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Article

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THE MULTICRITERIA ASSESSMENT OF THE GREEN GROWTH IN THE CONTEXT OF THE EUROPEAN UNION'S GREEN DEAL

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Abstract
The article deals with the issue of assessment of the green growth in context of the Green Deal in the European Union Countries. Because this issue leads to the decision problem which has typical the properties of multi-criteria decision making (MCDM), the Analytical Hierarchy Process (AHP) method, including the sensitivity analysis, was used as a suitable method for solving this issue. The main aim of the paper is to propose a new and suitable approach for a complex and systematically assessed Green Growth in countries of the European Union. The public OECD Green Growth database was used for the analysis. The multicriteria assessment model employs four criteria, indicators for monitoring progress towards green growth (1. Production-based CO_2 productivity; 2. Annual surface temperature; 3. The mean exposure of the population exposure to $PM_{2.5}$; 4. Environmentally related tax). Thanks to the new approach to the Green Growth assessment based on multicriteria evaluation, it is possible to automate this process and it is repeatedly applied. This ultimately provides management authorities with a tool to measure the maturity of the Green Deal not only in EU countries. Based on the proposed multi-criteria model, Ireland is evaluated as the land with the highest level of Green Growth and Latvia as the country with the lowest level in the analyzed year 2020.

Keywords: Green Deal, Green Growth, indicators, multicriteria decision-making, AHP (Analytical Hierarchy Process) method, OECD.

JEL Classification: C44, M10.

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Introduction

The European Green Deal (the priority of the European Commission) represents the largest European effort so far for a sustainable future and a solution to the climate crisis. The European Green Deal is being drafted as the current system strategy for further green growth. The Green Deal is a growth strategy, with the Green Growth and a sustainable circular economy driving it. The sub-strategies and initiatives of the Green Deal help build a more resilient and sustainable Europe and provide an investment environment conducive to green growth. According to the OECD, green growth means supporting economic growth and development while ensuring that natural resources continue to provide the resources and environmental services on which our well-being depends and which contribute to the country's prosperity (Kasztelan, 2017; Montanarella, 2020). At the end of 2019, the EU committed itself to achieving climate neutrality by 2050, notably through the introduction of solar and wind energy (D'Alessandro et al., 2020).

For the European Green Deal to be successful, comprehensive and systematic technological, political, and economic changes are needed (Paroussos et al., 2020; Furfari and Mund, 2021). In addition, these changes must be implemented (with regard to the defined time milestone 2050) in a relatively short time and with limited resources (personnel, material, costs, and investments from public and non-public budgets). All this in addition to the conditions of today's VUCA environment (Volatile, Uncertain, Complex, Ambiguous), which basically does not allow us to achieve our goals by several repeated attempts (Fassinger et al., 2017).

Filling in the above aspects requires the application of project management for the successful implementation of the Green Deal. Modern project management is based on two key principles. (1) The principle of teamwork plays a crucial role in the Green Deal project, because the project stakeholders are very diverse. This diversity is due both to the diversity of professions needed to implement the project (technicians, economists, managers, etc.) and to the international dimension (EU member states, EU citizens, EU companies). (2) The principle of a systems approach based on the application of exact methods in management (Lanfranchi et al., 2015).

It follows from the above principles that, to be able to manage the green contract project well, it is necessary to measure the partial results. Metrics for measuring green growth are known and available from public databases, OECD Green Growth Database (OECD, 2017). These databases contain values of specific criteria over time and can also be customized. These metrics served as a starting point for proposing a new approach to assess green growth. The evaluation is typically based on several criteria that can have different weights. It leads therefore to the problem of multi-criteria decision making (MCDM) theory (Bonissone et al., 2009; Sedaghat, 2013). The MCDM model (Hougaard and Smilgins, 2016) based on AHP (Analytic Hierarchy Process) method includes sensitivity analysis to assess the resulting rank of alternatives is employed in this research. This is the main aim of the article.

The main contribution of this article is the proposal of a suitable multicriterial approach for a complex and systematically assessed Green Growth in countries of the European Union. This approach enables to automate evaluation process and applied it repeatedly. In the end, this provides management authorities a useful tool to measure the maturity of the Green Deal not only in EU countries.

1. Review of the scientific literature

The research by Houssini and Geng (2021) developed the TOPSIS (The Technique for Order of Preference by Similarity to Ideal Solution) model based on the input-output framework to conduct a complex efficiency evaluation of the national system of Morocco. The TOPSIS model is a multi-criteria decision analysis method based on the concept that the chosen alternative should have the shortest distance from the positive ideal solution and the longest distance from the negative ideal solution. Data envelope analysis (DEA) was applied to measure the Green Growth efficiency for the period of 2000-2018 (Houssini and Geng, 2021).

The research by Lee and Chou applies the OECD Green Growth monitoring indicators in Taiwan. They use principal component analysis and the analytic hierarchy process as weighting methods to calculate an aggregating composite index and perform sensitivity testing. The results show that between the years 2002-2011, Taiwan has been moving toward green growth, although it has been negatively impacted by its natural capital stock. This means that improving natural capital stock is a key factor in sustaining Green Growth in Taiwan (Lee and Chou, 2018).

