across analyzed years). The stars (*) and circles (°) are used to indicate outliers or extreme outliers within the dataset represented by the boxplots. (°) denote outliers that fall outside the interquartile range (IQR) but are not considered extreme. They are located at a distance of 1.5 times the IQR from either the lower or upper limit of the boxplot. (*) represent extreme outliers, which are located at a distance greater than 3 times the IQR from the boxplot's boundaries. Source: the authors' projections using SPSS software 26 version.

Countries with upward trends in the GINI coefficient (Romania and Bulgaria) can experience higher economic risk, especially if this indicator continues to rise. Given the results so far, this forecast supports the need for redistributive and social protection policies to prevent the escalation of inequality and help reduce economic risk, thereby strengthening European economic stability in the long term.

Figure 6 provides important insights into the diversity of social expenditure in the EU27, reflecting the degree of economic and social protection offered to European citizens as a key factor in economic stability and resilience to crises. Differences between countries suggest that some Member States (Finland, France, Germany) invest significantly more in social protection than others. These variations determine economic resilience to economic shocks such as recessions or rising unemployment. Countries with high levels of social spending are better able to mitigate the negative effects of economic downturns by supporting household income and consumption in difficult times. Forecasting based on intra-year distributions suggests that countries that have maintained or increased spending on social protection have better prospects of managing future economic crises. If this trend in investment in social protection continues, these economies will have an advantage in managing the negative effects of global economic fluctuations. Conversely, countries that have reduced such spending (Romania, Bulgaria, or the Baltic countries) could become more vulnerable to economic downturns, highlighting the need for more robust social support policies.

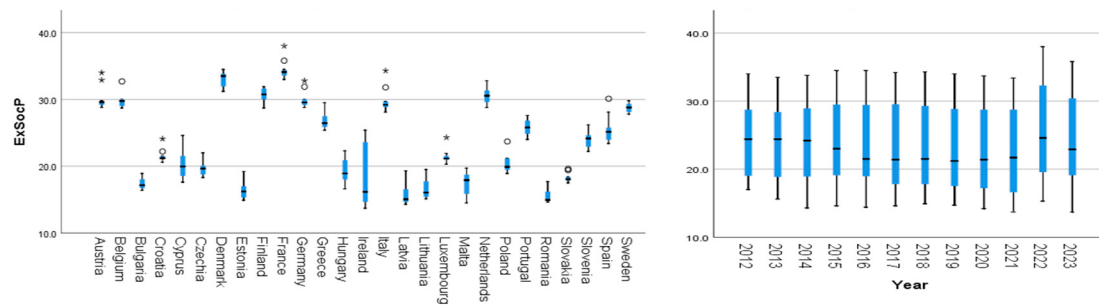


Figure 6. ExSocP Kruskal–Wallis diagram (across UE27 countries and across analyzed years). The stars (*) and circles (°) are used to indicate outliers or extreme outliers within the dataset represented by the boxplots. (°) denote outliers that fall outside the interquartile range (IQR) but are not considered extreme. They are located at a distance of 1.5 times the IQR from either the lower or upper limit of the boxplot. (*) represent extreme outliers, which are located at a distance greater than 3 times the IQR from the boxplot's boundaries. Source: the authors' projections using SPSS software 26 version.

Figure 7 highlights the significant variation in unemployment across the European Union, a fundamental indicator for assessing economic risks and overall economic stability, with direct links to the vulnerability of economies to crises. The cross-country distribution of the variable shows clear differences across Member States, reflecting different economic contexts and employment policies implemented at the national level. The results suggest that high levels of unemployment may amplify economic and social risks, confirming the hypothesis that unemployment is a significant predictor of crisis sensitivity. The extrapolation of the intra-annual analysis shows fluctuating trends in some countries (Portugal, Spain) and a steady increase in others (Greece), suggesting that some countries may be more vulnerable to future economic crises if the unemployment rate continues to rise. This points to the need for supportive policies to reduce unemployment, which would contribute to economic stability and reduce economic vulnerabilities to crises. This analysis supports the central role of unemployment in the risk sensitivity model and emphasizes the importance of reducing unemployment for maintaining economic stability in Europe.

