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An investigation of the interlinkages between green growth dimensions, the energy trilemma, and sustainable development goals: Evidence from G7 and E7 economies

Związek między wymiarami zielonego wzrostu, trylematem energetycznym i celami zrównoważonego rozwoju: analiza gospodarek G7 i E7

Abstract

Green growth dimensions, the energy trilemma, and accomplishing sustainable development goals have recently emerged as crucial topics in modern economics. This article examines the significance of green growth dimensions and the energy trilemma for achieving sustainable development goals (SDGs), as well as the effectiveness of the measures of green growth and the green energy transition in the G7 and E7 economies. The research was conducted by employing a range of methodological assessment instruments. This study contributes to our existing knowledge by highlighting the importance of green growth dimensions, the energy trilemma, and SDGs by exploring the interlinkages among the crucial indicators in the G7 and E7 economies. The results could be of assistance to policymakers, governments, and legislators. The diversity in rating positions between significant variables is the basis for the future approval of green and energy policies in G7 and E7 economies.

Keywords: sustainable development goals (SDGs), investigation of interlinkages, green growth dimensions, energy trilemma, G7 and E7 economies.

JEL: O40, O57, Q01, Q40, Q50

Streszczenie

Wymiary zielonego wzrostu, trylemat energetyczny i osiąganie celów zrównoważonego rozwoju stały się ostatnio kluczowymi tematami współczesnej ekonomii. W artykule zbadano znaczenie wymiarów zielonego wzrostu i trylematu energetycznego dla osiągnięcia celów zrównoważonego rozwoju (SDGs), a także skuteczność miar zielonego wzrostu i przejścia na zieloną energię w gospodarkach G7 i E7. W badaniu wykorzystano szereg metodologicznych narzędzi oceny. Niniejsze badanie wnosi wkład w naszą obecną wiedzę, podkreślając znaczenie wymiarów zielonego wzrostu, trylematu dotyczącego energii i celów zrównoważonego rozwoju poprzez badanie wzajemnych powiązań między kluczowymi wskaźnikami w gospodarkach G7 i E7. Wyniki mogą być pomocne dla decydentów, rządów i prawodawców. Różnorodność stanowisk ratingowych pomiędzy istotnymi zmiennymi stanowi podstawę przyszłego zatwierdzania polityk ekologicznych i energetycznych w gospodarkach G7 i E7.

Słowa kluczowe: cele zrównoważonego rozwoju (SDGs), badanie wzajemnych powiązań, wymiary zielonego wzrostu, trylemat energetyczny, gospodarki G7 i E7.

JEL: O40, O57, Q01, Q40, Q50

1. Introduction

In today›s increasingly globalized economy, green growth dimensions, the energy trilemma, and SDGs feature prominently in economics research. The international research sector has been focusing on green growth, the energy trilemma, and achieving SDGs in the context of implementing ecological solutions and transitioning to green energy. However, most of the recently published academic papers do not extensively examine these topics on account of the diversity of their characteristics. This paper explores the relationships between parameters of the green growth dimensions, including the efficient and sustainable resource use (ESRU) index, the natural capital protection (NCP) index, the green economic opportunities (GEO) index, the social inclusion (SI) index, the energy trilemma index (ETI), gross domestic product (at purchasing power parity) per capita (GDP [PPP] per capita), and the sustainable development goals (SDG) index, in the G7 and E7 economies.

The present study employs green growth dimensions, the energy trilemma index, and the SDG index to draw attention to the specific characteristics of green growth in implementing ecological solutions, transitioning to green energy, and bringing about sustainable growth and development. Over the past ten years, a sizable number of researchers have been investigating green growth, sustainable growth and development, (Acosta et al., 2020; Abid et al., 2022; Capasso et al., 2019; Jänicke, 2012; Fernandes et al., 2021; Bowen et al., 2018; Fouquet, 2019; Nogueira, 2019; Sachs et al., 2019; Sachs et al., 2023; OECD, 2017; Zhang & Zhu, 2020; GGGI, 2022; Terzić, 2022; Terzić, 2023a; Terzić, 2023b), the energy trilemma, and the green energy transition (WEC, 2022a; Jain & Goswani, 2021; Khan et al., 2021; Liu et al., 2022).

However, recent investigations have tended to overlook the significance of green growth dimensions and the ETI in achieving SDGs in the G7 and E7 economies. The studies conducted to date focus on particular measures and attempt to explain the differences in green growth, green energy transition, and sustainable development between countries in terms of e.g., renewable energy sources, green energy technologies, economic growth, degrowth, low carbon dioxide emissions, and energy use. The present study contributes a comparative investigation of the interlinkages between the measures of green growth, the energy trilemma, and sustainable development. It examines the interlinkages between green growth dimensions, the energy trilemma index, and the SDG index in the G7 and E7 economies by utilizing various methodological assessment tools. Spearman›s rank correlation coefficient is used to gauge the strength and direction of the significant correlations between important variables. The rho (ρ) test is used to assess the statistical significance of the Spearman associations, as is usually done on ordinal variables with normal distributions.

The interlinkages between the ESRU index, the NCP index, the GEO index, the SI index, the ETI, GDP (PPP) per capita, and the SDG index were examined using Spearman›s rank correlation coefficients. The results should prove useful to policymakers, governments, and legislators. The distinctions in how important factors are ranked and prioritized can be used to lay the groundwork for future assessments of green growth dimensions, the energy trilemma, and SDGs, and can also be of assistance in developing strategies to accelerate green growth and green energy transitions in the G7 and E7 economies. The present paper is divided into five sections. Section 2 explains the theoretical underpinnings of the research conducted to date on green growth dimensions, the energy trilemma, and SDGs. Section 3 details the research methodology, the data, and the instruments used to evaluate the variables and key metrics. Section 4 clarifies and discusses the results. Section 5 presents the conclusions.

2. A theoretical summary of the literature on green growth dimensions, the energy trilemma, and SDGs

In the past decade, numerous researchers have argued that classical economic frameworks will have to be radically altered before such pressing social and economic issues as decreasing environmental quality, imbalanced ecosystems, and water pollution can effectively be addressed. The concepts of green growth and sustainable development were developed as a consequence of these arguments (Daly, 1996; Jänicke, 2012; Bartelmus, 2013; Kasztelan, 2017; Fouquet, 2019; O'Neill, 2020; OECD, 2020; Abid et al., 2022). The 2030 Agenda for the Sustainable Development Goals acknowledges that efforts to reduce wealth disparities need to be balanced with those that encourage sustainable development (GSDR, 2019). Nevertheless, a fully sustainable economy is one in which economic activity does not harm biological ecosystems (D'Amato, 2021; Capasso et al., 2019; Sachs et al., 2023). The most recent analyses of the green economic paradigm address its theoretical underpinnings, the political context, and green growth and sustainable development initiatives (Bartelmus, 2013; Kasztelan, 2017; Heshmati, 2018; Fouquet, 2019; Capasso et al., 2019; Terzić, 2023). Green growth refers to promoting economic growth and development while conserving the natural resources that deliver the environmental and resource benefits essential for human wellbeing (OECD, 2017). Many worldwide affiliations, such as the Global Green Growth Institute and the World Energy Council (WEC), as well as several industry groups, are working towards worldwide carbon neutrality (an SDG), although there are regulatory hurdles that need to be removed in order to facilitate a shift towards low-carbon emissions. Many researchers have recently been focusing on analyzing the numerous facets of the transition to green and energy-efficient economies. A number of studies have examined various factors and measures that influence the effectiveness of green energy transitions. Green growth aims to create prosperous, resource-effective, biodiverse, and carbon-neutral economies (Bowen et al., 2016).

Carbon neutrality, resilience, ecosystem wellbeing, and comprehensive growth were used to set up connections between the four aspects of green growth (Acosta et al., 2020). The concepts mentioned above were shown to help determine which of the four groups of green growth dimensions corresponded to each aspect. These can be considered the "pillars" that support green growth. They serve as the foundation for the transition towards resource consumption that is effective and environmentally responsible, and which improves the preservation of natural capital by creating green economic prospects and facilitating social participation.

The Global Green Growth Index (GGGI) is composed of the following four elements: (i) efficient and sustainable resource use; (ii) NCP; (iii) GEOs; and (iv) social inclusion (GGGI, 2022). Achieving SDGs is contingent on those GGGI elements that contribute to green growth (Acosta et al., 2019a). The GGGI is a multifaceted green growth measure with an undisputed link to sustainable development. The GGGI interlinks a country's green growth and sustainability goals. It is essential that the GGGI be significant nationally and internationally. The conceptual frameworks of a low-carbon economy, a resilient society, a healthy ecosystem, and inclusive growth were used to determine the connections between the four green growth elements (Acosta et al., 2019a).