A multivariate analytical approach was employed in the research by Gavurova et al. (2021) focused on analyzing the condition and development of the OECD countries using a set of Green Growth indicators. The univariate and multivariate statistical approach was used to identify the main factors of the Green Growth maturity over two time spans – first period (years 2000-2009) and second period (years 2010-2019). The research results show that for stimulant indicators, an increase was achieved, while for destimulant variables, a decrease was reached between the analyzed periods (Gavurova et al., 2021).

The research by Shen et al. is focused on measuring the evolution of green productivity that includes carbon dioxide emissions based on the Luenberger productivity indicator (Briec and Kerstens, 2009). The research was carried out for the period 1971-2011 in 30 OECD countries. The research result is decomposed of growth in green productivity at the aggregate level. It separates the productivity changes into three components: (1) technological progress, (2) technical efficiency change, and (3) structural efficiency change. This structural effect captures the heterogeneity in the combination of input and output mixes among countries, which can impact productivity growth at a more aggregate level. This structural effect is a novelty. They state that the traditional TFP (Total Factor Productivity) index underestimates the Green Growth, which is motivated by the effective environmental policies of the OECD. For the last 20 years, green productivity growth has been mainly driven by technological progress (Shen et al., 2017).

The research by Kasztelan employed Hellwig's method (Roszkowska and Filipowicz-Chomko, 2021) for the evaluation of green growth in selected OECD countries. This approach allowed us to decompose the selected countries into four groups, characterized by similar levels of Green Growth. The research results show that in group 1 (the highest level of Green Growth), there is only one Denmark. In contrast, 12 of the 21 countries analyzed were in group 4 (the lowest level of Green Growth) (Kasztelan, 2017).

The research by Wang et al. (2019) analyses the stringency of environmental regulation policies and measures green productivity growth employing an extended Slack-Based Model-Directional Distance Function (SBM-DDF) approach based on panel data from OECD countries in industrial sectors. Dynamic panel regression investigates the impacts and

mechanism of environmental policy stringency on green productivity growth in the industrial sectors of OECD countries. The research results are: (1) the Porter hypothesis is validated that environmental policy has a positive impact on green productivity growth within a certain level of stringency (lower than 3.08); (2) the impact changes to adverse when environmental regulation policy is stringent over a certain level, because the compliance cost effect is higher than innovation offset effect (Wang et al., 2019).

The study by Bak et al. (2019) employed seven indicators that characterized Green Growth in OECD countries in 2004 and 2015. To identify the relations between them, the multidimensional correspondence analysis with a complex matrix of markers was used. The OECD countries were decomposed into four groups. These groups describe different levels of development in the Green Growth. The study results confirmed noticeable changes in the area of green growth in the observed period for most countries (Bak et al., 2019).

The study by Kim et al. (2014) used an OECD framework to select a set of 12 indicators proposed for cross-country comparisons of the Green Growth strategies. These indicators are used for the evaluation of 30 countries. The data obtained for each indicator is compared to the 10th percentile of OECD countries and is evaluated on a scale of 1 to 10. This study offers an approach to evaluate the overall effects of Green Growth strategies and provides the information necessary to rework national economic plans based on current knowledge (Kim et al., 2014).

He et al. (2022) dealt with the issue of sustainable Green Growth in developing economies. The research focused on the analysis of economic and environmental performance in 61 developing countries along the Belt and Road. The growth in the total factor productivity is divided with respect to the economic and environmental contributions. Both desirable and undesirable outputs are considered. Some countries experience strong economic growth, while environmental performance is slowing Green Growth. This suggests that developing economies should pay attention to environmental impacts and promote sustainable development by sharing emission-reduction technologies (He et al., 2022).

From the above literature review, it is clear that the authors applied various approaches to the evaluation of Green Growth of the countries, such as TOPSIS method, Luenberger productivity indicators, Hellwig method, SBM-DDF model, scoring scale. Therefore, the research gap is defined in a separate approach to Green Growth evaluation. The new proposed multi-criteria evaluation approach, based on the AHP method, respects the following principles:

- Hierarchy principle – takes into account all components that affect the outcome of the decision problem (individual elements, links between elements, the intensity of interaction of elements); the decision problem is represented by the so-called hierarchical linear structure (Song and Kang, 2016), which can be modified as needed.

- Principle of normalization – the normalization of evaluation of all variants for all criteria.

- The principle of pairwise comparison – elements are evaluated in pair-wise comparison scale so-called Saaty's scale, which allows, if necessary, to evaluate verbal or symbolic expressions (qualitative criteria) (Siekelova et al., 2021).

- Weighted average principle – applied in the process of final evaluation (synthesis).

2. Research methodology

2.1 Research design

The research methodology is based on the fundamental principles of scientific and research work. The selected scientific and research methods are based on a predefined research goal. The principles of system methodology that combine system approach, system thinking, system disciplines, and system algorithms were applied to the solution of a scientific problem (Janicek, 2017).

- System approach – entity definition: green growth in the context of the European Union's Green Deal; aim formulation: assessment of the green growth in the context of the European Union's Green Deal; approach to the entity: purposeful, complex and hierarchical assessment of entities; characteristics considered by the entity: assess the states and target behavior of entities; entity analysis methodology: multicriteria decision-making methods (MCDM) include sensitivity analysis.

- Systems thinking – application of progressive types of thinking: analytical-synthetic, creative, complex, and critical.