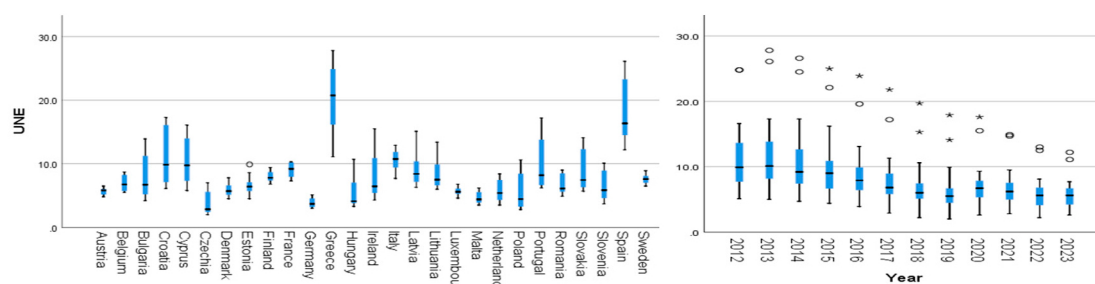


Figure 7. UNE Kruskal–Wallis diagram (across UE27 countries and across analyzed years). The stars (*) and circles (°) are used to indicate outliers or extreme outliers within the dataset represented by the boxplots. (°) denote outliers that fall outside the interquartile range (IQR) but are not considered extreme. They are located at a distance of 1.5 times the IQR from either the lower or upper limit of the boxplot. (*) represent extreme outliers, which are located at a distance greater than 3 times the IQR from the boxplot's boundaries. Source: the authors' projections using SPSS software 26 version.

Figure 8 highlights the significant differences between European economies in terms of investment in innovation. In the research context, these variations are important, as R&D spending is an indicator of economic resilience and crisis resilience. The distribution of RDGDP across countries shows that countries with developed economies, such as Germany and Sweden, have consistently allocated significant amounts to R&D, in contrast to smaller or emerging economies, such as Romania and Bulgaria. This disparity points to a significant

difference in the ability of these countries to adapt to economic change and cope with crises. The results suggest that countries with higher investment in RDGDP are better positioned to manage economic risks because innovation allows them to react more quickly to global economic changes.

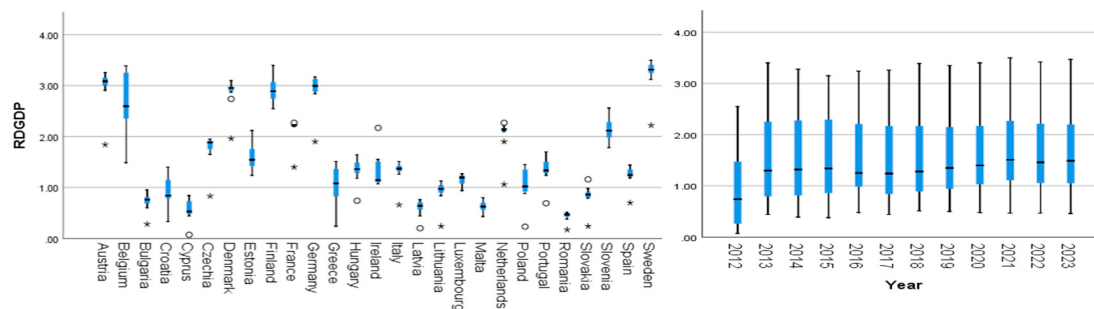


Figure 8. RDGDP Kruskal–Wallis diagram (across UE27 countries and across analyzed years). The stars (*) and circles (°) are used to indicate outliers or extreme outliers within the dataset represented by the boxplots. (°) denote outliers that fall outside the interquartile range (IQR) but are not considered extreme. They are located at a distance of 1.5 times the IQR from either the lower or upper limit of the boxplot. (*) represent extreme outliers, which are located at a distance greater than 3 times the IQR from the boxplot's boundaries. Source: the authors' projections using SPSS software 26 version.

