energies

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Achieving Environmental Policy Objectives through the Implementation of Sustainable Development Goals. The Case for European Union Countries

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Citation: Kluza, K.; Zioło, M.; Bąk, I.; Spoz, A. Achieving Environmental Policy Objectives through the Implementation of Sustainable Development Goals. The Case for European Union Countries. *Energies* **2021**, *14*, 2129. https://doi.org/10.3390/en14082129

Academic Editor: Robert Lundmark

Received: 7 March 2021
Accepted: 9 April 2021
Published: 11 April 2021

Abstract: One of the key challenges for climate policies is the identification of strategies that will effectively support the implementation of environmental goals. Environmental policies are connected with other development policies carried out by governments. In order to comprehensively shape environmental policy, it is important to understand the interactions between sustainable development goals (SDGs) as well as their impact on environmental goals. Employing econometric modeling based on the least absolute shrinkage and selection operator (Lasso) method and full-factorial analysis, the authors identify a number of statistically significant relationships between the implementation of sustainable development goals and the environmental variable represented by greenhouse gas emissions. Analysis reveals that implementation of particular sustainable development goals, namely SDG4 (Ensure inclusive and equitable quality education and promote lifelong learning opportunities) and SDG17 (Strengthen the means of implementation and revitalize the global partnership for sustainable development), explicitly facilitate the achievement of environmental policies. In addition, other SDGs exert an indirect influence on environmental goals through their reinforcing interactions with SDG4 and SDG17 variables. These are: SDG1 (End poverty), SDG3 (Ensure healthy lives and promote well-being), SDG8 (Promote sustained, inclusive and sustainable economic growth, and productive employment) and SDG15 (Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests and halt biodiversity loss). These findings have important implications for proper identification of effective government policy instruments which indirectly support the achievement of environmental goals.

Keywords: sustainable development goals; environmental policy; greenhouse gas emissions; education; poverty; health; policy implementation

1. Introduction

Greenhouse gas emissions (GHG) are one of the main drivers of global warming and climate change and at the same time are a contributing factor to environmental risk [1]. Environmental risk is one of the leading risk types of non-financial factors and has a real impact on the economy and public policies [2]. At the same time, greenhouse gas emissions are included in the so-called negative externalities, which public policies try to counteract [3]. One of the manifestations of the influence of states and institutions, including designing public policies, are sustainable development goals (SDGs), which are an instrument for implementing the concept of sustainable development.

Seventeen SDGs correspond with the environmental, social and economic pillar of sustainable development and include activities aimed at avoiding negative social and economic phenomena as well as environmental degradation. In addition to the measures indicated, within the framework of individual objectives, there are also indicators for monitoring their implementation. The individual SDGs are integrated and related to each other and interact with each other, and also affect the results of activities that have an impact on the simultaneous implementation of several goals [4]. Social goals affect the achievement of environmental and economic goals, and conversely, economic goals affect the achievement of social and environmental goals. Finally, environmental goals affect the achievement of social and economic goals.

The implementation of the objectives within individual SDGs varies in time and space. Each country is free to shape its policies in terms of influencing GHG through various public instruments. The amount of GHG is an individual feature of individual countries, some of which are less and others more exposed to the environmental risk associated with GHG. Therefore, there are different responses and actions by governments to reduce GHG and implement SDGs. Hence, the implementation level of the SDGs varies in each country [5].

The role of SDGs in achieving environmental goals and their impact on environmental policy is crucial. The incorporation of SDGs in environmental policy matters for strengthening environmental protection [6]. GHG reduction is possible thanks to a properly planned and implemented environmental policy. The impact on the environment takes place not only through the SDGs dedicated to the environment, but also through the SDGs indirectly related to the environment [7]. Hence, in order to comprehensively and effectively shape environmental policy, it is important to understand and learn about the interactions between the SDGs [8]. GHG reduction is key to ensuring environmental protection and stopping its degradation, thus the activities in this area are included in the SDGs. However, not all SDGs equally affect GHG, hence knowledge of the direct and indirect relationship and impact between SDGs and GHG as well as the relationship between SDGs is necessary to ensure the effective implementation of environmental policy.

The aim of this article is to investigate whether and how individual SDGs affect the amount of greenhouse gas emissions and what the direct and indirect interactions between SDGs ensuring emission reduction are. The paper aims to understand interactions among the environmental policy objectives and different SDGs, which is a novel and original approach and covers a research gap in knowledge. For the purposes of the study, the following research questions were asked: How effectively do SDGs contribute to reducing GHG? Which SDGs does this concern? Do the interactions between SDGs have an impact on GHG emission reduction and, if so, how?

The paper is organized as follows: the introduction is Section 1; in Section 2, the theoretical aspects related to SDGs and GHG are presented. Section 3 presents the methodological approach. Section 4 explains the data collection procedure and description of the methods. Section 5 discusses the research results. Section 6 presents the discussion and Section 7 is the conclusion.

2. Literature Review

The idea of sustainable development goals (SDGs) is a continuation of the Millennium Development Goals (MDGs) [9,10]. The SDGs, however, approach sustainable development in more comprehensive way [11]. They also provide more flexibility in achieving the goals on national and local level [12,13].

Although SDGs are the same for all countries, the perception of the importance and connections between economic, environmental, and social goals varies by country [14]. This is especially evident in the case of environmental policy goals. One of the most efficient elements of such policy aimed at reducing GHG emission are environmental taxes [15,16]. These taxes contribute in motivation to take actions mitigating negative impact on the environment, such as the choice of innovative and "green" technologies [17].

The example of this is the United Kingdom where a carbon tax led to switching away from coal and decreased greenhouse gas emissions [18]. Devi and Gupta [19] also showed that environmental tax is a good tool for controlling the level of GHG emission. Similar conclusions presented Bashir et al. [20] after analyzing the impact of environmental taxes and technology on carbon emissions. Due to the need for mitigating global climate change, the importance of environmental policy is constantly growing [21,22].

SGDs are the subject of a large number of studies, however, only some of them focus on interactions between particular goals or the impact of one goal on others [23]. An example of such a study is one conducted by Singh et al. [24] who highlighted importance of SDG 14 to other goals. Also Flörke et al. [25], focused on one goal (SDG 6.3) and found many interactions between this goal and others SDGs. There are also few studies with a more comprehensive approach to the relationship between SDGs. Hutton et al. [26] revealed multiple potential trade-offs between economic, social, and environmental SDGs, while Zhang et al. [27] mapped interactions across all goals.

The key to sustainable development and thus achieving the SDGs is integration of three dimensions: environmental, social, and economic [28]. However it is difficult to keep a balance between these dimensions. So far, no consensus has been reached on the synergies and trade-offs between environmental, social and economic goals [29]. The conflict between global sustainability and socioeconomic development is often a result of a trade-off across populations, consumption and production [30]. Similar results were obtained in independent studies by Repetto et al. [31] and Hamilton and Clemens [32], who argued that economic growth is by its nature a cause of the exhaustion of natural resources and aggravation of environmental service. A growing economy and rising standards of living do not prioritize the natural environment [33,34]. Potential inconsistencies in SDGs were modeled and quantified by Spaiser et al. [35].

In the assumption of the 2030 Agenda, the SDGs are integrated and should by implemented in accordance with this principle. Treating them as a unified whole is emphasized by the agenda. The holistic nature of SDGs results in many interactions between 17 goals and 169 targets [36]. Barbier et al. (2017) [37] showed how to characterize each of the 17 goals as primarily assigned either to the social, environmental or economic system and indicated that achieving all these goals at the same time may be associated with significant trade-offs.

Understanding the relationship between SDGs, both positive and negative, is fundamental for decision-making regarding these goals [24]. Nilsson et al. [38] analyzed the impact of factors such as resource endowments, time scope and geographical perspective on interactions between goals, based on a research study applied to the SDGs on energy, health and oceans.

Pradhan et al. [39] presented the first complete quantification of trade-offs and synergies across SDGs. They revealed many trade-offs associated with SDG 12 (Responsible production and consumption), and a synergetic relationship of SDG 1 (No poverty) with many goals.

Kroll et al. [40] described the synergies for SDGs 1, 3, 7, 8, and 9: Poverty reduction and economic development through innovations and modern infrastructure as the basis for achieving other SDGs, while goals 11, 13, 14, 16, and 17 will have trade-offs or no relations with the other SDGs.