- System disciplines – application of suitable methods in the field of modelling, systems theory, operations research, especially in the field of MCDM.

- System algorithms – design of a general procedure for assessment of the green growth in context of the green deal in the EU countries respecting a systems approach, thinking discipline.

2.2 Materials

The input data was obtained from the OECD Green Growth database (OECD, 2017). This public database contains selected indicators for monitoring progress towards Green Growth (see Table no. 3). The database synthesizes data and indicators across a wide range of domains. It draws on a range of OECD databases and external data sources.

There are many computer software applications, e.g., the Expert Choice (2021), Criterion Decision Plus (Anon., 2019), which could be used as a tool to solve MCDM problems. In this study, the add-in DAME (Decision Analysis Module for Excel) was used (Perzina and Ramik, 2014; Anon., 2021). Compared to other software tools for solving multi-criteria decision-making problems, DAME is free and user-friendly.

2.3 Research procedure

The empirical research was performed as quantitative research employing the technique of mathematical modelling in the area of MCDM based on the AHP method. The AHP method, developed by Saaty (Saaty, 1980; 1988; Rao Tummala and Ling, 1998) is considered a well-known, powerful, and flexible decision-making technique for modelling unstructured multi-criteria problems in economy, management, society, or politics (Winkler, 1990). It can help set priorities and make the best decision when both qualitative and quantitative aspects of a decision need to be considered.

The sensitivity analysis (Triantaphyllou and Sánchez, 1997) was used to determine the most critical criterion in the decision-making problem. The most critical criterion changes the ranking of the alternatives in the decision-making problem. In this multi-criteria problem, the most critical criterion is defined in the way the interest is on whether the indication of the best (top) alternative changes or not. (The second option to define the most critical criterion is the way the interest is on changes to the ranking of any alternative.) On the issue of criticality, we are connected with the term "the smallest change." It can be defined in two different ways. The first way is to define the smallest change in absolute terms. The second way is to define the smallest change in relative (percent) terms. The first approach could be misleading because it does not calculate the original value of the weight of the criteria. For this reason, it is more meaningful to use relative changes. This approach will be applied to this problem. The ways of expressing the most critical criterion are summarized in Table no. 1.

Table no. 1. The way expressed by the most critical criterion.

		The way of expressing of the change in the ranking of alternative	
		Top alternative	**Any alternative**
The way of expressing of the smallest change in the weights criteria	**Absolute**	*Absolute Top (AT)*	*Absolute Any (AA)*
	Relative (Percent)	*Percent Top (PT)*	*Percent Any (PA)*

Source: own processing based on Triantaphyllou and Sánchez (1997)

The research uses the following procedure (see Figure no. 1).

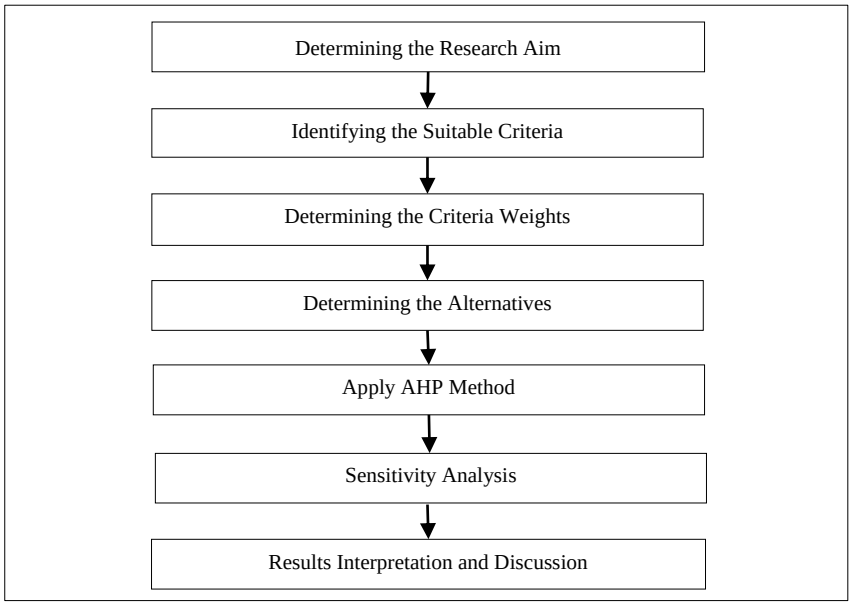

Figure no. 1. Research procedure
Source: own processing

3. Results

The AHP method is applied to multi-criteria assessing of the level of the Green Growth in context of the Green Deal strategy in the European Union Countries in the case study.

3.1 Identification of suitable criteria

The assessment of the level of Green Growth is based on OECD Green Growth Indicators. These indicators are in the OECD Green Growth database (OECD, 2017). It contains selected indicators for monitoring progress towards Green Growth. The database synthesizes data and indicators across a wide range of domains.

The indicators have been selected according to well-specified criteria and embedded in a conceptual framework, which is structured around four areas to capture the main features of the Green Growth:

- *Environmental and resource productivity* indicate whether economic growth is becoming greener with more efficient use of natural capital and to capture aspects of production which are rarely quantified in economic models and accounting frameworks.
- *The natural asset base* indicates the risks to growth from a declining natural asset base.
- *Environmental dimension of quality of life* – indicate how environmental conditions affect the quality of life and well-being of people.
- *Economic opportunities and policy responses* – indicate the effectiveness of policies in delivering green growth and describe the societal responses needed to secure business and employment opportunities.

