
Towards Green Growth: A Taxonomic Analysis Based on the Headline Indicators

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Abstract:

Purpose: Based on headline indicators, green growth's aggregate indexes have been constructed for 28 EU countries (including the United Kingdom). This allowed creating a ranking of the countries and identifying the strengths and weaknesses of green growth both at the European and national levels.

Design/Methodology/Approach: Research was carried out based on the taxonomic linear ordering method. The reference years 2013-2018 were chosen due to data availability for individual indicators on the OECD database.

Findings: The analysis showed that Sweden features the highest level of green growth, while Estonia received the lowest rating. Generalizing the study results, it can be stated that the level of 'greening' growth in European Union countries is still low.

Practical Implications: The research results fill in the existing information gap by providing an answer to the fundamental question: How can green growth be evaluated synthetically based on headline indicators? This also allows countries to identify areas where their performance is weak and prioritize their mitigation measures accordingly.

Originality/Value: The proposed method advances the OECD approach by adding evaluation metrics to assess each country's performance relative to other jurisdictions by indicator and by a synthetic measure.

Keywords: Green growth, sustainable development, taxonomic linear ordering method, EU countries.

JEL Codes: O13, O44, Q56, Q58.

Article Type: Research study.

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1. Introduction

Recently, the term 'green growth' has rapidly encroached on the international public debate. The concept was rolled out in 2005 by the United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP) to find options for introducing a low-emission model of sustainable development for fast-developing Asian countries (Satbyul, Ho and Yeora, 2014; ESCAP, 2005). As a consequence of the last financial crisis, green growth's interest increased among politicians and scientists. The term that was rarely used before 2008 is now a leading discussion point for many international institutions. The World Bank, together with five other multilateral development banks, agreed to implement the concept of green growth (The World Bank, 2012b; OECD, 2012). The Organization for Economic Cooperation and Development (OECD) developed the assumptions of the Green Growth Strategy (the Strategy) consisting of four documents: *Towards Green Growth*, *Towards Green Growth: Monitoring Progress – OECD Indicators*, *Tools for Delivering on Green Growth* or *Towards Green Growth: A summary for policymakers* (OECD, 2011a,b,c,d).

Despite a growing increase in green growth, this concept has not been clearly and unambiguously defined (Kasztelan *et al.*, 2019). According to the OECD (2011a), green growth means *fostering economic growth and development while ensuring that natural assets continue to provide the resources and environmental services on which our well-being relies*. The definition adopted by the World Bank (2012a) sees green growth as *efficient in its use of natural resources, clean in that it minimizes pollution and environmental impacts, and resilient in that it accounts for natural hazards*. Bowen and Hepburn (2014), in turn, define green growth as *increases in economic activity in the long term and possibly short term, without reducing aggregate natural capital*. On the other hand, Jacobs (2013) understands green growth as *GDP growth that also achieves 'significant' environmental protection*. Livermore (2013) claims that a useful definition of green growth focuses on reducing conflicts between economic growth and environmental quality.

Regarding UNO's position, it can be stated that green growth is seen as an efficient tool to ensure long-term sustainable development. Besides, considering the goal we should be aiming at – that is, a 'green' economy built on solid grounds – the following definition of green growth can be proposed: economic growth which takes into account rational utilization of natural capital prevents and reduces pollution, and creates chances to improve the overall social welfare by building a 'green' economy, making long-term sustainable development possible. Such treatment makes it possible to emphasize the trio's integrity: green growth – green economy – sustainable development (Kasztelan, 2017).

Along with developing initiatives regarding green growth, a necessity to develop methods for its evaluation appeared. Green growth is a complex phenomenon; therefore, the comparison of EU countries' levels in implementing its objectives is

particularly difficult. This paper aims to evaluate the advancement of green growth in the member states of the European Union. The studies attempt to fill the information gap regarding the degree of greening growth by constructing a synthetic measure considering the headline indicators. This type of analysis provides answers to the following questions: (1) At what stage are the individual countries placed in green growth? (2) What is the overall situation of EU countries according to the studied phenomenon? (3) What are the main challenges of green growth in Europe?

