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The Efficiency of Economic Growth for Sustainable Development—A Grey System Theory Approach in the Eurozone and Other European Countries

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Abstract: This article builds upon the authors' previous work on the Synthetic Efficiency Indicator for Economic Growth (SEI-EG), demonstrating the process of transforming economic-growth-related inputs into sustainable development outcomes. This innovative application of the SEI-EG provides a fresh perspective on the effects of eurozone membership on the sustainability efficiency of EU countries, thereby enriching the discourse on economic integration and sustainability efforts within the European Union. By integrating the economic dynamics of the euro area with environmental efficiency metrics, this study offers novel insights into the potential influence of currency union membership on achieving sustainable development goals. Covering the entire European Union, categorized by euro area and non-euro area membership, this study navigates through the risks to sustainability posed by global crises and the ongoing debate over the euro's integration success and setbacks. Conducted from 2019 to 2021 using grey system theory, this research incorporates a revised set of seven indicators in the domain of industry, innovation, and infrastructure as recommended by the Europe 2020 project. The findings confirm the initial hypothesis that countries outside the euro area tend to exhibit higher efficiency as measured by the SEI-EG indicator. This article is composed of five parts. The first two parts present characteristic features of economies in the euro area and non-euro area, along with a critical trend in the latest literature on the benefits and risks of economic integration. The subsequent sections introduce the methodology for determining the indicator and the authors' own corrections to it as well as the results of the research and a discussion.

Keywords: sustainable growth; grey systems theory; sustainable development goals achievement; convergence



Citation: Nowak, M.; Kokocińska, M. The Efficiency of Economic Growth for Sustainable Development—A Grey System Theory Approach in the Eurozone and Other European Countries. *Sustainability* **2024**, *16*, 1839. <https://doi.org/10.3390/su16051839>

Academic Editors: Małgorzata Jasiulewicz-Kaczmarek, Hanna Włodarkiewicz-Klimek, Agnieszka Merksiz-Guranowska and Ewa Dostatni

Received: 11 January 2024

Revised: 15 February 2024

Accepted: 21 February 2024

Published: 23 February 2024



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1. Introduction

The challenge of converting economic growth inputs into outcomes that align with sustainable development is becoming increasingly prominent in both academic research and economic practice, reflecting a global shift toward integrating sustainability into the core of economic strategies. This transition is crucial for addressing contemporary environmental, social, and economic challenges, ensuring that growth not only continues but does so in a manner that is equitable, environmentally responsible, and sustainable for future generations.

This article's scope encompasses several themes, including the economic characteristics and contemporary debates surrounding the benefits for countries integrated into the euro area within the context of economic convergence. This analysis is particularly viewed through the lens of the effects of the global crisis of 2008 and the COVID-19 crisis. The former led to increased debt and budget deficits in relation to the nominal Maastricht convergence criteria, while the latter resulted in a decline in economic activity. Both factors could potentially hinder the transformation of economies toward sustainable growth. This threat was further exacerbated by the fuel crisis and inflation as well as the war in Ukraine.

From the viewpoint of the classical convergence hypothesis, it is reasonable to assume that less-developed countries, which make up the majority in the non-euro area, have a greater distance to cover in transforming their economies into sustainable ones and should be characterized by relatively higher efficiency in achieving selected indicators. At the same time, some non-euro area countries (Denmark, Sweden) are at a higher level of development and have autonomously undertaken long-term actions toward sustainable development through national monetary and fiscal policy.

The research question posed in this article can be articulated as follows: do countries not belonging to the eurozone exhibit higher environmental efficiency as measured by the Synthetic Efficiency Indicator for Economic Growth (SEI-EG) compared to eurozone countries? Stemming from this inquiry, the main objective of this article is to examine the hypothesis that nations outside the euro area demonstrate higher efficiency toward sustainable development as gauged by the proprietary indicator SEI-EG. Achieving this article's goal entails creating a ranking of European Union countries, divided into those within the euro area and those outside of it. To reach this article's aim, the SEI-EG indicator calculation methodology based on grey system theory was utilized.

This article is structured into five sections. The first section serves as an introduction, primarily addressing the research problem, the objectives of the conducted study, and outlining the methods applied. The second section offers a review of the literature related to the issue of monetary integration in the EU in the context of achieving sustainable development goals (SDGs). Subsequent parts present the methodology for determining the indicator, including the authors' own modifications to it, and detail the research findings accompanied by a discussion.

2. Literature Review

2.1. Sustainable Development and SDGs in the Eurozone

The observed negative consequences, mainly of eurozone countries after two global crises, particularly after the financial crisis of 2008, prompted a critical response in the literature. Initially, accusations were levied against the very idea of country integration, deemed flawed due to economic integration preceding political integration. It was suggested that such an approach favored divergence rather than convergence, especially when the European Central Bank focused solely on inflation [1]. Other authors emphasized how a single crisis in Greece transformed into a full-scale debt crisis [2] and argued that the eurozone had no external deficit and that its aggregated budget situation was better than that of the United States [3]. Ashoka Mody outlines the emergence of the euro during a brief historical period as an imperfect agreement cloaked in misleading pro-European discourse of peace and unity [4]. On the other hand, it was highlighted that the eurozone's institutional structure was conceived to guard against irresponsible fiscal policy by governments. In reality, except for Greece, it was commercial banks that made irresponsible decisions undermining the eurozone's financial stability.

Reasons for the divergence in competitiveness among eurozone countries were also pointed out [5]. The message was that economies in southern Europe are less competitive because the euro caused an inflationary credit bubble. Their economies became too costly as wage growth, funded by credit, outpaced productivity. Meanwhile, calls for a path to efficient growth concern mainly productivity increases, including the adoption of new technologies [6]. Looking at the longer term, over the last few decades, convergence between member states has been achieved both economically and socially. The crisis stalled this trend, as evidenced by the performance of European Union member states since 2008. The varied results of member states, growing inequalities within the Union itself, the lack of visible effects of cohesion policy, and rising anti-European sentiment are more mediatically exposed than the actual benefits member states derive.

The eurozone economy is recovering from the crisis, and unutilized resources in the economy, assuming no policy errors, provide an opportunity to maintain eurozone GDP growth above potential growth for some time. However, reforms to increase productivity

and shock resilience should be accelerated [7]. In rebuilding post-crisis, it is also possible to address the escalating climate changes. In the next five years, 35% of World Bank investment funds will go to developing countries for climate-related purposes [8]. Prioritizing investment in research and development is significant for creating more and better jobs in Europe, improving citizens' quality of life, and enhancing the competitiveness of the EU economy. The EU is a leader in this regard; in recent decades, innovations have contributed to nearly two-thirds of its economic growth. Furthermore, EU investments account for nearly 20% of global investments in research and innovation, and the EU aims to increase spending on research and development [9].