Each of the four main areas is further divided into several sub-areas, which contain a set of specific indicators. For more details, see OECD (2017).

The database covers OECD member and accession countries, EU countries (the membership as of February 1st 2020), key partners (including Brazil, China, India, Indonesia, and South Africa), and other selected non-OECD countries.

To assess the level of the Green Growth in the context of EU countries (the membership as of 1 February 2020), it was necessary to have data on the indicators for all EU countries. Unfortunately, the OECD Green Growth database does not always contain complete data on these indicators for all countries. The criteria for selecting suitable indicators were the following aspects:

- The indicator must contain data or minimally their estimated values (E, see Table no. 3) for all EU countries for 2020 (most recent data) or for 2019 if complete data for 2020 are not yet available.
- At least one indicator from each of the four main areas must be selected for a comprehensive assessment.

Four specific indicators were selected for the overall assessment of green growth based on the above criteria:

- *Production-based CO_2 productivity, GDP per unit of energy-related CO_2 emissions* – Production-based CO2 productivity is calculated as the real GDP generated per unit of CO_2 emitted (USD/kg). Included are CO_2 emissions from the combustion of coal, oil, natural gas, and other fuels.

- *Annual surface temperature, change since 1951-1980* – annual surface temperature change is measured in Celsius degrees (°C). It is calculated as the difference between the annual average temperature (in a given year) and the average annual temperature of the 1951-1980 period.

- *Mean population exposure to $PM_{2.5}$* – The mean exposure of the population to fine particulate matter is calculated as the mean annual outdoor $PM_{2.5}$ concentration weighted by the population living in the area. It is the level of concentration, expressed in micrograms per cubic meter ($\mu g/m^3$), to which a typical resident is exposed throughout the year.

- *Environmentally related taxes, % GDP* – environmentally related tax revenue is expressed as a percentage of GDP. Environmentally related taxes include (i) energy products for transport purposes (petrol and diesel) and for stationary purposes (fossil fuels and electricity); (ii) motor vehicles and transport (one-off import or sales taxes, recurrent taxes on registration or road use, and other transport taxes); (iii) waste management (final disposal, packaging, and other waste-related product taxes); (iv) ozone-depleting substances, and (v) other environmentally related taxes.

These indicators were used as the criteria for the multi-criteria evaluation model (see Table no. 2).

Table no. 2. Summary of Criteria

No	Criteria	Units	Symbol	Max/ Min
1	Production-based CO_2 productivity, GDP per unit of energy-related CO_2 emissions	US dollars per kilogram, 2015	CO	Min
2	Annual surface temperature, change since 1951-1980	Micrograms per cubic meter	ST	Min
3	Mean population exposure to $PM_{2.5}$ (fine particulate matter)	Number	PM	Min
4	Environmentally related taxes, % GDP	Percentage	ET	Min

Source: own processing based on OECD (2017)

3.2 Determining Alternatives

Because our topic is focused on the assessment of the level of the Green Growth in EU countries (the membership as of 1st February 2020), these countries (27) represent the dataset of alternatives (variables) in the multi-criteria model (see Table no. 3).

Table no. 3. Numerical summary of the alternatives: decision matrix

Criteria / Alternative	CO (2020)	ST (2020; E)	PM (2019)	RT (2019; E)
Austria	7.66	2.36	12.22	2.36
Belgium	6.25	2.55	12.73	2.13

Criteria / Alternative	CO (2020)	ST (2020; E)	PM (2019)	RT (2019; E)
Czech Republic	4.58	2.36	16.97	2.47
Denmark	11.80	2.62	9.78	3.37
Estonia	5.12	3.60	5.95	3.69
Finland	6.90	3.34	5.64	2.80
France	10.41	2.48	11.37	2.32
Germany	6.80	2.52	11.93	1.77
Greece	5.94	1.45	14.32	1.58
Hungary	6.75	2.05	16.60	2.28
Ireland	13.81	1.10	7.85	1.30
Italy	7.59	1.90	15.85	3.27
Latvia	8.37	3.51	12.71	3.37
Lithuania	8.92	3.43	10.47	1.94
Luxembourg	8.75	2.63	10.09	1.74
Netherlands	6.68	2.48	12.03	3.63
Poland	4.43	2.65	22.77	2.44
Portugal	8.47	1.97	8.18	2.59
Slovak Republic	6.52	2.07	18.53	2.02
Slovenia	6.20	2.32	17.06	3.58
Spain	8.22	2.02	9.99	1.77
Sweden	15.84	2.94	5.72	2.00
Bulgaria	4.22	2.18	19.93	2.42
Croatia	7.02	2.11	18.23	4.22
Cyprus	5.23	1.80	15.79	2.63
Malta	12.09	1.24	13.07	2.58
Romania	7.54	2.29	15.06	2.23

Source: own processing based on OECD (2017).

Note: E – estimated value

3.3 Evaluation of the level of green growth in EU countries using the AHP method

The proposed decision-making model is created using an add-in DAME (Decision Analysis Module for Excel) (Perzina and Ramik, 2014; Anon., 2021). Compared to other software tools for solving multi-criteria decision-making problems, DAME is free and user-friendly.

