“A methodology to analyze sustainable development index: evidence from emerging markets and developed economies”

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A METHODOLOGY TO ANALYZE SUSTAINABLE DEVELOPMENT INDEX: EVIDENCE FROM EMERGING MARKETS AND DEVELOPED ECONOMIES

Abstract

The paper proposes a new approach for dealing with uncertainties in determining the level of sustainability at the national scale. Composite Sustainable Development Index (SDI) is a tool designed to assess comprehensively the progress made by 15 advanced economies and 15 emerging economies since 2004–2018 towards achieving sustainable development goals.

The proposed composite index aims to measure and monitor a sustainable development at the national level, and to increase the understanding of sustainability.

This method also sheds light on main problems of different economies at the current stage of their development: the methodology considers a set of indicators and arranged into four categories of sustainable development: economy, society, governance, and environment.

The present study shows that during the analyzed period, advanced economies had a satisfactory level of sustainability, while the level of SDI of the emerging markets was lower. Also, the obtained results reveal that since the adoption of Paris Agreement under the UN Framework Convention on Climate Change in 2015 developed countries have been showing better performance.

Moreover, the paper presents the research design of an optimization model for sustainable development with CO2 emissions consideration.

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INTRODUCTION

Nowadays, sustainable development is a multifaceted concept. Based on the materials of the United Nations Conference on Environment and Development (1992) and the seminal work of the World Commission on Environment and Development (1987), "sustainable development is a development of a society that meets the needs of present time without compromising the ability of future generations to meet their own needs." Altogether this sustainability concept combines economic, environmental, and social aspects.

The United Nations Conference on the Human Environment in Stockholm in 1972 and the creation of the United Nations Environment Program (UN, 1972) marked the inclusion of the international community at the national level in solving the environmental problems that began to restrain socio-economic development.

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In 1992, the United Nations Environment and Development Conference was held in Rio de Janeiro (UN, 1992). This conference is also known as Planet Earth Summit, as leaders from 178 countries, representatives of 1,600 non-governmental organizations attended it. This was the first conference that succeeded in raising public awareness of the need to integrate environment and development.

In 2015, at the 70th session, the United Nations Summit on Sustainable Development (UN, 2015a) adopted the Post-2015 Development Agenda in New York. The outcome document of the Summit "Transforming Our World: The 2030 Agenda for Sustainable Development" included 17 Sustainable Development Goals (SDGs) and 169 targets.

These 17 Sustainable Development Goals (SDGs), which include 169 targets, have a broader range and are more ambitious than the Millennium Development Goals (MDGs). The objectives cover different aspects of sustainable development: economic growth, social integration, and environmental protection.

It is obvious that most of environmental problems have arisen due to rapid economic development and industrialization (depletion of natural resources, pollution, destruction of ecosystems, etc.), as well as economic backwardness and poverty (depletion of potentially renewable resources, lack of investment in pollution control and ecosystem protection). Environmental management requires the consideration of issues related to natural resources and pollution.

Indicators and indexes as an extremely important basis for decision-making contribute to the transfer of knowledge from the physical and social sciences into managed information blocks. They can help measure and evaluate the progress in achieving the sustainable development goals, provide early warning and public awareness to prevent the critical condition and losses of the economy, problems in the social and environmental spheres. Indicators and indices are an important tool for exchanging ideas, thoughts, and values.

There is also a mechanism for practical integration of these indicators into the planning and evaluation system at the geographic region level. Sustainable development indicators are also used in a program-oriented approach to managing the development of settlements in the role of markers that determine the balanced development of the urban system. Thus, it is important to measure the level of sustainability at different scales: local, national, and global.

Some key indices have already been developed in the economic, environmental, and social spheres. Obtaining analytical and empirical justifications for effective decision-making is one of the most important aspects of politics in the environmental, economic, and social spheres of society. Hence, institutional factor is also important while measuring the level of sustainable development, especially if talking about the national scale.

Thus, the aim of the current study is twofold: to develop a new composite index of measuring and monitoring a sustainable development at the national level; and to present a research design of the optimization model for sustainable development with CO2 emissions consideration: new approach of SDI calculation contains CO2 emissions as one of the variables, and also tracks some aspects of environmental management.

1. LITERATURE REVIEW

A large number of works devoted to indicators and indices of sustainable development testify both to the urgent need for metrics and to methodological contradictions in the scientific thought.

One example of practically applicable indicators is the indices of sustainable development in the economic, environmental, and social components. They can be measured and displayed like multivariate growth indices used by the World Bank.

Different initiatives address the calculation of the level of sustainability at different scale. For example, Nagy, Benedek, and Ivan (2018) developed a methodology for assessing SDGs, applied on a local level in Romania.

According to Tanguay, Rajaonson, Lefebvre, and Lanoie (2010), there was proposed a new approach to estimating the level of sustainability at an urban level, which is based on 188 indices.