According to the new European Research Area, the investment target is set at 3% of GDP for research and development (up from 2.19% in 2018). Full implementation of the United Nations' Agenda 2030 is crucial for strengthening resilience and preparing the world for future shocks as we embark on the dual green and digital transformation. EU documents emphasize that the EU budget complements national EU budgets; it prevents the duplication of efforts and is used where spending funds at the EU level, rather than at the local, regional, or national level, yields better results. The guiding principle of the EU budget is also solidarity, meaning it can support the economic development of poorer member states. The EU budget allows for providing aid to EU countries affected by natural disasters [10]. There are also benefits to having the euro currency [11]. The European Commission has also transformed. "Shaping tomorrow's European economy is tantamount to building back better after the pandemic. It will require courageous political decisions. Within the EU, only the European Commission and its economists have the analytical capacity, the institutional competence, and the *esprit de finesse* to accomplish such a task" [7].

The second theme in the literature, significant from the perspective of this article's subject, is the implementation of the SDG goals. The European Union is a leader in striving to achieve sustainable development goals regardless of the division of countries according to the eurozone membership criterion. Numerous reports are emerging in this area. The key report "Sustainable development in the European Union—2022 monitoring report on progress towards the SDGs in an EU context" published by Eurostat is the sixth edition of the annual report monitoring sustainable development goal indicators within EU policy [12]. It shows that the implementation of five goals encompassed in key EU policy programs has made significant progress (these were SDG 1, SDG 7, SDG 8, SDG 9, and SDG 16). In the SDG 2023 ranking, in the top 10 countries by the overall score measuring the total progress toward achieving all 17 SDGs, only (except for Norway) EU countries are included, with four outside the eurozone and five within [13]. In this area, the literature raises the important and increasingly recognized problem of certain weaknesses in SDG goal implementation reports and supplements them with additional suggestions. One is a critical review of indicators that showed that indicators of varied quality were proposed to assess sustainable development [14].

The basic and most universal tool for evaluating the effectiveness of SDG goal implementation consists of assessing the degree of achievement of individual goals and creating rankings and profiles for each country [13]. Similarly, yet more narrowly in scope, the European Innovation Scoreboard (EIS) focuses on innovation as the most significant driver of economic growth in European countries [15]. Attempts to define a unified method for measuring countries' progress toward sustainable development have led to the concept of the ecological footprint, thereby shifting focus to corporate actions and consumer behaviors. Since 2013, with subsequent amendments, these calculation principles have been refined at the EU level. The Product Environmental Footprint (PEF) and Organization Environmental Footprint (OEF) methods are often used as reference methods for measuring environmental efficiency [16].

All these measures and methods are significant from the perspective of comparing countries, though they relate to outcomes without assessing efficiency in terms of comparing effects to inputs as well as the economic context of the evaluated countries and historical

factors that introduce motivations or disruptions on the path to sustainable development. In this context, questions about progress in sustainable development measurements and the identification of key indicators arise. There are also inquiries about new, simpler ways to measure SDGs' implementation. Lafortune, Fuller, Schmidt-Traub, and C. Kroll [17] provided a critical analysis, concluding that, as with any composite measure, standardization, normalization, and aggregation methods impact the outcome. While there is no single "correct" way to assess whether the EU and its member states are on track to achieve goals, different results stem from certain methodological choices. More forward-looking policy-tracking tools are needed to assess efforts to implement key sustainable development goal transformations. The authors suggest a more localized approach to assessing SDG progress. Attempts at alternative, simpler ways to assess progress in selected areas, such as an ecological footprint or the significance of innovations [18,19], are already being undertaken in the literature.

The Publications Office of the European Union, Luxembourg analyzes instruments improving the convergence process in the European Union [20]. The coronavirus pandemic reminds us that the full implementation of The Agenda for Sustainable Development is vital for enhancing resilience and equipping the world to face future challenges as we initiate the dual transitions toward green and digital advancements [21]. A literature review and critical assessment of indicators were conducted in the article "A literature-based review on potentials and constraints in the implementation of the sustainable development goals" [22]. This study introduces a new framework that could assist policy-makers, project developers, and experts in addressing challenges related to sustainability. The analysis in this section emphasizes the intertwined nature of economic resilience and sustainable development. The global financial crises, particularly their profound impact on the Eurozone, have necessitated a re-evaluation of economic policies and structures. This re-evaluation is crucial for fostering sustainable growth, aligning closely with the objectives set forth in the sustainable development goals (SDGs). The experiences of the Eurozone countries highlight the importance of resilient and sustainable economic systems in ensuring long-term growth and stability. These insights contribute to understanding the broader context of sustainable development within the EU and the pivotal role of economic policies in achieving the SDGs, particularly in areas related to industry, innovation, and infrastructure. The evolution of these policies in response to economic adversities illustrates the dynamic nature of the pursuit of sustainable development in the face of global challenges.

In the literature, despite the initial critical reaction to the idea of the euro area, many analyses and positive suggestions have also been presented, which have been utilized by the European Commission and form the basis for further actions toward sustainable development.

2.2. Basics of Grey Systems Theory

The grey system theory was initiated by J. Deng in 1982 [23]. Following the translation of his article into English, the theory gained international recognition [24]. In terms of tools, this theory includes various methods of uncertainty modeling, employing either the construct of grey numbers or the construct of whitening functions [25].

Intuitively, the concept of a grey number refers to a specific number d^* , whose precise value is unknown, but it is known to lie within a certain range or set of values. Thus, the number d^* can be perceived as a variable value belonging to a certain range (set). Grey numbers can be either discrete or continuous. If set A, in which the grey number resides, is discrete (stepwise), it is referred to as a discrete grey number. In cases where set A is continuous, such a number is called an interval (intervallic) grey number. In the literature, the following notations for grey numbers are adopted [25]:

- $\otimes = d^* \in [\underline{a}, \bar{a}]$ for interval grey numbers,
- $\otimes = d^* \in \{a_1, \dots, a_i, \dots, a_n\}$ for discrete grey numbers,

where:

- $\underline{a}$ is the lower bound of the range in which the interval grey number is located. The lower bound is also the smallest element of set A ; hence, it can also be denoted as $\min A$;
- $\bar{a}$ is the upper bound of the range in which the interval grey number is located. The upper bound is also the largest element of set A ; hence, it can also be denoted as $\max A$;
- it is assumed simultaneously that the condition must be met where $\bar{a} (\max A) \geq \underline{a} (\min A)$;
- a_i denotes the i -th element of this set A ;
- it is also assumed that the condition must be met where $a_{k-1} \leq a_k \leq a_{k+1}$.