DAME is used to structure the decision-making problem into criteria/sub-criteria and alternatives, measure the criteria and alternatives using pairwise comparisons, synthesize criteria and subjective inputs to arrive at a prioritized list of alternatives.

A four-step decision-making process is presented as follows.

Step 1: Breaking down the Decision-Making Problem

The first step in the AHP method is to develop a hierarchical structure to define the decision-making problem. The AHP method decomposes the overall decision aim into a hierarchic structure of criteria, sub-criteria, and alternatives (Saaty, 1994).

The highest level of the hierarchy is the aim, i.e., to assess the level of Green Growth in the EU countries. Level 2 represents the criteria (CO, ST, PM, ET). Level 3 contains the set of alternatives, which are EU countries in our case.

All criteria contribute to the defined goal. A list of alternatives provides the points that are assessed in this hierarchical structure (see Figure no. 2). Priorities will be derived for each alternative after the completion of the assessment. Priorities will reflect the degree to which the alternative satisfies the defined aim.

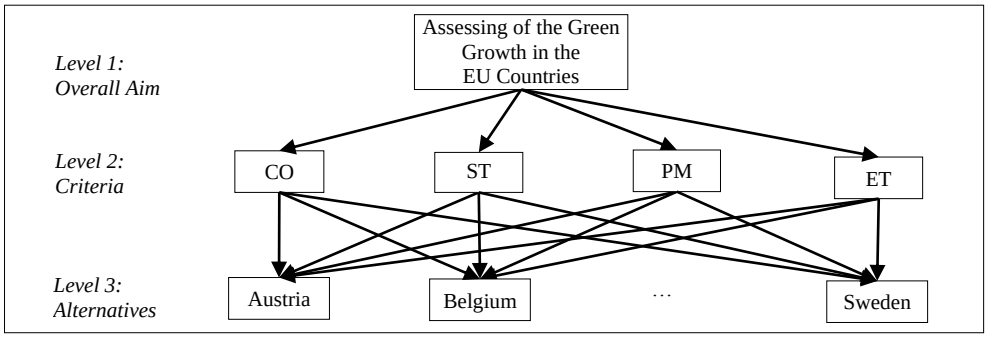

Figure no. 2. The hierarchy of the AHP model for assessing green growth in EU countries
Source: own processing

There is a form with basic multi-criteria decision-making problem characteristics. There are basic initial settings at the top of the panel, i.e., the number of scenarios, the number of criteria, and the number of variants (alternatives).

The field number of scenarios is typically used in the problems of risk-based decision-making. There are a defined number of criteria on the position of the number of scenarios in our case. Next, there are defined numbers of sub-criteria based on the position of the number of criteria. The last level of the hierarchy is defined as the number of alternatives (variants).

The methods of comparison of scenarios and criteria are defined in the second panel. Pairwise comparison or direct setting of weights is available.

In the panel model, the user sets the method of assigning weights (importance) to criteria/sub-criteria or scenarios. There are two options available: Multiplicative – works on the scale 1/9, 1/8, …1, 2, …,8, 9. The value of 1 means that each element (criterion/subcriterion, or scenario) of the pair is evaluated the same. Values greater than 1 indicate that the element marked in the table row is more important or probable than the element marked in the table column. Values less than 1 indicate that the element marked in the table column is more important or probable than the element in the table row. Additive – works with the scale 0 to 1, graduated by five hundredths. If the user considers a particular element of a pair (criterion/subcriterion, or scenario) to be more important or probable than another element of the pair, he assigns a value greater than 0.5 to the more important element. If the user considers a particular element of a pair (criterion/subcriterion or scenario) to be less important or probable than another element of the pair, he assigns a value less than 0.5 to the less likely element. If the user considers both elements of the pair equally important or probable, he assigns a value of 0.5 to both elements.

The methods of variant assessment according to individual criteria are defined in the last panel. There are three options: Pairwise comparison – each pair of variants is compared individually; the value max – indicates a maximization criterion, where each variant is

evaluated by a single value (in our case insurance penetration, earnings); value min – indicates a minimization criterion, where each variant is evaluated by a single value (in our case damage percentage, quick ratio).

Step 2. Establish criteria priorities

After the AHP model is set up, it is necessary to set the priorities of criteria for the multi-criteria assessing. According to the OECD Green Growth Indicators (OECD, 2017), preferences are not set between the criteria. For this reason, all criteria are assigned the same weight. Because we have 4 criteria $(n = 4)$ in our multi-criteria model each criterion has a normalized weight 0.25 $(w_j = 1/n)$.

Step 3. Evaluation

When all the elements of DAME are set, the total evaluation of alternatives is obtained. This process involves the evaluation between each alternative according to the specific values of four basic Green Growth indicators (input data; see Table no. 3) for the EU countries.

The overall assessment according to the CO, ST, PM, ET criteria is shown in Table no. 4. This table shows the specific priority values of the alternatives and the final ranking. Ireland is evaluated as the country with the highest level of Green Growth (Rank 1). Greece is ranked next, etc. As a country with the lowest level of the green growth, Latvia (rank 27) is evaluated in the analyzed year 2020. The graphical representation of the results of the assessment is in Figure no. 3.