Liu, Bai, and Chen (2019) clustered six indicators into several categories in a timeframe of six years when comparing achievement of SDG at the county scale in China.

The systematic approach developed by Čiegis and Šimanskiene (2010) proposes a wider range of sustainability parameters and considers different aspects (political, institutional, economic, social, environmental, etc.) This method presents an assessment of the balanced development of the Lithuanian economy for the period 2003–2008.

Guijarro and Poyatos (2018) defined a new version of the designing a Sustainable Development Goal Index through a goal programming model, based on comparison of the performance by the EU-28 countries.

Based on methodology for calculating the sustainable development indicators, proposed by Department of Economic and Social Affairs of UN (2007), the framework contains 14 themes and core 50 indicators. It should be highlighted that this range of indicators is widely used in development ranking by different international organizations.

The results of the study by Schmidt-Traub, Kroll, Teksoz, Durand-Delacre, and Sachs (2017) examining the relationship of SDG Index with other widely used development indices: Environmental Performance Index, Index of Economic Freedom, Global Competitiveness Index, Global Peace Index, Human Development Index, and GDP per capita. The results reveal that different countries pursue different development models, e.g., some countries can perform well in achieving SDGs, but can experience major deficits in inequality and peace and justice.

This proves the statement of imperfection of the existing approaches to assess SDG index.

In recent high-profile studies, Hickel (2020) concludes that human development index "is empirically incompatible with environmental stability". Hence, author proposes an alternative index – the Sustainable Development Index (SDI) that solves these problems.

Hence, it is obvious that there is a bulk of studies and contributed materials in the area of SDG index calculation, nevertheless, even in early works of Helm (1998) who mentioned about the importance and significance of institutions in the policy-making process.

According to methodology "Energy indicators for sustainable development", developed by International Atomic Energy Agency (IAEA, 2005), Sustainable Development Index is a parameter that is developed to assess "social equity, economic growth, institutional capacity, and environmental protection".

Thus, all the mentioned above proves that index of sustainability should be elaborated and improved, combining four main points of view: economic, social, environmental, and governance.

2. DATA AND METHODOLOGY

2.1. Materials

This paper applies annual data for 15 advanced economies and 15 emerging economies from 2004 to 2018. The data are collected via online surveys, including the World Bank database, Centre for Energy Economics Research and Policy.

The methodology for estimating the composite Sustainable Development Index of the countries is based on a set of 40 indicators and considers four dimensions of sustainable development: economy, society, governance, and environment (Table 1). The indices are calculated using World Bank Sustainable Development Goals indicators and other indices common in international practice: countries' competitiveness, human development, quality of life, knowledge-based society, sustain-

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able development of the environment, and political effectiveness. Based on the calculation of the composite Sustainable Development Index (SDI), the paper presents the research design of the optimization model for sustainable development with CO2 emissions consideration.

2.2. Methodology for SDI construction

All the mentioned above proves a need of measuring and monitoring the level of suitability in each country. Thus, it is proposed to consider a set of indicators, as contained in Table 1, and arranged into four categories of sustainable development: economy (*ECO*), society (*SOC*), governance (*GOV*), and environment (*ENV*).

All indicators are proposed for monitoring a progress towards sustainable development in each country through the implementation of methodology, proposed below.

Firstly, there is a need in standardization of stimulating (1) and destimulating indicators (2):

$$x_{ij}(st) = \frac{y_{ij}}{\max(y_{ij})}, \quad (1)$$

$$x_{ij}(des) = \frac{\min(y_{ij})}{y_{ij}}. \quad (2)$$

The next stage is devoted to the calculation of the sustainable development parameters (considered four directions): economy, society, governance and environment:

$$R_{m(category)} = \sqrt[n]{x_1 \cdot \ldots \cdot x_{n-1} \cdot x_n}, \quad (3)$$

where $R_{category}$ – general assessment of sustainable development of each category; m = 4 categories (economy (*ECO*), society (*SOC*), governance (*GOV*), and environment (*ENV*)).

The last stage of the methodology is the assessment of the composite Sustainable Development Index (SDI). The weight of the general assessment of economy, society, governance, and environment is assumed to be the same. Thus, the following formula will be used:

Table 1. Set of indicators that reflect the level of the countries' sustainable development