The GGGI elements can be defined as the "pillars" of green growth. They serve as the cornerstone of the shift towards efficient and sustainable resource consumption by enhancing NCP, creating green business opportunities, and facilitating social engagement. The four-dimensional GGGI framework is divided into the two environmental pillars of ESRU and NCP. These two distinct environmental imperatives underscore the need for a multipronged policy approach in order to enhance efficiency and protection, i.e. the two prerequisites for achieving green growth.

The economic dimension additionally reflects the "green" elements of growth, particularly in terms of GEOs, with indicator subcategories pertaining to green employment, green commerce, green investment, and green innovation. GEOs are anticipated to foster social inclusiveness, lead to more efficient use of resources, and preserve natural wealth. The GGGI framework and the selected indicators are consonant with the GGGI definition of green growth.

Efficient and sustainable resource use the first GGGI element, consists of: (i) efficient and sustainable energy; (ii) efficient and sustainable water consumption; (iii) sustainable land use; and (iv) efficient material consumption. NCP, the second element, consists of: (i) environmental quality; (ii) greenhouse gas emissions reductions; (iii) biodiversity and ecosystem protection; and (iv) cultural and social values. GEOs, the third element, consists of: (i) green investment; (ii) green trade; (iii) green employment; and (iv) green innovation. Social inclusion, the fourth element, consists of the following sub-dimensions: (i) access to basic services and resources; (ii) gender balance; (iii) social equity; and (iv) social protection (GGGI, 2022).

Sustainable utilization of resources, such as water and energy, can enhance wellbeing by consuming fewer natural resources and producing higher-quality goods in both high- and low-income economies (Shahbaz et al., 2013; IEA, 2020; Tian et al., 2022).

Examples of such practices include utilizing energy from renewable sources, implementing highly effective technologies, and recycling resources. Environmentally friendly land use is also essential for individuals, communities, and economic operations, particularly in agricultural regions where soil is a valuable resource for subsistence living (Ma et al., 2022). The enormous natural resources of many emerging economies do not suffice to increase their economic growth; they additionally need to improve their administrative efficiency (Afonso et al., 2006;

Mandl et al., 2008), better allocate resource refunds, and enhance the efficiency of other growth parameters (Daly, 1996; Timothy et al., 2005; Wang et al., 2021; Likaj et al., 2022).

As for protecting natural capital, accessibility to renewable resources underpins development and affects competitiveness, even though industrialized nations are frequently not reliant on natural resources in order to increase competitiveness and innovation (Terzić, 2023a). Many governments, of different political persuasions have therefore recently been amending their policies in order to reduce greenhouse gas emissions. Simply setting carbon reduction targets has given way to fostering a variety of both supply-side and demand-side advantages and to maintaining biodiversity by means of implementing effective environmental protection mechanisms (Zhuo et al., 2022).

Notwithstanding the disparities among high- and low-income nations, GEOs could improve the welfare of their populations via sustainable trade, green job creation, green investments, and green innovation. Economic measures that support a green economy can have direct and indirect benefits by contributing to economic growth and generating green jobs in environmentally friendly settings (Aceleanu, 2015; Bowen et al., 2018). Green trade, in tandem with innovative green technologies (Wang et al., 2022) and green investments generated by both private and public entities in energy-efficient and sustainable projects (Ren et al., 2022; Dong & Zao, 2023), might well prove indispensable to addressing the rise in emissions of greenhouse gases in order to tackle the ecological crisis and improve the general welfare (Capasso et al., 2019). Developing nations will admittedly have to invest greater amounts of money to create green economic opportunities, such as the creation of new green jobs and the provision of training, but these opportunities could potentially have a favorable impact on world economic growth (Bobylev et al., 2018).

Social inclusion varies from nation to nation, but improving it anywhere should make essential resources and services, as well as social security, more accessible, promote equality between men and women, and provide for a more equitable society. Although social inclusion is likely to have a greater positive impact on the economic growth of underdeveloped countries than on advanced ones, the latter are nevertheless more effective in this area, and have reaped the benefits on their economic growth and development (Li & Lin 2017; Terzić, 2022). Increased equality, wider access to social security, and a more equitable and proportional allocation of the necessities of life, including sanitation, drinking water, electrical power, nourishment, transportation, and housing are all necessary preconditions to enhancing wellbeing (GGGI, Global Green Growth Institute, 2022). Similarly, assigning women a greater economic role has significant consequences for society as a whole, including retirement benefits, medical care, etc. (GGGI, Global Green Growth Institute, 2022).

Acosta et al. (2020) state that the GGGI evaluates how effectively a nation has been achieving the SDGs, thereby fulfilling its obligations under the Paris Climate Agreement and meeting the Aichi Biodiversity targets. GGGI is the first index to assess green growth in a manner that is strongly associated with sustainable development. It assesses four categories: (i) green economic potential; (ii) ESRU; (iii) SI;

and (iv) NCP. Beneficial environmental outcomes that should theoretically improve welfare and general prosperity everywhere require that adequate environmental policies be developed and implemented. Moreover, a country's energy system is an essential factor in sustainable development. Several authors have found a positive relationship between energy and economic growth (Khan et al., 2021; Liu et al., 2022). Chien and Hu (2008) claim that expanding the capacity for renewable energy has a significant beneficial effect on capital creation and economic efficiency. They also found a positive relationship between renewable energy and economic growth. However, this relationship varies with a country's economic situation and income level (Akram et al., 2022). Ziolo et al. (2020) revealed that economic growth can enhance energy efficiency and reduce greenhouse gas emissions. Both sustainable economic growth (and consequently, increased efficiency) and a reduction in greenhouse gas emissions can be achieved with continuous financial support. Energy Transition (ET) measures the degree to which the energy system performs in three areas: (i) environmental sustainability; (ii) energy fairness; and (iii) security (Oliver & Sovacool, 2017).

Energy policymakers have to balance the trilemma›s competing requirements. The World Energy Trilemma Index is an annual ranking of countries in terms of energy security, energy equity, and environmental sustainability (WEC, 2022a; WEC, 2022b). The IEA (2020) defines energy security as the uninterrupted availability of energy sources at affordable prices. Energy Security assesses a country›s ability to stably fulfill present and future energy demands, cope with system fluctuations, and quickly recover from them with the least possible interruption to supply. This element subsumes the efficiency of managing internal and external renewable energy sources, along with the dependability and robustness of the infrastructure that supplies energy. Energy equity measures a nation›s capacity to offer unlimited accessibility to a substantial supply of reliable energy for household and commercial purposes. This measure includes fundamental access to power, sustainable cooking fuels, and various levels of utilization of energy that support economic growth, as well as the cost of gas, electric power, and fuels. The ecological sustainability of energy infrastructure quantifies the extent to which a country›s energy system has changed as a result of preventing, or at least reducing, negative environmental effects and the impact of global warming. Air quality, decarbonization, transmission, delivery, effectiveness, and the productivity of future generations are all emphasized.

The WEC›s ETI evaluates an economy›s ability to deliver renewable energy against the criteria of energy security, energy equity (accessibility and affordability), and environmental sustainability (WEC, 2022a). The equilibrium level, with «A» as the most effective, indicates how effectively a nation balances these competing criteria. A country's ranking reflects its overall success in developing a suite of policies to achieve sustainability. This index is used to determine the sustainability of a country's energy policies. The ETI is intended to promote a multi-stakeholder energy transition strategy that can recognize interrelationships across the entire system.

In accordance with the SDGs of the 2030 Agenda, a number of research studies aim to substantiate the significance of the goals mentioned above for a country's shift towards a green economy and its achievement of green growth. The primary objective of the most outstanding tool to discover how effectively different countries are meeting the SDGs is the SDG Index (SDGI). This index was compiled by the UN in 2015 and consists of 17 components: (i) no poverty; (ii) zero hunger; (iii) good health and wellbeing; (iv) quality education; (v) gender equality; (vi) clean water and sanitation; (vii) affordable and clean energy; (viii) decent work and economic growth; (ix) industry, innovation, and infrastructure; (x) reduced inequalities; (xi) sustainable cities and communities; (xii) responsible consumption and production; (xiii) climate action; (xiv) life below water; (xv) life on land; (xvi) peace, justice, and strong institutions; and (xvii) partnerships for the goals (Sachs et al., 2021). SDG 7 («Ensure access to Affordable, Reliable, Sustainable and Modern Energy for All") (United Nations, 2015) is crucial for general welfare, and especially for economic growth and the reduction of poverty (United Nations, 2023).