Another key element of grey system theory is the concept of whitening functions. Within many methods of this theory, there emerges a need to transform grey numbers into white numbers. This process is known as the whitening of grey numbers [26]. There are two main approaches to achieve whitening. One relies on the use of preference functions, representing a subjective, normative approach, while the other is based on functions that utilize probability distributions, considered to be a more objective method. Whitening functions used in grey system theory are characterized by their variety of forms, including types such as triangular functions, their modified versions, trapezoidal functions, and non-linear functions. Each of these types of whitening functions has its unique application, depending on the nature of the data and the specifics of the problem being analyzed.

In the realm of grey system theory, there is a range of decision-making, relational, and prognostic models [27]. Decision-making models in grey system theory focus on making choices under uncertainty and incomplete information. They allow for the analysis of various scenarios and the selection of optimal solutions in situations where traditional methods may be inadequate due to a lack of complete data. Relational models, on the other hand, enable the analysis and interpretation of relationships between different variables within a system. They are useful in examining the impact of certain factors on others, especially when the data are incomplete or unclear. Meanwhile, prognostic models in grey system theory are employed for predicting future trends and behaviors. Specifically, they are applicable in forecasting areas such as logistics, management, and economics, where precise prediction is challenging due to uncertainty and the dynamic nature of systems. These different types of models in grey system theory are used to better understand and effectively manage complex systems across various fields, from technical sciences to social sciences.

3. Materials and Methods

The Synthetic Efficiency Indicator for Economic Growth (SEI-EG), from a structural perspective, represents a unique form of efficiency indicator. In economic theory, efficiency is commonly defined as the ratio of achieved results to the expended resources within a set of analyzed entities [28]. This article introduces the concept of a new indicator that illustrates the efficiency of transforming inputs, such as GDP (per capita in PPS) and general government gross debt (percentage of GDP), into outcomes associated with sustainable development in the area of industry, innovation, and infrastructure [29,30]. The authors have termed this indicator the SEI-EG.

The selection of GDP (per capita in PPS) and general government gross debt (percentage of GDP) as inputs for calculating the Synthetic Efficiency Indicator for Economic Growth (SEI-EG) is likely due to their significant relevance to economic analysis. GDP per capita is a widely recognized measure of a country's economic performance and standard of living, reflecting the average economic output per person. It is a key indicator of economic productivity and prosperity. On the other hand, general government gross debt as a percentage of GDP is a crucial measure of a country's financial health, indicating the level of government indebtedness relative to its economic size. This metric is important for understanding the sustainability of government fiscal policies and their impact on the economy. Incorporating these two inputs into the SEI-EG provides a comprehensive view

of economic efficiency, combining aspects of economic output, individual prosperity, and fiscal sustainability. This approach aligns well with the goals of sustainable development, particularly Goal 9 of the SDGs, which focuses on building resilient infrastructure, promoting inclusive and sustainable industrialization, and fostering innovation. By using these inputs, the SEI-EG offers a multidimensional perspective on how efficiently resources are being used to achieve sustainable economic growth and development.

In this study, we analyzed European Union member states, specifically focusing on Austria, Belgium, Estonia, Finland, France, Greece, Spain, the Netherlands, Ireland, Lithuania, Luxembourg, Latvia, Malta, Germany, Portugal, Slovakia, Slovenia, Italy, Bulgaria, the Czech Republic, Denmark, Poland, Romania, Sweden, and Hungary. These nations were divided into two categories based on their currency (those utilizing the euro and those that do not). The investigation covered the period from 2019 to 2021. Notably, Cyprus and Croatia were not included in the analysis. The exclusion of Cyprus was due to the unavailability of all required indicators for the country, while Croatia's exclusion stemmed from its transitional status with respect to eurozone membership during the study period. The source of the data for our research was Eurostat, with the dataset being compiled in December 2023.

This study presents a formal (mathematical) model leading to the determination of the synthetic SEI-EG value, which is based on whitening functions (a fundamental theoretical concept of the grey system theory). The research assumes that efficiency is a relative measure, determined based on the existing empirical base, and also assumes the normalization of the efficiency indicator within the range $[0, 1]$. Each subject being studied has a specific efficiency indicator value that, although not known precisely, is understood to fall within a certain range $([0, 1])$. Therefore, the cognitive uncertainty regarding an entity's efficiency is represented as a so-called grey number. Grey numbers are a focus of the grey system theory, an increasingly popular method for modeling uncertainty. The developed methodology involves defining whitening functions, through which it becomes possible to determine a specific value for the synthetic indicator of sustainable economic growth. Determining the indicator in question can be conveyed as a research procedure consisting of seven distinct steps [26].

Step 1. Creation of a data matrix D , which undergoes the process of whitening
The data matrix D takes the form (1).

$$D = [d_{ik}] = \begin{bmatrix} r_{11} & r_{12} & \dots & r_{1m} \\ r_{21} & r_{22} & \dots & r_{2m} \\ \vdots & \vdots & \ddots & \vdots \\ r_{n1} & r_{n2} & \dots & r_{nm} \\ i_{11} & i_{12} & \dots & i_{1m} \\ i_{21} & i_{22} & \dots & i_{2m} \\ \vdots & \vdots & \ddots & \vdots \\ i_{j1} & i_{j2} & \dots & i_{jm} \end{bmatrix} \quad (1)$$

where:

- D is the data matrix;
- r_{ik} is the i -th result for the k -th entity, $i = 1, 2, \dots, n, k = 1, 2, \dots, m$;
- i_{ik} is the i -th input for the k -th entity, $i = 1, 2, \dots, j, k = 1, 2, \dots, m$.

Step 2. Development of the matrix of rescaled input data D^*

The following stage involves the creation of a matrix that contains the input data after rescaling, which is depicted in Equation (2).

$$D^* = [d_{ik}^*] = \begin{bmatrix} r_{11}^* & r_{12}^* & \cdots & r_{1m}^* \\ r_{21}^* & r_{22}^* & \cdots & r_{2m}^* \\ \vdots & \vdots & \ddots & \vdots \\ r_{n1}^* & r_{n2}^* & \cdots & r_{nm}^* \\ i_{11}^* & i_{12}^* & \cdots & i_{1m}^* \\ i_{21}^* & i_{22}^* & \cdots & i_{2m}^* \\ \vdots & \vdots & \ddots & \vdots \\ i_{j1}^* & i_{j2}^* & \cdots & i_{jm}^* \end{bmatrix} \quad (2)$$

where d_{ik}^* denotes:

1. For the stimulant

$$d_{ik}^* = \frac{d_{ik}}{d_{ik}^{min}} \quad (3)$$

2. For the de-stimulant

$$d_{ik}^* = \frac{d_{ik}^{min}}{d_{ik}} \quad (4)$$

Step 3. Creation of the synthetic input indicator vector I_k for all units

In the next step, the vector of synthetic inputs I_k is calculated using Formula (5).

$$I_k = \sum_{i=1}^j i_{ik}^* \quad (5)$$

where:

- I_k is the synthetic input indicator of the k -th decision-making unit;
- i_{ik}^* is the rescaled i -th input of the k -th decision-making unit.