Category	Indicator	Description	st/ds
Economy (*ECO*)	x_1	Exports of goods and services (% of GDP)	st
	x_2	Debt service (PPG and IMF only, % of exports of goods, services, and primary income)	ds
	x_3	GDP per capita growth (annual %)	st
	x_4	Manufacturing, value added (% of GDP)	st
	x_5	Research and development expenditure (% of GDP)	st
Society (*SOC*)	x_6	Access to electricity (% of population)	st
	x_7	School enrollment, tertiary (% gross)	st
	x_8	Unemployment, total (% of total labor force)	ds
	x_9	Urban population growth (annual %)	st
	x_{10}	Current health expenditure (% of GDP)	st
Governance (*GOV*)	x_{11}	Proportion of seats held by women in national parliaments (%)	st
	x_{12}	Control of corruption (percentile rank)	st
	x_{13}	Government effectiveness (percentile rank)	st
	x_{14}	Political instability and presence of violence/terrorism (percentile rank)	ds
	x_{15}	Regulatory quality (percentile rank)	st
Environment (*ENV*)	x_{16}	CO2 emissions (growth rate, %)	ds
	x_{17}	CO2 emissions ($MtCO_2$ per capita)	ds
	x_{18}	Renewable electricity output (% of total electricity output)	st
	x_{19}	Renewable energy consumption (% of total final energy consumption)	st
	x_{20}	Access to clean fuels and technologies for cooking (% of population)	st

$$SDI = \frac{\sum_{i=1}^{m} R_{m(categoty)}}{m}, \quad (4)$$

where *SDI* – Sustainable Development Index.

2.3. Mathematical modeling of the optimization model for sustainable development with CO2 emissions consideration

It should be noted that in economic and mathematical modeling, there are optimization problems, the main purpose of which is to find the best and the most maximum variant from the point of particular criteria. The main purpose of this study is to calculate the maximum level of carbon dioxide emissions (*CO2*), considering the condition of achieving the minimum level of sustainability in the country.

This model of setting up a maximum level of CO2 emissions (*CO2*) of the country have a systematic approach and provide at least a minimum level of sustainable development, which should be presented in the country.

The offered approach to determining a maximum level of carbon dioxide emissions (*CO2*), taking into account the sustainable development indicator (*SDI*), comprises the following steps:

1. Formalization of the dependency of the sustainable development (*SDI*) of the country on the indicators of environmental performance *(ENV*), which contributes to total sustainable development of the country and indicator of performance of other segments (economy, governance and society) – non-environmental performance *(NON-ENV).*

2. Presenting this dependency as a one-factor equation of the environmental performance indicator on sustainable development of the country.

3. Determination of the lags of environmental performance *(ENV*), which contributes to total sustainable development of the country, Sustainable Development Index (*SDI*) and the level of carbon dioxide emissions (*CO2*).

4. Presentation of the multifactor autoregressive model of the level of carbon dioxide emissions (*CO2*).

5. Formalization of the condition for ensuring the minimum level of sustainable development (*SDI*) based on the optimization of variable – the level of carbon dioxide emissions (*CO2*) in achieving the desired level of sustainability.

6. Multiple-factor optimization based on determining the maximum level of carbon dioxide emissions (*CO2*) and ensuring the minimum level of sustainability.

The abovementioned steps are organized in the form of the following algorithm, shown in Figure 1. At the first stage of implementation of the proposed model, it is considered to construct a one-factor equation of dependency between *SDI* as a dependent indicator and one control variable.

Thus, based on the formalization of the relationship between Sustainable Development Index (*SDI*) and the indicator environmental performance (*ENV)*, the following equation is considered:

$$SDI = \varphi_1\ ENV + \varphi_2(\varphi_1)(NON - ENV), \quad (5)$$

where ϕ_1 – control variable that characterizes environmental performance *(ENV*), which contributes to general sustainable development (*SDI*); ϕ_2 – the value characterizing non-environmental performance *(NON-ENV)*, which contributes to general sustainable development (*SDI*).

The second step is to formalize the relationship between the parameters of the equation by approximating the relationship between the characteristics (indicators ϕ_1 and ϕ_2) with the highest probability based on the polynomial function. Thus, the equation will be as follows:

$$\varphi_2(\varphi_1) = a_1\varphi_1^{n-1} + a_2\varphi_1^{n-2} + \ldots + a_n, \quad (6)$$

where a_m, $m = 0 \div n$ – equation parameters.

As a result of calculating the standardized parameters of the regression equations for different horizons of the studied period, one obtained dynamic

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Source: Compiled by the author.

Step 1. Formalization of the dependency of the sustainable development (*SDI*) of the country on the indicators of environmental performance *(ENV)*, which contributes to total sustainable development of the country and indicator of performance of other segments (economy, governance and society) - non-environmental performance (*NON-ENV*).

$$SDI = \varphi_1\ ENV + \varphi_2(\varphi_1)(NON - ENV)$$

Step 2. Presenting this dependency as a one-factor equation of the environmental performance indicator impact on sustainable development of the country.

$$\varphi_2(\varphi_1) = a_1{\varphi_1}^{n-1} + a_2{\varphi_1}^{n-2} + \ldots + a_n$$