The SDG index shows a country›s performance in relation to the highest achievable score for each SDG. It registered a notable decrease in the 2021 Sustainable Development Goals Report, primarily on account of the COVID-19 pandemic. The current economic situation has a direct impact on the three aspects of sustainable development that require the implementation of measures to foster economic growth and achieve the SDGs (Sachs et al., 2021).

Merino-Saum et al. (2018) used 494 green economy indicators drawn from twelve distinct frameworks that focus on the green economy and green growth to ascertain the link between the SDGs and natural resource utilization. the assessment of the green economy variables revealed that each of the SDGs is connected to at least one natural resource. Powerful interlinkages of varying magnitudes were also identified. Terzić (2023a) revealed the positive relationships between green and digital transitions by exploring the interconnections among the parameters of innovation, economic resilience, and SME competitiveness in EU economies. Moreover, Kasztelan (2021) used an artificial assessment score derived from the green economy indicators to highlight the significance of the green economy›s adoption in EU countries between 2000 and 2018.

The results show that low resource productivity, social marginalization, and insufficient energy efficiency have delayed greening activities. Nevertheless, China has proved to be a remarkable role model for achieving notable green growth and advancing sustainable development (Linster & Yang, 2018; Dong et al., 2023; Zhao et al., 2022). Terzić (2023b) highlights the significance of transitioning to a green economy to sustainability by reviewing the findings of the theoretical approaches and empirical research. In this context, the author reveals the positive interrelations between environmental performance indicators, the green economy, the green future, and green growth in G7 and E7 economies. In addition to technological advancements and GDP growth, the framework for the Lin and Zhou Green Economy Index (2022) identifies social advancement and environmental civilization as the primary drivers of green economic growth. The Strong Environmental Sustainability Indicator, which is founded on the Ecological Sustainability Gap, represents a different new indicator that Usubiaga-Liaño and Ekins (2021) proposed.

Several studies have examined the relationships between SDGs and energy efficiency. Global climate change organizations support SDG targets, as the transition to renewable energy is bound to reduce CO2 emissions. In particular, SDG 7 establishes three goals that have to be achieved by 2030: (i) universal access to reliable and cost-effective electrical services; (ii) a higher proportion of renewable energy in every nation›s energy mix; and (iii) doubling the pace of improving energy efficiency worldwide. This unleashed an enormous number of publications on the creation of composite indicators that permit comparative assessments, which might in turn influence the choices that should be undertaken by policymakers and other interested parties (Diaz-Sarachaga et al., 2018). According to Chien and Hu (2008), among the many sources of energy, expanding the potential of renewable energy has resulted in substantial effects on GDP, macroeconomic effectiveness, and capital creation.

3. Research methodology and data

The variables related to the dimensions of the GGGI (ESRU, NCP, GEO, SEI), the ETI, economic growth, and SDGs were identified and assessed using the SPSS 25 comparative method, which includes the utilization of both primary and secondary data from the G7 and E7 economies being analyzed. The country rankings are determined by the multifaceted nature and variety of their energy and green growth platforms. A broad range of resource-efficient outputs can be produced and developed with an extensive variety of highly challenging specialized skills. Once green growth dimensions outperform revenue expectations, future economic growth is predicted to accelerate considerably. The varied nature of green growth and energy efficiency performance is connected to a country's anticipated real income rankings. This indicates that the green growth dimension outputs (GGDO) and the energy trilemma indicators can be useful measures of GDP growth and sustainable development.

The research methodology was founded on a multifaceted theory of endogenous growth and growth driven by green innovation and efficient natural resource usage (Solow, 1956; Romer, 1990; Stiglitz et al., 1974; Peretto, 2015; Dykas et al., 2022). The concepts discussed above were used in the present study to emphasize the importance of country rankings on the basis of sustainability, energy efficiency, and the efficient use of natural resources. A prosperous and environmentally conscious nation should produce consumable goods that can be exploited to produce intermediate-level goods that are of higher quality or more innovative. This production process can be illustrated using the equations below. The approach proposed by Solow (1956) does not include natural resources or pollution of the environment. Nevertheless, this phenomenon is now more significant than ever because resources are rapidly dwindling due to the constant increase in production. An exogenous growth model that was fundamentally developed by Solow acquires the subsequent equation:

$$Y_{(i)} = C_{(i)}{}^{\alpha} \left(A_{(i)} L_{(i)}\right)^{1-\alpha} \tag{1}$$

where the economic growth is presented by capital accumulation (C), labor (L), population growth (i), and technological advancement (A). The last is an exogenous indicator of the increase in effectiveness. The Cobb-Douglas production function (2) has been expanded to incorporate the following variables: natural resources employed in production (Nr); the efficacy of resource utilization (Er); and soil fertility (S).

$$y_{(i)} = C_{(i)}{}^{\alpha} \left[Er_{(i)} Nr_{(i))} \right]^{\beta} S_{(i)}^{\gamma} \left[A_{(i)} L_{(i)} \right]^{1-\alpha-\beta-\gamma} \tag{2}$$

$$\alpha > 0, \beta > 0, \gamma > 0, \quad \alpha + \beta + \gamma < 1.$$

The parameters are essentially as dynamic as those described previously (2), but the changing nature of the additional factors must be described. Natural resources utilized in production (Nr), are bound to decrease over time as most of them are not renewable.

$$Nr_{(i)} = -eNr_{(i)}, b > 0 \tag{3}$$

Resource efficiency is the ability of natural resources to increase productivity and other significant factors, e.g. the contribution of a given resource, along with its effectiveness factor (ei) and Er value.

$$Er = \left(\frac{Er_i}{P} \right) * e_i \tag{4}$$

Without taking Nr, S, and Er into consideration, C/AL would eventually converge to a value that makes it simple to study the dynamics of an economy. However, it is useful to consider whether balanced and sustainable growth can be achieved with the inclusion of these new variables. The growth rates of A, Er, L, Nr, and S are assumed to be constant. C and Y must continue to develop at the same rate in order to follow the balanced growth pathway. C/Y needs to be constant, i.e., the growth rates of C and Y have to be equal in order to expand at a constant rate. The production function (equation 2) could be solved to find the growth rate of Y that is equal to the growth rate of C on a balanced growth pathway. The next step is to take the logarithms of both sides (equation 5):

$$lnY_{(i)} = \alpha lnC_{(i)} + \beta \left[lnEr_{(i)} + lnNr_{(i)} \right] + \gamma lnS_{(i)} + (1 - \alpha - \beta - \gamma) \left[lnA_{(i)} + lnL_{(i)} \right] \tag{5}$$

The literature uses these theories to emphasize the importance of ranking countries on the basis of growth dimensions, ETIs, and SDGIs. A sustainable economy should produce intermediate and/or final products, invest in improving product quality, or create new products. The qualities of modern «green» technologies help society with respect to variety at level (α) and efficiency at the proposed first level. By outlining how technological advancement affects prosperity, the economists Solow (1956), Stiglitz (1974a), and Peretto (2015) established the basis for this empirical method, which is now commonly employed to analyze the sustainable (green) growth of several countries. Such analyses can be conducted using two groups of countries. Data can be additionally employed to demonstrate how green growth and energy trilemma dimensions impact a country›s economy and sustainability over the long term. The indicators for the G7 and E7 economies can be calculated using the formula:

$$I = GGDO\,C_P^{\alpha} L_P^{\beta} Nr_P^{1-\alpha-\beta} \qquad 0 < \alpha < 1;\ 0 < \beta < 1 \tag{6}$$

$$GGDO = GGDO\,C_{GGDO}^{\alpha} L_P^{\beta} Nr_{GGDO}^{1-\beta-\gamma} \qquad 0 < \beta < 1;\ \gamma < 1 \tag{7}$$

where *I* is the number of variables utilized in green growth dimension performances, C is the capital devoted to knowledge dispersion, L is labor, Nr is natural resources, and GGDO is the number of variables related to green growth efficiency in the G7 and E7 economies. In order to evaluate the variables' aggregate index across their many dimensions (together with the best possible results and smallest permitted green growth dimensions achievement scores), each monitored GGDO indicator was made a „point of prosperity", and the G7 and E7 economies were rated between 0 and 100. This required readjusting every variable by applying the formula:

$$Indicator\_value_{c,i} = \left(\frac{Value_{c,i} - MinValue_i}{MaxValueV_i - MinValue_i} \right) * 100 \tag{8}$$

where:
– $Value_{c,i}$ represents a new score of the G7 and E7 economies for indicator (i);
– $MinValue_i$ is the lowest tolerable performance value for indicator (i) in a G7 or E7 economy;
– and $MaxValue_i$ is the G7/E7's greatest value for creating new green growth opportunities and moving towards sustainability.