The synthetic input indicators vector (I_k) can also be depicted as shown in Equation (6):

$$[I_1, I_2, \dots, I_m] \quad (6)$$

Step 4. Development of the partial efficiency matrix E

At this stage of the approach, the matrix of partial efficiencies for the decision units, E , is calculated using Equation (7).

$$E = [e_{ik}] = \begin{bmatrix} e_{11} & e_{12} & \cdots & e_{1m} \\ e_{21} & e_{22} & \cdots & e_{2m} \\ \vdots & \vdots & \ddots & \vdots \\ e_{n1} & e_{n2} & \cdots & e_{nm} \end{bmatrix} \quad (7)$$

where:

- E is the matrix of partial efficiencies of the analyzed decision-making units;
- $i=1, 2, \dots, m$ —denotes the partial efficiency indicator;
- $k=1, 2, \dots, n$ —denotes the decision-making units;
- e_{ik} is the i -th partial efficiency indicator for the k -th decision-making unit.

Partial efficiencies e_{ik} are determined using Formula (8).

$$e_{ik} = \frac{r_{ik}^*}{I_k} \quad (8)$$

where:

- r_{ik}^* is the rescaled value of the i -th result for the k -th object;
- I_k is the value of the synthetic input metric for the k -th entity.

The economic significance of the partial efficiencies e_{ik} is to assess the effectiveness of a unit in converting inputs into scaled outcomes, reflecting its capacity for efficient resource management and productivity.

Step 5. Establishing the reference and counter-reference vectors for partial efficiencies. The reference and anti-reference vectors are presented in forms (9) and (10), respectively.

$$REF = \begin{bmatrix} e_{1\max} \\ e_{2\max} \\ \vdots \\ e_{n\max} \end{bmatrix} \quad (9)$$

$$AREF = \begin{bmatrix} e_{1\min} \\ e_{2\min} \\ \vdots \\ e_{n\min} \end{bmatrix} \quad (10)$$

In the reference vector, the highest values for each partial efficiency are included, regardless of which object (country) achieved them. In the anti-reference vector, the lowest values for each partial efficiency are compiled, regardless of which object (country) achieved them.

Step 6. Normalizing the partial efficiency matrix E to fall within the range of (0, 1).

In the method's sixth phase, the components of the partial efficiency matrix E^* are scaled to fall within the (0, 1) range as per Equation (11).

$$e_{ik}^* = \frac{[e_{ik} - \min(e_{ik})] \cdot (e_{\max}^* - e_{\min}^*)}{\max(e_{ik}) - \min(e_{ik})} + e_{\min}^* \quad (11)$$

where:

- $\min(e_{ik})$ is the minimum value of the i -th partial efficiency among all objects;
- $\max(e_{ik})$ is the maximum value of the i -th partial efficiency among all objects;
- $e_{\max}^*$ is the presumed highest value of normalized partial efficiency;
- $e_{\min}^*$ is the presumed lowest value of normalized partial efficiency.

Step 7. Calculating the Synthetic Efficiency Indicator for Economic Expansion for each entity.

The SEI-EG can be represented on a radar chart. A radar chart is created with as many vertices as there are partial efficiencies. The value of SEI-EG constitutes the area of the figure formed by connecting points (representing the values of successive partial efficiencies) on each axis of the radar chart for the analyzed object relative to the maximum area determined by the reference vector. The value of the indicator falls within the range $<0, 1>$. Thus, the indicator represents a particular case of a whitening function and, for the k -th object, it is determined using Formula (12).

$$f(E^*) = \frac{S_k}{S_{REF}} \quad (12)$$

where:

- $f(E^*)$ is the whitening function (assigns a white value to a grey number);
- S_k is the area of the polygon determined by values from the vector describing standardized partial efficiencies of the k -th object;
- S_{REF} is the area of the polygon determined by values from the standardized reference vector.

The area S_k can be determined using the method for calculating the areas of polygons (13).

$$F = \frac{1}{2} \left| \sum_{i=1}^n X_i (Y_{i+1} - Y_{i-1}) \right| \quad (13)$$

where:

- F is the calculated area;
- X_i, Y_i are coordinates of the i -th vertex (vertices are sequentially numbered from 1 to n).

Using this formula to calculate the area S_k is justified in the SEI-EG indicator computation as it allows for the precise quantification of the geometric space enclosed by the polygon formed by the indicator's multidimensional data points, thereby providing a clear, mathematical measure of efficiency represented within a defined parameter space.

In the presented article, for the group of countries under study, the point-biserial correlation coefficient will be calculated to quantitatively determine the relationship between membership in the eurozone and the value of the SEI-EG indicator. To determine this relationship, Formula (14) will be used.

$$r_{pb} = \frac{M_1 - M_0}{\sigma} \cdot \sqrt{\frac{n_1 \cdot n_2}{n^2}} \quad (14)$$

where:

- r_{pb} is the point-biserial correlation coefficient;
- M_1 is the mean value of the SEI-EG coefficient for a country belonging to the eurozone;
- M_0 is the mean value of the SEI-EG coefficient for a country not belonging to the eurozone;
- σ is the standard deviation of the SEI-EG coefficient;
- n_1 is the number of countries in the eurozone (included in the study);
- n_2 is the number of countries not in the eurozone (included in the study);
- n is the total number of observations.

4. Research Results and Their Discussion

The research period covers the years 2019–2021 and directly reflects the cumulative economic effects of two global crises. Simultaneously, the period between the 2008 and 2019 crises was pivotal for making decisions to counteract climate warming, initiated by the climate summit in Paris in 2015 [31] and continued through the European Parliament's decisions to shorten the distance from 2050 to 2030 for achieving climate neutrality. The Paris Agreement on climate change represents the first worldwide and legally enforceable global agreement on climate. It was signed on 22 April 2016, and the European Union ratified it on 5 October 2016 [32]. Additionally, the Sustainable Development Goals (SDGs) were established by the United Nations in agreement with 195 countries. All these circumstances have influenced the economic situation of the European Union countries, particularly in the context of a union of multiple currencies. In recent years, the expansion process has stalled. One of the fundamental divisions in the EU currently runs between the eurozone and eight countries with their own currencies [33]. Currently, Bulgaria shows the greatest determination to join the eurozone.