The SDGs may be implemented in a microeconomic [41] or macroeconomic dimension [42–44]. Countries adopting the 2030 Agenda, may find the implementation of strategies to achieve sustainable development goals challenging. However, the coordinated implementation of SDG strategies, brings benefits, which was emphasized by Pedercini et al. [45].

Leveraging synergies among the SDGs can be obtained by integrated planning and implementing strategies of development, which require coordination and increased effort, particularly from governance. Bowen et al. (2017) [46] distinguished key challenges in the field of governance, crucial for implementing the SDGs: (1) cultivating cooperative action by creating inclusive decision spheres for stakeholder interaction across multiple scales and sectors; (2) making difficult tradeoffs, focusing on fairness, justice, and equity; and (3) ensuring mechanisms to involve societal actors into decision-making, action, investment, and outcomes. The enhanced effectiveness and reduced cost of implementation of SDGs can be achieved by greater focus on synergies and interlinkages between goals.

3. Data and Methodology

The analysis encompasses three groups of procedure: (1) data preparation and structuring of variables; (2) selection of basic model specification through the Lasso method and other econometric procedures; (3) identification of multiway interactions between variables through factorial analysis. Methodological aspects of all these stages are briefly described below. The final form of the data used in this research is presented in Tables A1 and A2 in the Appendices A and B. The graphical presentation of analytical framework is depicted at Figure A1 in Appendix C.

In our research, the data on sustainable development goals (SDG) extracted from Eurostat databases for 2017–2018 is used. All European countries are analyzed from this perspective, excluding Cyprus, Malta and Luxembourg due to their small economy size. To undertake this analysis, the data used require proper denominations and standardization allowing for comparability of all components comprising the sustainable goals. At the beginning, all indicators (I_n) comprising the sustainable goals were converted to relevant relative values such as per capita, share in GDP and so on (see Table A3 in Appendix D). Then, in order to obtain country rankings from the perspective of each SDG the authors had to firstly calculate the relative position of each country for each I_n indicator comprising a specific goal. Namely, if SDG10 (Reduce inequality within and among countries) is composed of four indicators: SDG10.10: purchasing power-adjusted GDP, real expenditure per capita; SDG10.20: adjusted gross disposable income of households purchasing power standard (PPS) per capita; SDG10.30: relative median at-risk-of-poverty gap, % distance to poverty threshold; SDG10.50: income share of the bottom 40% of the population, then for each indicator a separate ranking was built using a common methodology which allowed to merge these ranking into a final result.

Rankings for each indicator I_n were built using a ranking formula from Equation (1). Its main advantage compared to the classical ranking approach is that it satisfies the property of independence of irrelevant alternatives (see [47,48]). Such an approach also allows us to group similar indicator values into the same ranking position.

$$P_I : \begin{cases} 1, & when \;\; I_n \le m - \sigma \cdot \frac{4}{3} \\ p, & when \; \left(m + \sigma \cdot \frac{r-6}{3}\;\right) > I_n \ge \left(m + \sigma \cdot \frac{r-5}{3}\;\right) \; for \; each \; r \; from \; 2, \ldots, 9 \\ 10, & when \;\; I_n \ge m + \sigma \cdot \frac{4}{3} \end{cases} \quad (1)$$

where:

P_{In}—position in the ranking of each country for each indicator I_n comprising a specific SDG_i
R—ranking parameter, enabling to construct distinctive ranking groups between 1 and 10
M—mean value of countries' original parameters for each I_n
σ—tandard deviation of countries' original parameters for each I_n
N—number of I_n comprising a specific SDG_i

The next step is to verify whether all indicators I_n have the same behaviour as the dependent variable GHG, i.e., the higher the value (and the higher the ranking position) the less desirable (the worse) its economic outcome is. In the case of the indicators which have an opposite behaviour (the higher, the better—for example SDG10.20: adjusted gross disposable income of households' PPS per capita), they had to be inversed. Such a procedure is necessary to correctly aggregate the individual rankings of I_n into the composite country ranking for each SDG. The formula for inverting ranking positions is presented in Equation (2) and is applied only to these rankings of indicators, which do not exhibit a logic—the higher the value, the less desirable it is. The indicators which required to be inversed are shown in the last column of Table A3 in Appendix D as the stimulants.

$$P'_{In} = (-1)\ P_{In} + 11 \quad (2)$$

Finally, for this stage, the average ranking country position for each SDG was calculated as an arithmetic mean of respective rankings P_{In} and P'_{In} for each SDG. The obtained values were centered around the mean, thus each SDG ranking has a mean value of 0, which is a more suitable form for future prediction at mean calculations. As a result, each country ranking position for each SDG is calculated using Equation (3):

$$SDG_i = \frac{\sum_{n=1}^{l} P_l}{l} - m_P \quad (3)$$

where (for each country):

SDG_i—ranking value of a given country for an i-th sustainable development goal
P_l—ranking position (of a given country) by each indicator composing a specific SDG; individual indicators take the form of P_I (for indicators not inversed) or P'_{In} (for the inversed indicators)
l—number of indicators, which compose a specific SDG_i
m_p—average mean of all country ranking positions for a given SDG_i

A similar procedure was also carried out for the *ECON* variable, which was created as a composite indicator based on a set of economic indicators relevant for the measurement of sustainable development goals. Components of the *ECON* variable are presented in Table A3 in Appendix D. Finally, the countries were grouped into three distinctive geographic categories—Western and Northern Europe (WNE: Austria, Belgium, Denmark, Finland, France, Germany, Ireland, Netherlands, Sweden, United Kingdom), Mediterranean and Southern Europe (MSE: Greece, Italy, Portugal, Spain) and Central and Eastern Europe (CEE: Bulgaria, Croatia, Czechia, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia, Slovenia). The variable describing geographic distribution is referred to as *REG_NUM*.

The dependent variable in our research is 13.10 Greenhouse gas emissions—tonnes per capita (*GHG*), which is widely used in research (for example see [49–54]) as a proxy for environmental/climate degradation or the environmental performance of the economy. For the purpose of analysis consistency, this variable underwent an analogous amendment process as in the case of SDG_i variables. Namely, it was converted into a country ranking using Equation (1), and then it was centered around its mean value. The obtained data, used in a subsequent modelling, is presented in Tables A1 and A2 in the Appendices A and B.

The next phase of the analysis was devoted to extracting a basic form of analyzed phenomena, i.e., the relationship between the performance in various SDG policies and greenhouse gas emissions. For this purpose the authors used a two-stage approach. Firstly, a structured elimination of independent variables using the least absolute shrinkage and selection operator (Lasso) method was conducted.

When using the least-squares method to estimate the parameters of a linear model, the selection is most often carried out using the following methods: insertion, removal, backward elimination, and forward selection. Apart from the most popular, classical multivariate least squares method, its generalizations have been developed, making it possible to build correct models when the Gauss–Markov assumptions are violated. The best-known extensions are presented in the work of Stelmach [55]. One of these methods is the Lasso method, which eliminates the variables for which the estimators have a small value, and as a result, the mean square error is reduced. The Lasso method works better in situations where the response variable significantly depends only on a small number of predictors.

The Lasso method selects a subset of variables that are relatively well correlated with the outcome and are useful for prediction. The method was originally proposed by

Tibshirani [56] and is broadly described in Hastie et al. [57]. In Lasso's linear variant one looks for a solution for Equation (4):

$$y = \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_p x_p + \varepsilon \tag{4}$$

by minimizing both the in-sample prediction error and penalty resulting from model complexity (i.e., the $\lambda \sum_{j=1}^{p} |\beta_j|$ term) described by Equation (5):

$$\frac{1}{2N}\left(y - \boldsymbol{X}\beta'\right)'\left(y - \boldsymbol{X}\beta'\right) + \lambda \sum_{j=1}^{p} |\beta_j| \tag{5}$$

where:

y—dependent variable, in our case *GHG* variable;
x_i—independent variables, in our case SDG_i, *ECON* and *REG_NUM* variables (see Table A3 in Appendix D);
β_i—coefficients for independent variables;
p—number of independent variables; in our case p = 16;
λ—penalty term which tunes the coefficients such that if lambda increases, shrinkage occurs so that variables that are at zero are penalized—they can be thrown away.

Preliminary selection of independent variables with the LASSO method allowed us to move to the next step—improving the correctness of the model by further elimination of less insignificant variables with 'from-general-to-specific' procedure using the multiple linear regression method. The attained model had a linear form. Then, the Ramsey RESET test was conducted to check the suitability of the linear form.