An illustrative forecast shows that Germany, with a consistently high level of RDGDP, is likely to be more resilient in the face of a crisis due to its ability to innovate and stimulate growth through technology and development. In contrast, countries such as Romania and Bulgaria, with lower RDGDP, may be more vulnerable to economic crises due to their greater reliance on traditional sectors and a lack of investment in innovation. This forecast supports the importance of R&D investment, underlining the need for European economies to prioritize these investments to ensure long-term stability and reduce vulnerability to crises.

Figure 9 highlights the significant variations in the tax structure of the EU27 Member States, which contribute directly to financial stability and the ability of economies to respond to external shocks. The cross-country distribution of TXSwoSC across countries shows clear differences across European countries by tax structure. Countries such as Denmark and Sweden, which have high levels of taxation, manage to sustain extensive social programs, contributing to their economic stability. On the other hand, countries with lower tax levels, such as Ireland or Romania, have a narrower fiscal framework, which may limit their ability to implement support measures in times of crisis. We believe that a sound and well-balanced fiscal framework is essential to ensure economic resilience, helping to prevent and manage financial risks. A forecast based on this evidence emphasizes the role of robust tax structures in the economic risk sensitivity model, suggesting that more efficient taxation can contribute to economic stability by providing governments with the necessary resources to respond effectively in times of economic instability.

Based on the findings presented above, several adjustments to economic policy and risk management strategies are recommended to enhance resilience against economic crises within the EU27: it is necessary to increase social protection expenditure at the EU27 level, address income inequality, promote investment in research and development, and refine fiscal policies and tax structures at the EU27 level.

The significant impact of social protection expenditure on economic stability suggests that increasing allocations to social protection can be an effective buffer against economic downturns. States with higher ExSocP levels showed better resilience, underscoring the need for policy adjustments that prioritize social safety nets to mitigate the effects of potential crises. The results reflect the considerable differences in income inequality across EU

countries and the correlation of this factor with economic vulnerability; targeted interventions to reduce income inequality are essential. This may involve progressive tax reforms, enhanced minimum wage policies, and equitable access to education and healthcare. These measures could improve social stability, subsequently reducing economic risk.

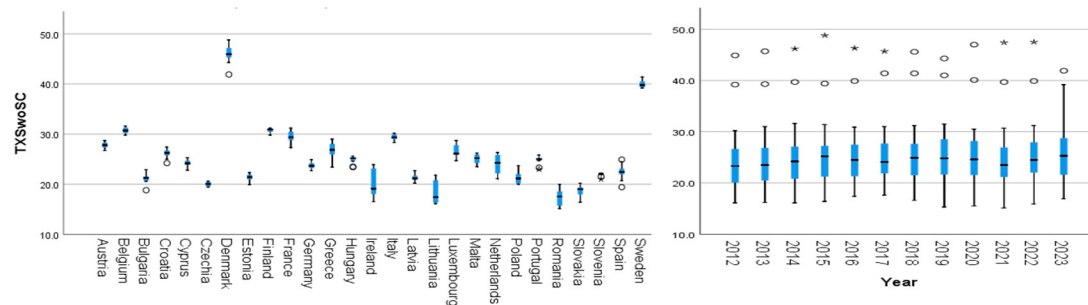


Figure 9. TXSwoSC Kruskal–Wallis diagram (across UE27 countries and across analyzed years). The stars (*) and circles (°) are used to indicate outliers or extreme outliers within the dataset represented by the boxplots. (°) denote outliers that fall outside the interquartile range (IQR) but are not considered extreme. They are located at a distance of 1.5 times the IQR from either the lower or upper limit of the boxplot. (*) represent extreme outliers, which are located at a distance greater than 3 times the IQR from the boxplot's boundaries. Source: the authors' projections using SPSS software 26 version.

We have demonstrated the existence of a strong link between R&D investment and economic resilience. An increase in R&D funding could support long-term adaptability and innovation, particularly in countries with low baseline investments. Policies encouraging public and private R&D investment would not only enhance immediate economic resilience but also foster sustainable growth in the face of future economic disruptions. The differences in tax structure effects underscore the need for a balanced and resilient fiscal approach, possibly by optimizing tax bases and reducing reliance on narrow revenue sources. Adjustments that create a more flexible tax system can enhance national responses to economic fluctuations, providing a stable revenue base during crises. These recommended adjustments align with the findings from Figure 2 and would contribute to a more robust, crisis-resilient economic framework across the EU27.