Bulgaria is probably unique regarding adopting the euro as its national currency because the euro serves as its reserve currency. For 25 years, Bulgaria operated under a currency board system [34]. The primary differences between the EU 27 countries in 2019–2021 are illustrated by data on GDP per capita (in market prices) and the pace of economic growth on the one hand and Maastricht criteria indicators, mainly concerning budget deficits and national debt, on the other. The former data define the economic potential of individual countries, while the latter define the cumulative effects of the 2008 and 2019 crises in the financial sphere. Extreme differences in GDP per capita within eurozone countries in 2019 ranged from EUR 100,700 (Luxembourg) to EUR 17,100 in Greece. After declines in all countries during the crisis year of 2020, recoveries in 2021 were respectively from EUR 113,050 (Luxembourg) to EUR 17,060 (Greece). This multiple increased from 5.9 to 6.6, as the wealthiest Luxembourg clearly increased its GDP pc while Greece was the only country in this group that did not rebuild its GDP pc potential relative to 2019 [35].

In contrast, the pace of economic growth in the eurozone fell most sharply in 2020 compared with the previous year in the so-called southern countries (Spain, minus 11.3; Italy, minus 9.0; Greece, minus 9.0; Portugal, minus 8.3). For comparison, in 2009 compared with the previous year, the deepest drops in the pace of economic growth were recorded by the Baltic States (Estonia, minus 14.3; Latvia, minus 14.3; Lithuania, minus 14.8), which were not yet in the eurozone. In non-euro countries, the corresponding figures in 2019 ranged from EUR 53,210 (Denmark) to EUR 8820 (Bulgaria). After declines in most countries (except Bulgaria, Denmark, and Sweden) in the crisis year of 2020, in 2021 they were respectively EUR 58,590 (Denmark) and EUR 10,330 (Bulgaria). This multiple, unlike in the eurozone, decreased from 6.0 to 5.7 [35]. Complementary significant indicators for assessing the economic situation of both groups of countries pertain to three Maastricht criteria: inflation, budget deficit, and national debt. The relevant data for the chosen research period for eurozone countries are presented in Table 1, and for non-euro countries in Table 2.

Table 1. Selected Maastricht Indicators in Euro Area Countries: 2019–2021.

Euro Area Countries	Years			Years			Years		
	2019	2020	2021	2019	2020	2021	2019	2020	2021
	Inflation			Budget Deficit			National Debt		
Austria	2.2	2.1	1.5	0.6	−8.0	−5.8	70.6	83.0	82.5
Belgium	2.2	2.1	1.2	−2.0	−8.9	−5.4	97.6	111.8	108.0
Cyprus	0.7	0.8	0.5	0.9	−5.7	−1.9	93.0	114.9	99.3
Estonia	3.7	3.4	2.3	0.1	−5.4	−2.5	8.5	18.6	17.8
Finland	1.1	0.4	2.1	−0.9	−5.6	−2.8	69.4	74.7	72.5
France	1.2	2.1	1.3	−3.1	−9.0	−6.5	97.4	114.6	112.9
Germany	1.7	1.9	1.4	1.5	−4.3	−3.6	59.6	68.8	69.0
Greece	1.1	0.8	0.5	−3.1	−10.1	−6.7	180.6	207.0	195.0
Ireland	0.3	0.7	0.9	0.9	−9.7	−7.0	57.1	58.1	54.4
Italy	1.3	1.2	0.6	−1.5	−9.6	−8.8	134.2	154.9	147.1
Latvia	2.9	2.6	2.7	−0.5	−4.5	−7.2	36.7	42.2	44.0
Lithuania	3.7	2.5	2.2	0.5	−6.5	−1.1	35.8	46.2	43.4
Luxembourg	2.1	2.0	1.6	2.2	−3.4	0.6	22.4	24.6	24.5
Malta	1.3	1.7	1.5	0.5	−9.6	−7.5	40.0	52.2	54.0
Netherlands	1.3	1.6	2.7	1.8	−3.7	−2.2	48.6	54.7	51.7
Portugal	1.6	1.2	0.3	0.1	−5.8	−2.9	116.6	134.9	124.5
Slovakia	1.4	2.5	2.8	−1.2	−5.4	−5.2	48.0	58.0	61.1
Slovenia	1.6	1.9	1.7	0.7	−7.6	−4.6	65.4	79.6	74.4
Spain	2.0	1.7	0.8	−3.1	−9.0	−6.5	98.2	120.3	116.8

Source: [35].

Table 2. Selected Maastricht Indicators in Non-Euro Area Countries: 2019–2021.

Non-Euro Area Countries	Years			Years			Years		
	2019	2020	2021	2019	2020	2021	2019	2020	2021
	Inflation			Budget Deficit			National Debt, % GDP		
Bulgaria	1.2	2.6	2.5	2.1	−3.8	−4.0	20.0	24.6	23.9
Czechia	2.4	2.0	2.6	0.3	−5.8	−5.1	30.0	37.7	42.0
Denmark	1.1	0.7	0.7	4.1	0.4	4.1	33.7	42.3	36.0
Croatia	1.3	1.6	0.8	0.2	−7.3	−2.5	70.9	86.8	78.1
Hungary	2.4	2.9	3.4	−2.0	−7.6	−7.2	65.3	79.3	76.7
Poland	1.6	1.2	2.1	-	-	-	45.7	57.2	53.6
Romania	1.1	4.1	3.9	−4.3	−9.3	−7.2	35.1	46.8	48
Sweden	1.7	0.7	2.7	0.5	−2.8	0.0	35.6	39.9	36.5

Source: [35].

The presented data indicate the combined effect of both crises in the form of an increase in the budget deficit and national debt beyond the Maastricht criteria in many countries,

not only in the “southern” countries. These exceedances are visible in both groups of countries and, apart from Greece, Portugal, Italy, and Spain, are also apparent in highly developed countries like Belgium and France. However, it is noteworthy that there was significantly greater financial discipline during the examined period in the non-euro area group. The Maastricht criterion breach, which stipulates limiting national debt to 60% of GDP, applied to only two countries: Croatia and Hungary. An additional indicator that defines the recovery after both crises is the pace of economic growth. Based on OECD data, its development in 2010 and 2021 shows that these increases were clearly higher after the COVID-19 crisis than after the 2008 financial crisis in both groups of countries. The leaders in the euro area were, in order, as follows: Ireland (13.4), Greece (8.3), Slovenia (8.2), Estonia (8.0), and Italy (7.0). In the non-euro area, the leaders were as follows: Croatia (13.1), Bulgaria (7.6), and Poland (6.8) [35]. This does not so much testify to a greater autonomous capacity for monetary and fiscal policy in countries outside the euro area but to a broad support program for the entire “eurogroup”, which in recent years has started operating in an inclusive format with the participation of non-euro countries’ representatives at the finance minister level [33].