The Ramsey RESET test is a specification validation test for linear regression models. In other words, it is used to check whether the linear form of the model (concerning a quadratic or cubic function) is the best model that can be selected. The test makes it possible to verify the correctness of the model specification without comparing it to an alternative form; therefore, in case of incorrectness, it does not suggest a better variant [58]. The null hypothesis H_0: $\gamma = 0$ (the regression equation is correctly specified) is put against the alternative hypothesis H_1: $\gamma \neq 0$ (the regression equation is incorrectly specified). When estimating the model:

$$y = \gamma_1 + \gamma_2 X_i + u_i \tag{6}$$

one obtains the calculated $\hat{y}$ values, that is, the non-standardized predicted values. Then, successive powers of $\hat{y}$ to the model are introduced:

$$y = \gamma_1 + \gamma_2 X_i + \gamma_3 \hat{y}^2 + \ldots + \gamma_{k-1} \hat{y}^k + u_i \tag{7}$$

Introducing subsequent powers $\hat{y}_i$ to the model in the form of an explanatory variable should increase the value of the coefficient of determination R^2. When the increase in this coefficient is statistically significant (check with the Fisher Snedecor F test), the model's original form is incorrect.

The Ramsey test is considered a high-power test, capable of rejecting the null hypothesis when it is false. Numerous studies on the Ramsey test have indicated that this test detects an incorrect specification of a regression equation known in advance to be poorly specified. Both R^2, the Durbin–Watson autocorrelation test, and Student t statistics indicate that the equation should be considered correct. This test is recommended in all situations where the equation's incorrect specification is suspected [59].

The third group of procedures in our modelling is based on the design of experiment concept. Their aim is to identify possible interactions between the SDG_i variables which affect the behaviour of the *GHG* dependent variable. This requires running hundreds of experiments with different variable combinations. The methodology is widely described by Oehlert [60,61]. In general, the following regression problem is solved (Equation (8) depicts a 2-way full factorial model with quadratic main effects):

$$y = \gamma_0 + \gamma_1 x_1 + \gamma_2 x_2 + \ldots + \gamma_k x_k + \gamma_{11} x^2{}_1 + \gamma_{22} x^2{}_2 + \ldots + \gamma_{kk} x^2{}_k + \gamma_{12} x_1 x_2 + \ldots + \gamma_{k-1,k} x_{k-1} x_k + \epsilon \quad (8)$$

where:

y—experiment yield; in our case *GHG* variable;
x_k—independent variables, in our case SDG_i, *ECON* and *REG_NUM* variables;
γ_k—coefficients for independent variables;
k—number of independent variables;
$x_{k-1}x_k$—interactions between $k-1$ and k-th variables;
$\gamma_{k-1,k}$—coefficients representing two factor interaction effects.

In such factorial designs, multiple factors are investigated during the test at the same time. The goal of these designs is to detect the factors that have a meaningful effect on the experiment yield, as well as investigate the effect of interactions on the experiment yield.

At the previous stage, the authors ruled out non-linear interactions, thus the problem is simplified to a model with linear interactions. So the next step is to find a solution (minimum or maximum) for the following problem:

$$\hat{y} = \hat{\gamma}_0 + \sum_{i=1}^{k} \hat{\gamma}_i x_i + \sum_{i=1}^{k} \sum_{j=1}^{i-1} \widehat{\gamma_{ij}} x_i x_j \quad (9)$$

The yield (response) $\hat{y}$ is optimized at the point where the partial derivatives, $\partial\hat{y}/\partial x_1$, $\partial\hat{y}/\partial x_2, \ldots, \partial\hat{y}/\partial x_k$, are all equal to zero.

In our research the *GHG* variable was set as the experiment yield. Firstly, using the model obtained in phase 2, the isolated 2-way interactions (2-way full factorial) of each SDG_i selected to the model with all other SDG_i variables were checked. Then, using this set of statistically significant interactions further experiments with pairwise interactions and 3-way interaction were carried out. The full procedure is described in the section devoted to the research results.

4. Description of Variables

The basis for empirical research on the implementation of the sustainable development goals is a database created based on Eurostat data, which are used to monitor the progress of the European Union countries in implementing the latest Strategy for Sustainable Development. Agenda 2030. The study analyzed data from 2017 and 2018, for which it was possible to create a comprehensive database covering the European Union (EU) Member States.

The sustainable development goals represent values that are crucial for European countries, especially those in the European Union. Europe plays a key role in the global achievement of the SGDs which is confirmed by the sustainability score of European countries. In the overall performance of United Nations (UN) Member States ranking, the top 10 positions belong to European countries, and the in the top 50 there are only 14 non-European counties (28%) (see Table A4 in Appendix E).

Based on the indicators for monitoring the sustainability performance, it can be noticed that EU countries made progress toward almost all of the SDG over the last several years. The strongest progress was made toward all targets of SDG 16 (Peace, justice and strong institutions). For SDG 1 (No poverty), SDG 2 (Zero hunger), SDG 3 (Good health and wellbeing), and SDG 8 (Decent work and economic growth) good progress was visible. For other SDGs, moderate progress was made by EU. No progress was noticed for SDG 13 (Climate action), and for SDG 5 (Gender equality) the EU has moved away from sustainable development goals.

Eurostat currently uses 100 different indicators to monitor progress in the implementation of the 2030 Agenda, some of them are updated less frequently than once a year (12 indicators), and in the case of the following 23, information about them is made available only in an aggregated form, at the level of Europe or the European Union level. In addition, some of them are not available for some countries, for example, regarding indicators describing the protection of the seas in the countries that do not have access to it [62]. For this reason, these indicators could not be included in the final database. Ultimately, the base of 78 indicators describing the 15 goals of the 2030 Agenda that was created became the basis for further analyses, presented in this paper. The research also took into account economic indicators. A detailed list of these indicators is presented in Table A3 in Appendix D.

In the next step, for each goal of sustainable development and for the *ECON* variable, rankings were constructed following the procedure indicated in the methodology section (Equation (1)). All rankings have been reduced to comparability so that higher values correspond to lower implementation of sustainable development goals and countries' economic situation. For this purpose, Equations (2) and (3) were used.

The prepared statistical material was used for econometric modelling, while the index describing the implementation of the target 13.10, namely greenhouse gas emissions in tonnes per capita, was adopted as the dependent (endogenous) variable. Thus, the variable is destimulant in nature, which means that the lowest possible values of this variable are desirable. The set of explanatory variables includes 16 synthetic, modified variables related to implementing the sustainable development goals, a variable related to the economic situation, and geographical location (three groups of countries).

In the first stage of econometric modelling, explanatory variables were selected. Apart from the choice of the regression method, selecting these variables is a crucial decision affecting both the fit and accuracy of the regression model forecasts. Too small and too many of them may negatively affect the quality of such models. As emphasized by Faraway [63], Hastie et al. [64] and Maddala [65], the excessive number of predictors is unfavourable due to:

- the risk of excessive collinearity of predictors and related problems;
- introducing unnecessary information (noise) and an unintentional loss of degrees of freedom into the model, which results in the increased variance of model parameters (despite a low load);
- the cost of preparing and acquiring observations expanded with redundant predictors;
- difficulties in interpreting the most significant influence of the predictors on the explained variable.

5. Results

After using the Lasso method, the set of explanatory variables was limited to the following variables: SDG7, SDG5, SDG17, SDG4, SDG1, SDG12, SDG2, ECON, REG_NUM—see Table 1.

Table 1. Results of variable selection by Lasso method.

ID	lambda	No. of Nonzero Coefficients	CV Mean Pred. Error	Variables (A)dded, (R)emoved, or Left (U)nchanged
24	11.05588	2	6.060523	A SDG7, REG_NUM
25	10.0737	3	5.999147	A SDG6
33	4.785826	4	5.407098	A SDG17
47	1.301069	5	4.540452	A SDG4
49	1.08017	7	4.57831	A SDG1 ECON
51	0.8967763	8	4.547108	A SDG12
71	0.1395094	9	3.967341	A SDG2
* 93	0.0180183	9	3.929894	U
100	0.0093948	9	3.978157	U

Lasso linear model; No. of obs = 50; No. of covariates = 16
Selection: Adaptive; No. of lasso steps = 2

* lambda selected by cross-validation in final adaptive step. Source: own calculations using Stata 16. Note: full descriptions of variables are presented in Table A3 in Appendix D.