The GGGI has values varying from 1 to 100, with 100 representing the best achievement and 1 representing the worst. A rating of 100 on the rating system, parameters, and indicator subcategories indicates that an economy has attained a specific aim, as the indicators are evaluated on progress towards goals associated with sustainability. The results are grouped into a range of values as follows:: a) a rating of 80 to 100 indicates that the economy has either achieved or is very close to achieving the goal; b) a rating of 60 to 80 indicates exceptional results, assuming a tactical position to fully reach the goal; c) a rating of 40 to 60 is considered moderate; it strikes a perfect balance between advancing towards the goal and avoiding veering away from it; d) a rating of 20 to 40 is considered poor; choosing the appropriate policies to coordinate development with achieving the goal; e) a rating of 1 to 20 is considered extremely low; major improvements are required. As stated above, the GGGI has four components: (i) ESRU; (ii) NCP; (iii) GEOs; and (iv) SI.

$$\text{GGGI} = ESRU + NCP + GEO + SI \tag{9}$$

The green growth indicators (ESRU, NCP, GEO, and SI) cannot be aggregated, as each has its own assessment units. In order to make it possible to compare indices (and years and countries), normalization is used to ensure consistency and common measurements.

$$X_i^{normalization} = a + \left(\frac{x_i - x_{minimum}}{x_{maximum} - x_{minimum}} \right) * (b - a) \tag{10}$$

Where: a is the lower limit and b the upper limit.

The parameters included in the GGGI were normalized using the min-max rescaling transformation. This method was chosen because it: (i) is straightforward; (ii) is the most commonly used method; (iii) can incorporate upper and lower constraints; and (iv) can be utilized for SDGs. The more basic computational function of the rescaling technique is shown in equation (8), which also includes data regarding the lower limit (a) and the higher limit (b).

In order to allow for comparisons over different periods and between different economies, the GGGI's four components are given values varying from 1 (worst) to 7 (best). The GGGI and the values of its components are also aligned with those of the SDGIs using a similar 1-7 scale (explained in more detail below). The GGGI is created via a three-step process (the precise formulas are given above). All the variables are normalized into a common scale of values from 1 (worst) to 7 (best). The indications for each pillar are then standardized, assigned equal weights, and averaged to determine the final rating for each pillar. Finally, a single overall index is produced by taking the equally weighted means of the pillar values. This is the method used to create the GGGI in the present paper on account of its ease of utilization, transparency, and widespread acceptability.

The ETI, which was compiled by the WEC in conjunction with the international management consultancy firm Oliver Wyman, provides a yearly overview of national energy system performances across each of the three Energy Trilemma dimensions. For the purpose of generating an overall ETI score, the arithmetic mean of the three dimension values is calculated as follows (WEC, 2022a):

$$ETI = \frac{Energy\,security + Energy\,equity + Environmental\,sustainability}{3} \tag{11}$$

Through the use of international and domestic data, the ETI rates the energy efficiency of 127 nations on all three dimensions and pinpoints areas that need development in order to improve comprehensive innovative policies and policy coherence, thereby assisting in creating accurately measured energy systems. The Trilemma framework remains a starting point for generating and updating indicators to assist policymakers in monitoring the progress and analyzing the results of energy transitions. Not only authorities, but society as a whole, are currently debating the best way to proceed with regard to energy regulations, prices, and new energy security alliances. The newly implemented modifications offer a rare chance to reconsider the value of maintaining the balance in the Trilemma dimensions and to give some thought to expanding the current framework as a useful tool for key stakeholders.

The Sustainable Development Report, published annually by the United Nations since 2015, examines the progress made towards meeting each of the SDGs. The Report examines the objectives of resuming and accelerating SDG development as it approaches the midpoint of the 2030 timeframe. It additionally assesses what has been achieved to date. An average rating for each of the parameters is employed to determine the ranking of the seventeen SDGs on the basis of the extent to which they were achieved during the most recent timeframe. These are listed in the various sections of the SDG tracking reports that summarize the goals and provide nation profiles.

$$SDG\,index = \frac{Indicator_{current\ value} - Indicator_{current\ year}}{\left|Target\ value - Indicator_{current\ year}\right|} \text{ x } Denoting\ indicator \tag{12}$$

where:

$$Denoting\ indicator = \begin{cases} 10 & increasing\ values\ are\ desirable \\ -10 & decreasing\ values\ are\ desirable \end{cases} \tag{13}$$

The above computations of the indicators used to track a given SDG serve as the basis for calculating average scores at the target grade. The compound annual growth rate is applied to indicators that do not have quantitative goals. The percentage of the necessary growth actually achieved is utilized for indicators with measurable goals.

A score of +7 (best) is determined by inserting these values within a ranking formula that varies for indices with and without measurable targets. In an attempt to determine a score associated with every gauge that fluctuates between +7 (the hightest score) and -7 (the t), these parameters are entered using a scoring formula that varies for variables regardless of whether they are quantifiable. The values of the variables selected for tracking every objective, involving both primary and secondary measures, are then computed. The arithmetic mean of those values is then used to calculate the average results at the target levels. Thus, the range among these goal-level values is similarly +7 (highest score) to – 7 (lowest score). The nation profile section of the SDG tracking reports uses a different method for determining the SDG rankings of the member countries. This method takes the most recent year for which data on each measure are available, as well as the relative standings of several countries with respect to one another. Formulas (14) and (15) below are used to calculate a nation's position score for a parameter based on the range of results from the nation with the lowest performance to the nation with the highest performance (after removing outliers). The calculation is based on the following normalization of measured values using the minimum-maximum method:

$$X_{p,e} = \frac{x_{p,e} - Minimum_p\left(x_{p.e}\right)}{Maximum_p\left(x_{p,e}\right) - Minimum_p\left(x_{p,e}\right)} * 100 \tag{14}$$

$$X_{p,e} = \frac{Maximum_p\left(x_{p.e}\right) - x_{p,e}}{Maximum_p\left(x_{p,e}\right) - Minimum_p\left(x_{p,e}\right)} * 100 \tag{15}$$

X e, is the normalized value of variable *X p,e,* where p is the parameter, e the economy, and the maximum and minimum scores of the parameters for all member countries for the most recent year of accessible data are also given. Equation (11) is employed when higher parameter values are preferable (e.g., GDP [PPP] per capita), while equation (8) is used when lower values are preferable (e.g., emissions of greenhouse gases per capita). In order to evaluate the interlinkages between the selected parameters, a correlation assessment utilizing the Spearman method, which is performed on ordinal parameters with a non-normal distribution, was carried out in this investigation. Using the rho (ρ) hypothesis test, the statistically significant value of Spearman's correlations was evaluated as well. The links between the SDG indices, GDP (PPP) per capita, the energy trilemma, and green growth dimensions were determined using Spearman's rank correlation coefficients. Spearman's correlation is an appropriate estimation method for the relationships described above. It can be considered a nonparametric test, as most of the variables examined in the present study are not normally distributed.

4. Research results and discussion

Two economic groups were examined in the analysis. The first group is known as the Group of Seven (G7) and comprises the United States, Japan, Germany, France, the United Kingdom, Italy, and Canada. The second group is known as the Emerging Seven (E7) and comprises the People's Republic of China, India, Brazil, Mexico, Russia, Indonesia, and Turkey. Table 1 provides the values and ranks of the G7 and E7 economies by the green growth dimensions for 2022–2023.

Table 1.
Scores and ranks of the G7 and E7 economies by the dimensions of green growth in 2022–2023

Dimension	ESRU Index		NCP Index		GEO Index		SI Index	
	Score	Rank	Score	Rank	Score	Rank	Score	Rank
United States	38.88	10	62.61	11	44.14	5	80.44	7
Japan	41.39	7	73.53	7	33.23	11	83.23	6
Germany	55.02	4	81.52	2	60.55	1	88.65	2

Dimension	ESRU Index		NCP Index		GEO Index		SI Index	
	Score	Rank	Score	Rank	Score	Rank	Score	Rank
France	55.80	3	77.74	3	45.39	4	88.77	1
United Kingdom	60.41	1	76.96	5	39.20	8	88.09	3
Italy	5831	2	83.15	1	57.63	2	87.01	4
Canada	46.90	6	55.24	13	38.68	9	85.13	5
China	34.49	14	70.15	9	55.41	3	70.32	9
India	34.58	13	63.24	10	40.31	7	48.95	14
Brazil	40.91	8	74.32	6	30.98	12	65.41	10
Mexico	37.70	12	77.36	4	40.70	6	65.03	11
Russia	37.81	11	58.56	12	37.27	10	73.36	8
Indonesia	52.42	5	70.48	8	12.30	14	61.04	12
Turkey	40,54	9	54.32	14	17.71	13	60.66	13

Source: GGGI (2022). Green Growth Index Report 2022, Measuring performance in the SDG targets, the Global Green Growth Institute, and the author's own calculations.