The negative experience of the economic effects following the 2008 crisis resulted in widespread support for countries, and particularly for the business sector, during the COVID-19 crisis and through special support programs after its conclusion [7,9,33]. The shock of the COVID-19 crisis also created an opportunity to reinvigorate the idea of sustainable growth in climate issues [36,37] and to establish a broad support plan by the World Bank [8]. The statistical portrayal of changes in the economic situation of the EU 27 countries, along with their division into euro countries and non-euro countries, allows for several general conclusions. First, the unprecedented situation of two global crises occurring close in time negatively impacted economic growth and public finance situations in many countries. These effects were varied and affected countries in both distinguished groups. From the standpoint of the Maastricht financial indicators, the non-euro area countries generally present a more favorable picture. This might indicate, despite a lower base in most countries in this group, greater capabilities for achieving economic convergence, including pro-sustainability convergence. The final country ranking presented in this article, concerning the efficiency of economic growth for sustainable development, seems to acknowledge this advantage. At the same time, there is a visible process of the European Union “learning its lesson” after the consequences of the 2008 crisis.

In the research, the following European Union countries were considered: Austria (o_1), Belgium (o_2), Estonia (o_3), Finland (o_4), France (o_5), Greece (o_6), Spain (o_7), The Netherlands (o_8), Ireland (o_9), Lithuania (o_{10}), Luxembourg (o_{11}), Latvia (o_{12}), Malta (o_{13}), Germany (o_{14}), Portugal (o_{15}), Slovakia (o_{16}), Slovenia (o_{17}), Italy (o_{18}), Bulgaria (o_{19}), the Czech Republic (o_{20}), Denmark (o_{21}), Poland (o_{22}), Romania (o_{23}), Sweden (o_{24}), and Hungary (o_{25}). These countries were analyzed in two groups (those that have the euro as their currency and those that do not). The research was conducted with data from 2019–2021. Cyprus and Croatia were not included in the study. Cyprus was excluded because not all the analyzed indicators have been determined for this country. Croatia was excluded because during part of the analyzed period it was outside the eurozone and for part of the period it was inside the eurozone.

Step 1. Creation of a data matrix D , which undergoes the process of whitening.

For the calculation of the SEI-EG indicator, the following metrics were adopted as outcomes in the efficiency model:

1. Gross domestic expenditure on R&D by sector (r_1)
2. R&D personnel by sector (r_2)
3. Patent applications to the European Patent Office by the applicant’s/inventor’s country of residence (r_3)
4. Share of buses and trains in inland passenger transport (r_4)
5. Tertiary educational attainment by sex (r_5)
6. High-speed internet coverage by type of area (r_6)

In the efficiency model of the SEI-EG, all indicators categorized under Goal 9—Industry, Innovation, and Infrastructure (sdg_9) were intended to serve as effects. However, due to informational gaps during the analysis period, the following indicators were omitted: Share of rail and inland waterways in inland freight transport, Air emission intensity from industry, and Gross value added in the environmental goods and services sector.

The selection of Goal 9—Industry, Innovation, and Infrastructure as the focal area of our research stems from its fundamental importance to sustainable development and economic growth within the European context. Goal 9 is directly linked to economic efficiency, innovations, and the development and modernization of infrastructure, which are pivotal for achieving sustainable development in the European Union. Furthermore, by analyzing indicators associated with this goal, we aimed to understand how effectively EU countries transform investments in research and development (R&D), infrastructure, and higher education into tangible outcomes that favor economic growth. Our choice was also motivated by previous publications on the Synthetic Efficiency Indicator for Economic Growth (SEI-EG), which have already highlighted the significance of this goal in the context of economic efficiency and innovation. Hence, Goal 9 naturally aligns with the logic of our study, which focuses on the transformation of inputs related to economic growth into outcomes for sustainable development, especially in the face of challenges and opportunities presented to EU countries by the global crisis and the debate over euro integration.

As inputs in the SEI-EG efficiency model, the following were adopted: Gross domestic product at market prices (current prices, euro per capita) (i_1) and General government gross debt (percentage of gross domestic product) (i_2). Table 3 compiles the data matrix necessary for determining the SEI-EG indicator for the example year 2021.

Table 3. Data necessary for the calculation of the SEI-EG indicator in 2021.

	o_1 (AUT)	o_2 (BEL)	o_3 (EST)	o_4 (FIN)	...	o_{22} (POL)	o_{23} (ROM)	o_{24} (SWE)	o_{25} (HUN)
r_1	3.256	3.43	1.752	2.985	...	1.432	0.473	3.402	1.642
r_2	1.9371	2.3283	1.0293	2.1085	...	1.1021	0.4218	2.1736	1.2933
r_3	2309	2480	69	2108	...	522	31	4947	119
r_4	18.8	14.4	10.7	12.3	...	13.7	17.0	15.9	20.7
r_5	42.4	50.9	43.2	40.1	...	40.6	23.3	49.3	32.9
r_6	45.4	68.9	74.9	73.4	...	72.4	66.7	68	82.5
i_1	45,270	43,820	23,430	45,280	...	15,100	12,630	51,910	15,860
i_2	101.59	128.41	24.34	82.24	...	68.01	57.35	58.87	88.66

All of the indicated variables are stimulants.

Step 2. Development of the matrix of rescaled input data D^* .

By applying Formulas (3) and (4), the variables from the first step were recalibrated (see Table 4).

Table 4. Matrix of rescaled input data for 2021.

	o_1 (AUT)	o_2 (BEL)	o_3 (EST)	o_4 (FIN)	...	o_{22} (POL)	o_{23} (ROM)	o_{24} (SWE)	o_{25} (HUN)
r_1	0.949	1.000	0.511	0.870	...	0.417	0.138	0.992	0.479
r_2	0.832	1.000	0.442	0.906	...	0.473	0.181	0.934	0.555
r_3	0.089	0.096	0.003	0.081	...	0.020	0.001	0.191	0.005
r_4	0.908	0.696	0.517	0.594	...	0.662	0.821	0.768	1.000
r_5	0.677	0.813	0.690	0.641	...	0.649	0.372	0.788	0.526
r_6	0.454	0.689	0.749	0.734	...	0.724	0.667	0.680	0.825
i_1	0.400	0.388	0.207	0.401	...	0.134	0.112	0.459	0.140
i_2	0.452	0.572	0.108	0.366	...	0.303	0.255	0.262	0.395

Step 3. Creation of the synthetic input indicator vector I_k for all units.