5. Conclusions

The study achieved the research objectives by developing and applying an economic and financial risk sensitivity model for use forecasting economic crises in Europe. The proposed model, which integrates key macroeconomic variables such as government deficit (NETGDP), GINI coefficient, social protection expenditure (ExSocP), unemployment rate (UNE), R&D expenditure (RDGDP) and tax structure (TXSwoSC), allowed for the early identification of economic vulnerabilities, thus providing an effective tool for policymakers. The main objective, to provide a framework for assessing economic risks, was achieved by highlighting the factors contributing to the vulnerability of European economies, facilitating the implementation of appropriate preventive measures. The novelty and originality of the research lies in the integrative approach and the use of the Kruskal–Wallis test to assess significant cross-country and cross-year variation in key variables, providing a thorough understanding of structural and social differences in Europe. This study fills an important gap in the literature by highlighting how tax structures and public spending contribute to economic resilience, an aspect insufficiently explored in the European context. This model provides a valuable contribution to the literature by allowing for the identification of the dynamics of long-term economic vulnerability and resilience. Research limitations relate

to the dependence on available data, which may not fully reflect rapid structural changes or unpredictable geopolitical influences. At the same time, the model could benefit from extending the variables analyzed to include other specific risk indicators, such as private debt and environmental risks. Correlation analysis was initially chosen as an exploratory tool to identify significant relationships between macroeconomic variables, providing an accessible and interpretable foundation for understanding sensitivity patterns. Another limitation of this study lies in the incomplete capture of the complexity of macroeconomic dynamics, especially in terms of causality, interaction effects, and nonlinear relationships. We intend to improve the risk sensitivity model in the future by adding additional analytical tools such as regression models and machine learning systems. Through future research, we aim to explore and adapt the model to forecast risks at the regional level and to assess the impact of economic sustainability policies on long-term stability. The main research results confirm that variables such as social protection expenditure, tax structure, and R&D investment are key determinants of economic resilience in Europe. These findings are particularly useful for policymakers and financial institutions, which can use this information to support public policies that reduce vulnerability to crises and strengthen economic stability across Europe.

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Appendix A

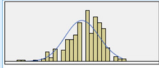
Table A1. New economic–financial risk sensitivity model summary.

Variable	Independent-Samples Kruskal–Wallis Test Average Across Country		
	Test Statistic	Std. Error	Std. Test Statistic
NETGDP	9.927	38.239	0.260

Input: NETGDP
Treat as (Measure): Continuous

Distributions:

Use	Distribution	Fit Statistics	Parameters
☐	Weibull	A=0.37 P=0.25(K=0.05 P=0.1)	b=89.0 b=38.69 c=0.0
☐	Normal	A=2.25 P=0.0(K=0.07 P=0.01)	mean=97.62 stddev=3.03
☐	Gamma	A=2.59 P=0.01(K=0.08 P=0.01)	scale=10.49 shape=1024.44
☒	Lognormal	A=2.78 P=0.0(K=0.08 P=0.01)	a=97.57 b=0.03
☐	Triangular	A=18.49 P=0.0(K=0.17 P=0.1)	max=104.1 min=85.4 mode=103.36
☐	Uniform	A=65.63 P=0.0(K=0.35 P=0.01)	max=104.1 min=85.4
☐	Exponential	A=139.92 P=0.0(K=0.59 P=0.01)	scale=0.01
☐	Empirical		min=85.4 max=104.1



Distribution: Lognormal
Range: Positive continuous
Example: The concentration of pollution following a spill ("Min and Max are optional")

Table A1. Cont.

Variable	Independent-Samples Kruskal–Wallis Test Average Across Country		
	Test Statistic	Std. Error	Std. Test Statistic
GINI	−3.618	38.240	−0.095
ExSocP	18.152	38.241	0.475
UNE	−10.841	38.239	−0.284
RDGDP	18.865	38.242	0.493
TXSwoSC	30.953	38.241	0.809

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