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Green Growth in Agriculture in the European Union: Myth or Reality?

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Abstract:

Purpose: *The concept of green growth gained in importance as a result of the recent financial and economic downturn. In the opinion of many experts it is a potential way of achieving a long-term goal, that is, sustainable development. An essential role in the context of green growth is attributed to the agricultural sector. The authors attempted to establish a synthetic measure of the level of green growth in agriculture.*
Design/Methodology/Approach: *Research was carried out based on the taxonomic linear ordering method. The reference years 2000-2017 were chosen due to data availability on Eurostat, FAO and OECD database. Due to the existing information gap, 25 EU countries were accepted for analysis.*
Findings: *The analysis showed that Poland is characterized by the highest level of green growth in agriculture, while Cyprus received the lowest rating. Generalizing the results of the study, it can be stated that the level of 'greening' agriculture in European Union countries is insufficient.*
Practical Implications: *The results fill in the existing information gap by providing an answer to the fundamental question: How can green growth in agriculture be evaluated synthetically? The proposed method advances the OECD approach by adding evaluation metrics to assess the performance of each country relative to other jurisdictions by indicator and by a synthetic measure. This allows countries to clearly identify areas where their performance is weak and to prioritize their mitigation measures accordingly.*
Originality/Value: *The proposed method advances the OECD approach by adding evaluation metrics to assess the performance of each country relative to other jurisdictions by indicator and by a synthetic measure. This allows countries to clearly identify areas where their performance is weak and to prioritize their mitigation measures accordingly.*

Keywords*: Green growth, agriculture, sustainable development, taxonomic linear ordering method, EU countries.*
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1. Introduction

The perception of growth as the driving force of development has changed since the Rio Convention from 1992 during which "Agenda 21", one of the key documents related to sustainable development, came into existence. The increasing environmental hazards and global economic crisis commenced in 2008 gave rise to immense interest in the new concept of economic growth referred to as "green growth". The need for changing the existing development path was also recognized as a priority by the Organization for Economic Cooperation and Development (OECD). The declaration concerning green growth adopted in June 2009 saw putting an end to crisis and the necessity to ensure sustainable growth as the main challenges in the coming years (OECD, 2009). Green growth refers to transformation of production and consumption processes in order to maintain or restore these functions to capital (Zervas, 2012). To this end, environmental goods must be deemed to be a significant production factor and not only external conditions (Jouvet & de Perthuis, 2013; Bowen & Hepburn, 2014). According to Schmalensee (2012), the main goal of creating green growth is solving environmental problems so as to achieve added value manifested as economic growth. The significance of this model of economic growth also increases in the light of forecasts of OECD regarding global hazards to appear if the existing paths of growth and development and related socio-economic and environmental trends are maintained (OECD, 2012).

Despite the growing interest in green growth, the concept has not been clearly and unambiguously defined. According to the OECD (2011b), green growth fostering economic growth and development, while ensuring that natural assets continue to provide the resources and environmental services on which our well-being relies. To this end, investments and innovations should be stimulated, which will be the basis for sustainable growth and will create new economic opportunities (OECD, 2011b; The World Bank, 2012; Kasztelan, 2017). According to the World Bank definition (2012), green growth is "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. Jacobs (2013) understands green growth as GDP growth that also achieves 'significant' environmental protection. A review of the definitions of green growth reveals certain shared features. They show a clear relation to the notion of sustainable development. In addition, these definitions comprise both the utilization of natural resources and the environmental effect, going far beyond fears related to climatic change only (Bowen and Hepburn, 2014). Livermore (2013) also proves that a useful definition of green growth focuses on the goal of reducing conflicts occurring between economic growth and environmental quality.

An essential role in the context of green growth is attributed to the agricultural sector as the main user of land, water and marine resources having a decisive influence on biodiversity (Wreford *et al.*, 2010; OECD, 2011a). Thus, its activity has a large influence on the availability and quality of such resources (Blanford, 2011; OECD, 2013). The key role of agriculture in green growth was also emphasized by the United Nations Food and Agriculture Organization (FAO). One of the reports reads that agriculture, as a sector making use of 60% of global ecosystems and providing maintenance to 40% of the global population, is of key importance to the ecologization of economy (FAO, 2012).