The United Kingdom achieved the best outcomes for the period under analysis based on ESRU scores and ranks. Italy has the highest NCP rank. Indonesia has the lowest GEO rank and India the lowest SI rank. Germany is the best G7 economy as measured by GEO Index and France has the best as measured by SI Index. Turkey has the lowest NCP rank and China the lowest ESRU rank.

The United Kingdom has the highest ESRU score (60.41). The following G7 and E7 economies have ESRU Indices between 40 and 60: Italy (55.80), France (58.31), Germany (55.02), Indonesia (52.42), Canada (46.90), Japan (41.39), Brazil (40.91), and Turkey (40.54). The G7 countries with the lowest ESRU Indices are the United States (38.88), Russia (37.81), Mexico (37.70), India (34.58), and China (34.49). Germany (81.52) and Italy (83.15) are the G7 economies with the highest NCP Indices. Almost half the G7 and E7 economies under analysis have high NCP Indices: France (77.74), Mexico (77.36), the United Kingdom (76.96), Brazil (74.32), Japan (73.53), Indonesia (70.48), China (70.15), India (63.24), and the United States (62.61). Canada (55.24), Russia (58.56), and Turkey (54.32) have moderate NCP Indices among the E7 economies.

Germany (60.55) is the G7 economy with the highest GEO Index, followed by Italy (57.63), China (55.41), France (45.39), the United States (44.14), Mexico (40.70), and India (40.31) with moderate Indices. The United Kingdom (39.20), Canada (38.68), Russia (37.27), Japan (33.23), and Brazil (30.98) have low GEO Indices, and Turkey (17.71) and Indonesia have very low Indices. All the G7 economies under analysis have very high SI Indices: France (88.77), Germany (88.65), the United Kingdom (88.09), Italy (87.01), Canada (85.13), Japan (83.23), and the United States (80.44). The E7 economies Russia (73.36), China (70.32), Brazil (65.41), Mexico (65.03), Indonesia (61.04), and Turkey (60.66) all have high SI Indices, while India (48.95) has a moderate Index. Table 2 presents the G7 and E7 economies' scores and ranks according to the ETI, GDP (PPP) per capita, and the SDGI for 2022–2023.

Table 2.
Scores and ranks of the G7 and E7 economies according to the ETI, GDP (PPP in USD) per capita, and the SDGI for 2022–2023

Dimension	ETI			GDP (PPP in USD) per capita		SDGI	
	Balance grade	Score	Rank	Score	Rank	Score	Rank
United States	AAC	78.5	5	63,593.40	1	75.91	7
Japan	BAA	75.4	7	40,193.30	5	79.41	4
Germany	AAA	80.6	4	46,208.40	2	83.36	1
France	AAA	81.1	3	39,030.40	6	82.05	2
United Kingdom	AAA	82.4	1	41,059.20	4	81.65	3
Italy	ABA	74.8	6	31,714.20	7	78.79	5
Canada	AAA	82.3	2	43,294.60	3	78.50	6
China	ABC	65.3	10	10,434.80	8	72.01	10
India	BDD	53.6	14	1,927.70	14	63.45	14
Brazil	ACA	69.8	8	6,796.80	12	73.69	9
Mexico	CBB	63.1	12	8,329.30	11	69.71	13
Russia	ABC	69.6	9	10,126.70	9	73.79	8
Indonesia	ACC	59.7	13	3,869.60	13	70.16	12
Turkey	BBB	64.1	11	8,536.40	10	70.78	11

Source: WEC. (2022b). ETI - WEC, Sustainable Development Report 2023, Dublin University Press, and the author's own calculations.

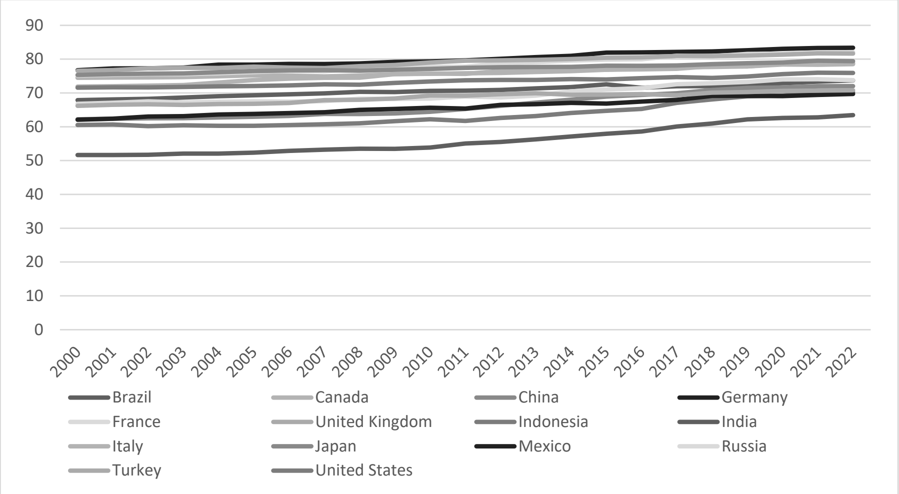
The United Kingdom has the highest ETI and the United States the highest GDP (PPP) per capita. Of all the G7 and E7 economies under analysis, India has the lowest ETI, GDP (PPP) per capita, and SDGI. Germany has the highest SDGI (83.36). The United Kingdom has an ETI of 82.4, followed by Canada (82.3), France (81.1), and Germany (80.6). These four countries perform effectively in all three areas and have an appropriately harmonious Trilemma profile, which is reflected in their balance grade (AAA). The balance grade, with "A" representing the best, indicates how effectively an economy balances the complexities of the Trilemma. The ranking gauges its overall achievement in developing a sustainable mix of policies. To ascertain whether national energy policies are sustainable, the most reliable measure includes the ETI.

The United States has a balance grade of AAC (Energy Security and Energy Equity are graded A and US Environmental Sustainability is graded C – partly because the US accounts for a very high percentage of global greenhouse gas emissions). Italy, with an ETI of 74.8, is one of the highest-rated Trilemma performers. This high score was attained by increasing the production of renewable energy and regulating greenhouse gas emissions in the context of sustainable development. Sustained affordability indices are reflected in the Equity dimension's robust and steady achievement. Despite the lower security component of Italy's balance grade (B), the index has significantly improved throughout all measures, mostly because of the country's increasing energy independence. This, in turn, is due to generational variety. Japan has a high ETI (75.4). Energy equity is robust and stable in Japan (graded A), despite fluctuations in energy affordability. Japan's Environmental Sustainability Index is likewise graded A, primarily due to a decrease in its greenhouse gas emissions. Energy security is Japan's weakest area (graded B). Japan's balance grade is therefore BAA.

Brazil has a high ETI (69.8), as well as high levels of Environmental Sustainability (A) and Energy Security (A). Brazil's weakest Energy Trilemma dimension is Energy equity (C). This gives the country a balance grade of ACA. Russia similarly has a high ETI (69.6) and a balance grade of ABC (Energy Security "A"; Energy Equity "B"; and Environmental Sustainability "C", mostly because of its high greenhouse gas emissions). China also has a balance grade of ABC. Turkey has a sustainable ETI of 64.1 and a balance grade of BBB.

The Energy Trilemma balance grades in Turkey indicate identical levels of Energy Security (B), Energy equity (B), and Environmental Sustainability (B), so there is obviously room for improvement. Mexico has an ETI of 63.1, but its balance grade (CBB) indicates that its weakest area is energy security (C). Indonesia has achieved a moderate ETI of 59.7 with a balance grade of ACC. This indicates that its Energy Security (A) is efficient, but not its Energy Equity (C) and Environmental Sustainability (C). India has the worst Energy Trilemma balance grade (BDD), which indicates poor Energy Equity (D) and Environmental Sustainability (D). Figure 1 below shows that the overall SDG scores of the G7 and E7 economies increased in 2000-2022.