In constructing an aggregate measure, a taxonomic linear ordering method that uses median and the standard deviation was chosen and applied. The method can be characterized by high resistance to extreme observations, which is specifically valuable in the analysis of EU countries. It can often be observed that analyzed countries differ significantly and have a considerable disparity in index values' asymmetry. This is why using the synthetic method with the median seems to be more appropriate (Strahl, 2006; Grzebyk and Stec, 2015).

The paper is organized as follows. The following section presents the headline indicators of green growth developed by the OECD. The third chapter presents the methodology for constructing a synthetic measure of green growth. In the fourth chapter, the author has developed a rating of EU countries regarding the synthetic measures' values and discusses the results obtained. An important component of the analysis was categorizing the countries into four groups: high, medium-high, medium-low, and low levels of green growth. The last section provides conclusions drawn from the analyses.

2. Headline Indicators of Green Growth

One of the main challenges at the present stage of the works is developing an effective system for monitoring progress towards green growth. To this end, during a forum of the OECD, a set of indicators was proposed to allow describing and tracking changes. In 2011 the first OECD report was issued presenting the conceptual framework, initial proposal of 30 basic green growth indicators, and selected indicators deriving from OECD databases. The indicators focus primarily on the mutual relations between the economy and the environment, and in particular, they should describe the level of 'greening' of economic activity (OECD, 2011b).

Some countries prepared comprehensive reports on the progress of national economies on their way towards green growth and designed additional indicators corresponding to national conditions (Federal Statistical Office, 2013; Havranek, Sidorov, 2011; Hak, Sidorov and Hajek, 2014; Statistics Korea, 2012; Statistics Netherlands, 2011; 2013). The results of those works are significant in terms of further development and improvement of the set of indicators and exchange of experience and good practices. They also demonstrate that respective countries and regions emphasize economic options, social issues, and natural capital management.

The work's experience and results on national sets of indicators carried out by respective countries provided grounds for developing a second version of the report by the OECD issued at the beginning of 2014. The new report identifies 41 basic indicators focusing on four main goals: developing a low-carbon economy efficiently using its resources, maintaining a basic pool of natural resources for the economy's needs, improving the living standard, and implementing relevant policy principles, and using the economic opportunities offered by green growth. Also, to facilitate communication with decision-makers, media, and society, a decision was made to design a representative set of headline indicators. These allow monitoring several essential elements of the green growth concept, i.e., carbon and resource productivity, multifactor productivity including environmental services, natural asset base, changes in land use and cover, and degree of exposure of the population to air pollution (OECD, 2014).

The latest OECD report on green growth indicators was issued in 2017 (OECD, 2017). *Green Growth Indicators 2017* updates and extends the sets of indicators presented in the 2014 and 2011 editions. It presents the progress made by OECD countries and G20 economies since 1990. The 2017 edition emphasizes the increase in productivity and political activities, including an enhanced analysis of environmental taxes and subsidies, technologies and innovations, and international financial flows.

Table 1. *Green growth headline indicators*

Indicator groups	Indicator symbol	Indicator name
Environmental and resource productivity	x ₁	Production-based CO ₂ productivity, GDP per unit of energy-related CO ₂ emissions (US dollars per kilogram)
	x ₂	Demand-based CO ₂ productivity, GDP per unit of energy-related CO ₂ emissions (US dollars per kilogram)
	x ₃	Non-energy material productivity, GDP per unit of DMC (US dollars per kilogram)
	x ₄	Environmentally adjusted multifactor productivity growth (Percentage points)
The natural asset base	x ₅	Loss of natural and semi-natural vegetated land (% since 1992)
	x ₆	Gain of natural and semi-natural vegetated land (% since 1992)
Environmental quality of life	x ₇	Mean population exposure to PM _{2.5} (Micrograms per cubic metre)
Economic opportunities and policy responses		Technology and innovation, environmental goods and services, prices and transfers, etc. Placeholder - no indicator specified

Source: *Own elaboration based on OECD (2017) and OECD database.*

The OECD report from 2011 provides for developing a limited set of headline indicators facilitating communication with decision-makers, media, and citizens. It states that the presentation of an extended set of indicators, although helping to describe the multidimensional nature of green growth, entails a risk of a clear message to the entities concerned. Thus, a decision was made to design a small, representative set of headline indicators to monitor the green growth concept's key elements. A specially appointed group of experts proposed six headline indicators plus a placeholder for a future headline indicator on economic opportunities and policy responses. As the measurement methodology progresses, new data may come to light, and then the list of headline indicators will be modified accordingly (OECD, 2017).