The specificity of agriculture is that it can generate both negative and positive environmental effects and contribute to public goods supply (European Commission, 2010; Blanford, 2011). Intensive farming systems led to mass deforestation, water deficiency, soil exhaustion and high levels of greenhouse gas emissions (Hezri & Ghazali, 2011; FAO, 2017). Tubiello *et al.* (2014) recount that in the past 50 years emissions of greenhouse gases (GHG) according to Agriculture, Forestry and Other Land Use (AFOLU) nearly doubled and forecasts suggest they will continue to increase until 2050. Thus, a need arises for innovative agricultural production systems to protect and reinforce the natural resources base, and at the same time boost their efficiency (FAO, 2017). Challenges to agriculture also include those related to increased competition regarding alternative uses of natural resources, maintenance of biodiversity, food safety and mitigating climatic change (Ahtiainen, 2015; OECD, 2015; Musvoto *et al.*, 2015, FAO, 2017). A response to such challenges is green growth in agriculture that may be interpreted as a way of achieving economic growth and development in the agricultural sector, at the same time preventing the degradation of natural environment and resources, mitigating negative external effects and increasing the efficiency of resources utilization (European Commission, 2010; Hall and Dorai 2010; Blanford, 2011).

Green growth is a complex phenomenon; therefore, the comparison of levels of EU countries in implementing its objectives is particularly difficult. With regard to high importance of the agricultural sector in green growth, the aim of this paper is evaluating the advancement of green growth in agriculture in the member states of the European Union. The studies attempt to fill the information gap regarding the degree of greening of agriculture by constructing a synthetic measure taking into account both the economic performance of this sector and its environmental impact. This type of analysis provides answers to the following questions: (1) At what stage are the individual countries placed in terms of the green growth in agriculture? (2) What is the overall situation of EU countries according to the studied phenomenon? (3) What are the weak points of the analyzed countries?

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

The paper is organized as follows. The next section presents a comparison of green growth indicators developed for national economies according to the OECD methodology (2017), with a set of indicators for evaluation strictly the agricultural sector. The following section presents the methodology for constructing a synthetic measure of green growth in agriculture. In the fourth section, authors have developed rating of EU countries in respect of values of the synthetic measures and have discussed the results obtained. An important component of the analysis was the categorization of the countries into several groups of high, medium–high, medium–low and low levels of green growth. The last section provides conclusions drawn from the analysis.

2. Indicators of Green Growth in Agriculture

Along with the development of initiatives regarding green growth a necessity to develop methods for its evaluation appeared. This referred to both economy as a whole and to its respective sectors, including agriculture. Reliable, adequately selected and current data on green growth forms a significant element shaping development strategies and a component of instruments boosting the dynamics of changes in that respect. Previously more importance was attached to the so-called environmental indicators for agriculture (OECD, 2001; OECD, 2013; Makowski *et al.*, 2009). Proposals of indicators that would allow tracking progress towards green growth in agriculture appeared in elaborations by the OECD only in the present decade (OECD, 2011a; OECD, 2014b; Stevens, 2011). These are partial indicators helping to illustrate specific issues such as, for instance, the relation between agricultural production and natural resources, consumption of water for irrigation in agriculture, greenhouse gas emissions resulting from agricultural production, and the balance of nutrients (nitrogen and phosphorus) with reference to agricultural production. Stevens (2011), on the other hand, includes indicators for measuring progress on green growth in agriculture into four groups: 1) green policies, 2) economic performance, 3) environmental performance, 4) social performance. Most authors agree that the indicators must be rigorous, repetitive, widely accepted and easy to understand (Balmford *et al.*, 2005; Cornescu and Adam, 2014).

The OECD has defined the conceptual framework for measuring green growth by including its key elements, i.e. production, consumption and the environment. The proposed indicators have been included into five groups, i.e. 1) the environmental and resource productivity of the economy, 2) the natural asset base, 3) the environmental dimension of quality of life, 4) economic opportunities and policy responses, 5) socio-economic context and characteristics of growth (OECD, 2011c; OECD, 2014a; OECD, 2017). It was also emphasized that the list of proposed indicators is not exhaustive, especially that not all characteristics of green growth can be measured in quantitative terms. In addition, not all of the indicators indicated are relevant for individual countries (OECD, 2011b) (Table 1).