Table no. 4. The overall assessment of green growth in EU countries

Alternative	Weights	Rank
Austria	0.034906	18
Belgium	0.036841	14
Czech Republic	0.037834	13
Denmark	0.030449	25
Estonia	0.041929	3
Finland	0.041909	4
France	0.033036	21
Germany	0.038713	9
Greece	0.046043	2
Hungary	0.035411	17
Ireland	0.053215	1
Italy	0.032539	23
Latvia	0.028284	27
Lithuania	0.034447	19
Luxembourg	0.038049	12
Netherlands	0.032665	22
Poland	0.035909	16
Portugal	0.039218	7
Slovak Republic	0.036222	15
Slovenia	0.031496	24
Spain	0.040751	5
Sweden	0.040222	6
Bulgaria	0.039023	8

Alternative	Weights	Rank
Croatia	0.029819	26
Cyprus	0.038659	10
Malta	0.038191	11
Romania	0.034220	20

Source: own processing based on OECD (2017)

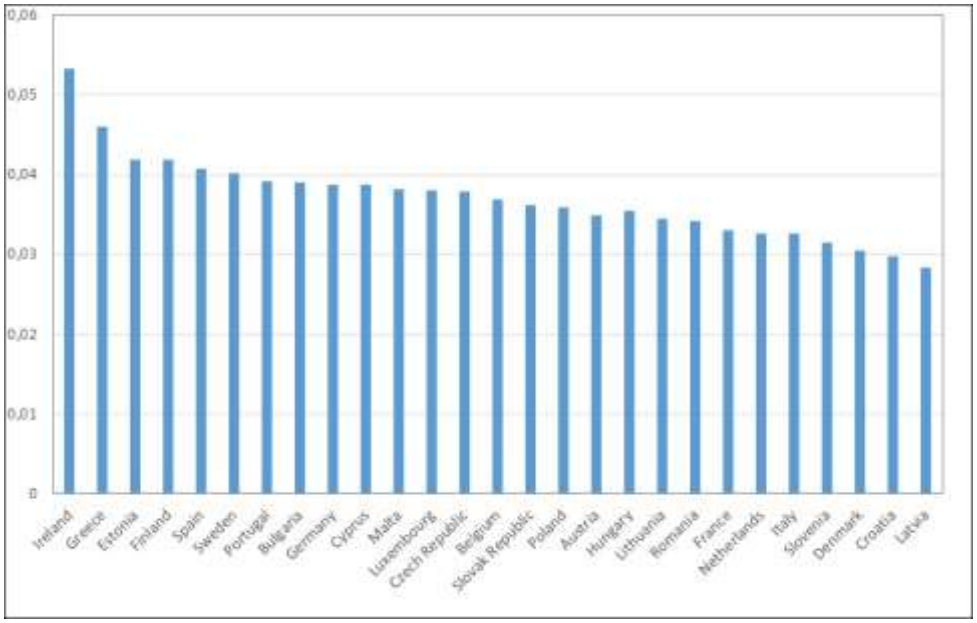

Figure no. 3. Graphical representation of the evaluation of green growth in EU countries

Source: own processing based on OECD (2017)

Step 4. Sensitivity analysis of overall priority

According to the formula $\frac{N[M(M-1)]}{2}$ there are $\frac{4[27(27-1)]}{2} = 1404$ such possible $\delta'_{k,i,j}$ quantities. Thanks this high number of $\delta'_{k,i,j}$ quantities, the identification of the most critical criterion will be achieved only by the *percentage top (PT)* approach in the context of sensitivity analysis.

Table no. 5 depicts in their rows all pairs of alternatives which are related to the best alternative for all four criteria. According to current final preferences is the best (top) alternative A_{11} i.e., Ireland. The values in the cells depict the absolute values of $\delta_{k,i,j}$ for all four criteria. The bold highlighting number indicates the minimum critical changes.

Table no. 5. All possible $\delta_{k,i,j}$values: absolute change in criteria weights

C_k (W_k) / Pair of Alternatives	C_1: CO ($W_1 = 0.25$)	C_2: PM ($W_2 = 0.25$)	C_3: ST ($W_3 = 0.25$)	C_4: ET ($W_4 = 0.25$)
$A_{11} - A_9$	-0.286	N/F	N/F	N/F
$A_{11} - A_5$	-0.351	-0.661	**0.221**	N/F
$A_{11} - A_6$	-0.596	-0.539	0.229	N/F
$A_{11} - A_{21}$	-0.968	N/F	N/F	N/F
$A_{11} - A_{22}$	N/F	-0.652	N/F	N/F
$A_{11} - A_{18}$	-1.172	N/F	N/F	N/F
$A_{11} - A_{23}$	-0.330	N/F	N/F	N/F
$A_{11} - A_8$	-0.743	N/F	N/F	N/F
$A_{11} - A_{25}$	-0.468	N/F	N/F	N/F
$A_{11} - A_{26}$	-5.575	N/F	N/F	N/F
$A_{11} - A_{15}$	-1.384	N/F	N/F	N/F
$A_{11} - A_3$	-0.403	N/F	N/F	N/F
$A_{11} - A_2$	-0.715	N/F	N/F	N/F
$A_{11} - A_{19}$	-1.384	N/F	N/F	N/F
$A_{11} - A_{17}$	-0.431	N/F	N/F	N/F
$A_{11} - A_{10}$	-0.899	N/F	N/F	N/F
$A_{11} - A_1$	-1.204	N/F	N/F	N/F
$A_{11} - A_{14}$	-1.807	N/F	N/F	N/F
$A_{11} - A_{27}$	-1.206	N/F	N/F	N/F
$A_{11} - A_7$	-3.261	N/F	N/F	N/F
$A_{11} - A_{16}$	-1.016	N/F	N/F	N/F
$A_{11} - A_{12}$	-1.332	N/F	N/F	N/F
$A_{11} - A_{20}$	-0.934	N/F	N/F	N/F
$A_{11} - A_4$	-7.055	N/F	N/F	N/F
$A_{11} - A_{24}$	-1.277	N/F	N/F	N/F
$A_{11} - A_{13}$	-2.025	N/F	N/F	N/F