Creating a set of indicators for evaluating progress towards green growth is a difficult task. Each of the indicators presented in Table 1 can be interpreted individually, but such an interpretation does not provide grounds for evaluating the level of green growth from a general perspective. Studies carried out fill in the existing information gap by answering the fundamental question: How can green growth be evaluated synthetically, taking into account the headline indicators?

3. Materials and Methods

The evaluation of green growth was based on a taxonomic linear ordering method based on constructing a synthetic measure of the studied phenomenon (Hellwig, 1968; Kasztelan *et al.*, 2019). An aggregate measure was built based on the median and standard deviation. The median is the middle value of a specific variable ordered from the maximum to the minimum value. Standard deviation indicates the extent to which the specific variable for all the analyzed member states differs on average from the arithmetic mean for such a variable (Strahl, 2006; Grzebyk and Stec, 2015). Taxonomic procedures are used in the study of complex phenomena that cannot be measured directly. This kind of analysis provides an estimate of the level of diversity of objects (e.g., countries) described by a set of statistical characteristics (e.g., indicators). In a linear hierarchy, the maximum degree is 1 (Łogwiniuk, 2011).

At the first stage of the study procedure, the seven headline indicators and 28 European Union countries were collected (Table 1). The reference years 2013-2018 were chosen due to data available on the OECD database. Among the indicators, five were considered larger-the-better (stimulants) characteristics having a positive influence on the measure, whereas two were regarded as smaller-the-better (de-stimulants) reducing the synthetic measure of green growth. Stimulants are explanatory (independent) variables whose increased values cause an increased value in the dependent variable (green growth), while de-stimulants are explanatory variables whose increased values induce a decrease in the dependent value variable. Values of variables (X_j , $j=1,2,\dots,m$) representing each country (O_i , $i=1,2,\dots,n$) are presented as a matrix of observations in the form (Grzebyk and Stec, 2015):

$$X = \begin{bmatrix} x_{11} & x_{12} & \dots & x_{1m} \\ x_{21} & x_{22} & \dots & x_{2m} \\ \dots & \dots & \dots & \dots \\ x_{n1} & x_{n2} & \dots & x_{nm} \end{bmatrix} \quad (1)$$

Since the set of independent features contains variables that cannot be aggregated directly using appropriate standardization, normalization formulas were applied. Among the formulas, zero unitarization was selected based on the interval of a normalized variable. Indicators selected for testing the green growth of EU countries have been subjected to a standardization process based on the following formulas (Kukuła, 1999, 2000; Kijek, 2013):

– For stimulants:

$$z_{ij} = \frac{x_{ij} - \min(x_{ij})_i}{\max(x_{ij})_i - \min(x_{ij})_i} \quad (2)$$

– For de-stimulants:

$$z_{ij} = \frac{\max(x_{ij})_i - x_{ij}}{\max(x_{ij})_i - \min(x_{ij})_i} \quad (3)$$

where:

z_{ij} is the normalized value of the j -th variable in the i -th country

x_{ij} is the initial value of the j -th variable in the i -th country.

Diagnostic features normalized in the abovementioned way take the value from the interval [0; 1]. The closer the value to unity, the better the situation in terms of the investigated feature, and the closer the value to zero, the worse the situation. In the next step, the normalized values of variables formed the basis for calculating the median and standard deviation for each of the countries studied. Median values were determined using the formula (Strahl, 2006; Grzebyk and Stec, 2015):

$$Me_i = \frac{z_{(\frac{m}{2})_i} + z_{(\frac{m}{2}+1)_i}}{2} \quad (4)$$

for even number of observations, or:

$$Me_i = z_{(\frac{m}{2}+1)_i} \quad (5)$$

for odd number of observations,

where: $z_{i(j)}$ is the j -th statistical ordinal for the vector $(z_{i1}, z_{i2}, \dots, z_{im})$, $i = 1, 2, \dots, n$; $j = 1, 2, \dots, m$.