The econometric modelling of GHG emissions in the European Union countries is presented in Table 2. The determination coefficient of the estimated model means that the model explained more than 63% of the overall observed variability of the response variable, and most parameters at the significance level of 0.05 (or (0.1) are statistically significant, except for the variable related to the geographical location of countries. The Ramsey RESET test confirmed the hypothesis about the usefulness of the linear form of the econometric model. The tested specification of the model (square and cube of the variable) provided the test statistic: F = 2.240246, which means that with p = P (F (2,43) > 2.24025) = 0.119, there is no reason to reject H0 with the correct model specification.

Table 2. The evaluation of the parameters of the basic model of greenhouse gas emissions in the European Union countries.

Scheme	Coefficient	Standard Error	t Statistics	p-Value
SDG4	−0.3430	0.2018	−1.70	0.096
SDG5	0.9686	0.1727	5.61	0.000
SDG7	1.3772	0.2934	4.69	0.000
SDG17	−0.7363	0.2572	−2.86	0.006
ECON	−0.6421	0.3355	−1.91	0.062
REG_NUM	0.6046	0.3949	1.53	0.133
CONS	−1.1849	0.8134	−1.46	0.152
R^2 = 63.44%; F(6.43) = 12.43; Prob > F = 0.0000; n = 50				

Source: own calculations using Stata 16. Note: full descriptions of variables are presented in Table A3 in Appendix D.

As indicated by the parameters' values, the most significant impact on shaping the dependent variable, regardless of other variables, is the implementation of SDG7, which increases greenhouse gas emissions. That is not surprising as there is a high correlation between the consumption (combustion) of fuels and energy and the concentration of carbon dioxide in the atmosphere. Until the industrial revolution, the concentration of this gas remained approximately the same, i.e., 260–270 particles of CO_2 per million particles of atmospheric gases. The development of industry and the growing consumption of fossil fuels have resulted in a sharp increase in CO_2 concentration in the atmosphere, and, unfortunately, this increase is getting faster.

A similar influence (direction) on the explained variable has the SDG5 variable related to achieving gender equality and empowering women. Difficulties related to the implementation of this goal translate into the quality of the natural environment. Research shows that women have more favourable attitudes than men towards the environment and ecological products [66,67]. Caring for the family's health and safety, particularly for children's health, emerges as a strong motivator for purchasing ecological products. They care more about the environment's qualities, and their attitudes are more pro-social and altruistic [68,69].

In turn, the following variables positively impact GHG, i.e., the reduction of gas emissions: SDG17, ECON, and SDG4. The first of these variables represents goal 17, related to the enhancement of sustainable development measures and is a result of indicators, the vast majority of which are stimulants. High values of these indicators have a positive impact on the implementation of GHG and SDG13. The situation is similar in the case of the ECON variable—the good economic situation of countries, support from government institutions in many sectors of the economy (education, health, social protection), and the impact of environmental taxes improve the quality of the natural environment by reducing greenhouse gas emissions.

The positive impact of SDG4 implementation on the explained variable follows from the increased awareness of the negative consequences on the environment and health due to human activities. People with higher education have a higher level of health orientation and are more sensitive to ecological issues; hence they represent more favourable environmental attitudes.

In the next step, a series of econometric modelling simulations were conducted to identify possible interactions between the different SDGs that could affect the dependent variable (GHG). Two, three, and four-factor interactions were tested. Tables 3–8 present selected modelling results, taking into account the type of interaction, the significance of parameter estimates, and the degree of matching the model to real data, which in each case exceeded 65%. As it results from the obtained models, the dependent variable, i.e., greenhouse gas emission in tonnes per capita, is also influenced by interactions between various variables, and importantly, the vast majority of these iterations reduce greenhouse gas emissions. Based on the models presented in Tables 3–8, the following additional conclusions may be formulated:

1. SDG4_SDG 5: "Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all" and "Achieve gender equality and empower all women and girls" contribute to reducing greenhouse gas emissions (Table 3);
2. SDG5_SDG15: "Achieve gender equality and empower all women and girls" and "Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss" contribute to reducing greenhouse gas emissions (Tables 3 and 7);
3. SDG17_SDG3: "Strengthen the means of implementation and revitalize the global partnership for sustainable development" and "Ensure healthy lives and promote well-being for all at all ages" contribute to reducing greenhouse gas emissions (Table 4);
4. SDG17_SDG7: "Strengthen the means of implementation and revitalize the global partnership for sustainable development" and "Ensure access to affordable, reliable, sustainable, and modern energy for all" contribute to the reduction of greenhouse gas emissions (Tables 4–6);
5. SDG17_SDG8: "Strengthen the means of implementation and revitalize the global partnership for sustainable development" and "Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all" contribute to reducing greenhouse gas emissions (Table 5);
6. SDG7_SDG17_SDG1: ensuring access to affordable, reliable, sustainable, and modern energy for all, strengthening the means of implementation and revitalizing the Global Partnership for Sustainable Development and eradicating poverty in all its forms everywhere contribute to reducing greenhouse gas emissions (Table 6);
7. SDG5_SDG15_SDG17: "Ensure access to affordable, reliable and modern energy for all" and "Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss" and "Strengthen the means of implementation and revitalize the global partnership for sustainable development" contribute to the growth of greenhouse gas emissions (Table 7);
8. SDG4_SDG5_SDG15_SDG17: "Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all" and "Achieve gender equality and empower all women and girls" and "Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss" and "Strengthen the means of implementation and revitalize the global partnership for sustainable development" contribute to the reduction of greenhouse gas emissions (Table 8).

Table 3. The evaluation of the parameters of the linear model of greenhouse gas emissions in the European Union countries using the interaction of two variables.

Specification	Coefficient	Standard Error	t Statistics	*p*-Value
SDG7	1.2682	0.2648	4.79	0.000
REG_NUM	0.9299	0.3611	2.58	0.014
SDG4	−0.3086	0.2344	−1.32	0.195
SDG5	0.9743	0.1794	5.43	0.000
SDG17	−0.7606	0.2453	−3.10	0.004
ECON	−0.7358	0.3164	−2.33	0.025
SDG4_SDG5	−0.2462	0.0765	−3.22	0.003
SDG15	−0.3537	0.1723	−2.05	0.047
SDG5_SDG15	−0.1147	0.0611	−1.88	0.068
CONS	−1.2893	0.7350	−1.75	0.087
R^2 = 74.64%; F(9.40) = 13.08; Prob > F = 0.0000; n = 50				

Source: own calculations using Stata 16.

Table 4. The evaluation of the parameters of the linear model of greenhouse gas emissions in the European Union countries using the interaction of two variables.

Specification	Coefficient	Standard Error	t Statistics	*p*-Value
SDG7	1.2951	0.2771	4.67	0.000
REG_NUM	0.7604	0.3626	2.10	0.042
SDG4	−0.4327	0.1852	−2.34	0.024
SDG5	1.0780	0.1608	6.70	0.000
SDG17	−0.8492	0.2617	−3.25	0.002
ECON	−0.7978	0.3246	−2.46	0.018
SDG17_SDG3	−0.3714	0.1335	−2.78	0.008
SDG17_SDG7	−0.5632	0.2392	−2.35	0.023
CONS	−1.3352	0.7419	−1.80	0.079
R^2 = 65.81%; F(8.41) = 12.79; Prob > F = 0.0000; n = 50				

Source: own calculations using Stata 16.

Table 5. The evaluation of the parameters of the linear model of greenhouse gas emissions in the European Union countries using the interaction of two variables.

Specification	Coefficient	Standard Error	t Statistics	*p*-Value
SDG7	1.1533	0.2765	4.17	0.000
REG_NUM	1.2019	0.3992	3.01	0.004
SDG4	−0.4010	0.1829	−2.19	0.034
SDG5	1.1655	0.1660	7.02	0.000
SDG17	−1.0450	0.2908	−3.59	0.001
ECON	−0.9752	0.3252	−3.00	0.005
SDG17_SDG7	−0.7999	0.2646	−3.02	0.004
SDG17_SDG8	−0.5049	0.1768	−2.86	0.007
CONS	−1.8381	0.7582	−2.42	0.020
R^2 = 66.10%; F(8.41) = 12.94; Prob > F = 0.0000; n = 50				

Source: own calculations using Stata 16.

Table 6. The evaluation of the parameters of the linear model of greenhouse gas emissions in the European Union countries using the interaction of three variables.