Source: own processing based on OECD (2017)

Note: N/F stands for non-feasible; i.e., the corresponding $\delta_{k,i,j}$ value does not satisfy the relation $\frac{(P_j - P_i)}{(a_{j,k} - a_{i,k})} \leq W_k$ or impossibility of dividing by zero in the formula $\frac{(P_j - P_i)}{(a_{j,k} - a_{i,k})}$.

The negative changes indicate an increase of the current weight W_k of criterion C_k (before normalization), while positive changes indicate decreases of the current weight W_k of criterion C_k (before normalization).

Table no. 6 depicts in their rows all pairs of alternatives which are related to the best alternative for all four criteria. According to current final preferences is the best alternative A_{11} i.e., Ireland. The values in the cells represent the relative (percent) values of $\delta'_{k,i,j}$ for all four criteria.

Table no. 6. All possible $\delta'_{k,i,j}$values: percent change in criteria weights

C_k (W_k) / Pair of Alternatives	C_1: CO ($W_1 = 0.25$)	C_2: PM ($W_2 = 0.25$)	C_3: ST ($W_3 = 0.25$)	C_4: ET ($W_4 = 0.25$)
$A_{11} - A_9$	-114.301	N/F	N/F	N/F
$A_{11} - A_5$	-140.410	-264.205	**88.222**	N/F
$A_{11} - A_6$	-238.375	-215.678	91.507	N/F
$A_{11} - A_{21}$	-387.009	N/F	N/F	N/F
$A_{11} - A_{22}$	2140.691	-260.819	N/F	N/F
$A_{11} - A_{18}$	-468.784	N/F	N/F	N/F
$A_{11} - A_{23}$	-131.865	N/F	N/F	N/F
$A_{11} - A_8$	-297.051	N/F	N/F	N/F
$A_{11} - A_{25}$	-187.354	N/F	N/F	N/F
$A_{11} - A_{26}$	-2229.867	N/F	N/F	N/F
$A_{11} - A_{15}$	-553.760	N/F	N/F	N/F
$A_{11} - A_3$	-161.159	N/F	N/F	N/F
$A_{11} - A_2$	-285.838	N/F	N/F	N/F
$A_{11} - A_{19}$	-553.760	N/F	N/F	N/F
$A_{11} - A_{17}$	-172.579	N/F	N/F	N/F
$A_{11} - A_{10}$	-359.433	N/F	N/F	N/F
$A_{11} - A_1$	-481.512	N/F	N/F	N/F
$A_{11} - A_{14}$	-722.882	N/F	N/F	N/F
$A_{11} - A_{27}$	-482.331	N/F	N/F	N/F
$A_{11} - A_7$	-1304.561	N/F	N/F	N/F
$A_{11} - A_{16}$	-406.537	N/F	N/F	N/F
$A_{11} - A_{12}$	-532.739	N/F	N/F	N/F
$A_{11} - A_{20}$	-373.632	N/F	N/F	N/F
$A_{11} - A_4$	-2822.077	N/F	N/F	N/F
$A_{11} - A_{24}$	-510.737	N/F	N/F	N/F
$A_{11} - A_{13}$	-809.961	N/F	N/F	N/F

Source: own processing based on OECD (2017)

Note: N/F stands for non-feasible; i.e., the corresponding $\delta_{k,i,j}$ value does not satisfy the relation $\frac{(P_j - P_i)}{(a_{j,k} - a_{i,k})} \leq W_k$ or impossibility of dividing by zero in the formula $\frac{(P_j - P_i)}{(a_{j,k} - a_{i,k})}$.
The negative changes indicate an increase of the current weight W_k of criterion C_k (before normalization), while positive changes indicate decreases of the current weight W_k of criterion C_k (before normalization).

The bold highlight number indicates the minimum critical change, which corresponds to the most critical criterion. In our case, the smallest such percentage, i.e., 88.222 corresponds to the criterion C_3: ST (annual surface temperature) by the pair of alternatives $A_{11}$and A_5 (see Table no. 4). For the criterion C_3 a reduction of its current weight by 88.222% will make the alternative A_5 (Estonia) the most preferred alternative (see Table No. 5).

The new weights of the criterion (after normalization) are as follows: $W'_1 = 0{,}321$ for criterion C_1: CO, $W'_2 = 0{,}321$ for criterion C_2: PM, $W'_3 = 0{,}038$ for criterion C_3: ST and $W'_4 = 0{,}321$ for criterion C_4: ET. The new total evaluation of alternatives, i.e., the new ranking of alternatives, depicts Table no. 7.