In turn, the standard deviation was calculated according to the following formula:

$$Se_i = \sqrt{\frac{1}{m} \sum_{j=1}^m (z_{ij} - \bar{z})^2} \quad (6)$$

Based on the median and standard deviation, an aggregate measure of green growth was developed for each country (w_i):

$$w_i = Me_i (1 - Se_i), \quad w_i < 1 \quad (7)$$

Values of the measure closer to one indicate a higher level of greening growth in the specific member state, resulting in a higher rank. The aggregate measure prefers countries with a higher median of features describing the specific country and with smaller differentiation between the values of features in the specific country expressed as standard deviation.

The procedure chosen for evaluating green growth provided multidimensional comparative analysis. It allowed a comparison between member states of the EU providing grounds for classifying them into uniform groups:

group I:	$w_i \geq \bar{w} + S$	high level
group II:	$\bar{w} + S > w_i \geq \bar{w}$	medium-high level
group III:	$\bar{w} > w_i \geq \bar{w} - S$	medium-low level
group IV:	$w_i < \bar{w} - S$	low level

where: \bar{w} is the mean value of the synthetic measure and S is the standard deviation of the synthetic measure.

According to the w_i values the EU countries were assigned to one of the groups with regard to their level of greening the growth.

4. Results and Discussion

The level of green growth was evaluated in 28 EU countries based on 7 variables, and the results of the analysis were presented in Table 2 and Figure 1. The analysis shows that four countries assigned to group I – Sweden, Luxembourg, Lithuania, and Denmark achieved the highest level of green growth. Group II was made up of twelve countries with medium-high levels of 'greening' the growth, while eight EU countries were classified into the medium-low group III. The lowest evaluation of the green growth among 28 member states was received by Estonia, for which the w_i indicator was 0.0608. Together with Cyprus, Poland, and Bulgaria, this country was included in the lowest evaluation class IV. The average value of the synthetic measure for all member states covered by the analysis was 0.3263, which testifies to a shallow general level of "greening" the EU member states' growth. Synthetic

measure values differed from the arithmetic mean by 0.1165, which suggests that the analyzed phenomenon is highly variable from country to country.

Table 2. *Groups of EU countries with similar levels of green growth*

Group number	The level of 'greening' the growth	EU countries
I	High	Sweden, Luxembourg, Lithuania, Denmark
II	Medium-high	France, Ireland, Belgium, Spain, Hungary, United Kingdom, Austria, Germany, Netherlands, Romania, Portugal, Latvia
III	Medium low	Italy, Malta, Croatia, Slovenia, Czech Republic, Finland, Slovak Republic and Greece
IV	Low	Bulgaria, Poland, Cyprus, Estonia

Source: Own elaboration.