Figure 1.
Overall SDG scores for the G7 and E7 economies in 2000–2022



Source: Author's own compilation from the SDGI, 2000-2022.

Table 3 shows the interlinkages between green growth variables, the energy trilemma, GDP (PPP) per capita, and the SDGs in the G7 and E7 economies under analysis. The Spearman's correlation coefficients indicated very significant correlations between ESRU, NCP, GEOs, SI, ETI, GDP (PPP) per capita, and SDGs. The research data was derived from primary and secondary sources. The investigation was conducted using SPSS 25.

Table 3.

Interlinkages between the green growth variables, the energy trilemma, GDP (PPP) per capita, and the SDGI in the G7 and E7 economies in 2022–2023

	ESRU	NCP	GEO	SI	ETI	GDP (PPP) per capita	SDG
ESRU	1.000	0.877**	0.943**	0.938**	0.868**	0.749**	0.899**
NCP		1.000	0.947**	0.846**	0.890**	0.771**	0.864**
GEO			1.000	0.886**	0.930**	0.780**	0.903**
SI				1.000	0.749**	0.618*	0.837**
ETI					1.000	0.855**	0.895**
GDP (PPP) per capita						1.000	0.807**
SDG							1,000

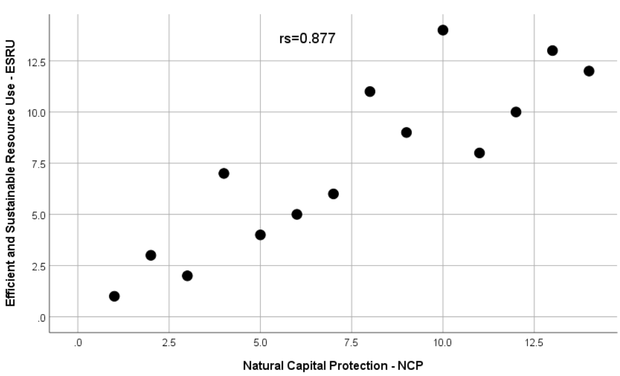
Note: ** The correlation is significant (p<0.001).

Source: Estimation by the author.

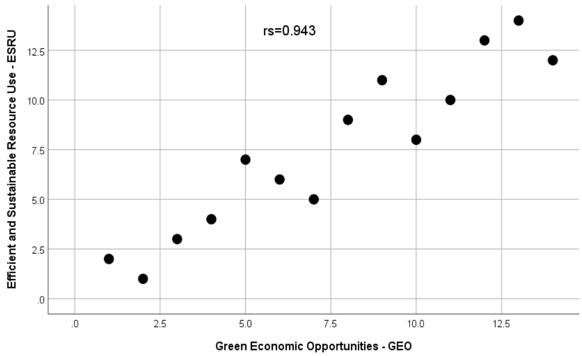
Figure 2.

A scatter diagram displaying the interlinkage between: a) NCP and ESRU; b) GEO and ESRU; c) SI and ESRU.

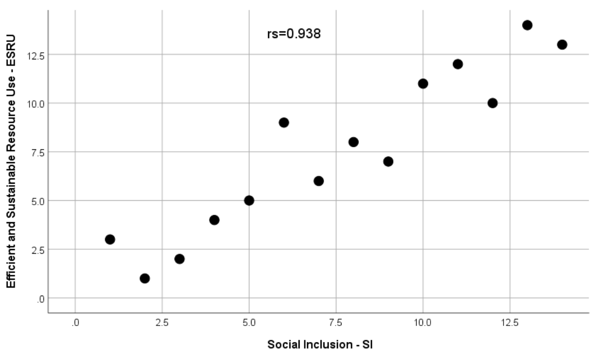
a) NCP and ESRU



b) GEO and ESRU



c) SI and ESRU



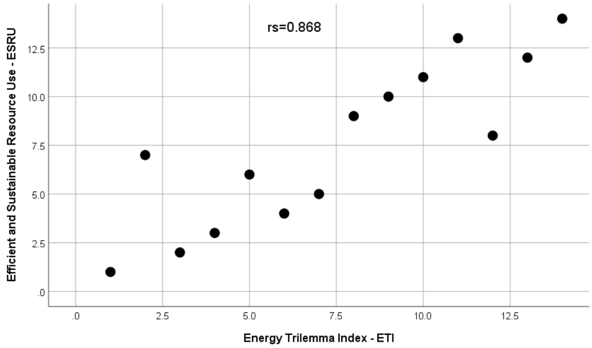
Source: Created by the author utilizing SPSS 25.

The scatter diagrams above show the ranked correlations using Spearman's rank correlation coefficients for the G7 and E7 economies in 2022–2023. The scatter diagram (2a) in Figure 2 shows a very strong positive and significant relationship between NCP and ESRU, as confirmed by Spearman's rank-order correlation coefficient rs = 0.877, p<0.001. The positive correlation coefficient between NCP and ESRU (0.877**) suggests that NCP and efficient and sustainable resource consumption are important in attaining sustainable green growth. A very strong positive relationship was observed between GEOs and ESRU, as presented in the scatter diagram (2b); the correlation coefficient was rs = 0.943, p<0.001. The positive correlation coefficient between GEOs and ESRU (0.943**) shows that the former, which rely on green trade, green employment, green investments, and green innovation, are crucial for efficient and sustainable resource consumption. The scatter diagram (2c) in Figure 2 shows a very strong positive and significant relationship between SI and ESRU, as confirmed by a Spearman's rank correlation coefficient of rs = 0.938, p<0.001. The positive correlation coefficient between SI and ESRU (0.938**) indicates that social inclusion mirrored through accessibility of essential resources and services, equality between men and women, an equitable society, and social security are essential for efficient and sustainable resource use.

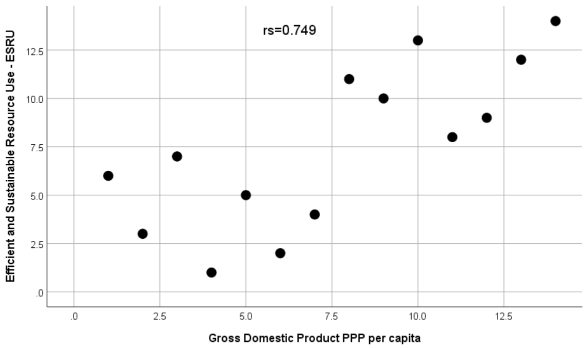
Figure 3.

A scatter diagram displaying the interlinkage between: a) ETI and ESRU; b) GDP (PPP) per capita and ESRU; c) SDGs and ESRU

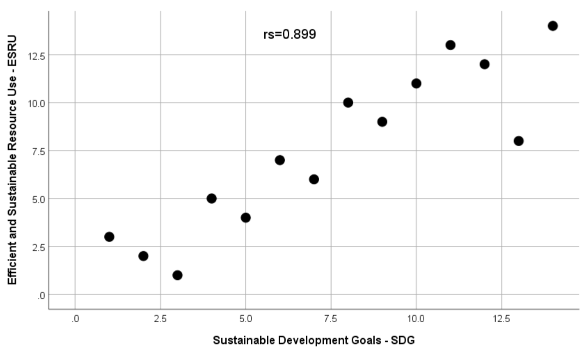
a) ETI and ESRU



b) GDP (PPP) per capita and ESRU



c) SDGs and ESRU



Source: Created by the author utilizing SPSS 25.

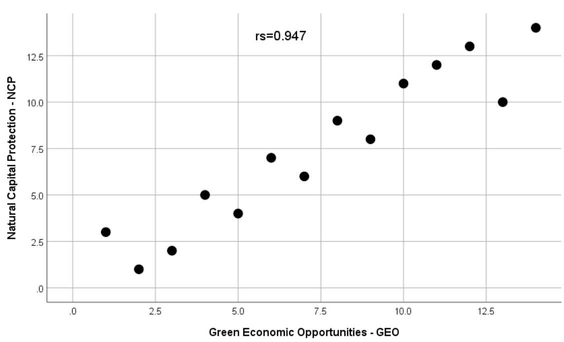
A very strong positive relationship was observed between the ETI and ESRU. This is illustrated in the scatter diagram (3a) and the correlation coefficient of rs = 0.868, p<0.001.