Specification	Coefficient	Standard Error	t Statistics	*p*-Value
SDG7	2.1434	0.3598	5.96	0.000
REG_NUM	0.4394	0.3549	1.24	0.223
SDG4	−0.6137	0.2041	−3.01	0.005
SDG5	0.9998	0.1546	6.47	0.000
SDG17	−1.5685	0.3863	−4.06	0.000
ECON	−0.3629	0.4263	−0.85	0.400
SDG7_SDG17	−0.9841	0.3296	−2.99	0.005
SDG1	0.4639	0.2492	1.86	0.070
SDG7_SDG1	−0.1582	0.2124	−0.75	0.461
SDG17_SDG1	−0.2734	0.2154	−1.27	0.212
SDG7_SDG17_SDG1	−1.5445	0.4029	−3.83	0.000
CONS	−0.6364	0.7381	−0.86	0.394
R^2 = 77.35%; F(11.38) = 11.79; Prob > F = 0.0000; n = 50				

Source: own calculations using Stata 16.

Table 7. The evaluation of the parameters of the linear model of greenhouse gas emissions in the European Union countries using the interaction of three variables.

Specification	Coefficient	Standard Error	t Statistics	*p*-Value
SDG7	1.4719	0.2673	5.51	0.000
REG_NUM	1.4455	0.4371	3.31	0.002
SDG4	−0.7698	0.2269	−3.39	0.002
SDG5	1.4013	0.1953	7.18	0.000
SDG17	−1.09330	0.2912	−3.75	0.001
ECON	−0.3115	0.3271	−0.95	0.347
SDG15	−0.6895	0.2180	−3.16	0.003
SDG5_SDG15	−0.2077	0.0746	−2.78	0.008
SDG5_SDG17	−0.4651	0.1658	−2.81	0.008
SDG15_SDG17	0.4155	0.2012	2.07	0.046
SDG5_SDG15_SDG17	0.2796	0.0869	3.22	0.003
CONS	−2.5324	8561	−2.96	0.005
R^2 = 76.10%; F(11.38) = 11.00; Prob > F = 0.0000; n = 50				

Source: own calculations using Stata 16.

Table 8. The evaluation of the parameters of the linear model of greenhouse gas emissions in the European Union countries using the interaction of four variables.

Specification	Coefficient	Standard Error	t Statistics	*p*-Value
SDG7	1.4508	0.2858	5.08	0.000
REG_NUM	0.4388	0.3912	1.12	0.267
SDG4	−0.3734	0.1955	−1.91	0.063
SDG5	0.9198	0.1686	5.46	0.000
SDG17	−0.4655	0.2822	−1.65	0.106
ECON	−0.4337	0.3401	−1.28	0.209
SDG4_SDG5_SDG15_SDG17	−0.0575	0.0284	−2.02	0.050
CONS	−1.0130	0.7902	−1.28	0.207
R^2 = 66.68%; F(7.42) = 12.01; Prob > F = 0.0000; n = 50				

Source: own calculations using Stata 16.

6. Discussion

The number of publications on the importance of environmental education and its transfer to education for sustainable development has significantly grown in recent years [70–72]. Research has revealed that the implementation of SDG4, i.e., education policies, clearly facilitate the achievement of environmental policies. The importance of environmental education was the subject of the educational research review by Jorgenson et al. [73]. They analyzed 70% of studies and found educators more interested in environmental changes than in energy issues. According to the authors, environmental education has a significant impact on pro-environmental behaviour and thus limits environmental changes. Yates et al. [74] showed that women present stronger pro-ecological attitudes than men. In addition, women are more involved in private environmental behaviour and are more likely to sign pro-environmental petitions.

This analysis showed that SDG17 explicitly facilitate the achievement of environmental policies. This is consistent with the result obtained by Glasbergen and Groenenberg [75], who based on the case in the field of sustainable energy production demonstrated the potential of partnerships between the private sector and environmental organizations. Such partnerships call the government to implement policies helping in further development of sustainable products.

SDG17 also refers to environmental taxes. Li et al. [76] demonstrated a negative but limited impact of environmental taxes on GDP. Wang et al. [77] showed that the optimal environmental tax should be proportional to the level of emissions. Hassan et al. [78] analysing the sample of 31 Organisation for Economic Cooperation and Development (OECD) countries in the years 1994–2013 revealed the supportive role of green taxes for economic growth in the case of a high initial level of GDP per capita (high developed countries).

This research also demonstrated that SDG1, SDG3, SDG8 and SDG15 exert an indirect influence on the environmental goal through their reinforcing interactions with SDG4 and SDG17 variables, which is in line with the conclusions made by Mihai et al. [79], who proved that education is a factor reducing poverty. The role of universities in fighting poverty, referring to the Bologna Declaration, was indicated by Sanz et al. [80]. Tilak [81] drew attention to the importance of education in the elimination or at least reduction of poverty as an important element towards implementing a sustainable development strategy.

The SDGs create new opportunities for addressing the relation between poverty and the environment in a more integrated and holistic way. However, deep changes in the measurement and understanding of development are required, as well as in environmental development and intervention designed to positively influence prosperity [82].

The impact of the environment on human health was the subject of a study by Schleicher et al. [82], and Di Maria et al. [83]. Regarding the goals related to the environment (SDG13 and SDG15), a strong relationship with providing access to drinking water and energy (SDG7 and SDG6) was revealed. In turn, SDG 6 and SDG7, are key factors to a better health situation (SDG3). Markets of green technology additionally provide chances to create new jobs (SDG8) [84].

Hall et al. [85] showed the crucial influence of the environmental goal (SDG13) and the partnerships goal (SDG17) on all other SDGs. The health and wellbeing goal (SDG3) is the dominant goal and all other SDGs contribute to it. The three most influential SDGs are those for poverty reduction (SDG1), education (SDG4), and work and economy (SDG8).

7. Conclusions

The article investigates the impact of SDGs on the level of greenhouse gas emissions in European Union countries. The EU countries play a leading role in reducing greenhouse gas emissions. As part of the Paris Agreement, EU member countries have committed to reducing overall greenhouse gas emissions by 40% from 1990 levels by 2030 [5]. However, the amount of GHG emissions significantly differs in the EU member states, hence individual countries also differentiate their environmental policy instruments, which allows for the adaptation of environmental policy instruments to the specific characteristics of individual countries. There are also differences at the level of implementation of individual SDGs in the EU member states. Sweden, Malta and Romania are the countries that pollute the least and Ireland, Estonia and Luxembourg pollute the most. Comparing the actual GHG emissions and 2020 limit set by the EU, Greece, Spain and Italy are performing particularly well and Estonia, Latvia, and Poland are the worst-performing countries that even increased their emissions [8]. Taking into consideration the SDG index, the Scandinavian countries are on the top of the ranking list and Greece, Bulgaria, Romania, Cyprus rank as the worst. The analysis of SDGs in EU member states shows that these countries perform poorly on goals related to responsible consumption and production, climate action, and biodiversity. EU member states report best results on the socio-economic goals, including SDG 1, SDG 3 and SDG 6 [86].

The research was conducted for all 17 SDGs in the period 2017–2018 for 25 EU countries. The research results showed that the relationship between the dependent variable (GHG) and SDGs can be two-fold, direct and indirect. As a result of the analysis, it was shown that the implementation of SDG7 (affordable and clean energy) and SDG5 (gender equality) has the greatest impact on GHG. On the other hand, from the perspective of implementing an effective climate policy, SDG4 (quality education) and SDG17 (partnership for the goals) are of significant importance. Indirect relationships are observed in the enhancement of the achievement of SDG4 and SDG17 by the interaction of SDG1 (no poverty), SDG3 (good health and well-being), SDG8 (decent work and economic growth) and SDG15 (life on land).

Knowledge about the relationships occurring on two levels, i.e., between the goals of the SDGs and the GHG, and between the SDGs itself, is useful from the point of view of decision-makers responsible for creating environmental policy as well as environmental risk management and climate change prevention strategies. Knowledge of the relationship between the goals allows for the integrated management of public policies in such a way as to neutralize and reduce emissions of GHG effectively. The comprehensive approach to SDG analysis from the perspective of environmental, social and economic variables is noteworthy. Such an approach to the perception of the relationship between the implementation of the SDG and the GHG allows governments to accurately design the state's actions to shape the economy in a climate-neutral manner. These activities include both building social awareness and the implementation of pro-environmental investments and taking actions in the field of natural resources management. Future research directions relate to an in-depth analysis of two interaction perspectives—direct understanding of their impact on GHG. The authors also plan to expand the time and geographical scope of the analysis. This research showed that moderately significant geographical differentiations also exist among Western and Northern, Mediterranean, and Central and Eastern European countries, which may to a certain degree amend the primary interactions between SDGs and environmental performance for a specific country. Thus, in order to formulate precise policy recommendations, the geographical context should be cautiously investigated, as well.