Table 1. *Indicators for assessing green growth in the national economy, with particular emphasis on the agricultural sector*

Green growth		**Green growth in agriculture**	
Indicator groups	Examples of indicators	Indicator groups	Examples of indicators
The environmental and resource productivity of the economy	• Carbon and energy productivity • Resource productivity: materials, nutrients, water • Multi-factor productivity	Environmental efficiency and natural resource productivity	• Carbon productivity (Agricultural GDP per unit of agricultural GHG emissions)
The natural asset base	• Renewable stocks: water, forest, fish resources • Non-renewable stocks: mineral resources • Biodiversity and ecosystems	The impact of agriculture on the natural asset base and environmental quality of life	• Renewable stocks • Share of agricultural freshwater • Withdrawal in total freshwater withdrawal
The environmental dimension of quality of life	• Environmental health and risks • Environmental services and amenities	The economic performance of agriculture	• Growth of total agricultural production • Total factor productivity • Relative importance of agricultural trade • Share of agricultural GDP in total • Share of agricultural employment in total
Economic opportunities and policy responses	• Technology and innovation • Environmental goods & services • International financial flows • Prices and transfers • Skills and training • Regulations and management approaches	Green growth policies and economic opportunities in agriculture	• Trends of potentially the most environmentally harmful producer support • Share of agriculture in energy and transport taxes • Farmers with agricultural training • Trends of agricultural

Socio-economic context and characteristics of growth	• Economic growth and structure • Productivity and trade • Labor markets, education and income • Socio-demographic patterns	R&D payments in total support to agriculture

Source: *Own elaboration based on OECD (2011c; 2014ab; 2017).*

Creating a set of indicators for evaluating progress towards green growth in the agricultural sector is a difficult task due to the complexity of the sector and the diversity of its environmental impact. Indicators proposed by OECD (2014b) refer to environmental efficiency, production, consumption and green growth drivers such as policy instruments and innovation. Therefore, it can be concluded that they are based on a general framework of measuring green growth, in addition taking into account the specificity of the agricultural sector. 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. The results of studies carried out by the authors of this paper fill in the existing information gap by providing an answer to the fundamental question: How can green growth in agriculture be evaluated synthetically?

3. Materials and Methods

The evaluation of green growth in agriculture sector was based on a taxonomic linear ordering method, which is based on the construction of a synthetic measure of the studied phenomenon (Hellwig, 1968). 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 to what extent 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 indicators were initially selected. The reference years 2000-2017 were chosen due to data availability on Eurostat, FAO and OECD database. Diagnostic variables defining the level of greening the agriculture sector for particular countries were adjusted in an attempt to meet two criteria: substantive and formal. Substantive indicators selection was based on OECD studies (2011a; 2013; 2014b; 2017), as well as on review of the databases. The next step was to check, if they meet formal criteria, i.e. whether they are measurable, complete and ensure comparability. Ultimately 19 diagnostic variables were selected for the green growth analysis (Table 2).

Among the selected variables, 15 were considered to be larger-the-better (stimulants) characteristics having a positive influence on the measure, whereas 4 were regarded as smaller-the-better (de-stimulants) reducing the synthetic measure of green growth. Stimulants (selected indicators) are explanatory (independent) variables whose increased values cause an increased value in the dependent variable (green growth in agriculture), while de-stimulants are explanatory variables whose increased values induce a decrease in the value of the dependent variable. Due to the existing information gap, 25 EU countries were accepted for analysis (except Croatia, Ireland and Italy).Values of variables (Xj, j=1,2,…,m) representing each country (Oi, i=1, 2,…, n) are presented as a matrix of observations in the form (Grzebyk and Stec, 2015):

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

Table 2. *Indicators selected for the evaluation of green growth in agriculture*

Indicator groups	**Indicator symbol**	**Indicator name**
Measuring the economic performance of agriculture.	x_1	Share of agriculture in GDP (%)
	x_2	Employment in agriculture (% of total employment)
	x_3	Average annual growth in agricultural total production volume (%)
	x_4	Total factor productivity (TFP) of agriculture, average annual growth rates (%)
	x_5	Cereal yield growth rates (%)
	x_6	Agricultural labor productivity growth rates (%)
	x_7	Nitrogen intensities per area of agricultural land (kg/ha)
	x_8	Phosphorus intensities per area of agricultural land (kg/ha)
Indicators for monitoring the impact of agriculture on the natural asset base and environmental quality of life.	x_9	Share of agricultural freshwater withdrawal in total freshwater withdrawal (%)
	x_{10}	Trends in arable and permanent crop land area, annual growth rates (%)
	x_{11}	Trends in permanent pasture, annual growth rates (%)
Indicators for monitoring green growth policies and economic opportunities in agriculture.	x_{12}	Share of environmental taxes in agriculture in total environmentally-related tax revenues (%)
	x_{13}	Share of agriculture in energy taxes (%)
	x_{14}	Share of agriculture in transport taxes (%)
	x_{15}	Share of agriculture in pollution taxes (%)
	x_{16}	Farm managers with agricultural training: basic and full (% of farm managers)