The positive correlation coefficient between ETI and ESRU (0.868**) shows that energy transition is vital for efficient and sustainable resource use. Specifically, the findings suggest that energy security, energy equality (accessibility and affordability), and environmental sustainability may all improve as a result of more efficient and sustainable energy consumption. Compared to other energy sources, renewable energy sources utilize natural resources more efficiently for overall production and consumption. A strong positive interlinkage was observed between GDP (PPP) per capita and ESRU, as presented in Figure 3 (scatter diagram 3b) and the correlation coefficient rs = 0.749, p<0.001. The positive correlation coefficient between GDP (PPP) per capita and ESRU (0.749**) suggests that efficient and sustainable resource consumption is important for fostering income-levels, growth, and sustainability. A very strong positive relationship was observed between SDGs and ESRU, as indicated by the scatter diagram (3c) and the correlation coefficient rs = 0.899, p<0.001. The positive correlation coefficient between SDGs and ESRU (0.899**) shows that efficient and sustainable resource use via efficient and sustainable energy, efficient and sustainable water consumption, sustainable land use, and efficient material consumption are important for achieving SDGs.

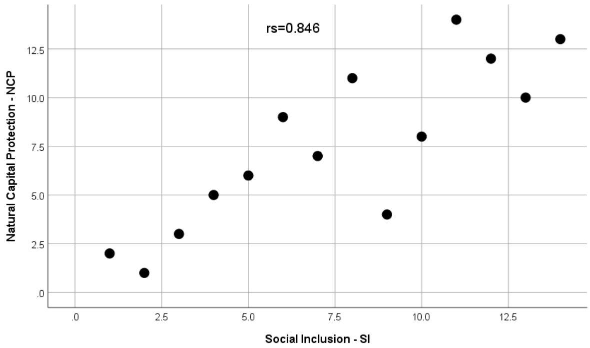
Figure 4.

A scatter diagram displaying the interlinkage between: a) GEO and NCP; b) SI and NCP; c) ETI and NCP

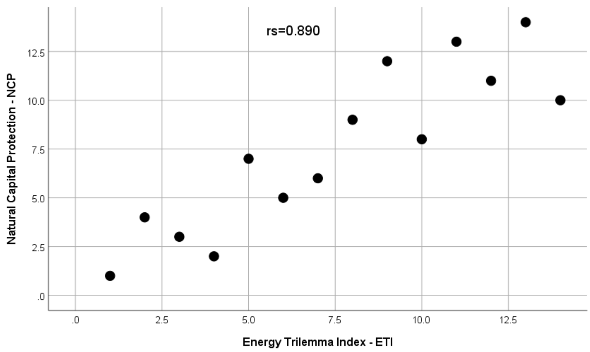
a) ETI and ESRU



b) SI and NCP



c) ETI and NCP



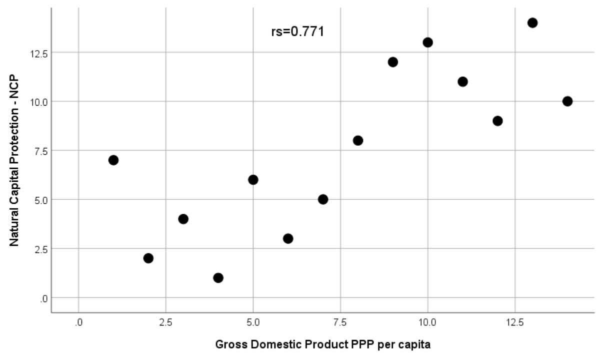
Source: Created by the author utilizing SPSS 25.

The scatter diagram (4a) in Figure 4 shows a very strong positive and significant relationship between GEO and NCP, as confirmed by a Spearman's rank correlation coefficient of rs = 0.947, p<0.001.

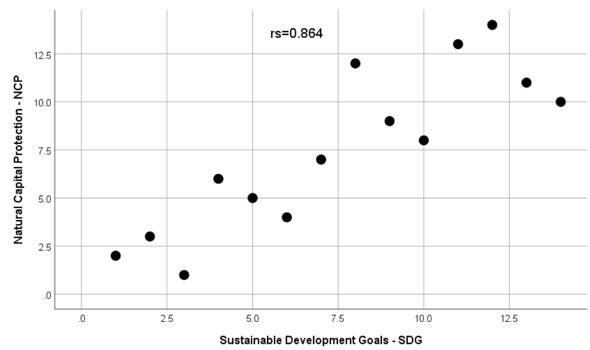
The positive correlation coefficient between GEO and NCP (0.947**) indicates that green economic opportunities could increase national welfare through NCP. Economic policies that support a green economy can have indirect as well as direct benefits by contributing to economic growth and generating green jobs in an environmentally friendly environment. A very strong positive relationship was observed between SI and NCP, as presented by the scatter diagram (4b) and a correlation coefficient of rs = 0.846, p<0.001. The positive correlation coefficient between SI and NCP (0.846**) indicates that social inclusion is important for improving environmental quality, reducing greenhouse gas emissions, maintaining biodiversity, protecting ecosystems, and preserving cultural and social values. A very strong positive interlinkage was observed between the ETI and NCP, as presented by Figure 4 (scatter diagram 4c) and a correlation coefficient of rs = 0.890, p<0.001. The positive correlation coefficient between ETI and NCP (0.890**) shows that energy security, energy equality, and environmental sustainability are vital for NCP.

Figure 5.
A scatter diagram displaying the interlinkage between: a) GDP PPP per capita and NCP; b) SDG and NCP; c) SI and GEO

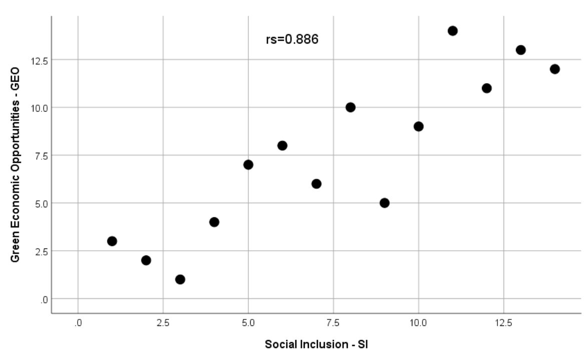
a) GDP PPP per capita and NCP



b) SDG and NCP



c) SI and GEO



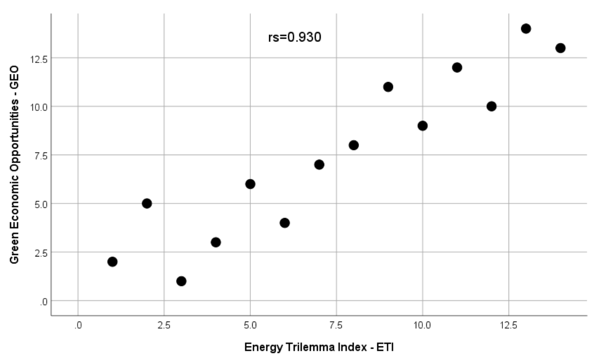
Source: Created by the author utilizing SPSS 25.

A strong positive relationship was observed between GDP (PPP) per capita and NCP, as indicated by the scatter diagram (5a) and a correlation coefficient of rs = 0.771, p<0.001. The positive correlation coefficient between GDP (PPP) per capita and ESRU (0.771**) suggests that NCP is important for increasing economic growth and prosperity. The scatter diagram (5b) in Figure 5 shows a very strong positive and significant relationship between SDGs and NCP, as confirmed by a Spearman's rank correlation coefficient of rs = 0.864, p<0.001. The positive correlation coefficient between SDG and NCP (0.864**) shows that feasible NCP, efficient and sustainable energy, efficient and sustainable water consumption, sustainable land use, and efficient material consumption are all important for the achieving SDGs. A very strong positive relationship was observed between SI and GEOs, as presented by the scatter diagram (5c) and a correlation coefficient of rs = 0.886, p<0.001. The positive correlation coefficient between SI and NCP (0.886**) indicates that SI is essential for creating and developing GEOs.

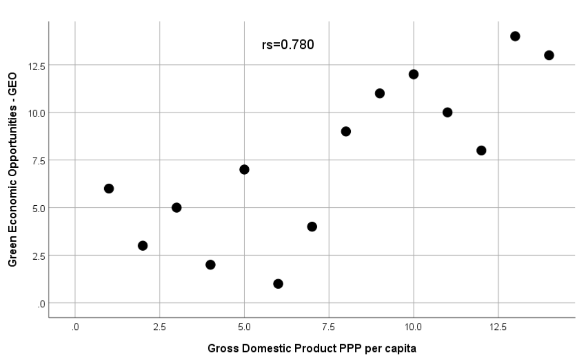
Figure 6.