Author Contributions: Conceptualization, M.Z., K.K.; methodology, K.K, I.B.; software, K.K.; validation, K.K.; formal analysis, K.K., I.B.; investigation, K.K.; resources, K.K., I.B., A.S.; data curation, K.K.; writing—original draft preparation, K.K., M.Z., I.B., A.S.; writing—review and editing, K.K., M.Z., I.B., A.S.; visualization, K.K., M.Z., I.B., A.S.; supervision, K.K.; project administration, K.K.; funding acquisition, K.K. All authors have read and agreed to the published version of the manuscript.

Funding: The APC was partially funded by SGH Warsaw School of Economics, Poland.

Data Availability Statement: Source data is available from Eurostat database at https://ec.europa.eu/eurostat/data/database (accessed on 2 December 2020).

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

Appendix A

Table A1. Post-transformation variables relating to the sustainable development goals (from 1 to 17, in respective columns) and the economic variable in 2018.

Variable/ Country	1	2	3	4	5	7	8	9	10	11	12	13 (GHG)	15	16	17	ECON
Belgium	0.67	−0.37	−1.07	−0.71	−1.27	2.74	0.23	−2.42	−2.77	−0.66	−1.26	2.60	2.88	−1.09	0.63	−0.99
Bulgaria	2.83	2.29	1.33	3.29	0.53	−0.41	3.07	2.18	3.98	1.94	2.24	−0.40	−1.12	3.07	−1.12	1.01
Czechia	−3.17	−1.04	0.13	0.13	2.73	0.59	−0.10	0.18	−2.02	0.74	0.49	4.60	0.88	1.07	0.88	−0.21
Denmark	−0.33	−2.37	−1.47	−2.04	−2.67	−1.12	−1.93	−3.02	−2.77	−1.66	−1.26	0.60	3.38	−2.26	−1.87	−2.65
Germany	−0.33	−1.71	−1.07	0.13	−1.67	0.59	−2.43	−2.82	−1.77	−0.66	−0.01	2.60	−0.62	−2.43	−1.12	−0.32
Estonia	−0.33	−0.71	3.13	−1.37	1.53	0.45	−0.10	0.78	1.23	−1.46	3.24	4.60	−0.62	0.74	−0.62	−0.65
Ireland	−0.33	−0.71	−2.27	−2.71	2.33	−0.12	−0.43	0.58	−2.52	−2.26	−0.26	4.60	3.38	−2.26	0.38	0.57
Greece	3.33	0.63	−1.27	1.79	2.73	−0.12	1.23	2.38	2.73	2.34	−0.51	0.60	−1.12	2.07	1.13	1.01
Spain	1.50	−2.37	−2.67	0.83	−0.47	−0.26	1.57	1.78	1.73	−0.66	−0.76	−1.40	−2.62	1.24	0.88	1.24
France	−1.33	−1.04	−1.61	−1.04	−3.27	0.31	1.07	−0.82	−2.27	−0.46	−3.26	−2.40	−1.12	0.41	0.38	−0.21
Croatia	0.83	2.29	1.13	1.63	1.53	−1.12	2.23	2.18	2.73	1.54	−0.26	−3.40	−1.12	1.24	0.38	−0.32
Italy	1.67	−1.04	−2.47	2.63	0.93	0.17	1.57	1.18	0.98	−0.06	−2.51	−1.40	−1.12	1.07	0.13	0.90
Latvia	2.00	0.63	4.13	−0.21	−0.87	−0.98	1.07	1.58	3.23	1.54	1.24	−3.40	−0.12	1.74	−0.62	0.35
Lithuania	1.83	1.63	3.73	−1.04	0.73	0.59	0.07	1.18	2.48	−0.46	1.49	−1.40	1.38	0.91	0.88	1.24
Hungary	−0.17	1.96	2.53	1.13	3.33	0.31	0.57	0.38	1.23	−0.26	1.49	−2.40	1.88	0.41	1.13	0.90
Netherlands	−1.00	−1.04	−1.87	−1.71	−2.07	1.17	−2.77	−3.02	−2.77	−0.66	−3.26	3.60	3.38	−1.59	−3.12	−0.65
Austria	−1.83	−1.37	−1.47	−0.87	−1.07	0.45	−0.43	−2.42	−2.77	−0.86	−0.26	0.60	−0.12	−2.26	1.38	−0.99
Poland	−1.67	2.96	1.73	−0.87	2.33	−0.41	−0.60	1.78	0.98	1.94	1.24	2.60	−1.12	−0.09	0.13	0.12
Portugal	0.33	1.63	0.13	1.13	−1.67	−0.69	−0.43	1.58	1.23	1.74	−0.26	−2.40	−0.12	−0.43	1.63	1.12
Romania	1.83	3.29	1.73	3.79	2.73	−2.83	2.07	2.18	3.73	3.74	1.49	−3.40	−0.62	1.41	−0.12	1.90
Slovenia	−1.17	−0.04	0.93	−0.87	−1.07	0.02	−0.77	−0.42	−1.77	−1.26	−0.01	−0.40	−1.12	1.07	−0.12	−1.88
Slovakia	−2.50	0.29	0.33	1.96	1.93	−0.12	0.90	1.58	0.48	0.34	1.24	−1.40	−0.12	1.24	0.63	0.01
Finland	−2.00	−1.71	−0.27	−1.21	−3.47	1.31	−1.27	−2.82	−3.02	−2.06	0.99	2.60	−3.12	−2.43	0.38	−1.43
Sweden	−1.50	−1.37	−2.07	−2.37	−4.07	0.31	−2.27	−3.62	−2.02	−1.86	0.49	−4.40	−3.62	−2.09	−0.37	−0.76
United Kingdom	0.83	−0.71	−1.27	−1.37	0.33	−0.83	−2.10	−0.22	−0.27	−0.66	−1.76	−1.40	2.38	−0.76	−1.87	0.68

Source: own calculations using Microsoft Excel 2010.

Appendix B

Table A2. Post-transformation variables relating to the sustainable development goals (from 1 to 17, in respective columns) and the economic variable in 2017.