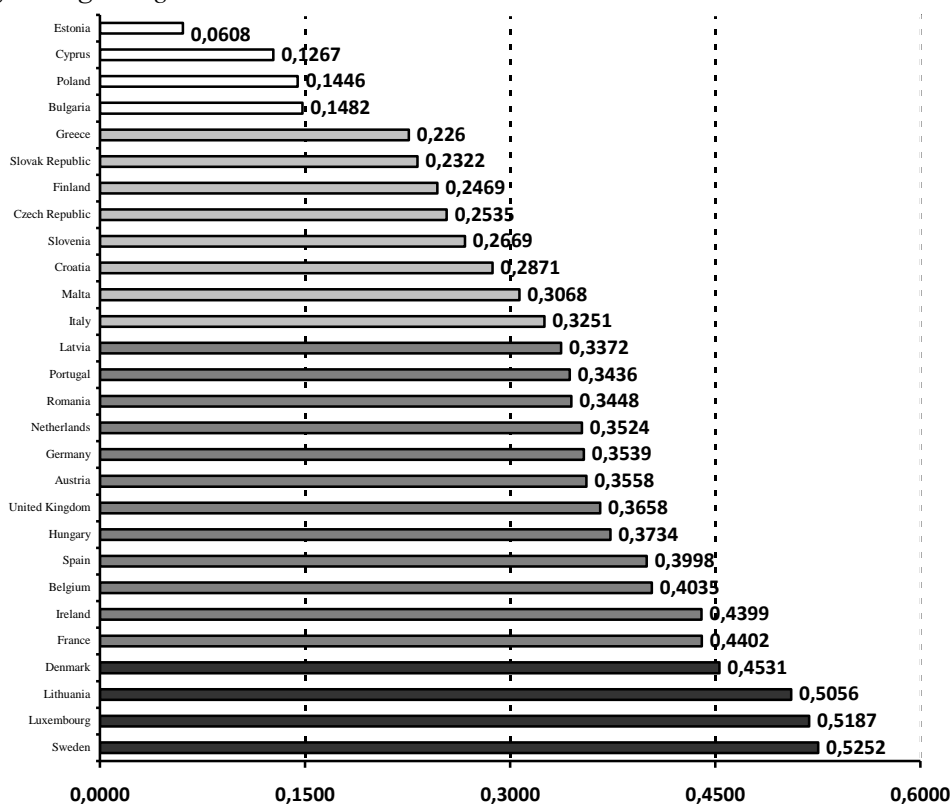
A deeper analysis of headline indicators for 28 EU member states makes it possible to state that only three of them (42.9%) were average standardized mean values exceeded. This refers to issues connected with the loss of natural and semi-natural vegetated land since 1992 (0.6972), demand-based CO₂ productivity (0.5345) as well as mean population exposure to PM_{2.5} indicator (0.5171). Particularly unfavorable values of the indicator were noted about:

- non-energy material productivity (0.2881),
- the gain of natural and semi-natural vegetated land since 1992 (0.3440), and
- production-based CO₂ productivity (0.3495).

Looking closer at respective member states, it is possible to identify their strong and weak points in greening growth. With the best result among the 28 EU member states, Sweden owes its success mostly to the high rating (0.9700-1.0000) regarding production and demand-based CO₂ productivity and mean population exposure to PM_{2.5}. On the other hand, improvement is needed in non-energy material productivity. Estonia, which was placed last in the ranking of green growth in two areas, received the lowest normalized values of indicators (0.0000) regarding production and demand-based CO₂ productivity. What is more, the average values (0.5000) were not exceeded about 6 out of 7 headline indicators.

This paper's evaluation methodology provides a comprehensive and transparent framework for evaluating the level of greening growth in EU countries. The evaluation was based on the set of headline indicators proposed by the OECD. Analysis of each indicator separately about individual countries provides information on the degree of greening growth's strengths and weaknesses. At the same time, synthetic measures allow for comparison and categorization of individual countries and the overall assessment of the level of greening growth in the European Union.

Figure 1. Rating of EU countries in respect of values of synthetic measures of 'greening' the growth



Source: Own elaboration.

While the proposed method provides an effective framework for evaluating green growth, further research can also be strengthened. Further research should focus on finding a proper definition of international trade indicators in raw materials, improved assessment of sustainable use of natural resources, and a better understanding of land cover changes.

5. Conclusions

The Green Growth Strategy, published by the OECD in 2011, gave rise to designing and implementing 'green' growth programs under national policies. Issues related to 'greening' growth became an integral element of national reviews (on the economy, the environment, investment, and innovation) prepared by the OECD. A significant direction of research and analysis is to work out a universal method for measuring respective countries' progress in implementing green growth. This refers, in particular, to the selection of a small set of the so-called headline indicators.

This paper describes an evaluation framework for measuring green growth in the EU countries based on headline indicators and aggregate measures. The study attempts to advance existing methods by including the taxonomic linear ordering procedure, enabling multidimensional comparative analysis. The case study illustrates that the methodology is relatively easy to apply, comprehensive and transparent, identifies the strengths and weaknesses of each EU country, and compares the level of greening growth between them. The taxonomic linear ordering method in the research allowed classifying the EU countries into one of four classes identified based on their green growth level. In this respect, Sweden achieved the best result, while Estonia ranked the worst. The overall level of the studied phenomenon is still low in EU countries.

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