	x_{17}	Farm managers with practical experience (% of farm managers)
	x_{18}	Share of young farmers (< 35) (% of farmers)
	x_{19}	Share of elderly farmers (> 65) (% of farmers)

Source: *Own elaboration based on OECD (2014a).*

Since the set of independent features contains variables that cannot be aggregated directly using appropriate standardization, normalization formulas were applied. Among the formulas, the method of zero unitarization was selected based on the interval of a normalized variable. The first mention of this method can be found in the works of Wesołowski (1971), Kolman (1973), Borys (1978) and Bellinger (1978). Indicators selected for testing the greening of EU agriculture have been subjected to a standardization process based on the following formulas (Kukuła, 1999, 2000; Kijek, 2013):

– For stimulants:

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

– For de-stimulants:

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

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):

$$Me_i = \frac{z_{\left(\frac{m}{2}\right)i} + z_{\left(\frac{m}{2}+1\right)i}}{2} \tag{4}$$

for even number of observations, or:

$$Me_i = z_{\left(\frac{m}{2}+1\right)i} \tag{5}$$

for odd number of observations,

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

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

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

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

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

Values of the measure closer to one indicate a higher level of greening of agriculture 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 in agriculture 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 agriculture sector.

4. Results and Discussion

The level of green growth in agriculture was evaluated in 25 EU based on 19 variables, and the results of the analysis were presented in Table 3 and Figure 1. The analysis shows that five countries assigned to group I – Poland (0.4244), Denmark (0.4160), Hungary (0.3977), Bulgaria (0.3910) and Slovak Republic (0.3881) achieved the highest level of green growth in agriculture sector. Group II was made up of seven countries with medium–high levels of 'greening' the growth whereas nine EU countries were classified into the medium–low group III, the largest one.

The lowest evaluation of the green growth in agriculture sector among 25 member states received Cyprus for which wi indicator amounted to 0.0681. This country, together with Slovenia (0.1439), Malta (0.1606) and the United Kingdom (0.1845), was included in the lowest evaluation class IV. The average value of the synthetic measure for all member states covered by the analysis was 0.2904, which testifies to a very low general level of "greening" of agriculture in the EU member states. Synthetic measure values differed from the arithmetic mean by 0.0885, which suggests that the analysed phenomenon is highly variable from country to country.

A deeper analysis of green growth factors in agriculture for 25 EU member states makes it possible to state that in 8 of them (42.1%) average standardized mean values were exceeded. This primarily refers to issues connected with decreasing the negative environmental impact of agriculture (Share of agricultural freshwater withdrawal in total freshwater withdrawal - 0.8523; Phosphorus intensities per area of agricultural land - 0.7405; Nitrogen intensities per area of agricultural land – 0.6738), as well as positive changes in the field trends in arable and permanent crop land area (0.5683), share of elderly farmers (> 65) (0.5555) and average annual growth in agricultural total production volume (0.5494). Particularly unfavorable values of indicators were noted in relation to: trends in permanent pasture (0.1324), share of agriculture in pollution taxes (0.1377), employment in agriculture (0.1826), and share of agriculture in transport taxes (0.1985).