Variable/ Country	1	2	3	4	5	7	8	9	10	11	12	13 (GHG)	15	16	17	ECON
Belgium	0.69	−0.41	−0.87	−0.56	−1.43	2.53	0.30	−2.19	−2.79	−0.90	−1.48	2.68	2.88	−0.93	0.67	−0.84
Bulgaria	3.02	2.25	1.33	3.27	0.17	−0.33	2.13	2.21	4.46	1.70	2.27	−0.32	−1.12	2.74	−1.08	0.94
Czechia	−2.81	−0.75	0.13	−0.23	3.17	0.67	−0.53	0.21	−1.79	0.30	0.52	4.68	0.88	1.07	0.92	−0.06
Denmark	−0.65	−3.08	−1.47	−2.06	−3.23	−1.33	−2.37	−3.19	−2.29	−1.30	−1.23	−0.32	3.38	−2.26	−1.83	−2.62
Germany	−0.48	−1.75	−1.07	−0.06	−2.03	0.82	−2.37	−2.79	−2.29	−0.70	0.02	2.68	−0.62	−2.09	−1.33	−0.40
Estonia	−0.48	−1.41	3.13	−1.23	1.37	0.25	−0.53	0.61	1.21	−1.90	3.27	4.68	−0.62	0.74	−0.83	−0.62
Ireland	0.02	−0.75	−2.07	−2.56	2.37	−0.18	−0.20	0.01	−1.79	−2.30	−0.23	4.68	3.38	−2.43	−0.08	0.38
Greece	3.52	1.25	−0.87	1.94	2.77	0.25	1.47	2.41	2.96	2.30	−0.73	0.68	−1.12	2.24	0.67	0.72
Spain	1.02	−1.41	−2.67	1.20	0.37	−0.47	1.80	1.81	2.21	−0.70	−0.98	−1.32	−2.62	0.74	0.92	1.38
France	−1.81	−0.75	−1.61	−1.06	−3.23	0.25	0.97	−0.79	−2.29	−0.50	−2.98	−2.32	−1.12	0.57	0.67	−0.17
Croatia	0.85	2.25	1.13	2.10	0.97	−1.18	2.47	2.21	2.21	1.50	−0.48	−3.32	−1.12	0.91	0.42	−0.28
Italy	1.69	−1.08	−2.87	2.27	0.37	−0.04	1.80	1.01	0.71	0.30	−2.73	−1.32	−1.12	1.24	0.17	0.60
Latvia	1.69	0.59	4.33	−0.06	0.17	−1.04	0.30	1.81	2.71	1.50	1.27	−3.32	−0.12	1.41	−0.58	0.49
Lithuania	1.52	1.59	3.53	−0.73	−0.03	0.25	0.30	1.21	2.46	−0.30	1.52	−1.32	1.38	0.91	0.92	1.38
Hungary	0.85	1.92	2.73	1.10	3.17	0.53	0.47	0.81	0.21	1.10	1.27	−2.32	1.88	0.57	1.42	0.72
Netherlands	−1.15	−1.08	−1.87	−1.90	−2.23	1.25	−2.70	−2.79	−3.04	−0.70	−3.23	3.68	3.38	−1.76	−2.83	−0.62
Austria	−1.48	−1.41	−1.47	−1.06	−0.23	0.67	−0.87	−2.39	−2.54	−0.90	−0.48	0.68	−0.12	−1.59	1.42	−0.95
Poland	−1.48	2.59	1.53	−0.73	1.97	−0.33	−0.03	2.01	1.21	1.90	1.77	2.68	−1.12	−0.09	0.17	0.38
Portugal	0.69	1.59	0.13	0.77	−0.83	−0.75	0.30	1.81	1.71	1.30	−0.23	−2.32	−0.12	0.24	1.67	1.16
Romania	1.85	3.25	1.93	3.44	2.77	−2.75	2.47	2.21	3.71	3.70	1.52	−3.32	−0.62	1.24	0.17	2.05
Slovenia	−1.15	0.92	0.93	−1.06	−1.43	0.10	−0.70	−0.39	−1.04	−1.30	0.02	−0.32	−1.12	0.91	−0.33	−1.62
Slovakia	−2.48	0.59	0.33	2.27	2.17	0.25	1.47	1.21	0.46	1.10	1.27	−1.32	−0.12	1.41	0.67	0.05
Finland	−2.31	−2.08	−0.67	−1.06	−3.23	1.25	−1.20	−2.99	−3.04	−2.10	1.27	1.68	−3.12	−2.76	0.17	−1.73
Sweden	−1.65	−2.08	−2.07	−2.40	−4.23	0.39	−2.53	−3.59	−2.29	−2.30	0.77	−4.32	−3.62	−2.26	−0.33	−0.84
United Kingdom	0.52	−0.75	−1.47	−1.56	0.37	−1.04	−2.20	−0.39	−1.04	−0.70	−1.98	−1.32	2.38	−0.76	−1.83	0.49

Source: own calculations using Microsoft Excel 2010.

Appendix C

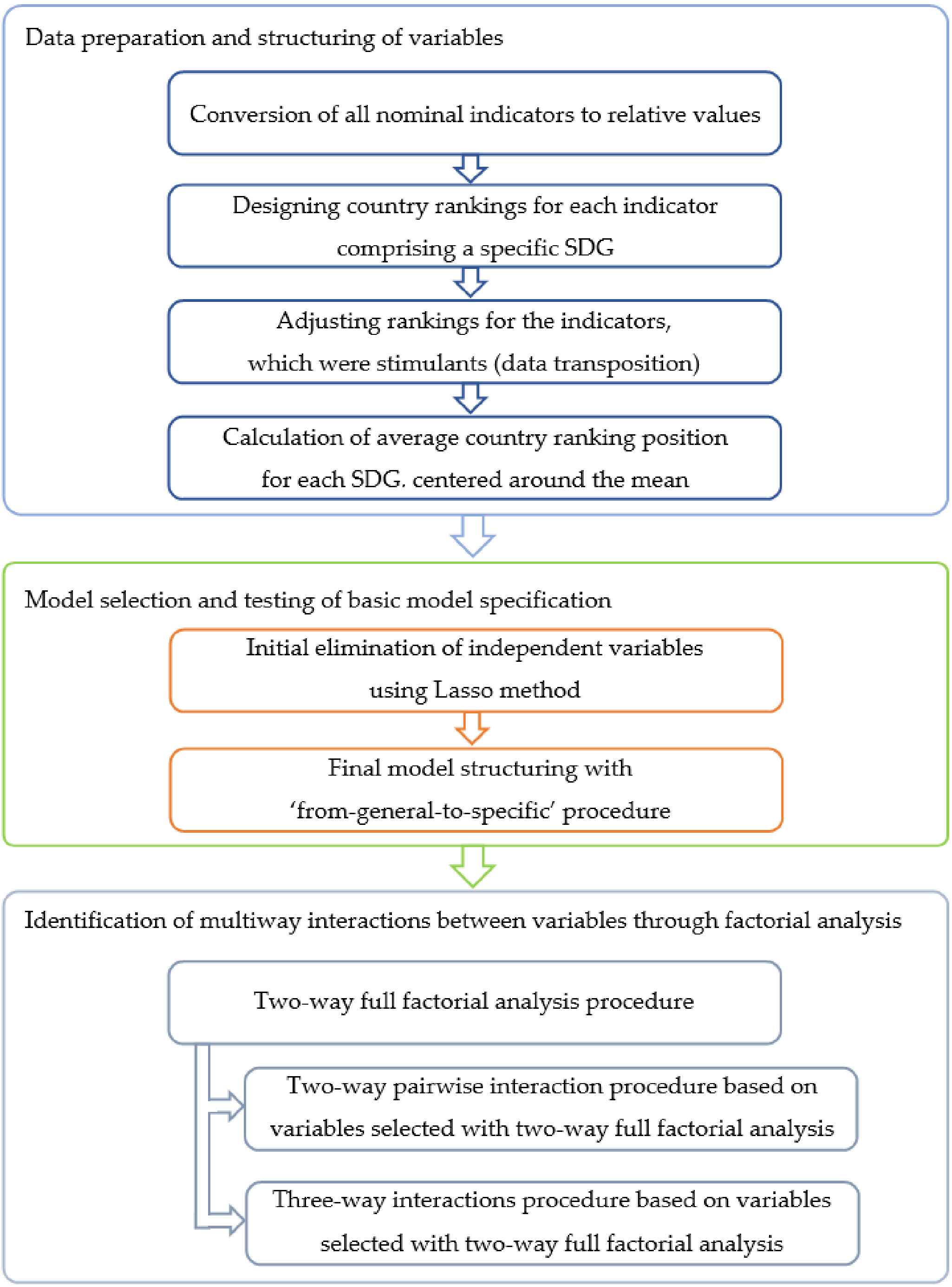

Figure A1. The graphical presentation of the analytical framework used in the research.

Appendix D

Table A3. Indicators describing the goals of sustainable development and separate economic indicators.