The vector of synthetic input indicators I_k for all countries is as follows:

$$I_k = [0.85; 0.96; 0.32; 0.77; 0.94; 1.15; 0.86; 0.73; 1.05; 0.40; 1.14; 0.41; 0.50; 0.74; 0.82; 0.51; 0.62; 1.04; 0.24; 0.41; 0.74; 0.44; 0.37; 0.72; 0.53]$$

Step 4. Development of the matrix of partial efficiencies E .

Table 5 presents the developed matrix of partial efficiencies E for the year 2021.

Table 5. Matrix of partial efficiencies E for the year 2021.

	o_1 (AUT)	o_2 (BEL)	o_3 (EST)	o_4 (FIN)	...	o_{22} (POL)	o_{23} (ROM)	o_{24} (SWE)	o_{25} (HUN)
e_1	1.113	1.043	1.618	1.135	...	0.957	0.376	1.375	0.895
e_2	0.976	1.043	1.401	1.181	...	1.085	0.494	1.294	1.038
e_3	0.105	0.100	0.008	0.106	...	0.046	0.003	0.265	0.009
e_4	1.065	0.725	1.638	0.775	...	1.517	2.238	1.065	1.869
e_5	0.794	0.848	2.187	0.836	...	1.486	1.014	1.092	0.982
e_6	0.532	0.718	2.373	0.957	...	1.659	1.817	0.943	1.542

Step 5. Establishing the reference and counter-reference vectors for partial efficiencies.

The empirical reference vector (REF) is as follows:

$$REF = [1.618, 1.689, 1.357, 2.238, 2.284, 2.949]$$

The empirical anti-reference vector (AREF) is defined as follows:

$$AREF = [0.267, 0.494, 0.002, 0.512, 0.437, 0.172]$$

Step 6. Normalizing the partial efficiency matrix E to fall within the range of (0, 1).

Table 6 presents the results of standardizing the partial efficiency matrix E to the range (0, 1).

Table 6. Standardized matrix of partial efficiencies E for 2020.

	o_1 (AUT)	o_2 (BEL)	o_3 (EST)	o_4 (FIN)	...	o_{22} (POL)	o_{23} (ROM)	o_{24} (SWE)	o_{25} (HUN)
e_1^*	0.626	0.574	1.000	0.643	...	0.511	0.081	0.820	0.465
e_2^*	0.403	0.459	0.759	0.575	...	0.494	0.000	0.670	0.456
e_3^*	0.076	0.072	0.005	0.077	...	0.033	0.001	0.194	0.005
e_4^*	0.321	0.124	0.652	0.153	...	0.582	1.000	0.321	0.787
e_5^*	0.194	0.223	0.947	0.216	...	0.568	0.313	0.355	0.295
e_6^*	0.130	0.197	0.793	0.283	...	0.536	0.593	0.278	0.493

In the standardized reference vector, values of 1.00 will be present for each of the partial efficiencies. In the anti-reference vector, on the other hand, there will be values of 0.00.

Step 7. Calculating the Synthetic Efficiency Indicator for Economic Expansion for each entity.

Table 7 presents the values of the SEI-EG indicator for all analyzed countries in 2019, 2020, and 2021.

Table 7. Values of the SEI-EG indicator for the analyzed countries in the years 2019–2021.

	SEI-EG ₂₀₁₉	SEI-EG ₂₀₂₀	SEI-EG ₂₀₂₁
Austria (o_1)	0.052	0.067	0.079
Belgium (o_2)	0.051	0.061	0.082
Estonia (o_3)	0.448	0.421	0.488
Finland (o_4)	0.083	0.105	0.117
France (o_5)	0.036	0.057	0.060
Greece (o_6)	0.001	0.001	0.000
Spain (o_7)	0.025	0.028	0.031
Netherlands (o_8)	0.076	0.096	0.110
Ireland (o_9)	0.009	0.012	0.011
Lithuania (o_{10})	0.106	0.110	0.125

Table 7. Cont.

	SEI-EG ₂₀₁₉	SEI-EG ₂₀₂₀	SEI-EG ₂₀₂₁
Luxembourg (o ₁₁)	0.002	0.005	0.005
Latvia (o ₁₂)	0.170	0.202	0.176
Malta (o ₁₃)	0.072	0.087	0.091
Germany (o ₁₄)	0.219	0.219	0.223
Portugal (o ₁₅)	0.009	0.016	0.032
Slovakia (o ₁₆)	0.127	0.129	0.115
Slovenia (o ₁₇)	0.119	0.119	0.141
Italy (o ₁₈)	0.006	0.007	0.008
Bulgaria (o ₁₉)	0.516	0.523	0.464
Czech Republic (o ₂₀)	0.351	0.384	0.367
Denmark (o ₂₁)	0.124	0.128	0.148
Poland (o ₂₂)	0.160	0.152	0.199
Romania (o ₂₃)	0.096	0.090	0.091
Sweden (o ₂₄)	0.143	0.169	0.197
Hungary (o ₂₅)	0.089	0.112	0.138

Table 8 shows the ranking of countries for the period 2019–2021 based on the SEI-EG.

Table 8. Ranking of countries for the years 2019–2021 based on the SEI-EG indicator value.