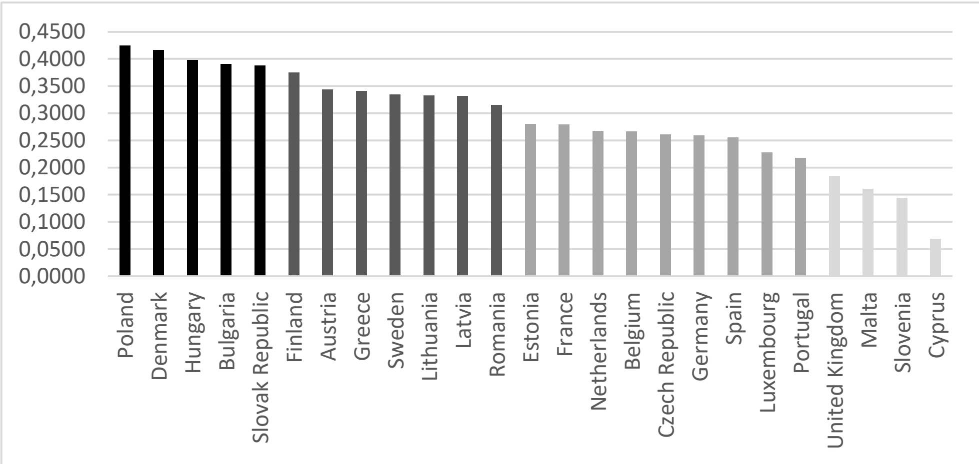
Table 3. *Groups of EU countries with similar levels of green growth in agriculture*

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

Source: *Own elaboration.*

Looking closer at respective member states it is possible to identify their strong and weak points in greening the agricultural growth. Poland, with the best result among the 25 EU member states, owes it success mostly to the highest rating (1.0000) regarding average annual growth in agricultural production, improvement of labor efficiency and a high percentage of young farmers (aged <35) in charge of farm management. On the other hand, improvement is needed with regard to environmental taxation in agriculture or continuing farmland consolidation processes.

Figure 1. *Rating of EU countries in respect of values of synthetic measures of 'greening' the agriculture sector*



Source: *Own elaborations.*

Cyprus, which placed the last position in the ranking of green growth in agriculture, in five areas received the lowest normalized values of indicators (0.0000), i.e. cereal yield growth rates, agricultural labor productivity growth rates, phosphorus intensities per area of agricultural land, share of agriculture in pollution taxes and share of young farmers (< 35). What's more, the average values were not exceeded in relation to 16 indicators (0.5000).

The evaluation methodology presented in this paper provides a comprehensive and transparent framework for evaluating the level of greening growth in agriculture sectors of EU countries. The evaluation was based on literature review and the set of green growth indicators proposed by the OECD. Analysis of each indicator separately, in relation to individual countries provides information on the strengths and weaknesses of the degree of greening of agriculture, while synthetic measures allow for comparison and categorization of individual countries, as well as for the overall assessment of the level of greening of agricultural growth in the European Union.

The synthetic evaluation of green growth is an improvement of the OECD method. The proposed method uses a comprehensive list of OECD indicators but advances the OECD approach by adding evaluation metrics to assess the performance of each country relative to other jurisdictions by indicator and by a synthetic measure. This allows countries to clearly identify areas where their performance is weak and to prioritize their mitigation measures accordingly.

While the proposed method provides an effective framework for evaluating green growth in agriculture, it can also be strengthened by further research. It would be helpful to assess its applicability and relevance to the rest of the EU countries. As of today, too much information gap in relation to the three countries does not allow full evaluation of the green growth in agriculture of all EU countries. A second area for future research is to develop an effective system for collecting information necessary to assess all indicators.

5. Conclusions

Green growth is a complex issue, making its study relatively difficult. As a multi-criteria concept, it requires aggregate measures, based on the integration of the different domains, that in due course define whether an economy/sector is 'green' or not. This paper describes an evaluation framework for measuring green growth in the agriculture sector and applies the framework in a case study evaluation of EU countries. The study attempts to advance existing methods by including the taxonomic linear ordering procedure, which enabled multidimensional comparative analysis. The case study illustrates that the methodology is relatively easy to apply, is comprehensive and transparent, and identifies the strengths and weaknesses of each EU country as well as enables comparing the level of greening agriculture between them.

The use of the taxonomic linear ordering method in the research allowed the classification of the EU countries into one of four classes identified based on their green growth level. In this respect, Poland achieved the best result, while Cyprus ranked the worst. The overall level of the studied phenomenon is still low in EU countries. It should be stressed, however, that the research was based on 19 out of 36 indicators developed by the OECD. There is, therefore, a significant information gap with regard to specific indicators. Due to better data availability, it would be possible to expand the set of indicators for the analysis, as well as the number of countries, which in turn would lead to more comprehensive evaluation of green growth. This is a challenge for further research in this issue.

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