Name	Goal No. from Agenda 2030	Character of Indicator *
Goal 1: End poverty in all its forms everywhere (SDG1)		
People at risk of poverty or social exclusion, %	SDG 01.10	D
People at risk of income poverty after social transfers, %	SDG 01.20	D
Severely materially deprived people, %	SDG 01.30	D
People living in households with very low work intensity, Percentage of total population aged less than 60	SDG 01.40	D
Housing cost overburden rate, % of population	SDG.01.50	D
Population living in a dwelling with a leaking roof, damp walls, floors or foundation or rot in window frames of floor, % of population	SDG 01.60	D
Goal 2: End hunger, achieve food security and improved nutrition and promote sustainable agriculture (SDG2)		
Agricultural factor income per annual work unit (AWU) (source: European Commission services), euro per AWU	SDG 02.20	S
Government support to agricultural research and development, euro per inhabitant	SDG 02.30	S
Area under organic farming, % of utilised agricultural area (UAA)	SDG 02.40	S
Goal 3: Ensure healthy lives and promote well-being for all at all ages (SDG3)		
Life expectancy at birth, years	SDG 03.10	S
Self-perceived health, very good or good, % of population aged 16 or over	SDG 03.20	S
Death rate due to chronic diseases, number per 100,000 persons aged less than 65	SDG 03.40	D
Death due to suicide, Standardised death rate by 100,000 inhabitants	SDG 03.50	D
Self-reported unmet need for medical care by detailed reason, % of population aged 16 and over, Too expensive or too far to travel or waiting list	SDG 03.60	D
Goal 4: Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all (SDG4)		
Early leavers from education and training, % of population aged 18 to 24	SDG 04.10	D
Total Tertiary educational attainment, % of population aged 30 to 43	SDG 04.20	S
Participation in early childhood education, % of the age group between 4-years-old and the starting age of compulsory education	SDG 04.30	S
Underachievement in reading, maths or science (source: Organisation for Economic Cooperation and Development (OECD)), reading	SDG 04.40	D
Employment rates of recent graduates, % of population aged 20 to 34 with at least upper-secondary education	SDG 04.50	S
Adult participation in learning, % of population aged 25 to 64	SDG 04.60	S
Goal 5: Achieve gender equality and empower all women and girls (SDG5)		
Gender employment gap, percentage points	SDG 05.30	D
Inactive population due to caring responsibilities, % of inactive population aged 20 to 64	SDG 05.40	D
Seats held by women in national parliaments, % of seats	SDG 05.50A	S
Seats held by women in national governments, % of seats	SDG 05.50B	S
Positions held by women in senior management positions (source: European Institute for Gender Equality), % of positions, Board members	SDG 05.60B	S
Goal 7: Ensure access to affordable, reliable, sustainable and modern energy for all (SDG7)		
Primary energy consumption, Tonnes of oil equivalent per capita	SDG 07.10	D
Final energy consumption, Tonnes of oil equivalent per capita	SDG 07.11	D
Final energy consumption in households per capita, kg of oil equivalent	SDG 07.20	D
Energy productivity, Purchasing power standard (PPS) per kilogram of oil equivalent	SDG 07.30	S
Share of renewable energy in gross final energy consumption, %	SDG 07.40	S
Energy import dependency by products, % of imports in total gross available Energy	SDG 07.50	D
Population unable to keep home adequately warm by poverty status, % of population	SDG 07.60	D
Goal 8: Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all (SDG8)		
Real GDP per capita, in euro	SDG 08.10	S
Investment share of GDP by institutional sectors, % of GDP, total investment	SDG 08.11	S
Total Young people neither in employment nor in education and training, % of population aged 15 to 29	SDG 08.20	D
Total Employment rate, % of population aged 20 to 64	SDG 08.30	S
Total Long-term unemployment rate, % of active population (aged 15 to 74 years)	SDG 08.40	D
People killed in accidents at work, number per 100,000 employees	SDG 08.60	D
Goal 9: Build resilient infrastructure, promote inclusive and sustainable industrialization, and foster innovation (SDG9)		
Gross domestic expenditure on R&D by sector, % of GDP	SDG 09.10	S
Total Employment in high- and medium-high technology manufacturing and knowledge-intensive services, % of total employment	SDG 09.20	S
R&D personnel by sector, % of active population, All sectors	SDG 09.30	S
Patent applications to the European Patent Office (source: EPO), Per million inhabitants	SDG 09.40	S
Share of rail and inland waterways in total freight transport, % of total inland freight tonne-km	SDG 09.60	S
Goal 10: Reduce inequality within and among countries (SDG10)		
Purchasing power adjusted GDP per capita	SDG 10.10	S
Adjusted gross disposable income of households per capita	SDG 10.20	S
Relative median at-risk-of-poverty gap, % distance to poverty threshold	SDG 10.30	D
Income share of the bottom 40% of the population, % of income	SDG 10.50	D
Goal 11: Make cities and human settlements inclusive, safe, resilient and sustainable (SDG11)		
Total Overcrowding rate by poverty status, % of population	SDG 11.10	D
Total Population living in households considering that they suffer from noise, by poverty status, % of population	SDG 11.20	D
Settlement area per capita, m^2 per capita	SDG 11.31	S
People killed in road accidents (source: EC services), rate	SDG 11.40	D
Recycling rate of municipal waste, % of total waste generated	SDG 11.60	S

Table A3. *Cont.*

Name	Goal No. from Agenda 2030	Character of Indicator *
Goal 12: Ensure sustainable consumption and production patterns (SDG12)		
Resource productivity and domestic material consumption (DMC), euro per kilogram	SDG 12.20	S
Average CO_2 emissions per km from new passenger cars (source: EEA and EC services), g CO_2 per km	SDG 12.30	D
Circular material use rate, % of material input for domestic use	SDG 12.41	S
Generation of waste excluding major mineral wastes by hazardousness, kg per capita	SDG 12.50	D
Goal 13: Take urgent action to combat climate change and its impacts (SDG13)		
Greenhouse gas emissions—tonnes per capita (GHG)	SDG 13.10	D
Goal 15: Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss (SDG15)		
Share of forest area, % of total land area	SDG 15.10	S
Surface of terrestrial sites designated under Natura 2000 (source: DG ENV, EEA), Terrestrial protected area (km^2)	SDG 15.20	S
Goal 16: Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels (SDG16)		
Death rate due to homicide, number per 100,000 persons	SDG 16.10	D
Population reporting occurrence of crime, violence or vandalism in their area by poverty status, % of population	SDG 16.20	D
General government total expenditure on law courts, euro per inhabitant	SDG 16.30	S
Perceived independence of the justice system (source: DG COMM), % of population, Very good or fairly good	SDG 16.40	S
Corruption Perceptions Index (source: Transparency International), score scale of 0 (highly corrupt) to 100 (very clean)	SDG 16.50	S
Population with confidence in EU institutions—European Parliament, % of population	SDG 16.61	S
Goal 17: Strengthen the means of implementation and revitalize the global partnership for sustainable development (SDG17)		
Official development assistance as share of gross national income (source: OECD), % of gross national income (GNI)	SDG 17.10	S
EU imports from developing countries by country income groups, million EUR, Development assistance committee (DAC) recalculated per 100,000 inhabitants	SDG 17.30	S
General government gross debt, % of GDP	SDG 17.40	D
Shares of environmental taxes in total tax revenues, % of total taxes	SDG 17.50	S
ECON		
Government support to agricultural research and development, euro per inhabitant	SDG 02.30	S
Gross domestic expenditure on R&D by sector, % of GDP	SDG 09.10	S
Gini coefficient of equivalised disposable income, coefficient of 0 (maximal equality) to 100 (maximal inequality)	SDG 10.40	D
General government expenditure on education, % of GDP		S
General government expenditure on health % of GDP		S
General government expenditure on social protection, % of GDP		S
General government gross debt, % of GDP	SDG 17.40	D
Shares of environmental taxes in total tax revenues, % of total taxes	SDG 17.50	S
Consolidated banking leverage, domestic and foreign entities (asset-to-equity multiple)		D

* S and D describe the character of indicator: S is dedicated for stimulants, and D indicates destimulants. Source: own elaboration.

Appendix E

Table A4. The 2020 SDG Index scores (top 50).

	Country	2020 SDG Index Score
1	Sweden	84.72
2	Denmark	84.56
3	Finland	83.77
4	France	81.13
5	Germany	80.77
6	Norway	80.76
7	Austria	80.70
8	Czech Republic	80.58
9	Netherlands	80.37
10	Estonia	80.06
11	Belgium	79.96
12	Slovenia	79.80
13	United Kingdom	79.79
14	Ireland	79.38
15	Switzerland	79.35
16	New Zealand	79.20
17	Japan	79.17
18	Belarus	78.76
19	Croatia	78.40
20	Korea, Rep.	78.34
21	Canada	78.19
22	Spain	78.11
23	Poland	78.10

Table A4. *Cont.*

	Country	2020 SDG Index Score
24	Latvia	77.73
25	Portugal	77.65
26	Iceland	77.52
27	Slovak Republic	77.51
28	Chile	77.42
29	Hungary	77.34
30	Italy	77.01
31	United States	76.43
32	Malta	75.97
33	Serbia	75.23
34	Cyprus	75.21
35	Costa Rica	75.08
36	Lithuania	74.95
37	Australia	74.87
38	Romania	74.78
39	Bulgaria	74.77
40	Israel	74.60
41	Thailand	74.54
42	Moldova	74.44
43	Greece	74.33
44	Luxembourg	74.31
45	Uruguay	74.28
46	Ecuador	74.26
47	Ukraine	74.24
48	China	73.89
49	Vietnam	73.80
50	Bosnia and Herzegovina	73.48

Source: Sustainable Development Report 2020, p. 26.

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