Table no. 7. The new total evaluation of alternatives

Alternative	Weight	Rank
A_1 **(Austria)**	0.035064777	17
A_2 **(Belgium)**	0.038270537	12
A_3 **(Czech Republic)**	0.038820443	10
A_4 **(Denmark)**	0.030310612	24
A_5 **(Estonia)**	0.047421833	1
A_6 **(Finland)**	0.046901147	3
A_7 **(France)**	0.033135666	20
A_8 **(Germany)**	0.040565019	7
A_9 **(Greece)**	0.043253408	5
A_{10} **(Hungary)**	0.034242306	18
A_{11} **(Ireland)**	0.047421833	2
A_{12} **(Italy)**	0.029674545	26
A_{13} **(Latvia)**	0.029752603	25
A_{14} **(Lithuania)**	0.037507437	13
A_{15} **(Luxembourg)**	0.040094614	8
A_{16} **(Netherlands)**	0.032659147	21
A_{17} **(Poland)**	0.037414982	14
A_{18} **(Portugal)**	0.038672542	11
A_{19} **(Slovak Republic)**	0.035391505	16
A_{20} **(Slovenia)**	0.030521769	22
A_{21} **(Spain)**	0.040927206	6
A_{22} **(Sweden)**	0.043802366	4
A_{23} **(Bulgaria)**	0.039544068	9
A_{24} **(Croatia)**	0.027386911	27
A_{25} **(Cyprus)**	0.036855246	15
A_{26} **(Malta)**	0.030500670	23
A_{27} **(Romania)**	0.033886809	19

Source: own processing based on OECD (2017)

4. Discussion

The new proposed approach to assessing the Green Growth in context of the Green Deal strategy is based on respecting the following five principles:

1) Complexity – the multi-criteria model enables a comprehensive evaluation of key criteria, including the possibility of their change or addition. It also includes a sensitivity analysis of the most critical criterion implemented by the 'Percent Top' approach, including the interpretation of the results.
2) Systematicity (methodical) – the multicriteria model respects the principles of system methodology as an abstract object in the structure of system thinking, system approach, system disciplines, and system algorithms:
    - System approach – a definition and formulation of the problem (aim), identification of suitable criteria, defining the weights of the criteria, including the possibility of their modification according to the preference of the evaluator or evaluators, defining

alternatives, including the possibility of their modification according to the scope of evaluation).

- System thinking – an application of analytical-synthetic and complex approach (normalization principle, pairwise comparison principle, weighted average principle in the context of AHP method) and creative approach (choice of criteria and possibility of their modification or decomposition into sub-criteria, etc.).
- System disciplines – application of suitable methods in the field of modelling, systems theory, operations research, especially in the field of MCDM.
- System algorithms – design of a general procedure for assessment of the green growth in context of the green deal in the EU countries respecting a systems approach, thinking discipline. An application of methods of multi-criteria evaluation of variants for solving multi-criteria decision problems in a socio-technical system.

3) Hierarchicality – the multicriteria model in the context of the AHP method takes into account all key components that affect the outcome of the evaluation problem. The individual elements, the links between them, and their mutual intensity are quantitatively evaluated. In our case, it is a three-level hierarchy: aim – criteria – alternatives (variants).
4) Practicality – development of templates (including their modification) in the environment of the most widespread MS Excel application using the freely available add-in DAME.
5) Repeatability – the possibility of repeated evaluation at regular intervals in order to obtain a set of data that can be employed as input data for prediction.

Respecting the above principles increases the quality, reliability, and availability of measurement of the problem, which is its main contribution. The responsible managers will have a tool at their disposal to effectively measure and, therefore, manage the level of the Green Deal strategy in the context of growth.

The accuracy of the evaluation results depends mainly on the accuracy of the input data obtained from the public database and on the selection of suitable criteria and respective sub-criteria. In the case of defining their weights, then also on the preferences of evaluators (experts). The above facts are the main limits of the proposed model.

With regard to subjectivity in the process of defining the weights of the criteria, it could be appropriate to transform the model, e.g., into a fuzzy MCDM form. An adaptive neuro-fuzzy inference system (ANFIS) can be also used (Marjani et al., 2020). The Fuzzy Logic Toolbox in MATLAB software is recommended for this purpose. Input data will be used for training process with the aim to identify the setting of membership function and inference rules. This approach allows you to work with vague terms that are commonly used in expert options. This topic will be the aim of the next research.

Conclusions

The article deals with the issue of evaluation of the Green Growth in the context of the Green Deal strategy in the countries of the European Union. The research presents a new multi-criteria approach using the AHP method to measure Green Growth. The input data was obtained from the OECD Green Growth Database. The sample analyzed was the countries of

the European Union. The proposed model allows us to evaluate the Green Growth comprehensively, systematically, and repeatedly.

Repeated regular measurements can obtain a set of data over time, which can also serve as a basis for prediction. This will provide information and knowledge to identify specific problems and implement the necessary measures to minimize the risks associated with the successful implementation of the Green Deal project. As a final consequence, its main mission will be fulfilled, i.e., to keep the EU economy competitive and sustainable (see 17 sustainable development goals of the UNESCO study) in the future (Nilsson et al., 2016).

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