A scatter diagram displaying the interlinkages between: a) ETI and GEOs; b) GDP (PPP) per capita and GEOs; c) SDGs and GEOs

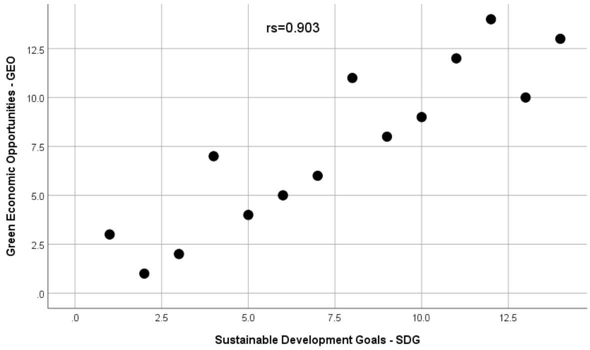
a) ETI and GEOs



b) GDP (PPP) per capita and GEOs



c) SDGs and GEOs



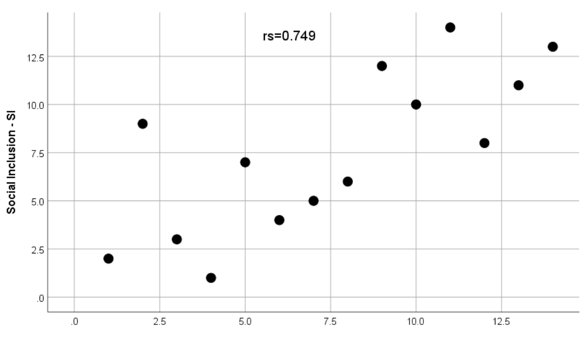
Source: Created by the author utilizing SPSS 25.

A very strong positive interlinkage was observed between the ETI and GEOs, as presented by Figure 6 (scatter diagram 6a) and a correlation coefficient of rs = 0.930, p<0.001. A positive correlation coefficient between the ETI and GEOs (0.930**) indicates that the latter are important for energy security, energy equality, and environmental sustainability. A strong positive relationship was observed between GDP (PPP) per capita and GEOs, as indicated by the scatter diagram (6b) and a correlation coefficient of rs = 0.780, p<0.001. A positive correlation coefficient between GDP (PPP) per capita and GEOs (0.780**) shows that green trade, green employment, green investments, and green innovation are crucial for fostering growth and sustainable development. The scatter diagram (6c) in Figure 6 shows a very strong positive and significant relationship between SDGs and GEOs, as confirmed by a Spearman's rank correlation coefficient of rs = 0.903, p<0.001. The positive correlation coefficient between SDGs and ESRU (0.903**) shows that GEOs are important for achieving SDGs.

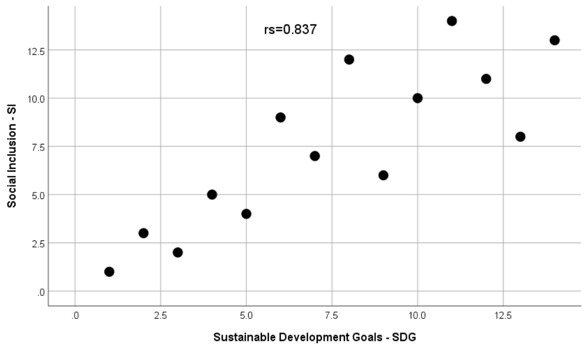
Figure 7.

A scatter plot displaying the interlinkages between: a) ETI and SI; b) SDGs and SI; c) GDP (PPP) per capita and ETI

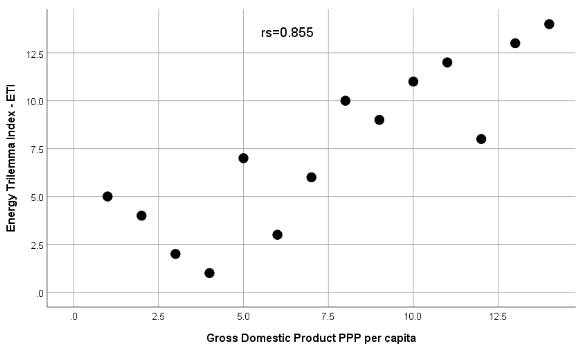
a) ETI and SI



b) ETI and SI

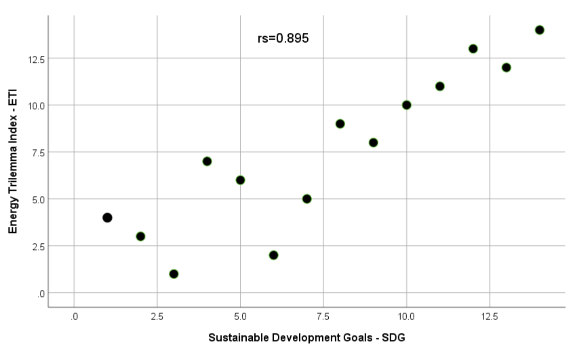


c) GDP (PPP) per capita and ETI



Source: Created by the author utilizing SPSS 25.

Figure 8.
A scatter plot displaying the interlinkage between SDG and ETI



Source: Created by the author utilizing SPSS 25.

A strong positive relationship was observed between the ETI and SI, as presented by the scatter diagram (7a) and a correlation coefficient of rs = 0.749, p<0.001. The positive correlation coefficient between ETI and SI (0.749**) indicates that energy security, energy equality, and environmental sustainability are important for SI. A very strong positive interlinkage was observed between SDGs and SI, as presented by Figure 7 (scatter diagram 7b) and a correlation coefficient of rs = 0.837, p<0.001. The positive correlation coefficient between SDGs and SI (0.837**) suggests that SDGs, especially SDG 10 (reduced inequalities) are heavily dependent on social inclusion (via improved environmental quality, reduced greenhouse gas emissions, preserved biodiversity, and protected ecosystems and cultural and social values). A strong positive relationship was observed between GDP (PPP) per capita and the ETI, as indicated by the scatter diagram (7c) and a correlation coefficient of rs = 0.855, p<0.001. The positive correlation coefficient between ETI and GDP (PPP) per capita (0.855**) indicates that energy security, energy equality, and environmental sustainability are important for achieving national prosperity. The scatter diagram in Figure 8, shows a very strong positive and significant relationship between the SDGs and the ETI, as confirmed by a Spearman›s rank correlation coefficient of rs = 0.895, p<0.001. A positive correlation coefficient between SDGs and the ETI (0.895**) indicates that energy security, energy equality, and environmental sustainability are important for achieving SDGs, especially SDG 7 (clean and affordable energy).

The GGGI and the ETI are designed to assist governments and policymakers in evaluating the challenging SDGs that have to be achieved in order to ensure universal access to affordable and reliable energy while protecting the natural environment. This investigation is a first step in ranking the nations under analysis on the basis of these key elements and national economic circumstances in order to find similarities in their approaches to sustainable green growth and energy infrastructure. New technology and proactive legislation aimed at embracing clean, affordable energy for every community should be encouraged by decision-makers charged with implementing green growth and energy policies.

5. Conclusion

This study assesses the importance of green growth dimensions and the energy trilemma for achieving SDGs, as well as the effectiveness of green growth initiatives and the green energy transition in the G7 and E7 nations. By using a number of analytical assessment methodologies, it was shown that the key components of green growth, the energy trilemma, and SDGs are interconnected. The study found significant and positive correlations between ESRU, NCP, Green Economic Opportunities GEOs, SI, the ETI, GDP (PPP) per capita, and SDGs.

This study contributes to our existing knowledge by facilitating a deeper theoretical understanding of, and providing empirical research into, the connections between the key metrics for green growth, the energy trilemma, and sustainable development in the G7 and E7 economies. In the process, it has created a substantial dataset that may be utilized in additional empirical research on green growth dimensions, the energy trilemma, and SDGs. The findings have significant policy ramifications. They may contribute to ensuring a key platform for understanding the significance of the energy trilemma factors and green growth dimensions in achieving SDGs and economic growth, and to improving the predicted theoretical framework for appropriate new economic policies in the G7 and E7 countries.

The findings demonstrate the necessity of considering the features and geographies of individual countries without losing focus on the results of their specific rating analyses. As energy demand and political objectives vary between countries, policymakers are advised to treat initiatives characterized by uniform renewable energy sources with caution. Achieving SDGs requires that all aspects of green growth and the energy trilemma be taken into consideration, including efficient and sustainable resource use, NCP, GEOs, SI, energy security, equity, and environmental sustainability. To this end, governments and legislators need to develop an adequate and efficient resource utilization policy as well as a balanced energy policy that takes into account the energy trilemma and all aspects of green growth. Even though environmental protection and climate change are crucial, ignoring any one of the dimensions could present an imminent danger to energy availability, energy requirements, and energy security.

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