2019			2020			2021		
1	Bulgaria (o ₁₉)	0.516	1	Bulgaria (o ₁₉)	0.523	1	Estonia (o ₃)	0.488
2	Estonia (o ₃)	0.448	2	Estonia (o ₃)	0.421	2	Bulgaria (o ₁₉)	0.464
3	Czech Republic (o ₂₀)	0.351	3	Czech Republic (o ₂₀)	0.384	3	Czech Republic (o ₂₀)	0.367
4	Germany (o ₁₄)	0.219	4	Germany (o ₁₄)	0.219	4	Germany (o ₁₄)	0.223
5	Latvia (o ₁₂)	0.170	5	Latvia (o ₁₂)	0.202	5	Poland (o ₂₂)	0.199
6	Poland (o ₂₂)	0.160	6	Sweden (o ₂₄)	0.169	6	Sweden (o ₂₄)	0.197
7	Sweden (o ₂₄)	0.143	7	Poland (o ₂₂)	0.152	7	Latvia (o ₁₂)	0.176
8	Slovakia (o ₁₆)	0.127	8	Slovakia (o ₁₆)	0.129	8	Denmark (o ₂₁)	0.148
9	Denmark (o ₂₁)	0.124	9	Denmark (o ₂₁)	0.128	9	Slovenia (o ₁₇)	0.141
10	Slovenia (o ₁₇)	0.119	10	Slovenia (o ₁₇)	0.119	10	Hungary (o ₂₅)	0.138
11	Lithuania (o ₁₀)	0.106	11	Hungary (o ₂₅)	0.112	11	Lithuania (o ₁₀)	0.125
12	Romania (o ₂₃)	0.096	12	Lithuania (o ₁₀)	0.110	12	Finland (o ₄)	0.117
13	Hungary (o ₂₅)	0.089	13	Finland (o ₄)	0.105	13	Slovakia (o ₁₆)	0.115
14	Finland (o ₄)	0.083	14	Netherlands (o ₈)	0.096	14	Netherlands (o ₈)	0.110
15	Netherlands (o ₈)	0.076	15	Romania (o ₂₃)	0.090	15	Romania (o ₂₃)	0.091
16	Malta (o ₁₃)	0.072	16	Malta (o ₁₃)	0.087	16	Malta (o ₁₃)	0.091
17	Austria (o ₁)	0.052	17	Austria (o ₁)	0.067	17	Belgium (o ₂)	0.082
18	Belgium (o ₂)	0.051	18	Belgium (o ₂)	0.061	18	Austria (o ₁)	0.079
19	France (o ₅)	0.036	19	France (o ₅)	0.057	19	France (o ₅)	0.060
20	Spain (o ₇)	0.025	20	Spain (o ₇)	0.028	20	Portugal (o ₁₅)	0.032
21	Portugal (o ₁₅)	0.009	21	Portugal (o ₁₅)	0.016	21	Spain (o ₇)	0.031
22	Ireland (o ₉)	0.009	22	Ireland (o ₉)	0.012	22	Ireland (o ₉)	0.011
23	Italy (o ₁₈)	0.006	23	Italy (o ₁₈)	0.007	23	Italy (o ₁₈)	0.008
24	Luxembourg (o ₁₁)	0.002	24	Luxembourg (o ₁₁)	0.005	24	Luxembourg (o ₁₁)	0.005
25	Greece (o ₆)	0.001	25	Greece (o ₆)	0.001	25	Greece (o ₆)	0.000

Countries not belonging to the eurozone are marked in gray.

In Table 8, countries not belonging to the eurozone are marked in gray. Regardless of the year analyzed, Bulgaria, Estonia, and the Czech Republic are always in the top three. In 2019 and 2020, Bulgaria led the ranking, followed by Estonia and the Czech Republic. In 2021, Estonia topped the list, ahead of Bulgaria and the Czech Republic. Greece, Luxembourg, Italy, and Ireland were consistently at the bottom of the SEI-EG ranking in all years.

The notable disparities in SEI-EG values observed across different countries, particularly the elevated values for Bulgaria and Estonia, can be substantially attributed to their

fiscal prudence, characterized by low budget deficits and public debt during the study period. This fiscal discipline has been instrumental in their ability to finance sustainable development goal (SDG) initiatives. Estonia, within the euro area, stands out for its minimal public debt and one of the lowest budget deficits, which underscores its efficient allocation of resources toward SDG-related projects. Conversely, Bulgaria, among the non-euro area countries, maintained the lowest public debt over the three years under review, enhancing its capacity to fund SDG endeavors.

Furthermore, Bulgaria's unique motivation to adopt the euro has spurred its commitment to SDG implementation, reflected in its active pursuit of SDG objectives despite starting from a lower baseline. This contrasts with Estonia, which, despite a higher initial SDG performance baseline, saw a reduction in its SDG activity. This dynamic highlights how fiscal health and strategic priorities toward economic integration and SDG fulfillment significantly influence a country's efficiency in translating economic growth inputs into sustainable development outcomes as measured by the SEI-EG indicator.

To quantitatively determine the relationship between being in the eurozone and the value of the SEI-EG indicator, the point-biserial correlation coefficient was used. The results of this indicator are compiled in Table 9.

Table 9. Value of the point-biserial correlation coefficient between being in the eurozone and the SEI-EG indicator value for the years 2019–2021 for the analyzed countries.

Year	2019	2020	2021
r_{pb}	−0.417	−0.434	−0.435

In each of the analyzed years, the point-biserial correlation coefficient between being in the eurozone and the SEI-EG indicator value ranged from −0.417 to −0.435, indicating a negative correlation between being in the eurozone and the value of the SEI-EG indicator. This means that countries outside the eurozone, on average, demonstrate higher SEI-EG efficiency indicators than eurozone countries. Thus, the hypothesis posed in the article is confirmed.

5. Findings

In this article, values of the proprietary Synthetic Efficiency Indicator for Economic Growth (SEI-EG) were determined for European Union countries for the period 2019–2021. It was then confirmed that countries not belonging to the eurozone exhibited higher efficiency for sustainable development as measured by the SEI-EG indicator during the studied period. To verify this hypothesis, the point-biserial correlation coefficient was used. It turned out that the value of this statistic fluctuated between −0.417 and −0.435 during the studied period, indicating a moderate strength of the analyzed relationship.

Over these years, Bulgaria and Estonia, which are not part of the eurozone, often occupied leading positions in the ranking, which may suggest their higher efficiency in sustainable development. Nevertheless, some variability in the rankings can be observed, which could be associated with diverse economic and political factors influencing individual countries.

This article confirms that the developed indicator can serve as a measure of efficiency in achieving sustainable development outcomes in a European context. It can be regarded as a measure of pro-sustainability convergence and is related to the European Union as a whole. Its advantages are its independence from any socio-economic conditions and its limitation to only selected economic and financial indicators, without considering all sustainable development goals. The limitation of the developed method is the relative nature of the indicator.

It is important to emphasize the potential practical applications of the research findings. This study, focusing on the Synthetic Efficiency Indicator for Economic Growth (SEI-EG) and its implications for sustainable development within the European Union, suggests that these findings could be instrumental in shaping economic policies. They provide insights

into the areas where non-eurozone countries have demonstrated higher efficiency, which could serve as a benchmark for eurozone countries. The future expansion of the research to include actionable economic policies and strategies could further enhance the utility and relevance of the SEI-EG in real-world applications and decision-making.

Future research may involve refining the developed indicator, mainly by expanding the list of inputs and effects, prioritizing selected indicators, and giving it a dynamic, time-comparable character. This article supports the calls for a re-evaluation of the SDG indicators in terms of their utility, relevance, and update over time.

Author Contributions: Conceptualization, M.N. and M.K.; Methodology, M.N. and M.K.; Investigation, M.N. and M.K. All authors have read and agreed to the published version of the manuscript.

Funding: This study was funded by the research project of the Faculty of Engineering Management, Poznan University of Technology, 0811/SBAD/1074, entitled “Application of selected machine learning methods in management 4.0”, led by Marcin Nowak.

Data Availability Statement: Data are contained within the article.

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

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