Step 3. Determination of the lags of environmental performance (ENV), which contributes to total sustainable development of the country; sustainable development index (SDI) and the level of carbon dioxide emissions (CO2)

$$CO2:\ t-m;\quad ENV:\ t-m;\quad SDI:\ t-m$$

Step 4. Presentation of the multifactor autoregressive model of the level of carbon dioxide emissions (CO2)

$$max(CO2)_t = \beta_0 + \sum_{m=1}^{n}\beta_m(CO2)_{t-m} + \sum_{m=0}^{n}\beta_{m+n}(ENV)_{t-m} + \sum_{m=0}^{n}\beta_{m+2n}(SDI)_{t-m},$$

Step 5. Formalization of the condition of ensuring the minimum level of sustainable development (*SDI*) on the basis of optimization of variable - the level of carbon dioxide emissions (*CO2*) in achieving the desired level of sustainability

$$SDI(\varphi_1) \le (\min\ SDI(\varphi_1) - \Delta F_1)SDI(\varphi_1)$$

Step 6. Multiple-factor optimization based on determining the maximum level of carbon dioxide emissions (*CO2*) and ensuring the minimum level of sustainability

$$\begin{cases}(CO2)_t = \beta_0 + \sum_{m=1}^{n}\beta_m(CO2)_{t-m} + \sum_{m=0}^{n}\beta_{m+n}(ENV)_{t-m} + \sum_{m=0}^{n}\beta_{m+2n}(SDI)_{t-m} \to \max \\ SDI = \varphi_1 ENV + (a_1{\varphi_1}^3 + a_2{\varphi_1}^2 + a_3\varphi_1 + a_4)\cdot(NON - ENV) \to \min\end{cases}$$

$$(CO2)_t = \beta_0 + \sum_{m=1}^{n}\beta_m(CO2)_{t-m} + \sum_{m=0}^{n}\beta_{m+n}(ENV)_{t-m} + \sum_{m=0}^{n}\beta_{m+2n}(NON - ENV)_{t-m} \to \max$$

$$\begin{cases}SDI(\varphi_1) \ge (\min SDI(\varphi_1) - \Delta F_1) \\ \frac{\partial SDI(\varphi_1)}{\partial \varphi_1} = ENV + (a_1{\varphi_1}^3 + a_2{\varphi_1}^2 + a_3\varphi_1 + a_4)\cdot(NON - ENV)\end{cases}$$

$$(\mathrm{CO2})_t = \beta_0 + \sum_{m=1}^{n}\beta_m(\mathrm{CO2})_{t-m} + \sum_{m=0}^{n}\beta_{m+n}(ENV)_{t-m} + \sum_{m=0}^{n}\beta_{m+2n}(NON - ENV)_{t-m} \to \max$$

$$\begin{cases}SDI(\phi_1) \ge (\min SDI(\phi_1) - \Delta F_1) \\ \phi_1 = \frac{-a_2(ENV) + \sqrt{a_2{}^2(NON - ENV)^2 - 3a_1(NON - ENV)\cdot(ENV) - 3a_1a_3(NON - ENV)^2}}{3a_1(NON - ENV)}\end{cases}$$

Figure 1. Methodology for determining the maximum level of carbon dioxide emissions (CO2)

series of indicators of sustainable development ϕ_1 and ϕ_2. Thus, the obtained polynomial equation enables to determine the indicators ϕ_1 and ϕ_2:

The third step of the proposed model provides determination of the lag of environmental performance *(ENV)*, Sustainable Development

$$\varphi_1 = \frac{-a_2(NON - ENV) + \sqrt{a_2{}^2(NON - ENV)^2 - 3a_1(NON - ENV)\cdot ENV - 3a_1a_3(NON - ENV)^2}}{3a_1(NON - ENV)}. \quad (7)$$

Index (*SDI*), and the level of carbon dioxide emissions (*CO2*).

It should be noted that the objective function within the framework of the proposed scientific and methodological approach is a multivariate autoregressive function:

$$\max(\mathrm{CO2})_t = \beta_0 + \sum_{m=1}^{n} \beta_m (\mathrm{CO2})_{t-m} + \\ + \sum_{m=0}^{n} \beta_{m+n} (ENV)_{t-m} + \sum_{m=0}^{n} \beta_{m+2n} (SDI)_{t-m}, \quad (8)$$

where β_0 is a free model parameter, which characterizes the level of carbon dioxide emissions (*CO2*) in case of zero of all variables of this model; β_m is a constant value, which indicates to what extend the level of carbon dioxide emissions (*CO2*) will change (increase or decrease) by increasing the same parameter by one unit with a given time lag ($t - m$); β_{m+n} is a multivariate regression parameter that indicates to what extend the level of carbon dioxide emissions (*CO2*) will change (increase or decrease) by increasing environmental performance (*ENV*) indicator by one unit with a given time lag ($t - m$); β_{m+2n} is a constant parameter similar to parameter β_{m+n},, but in the context of increasing the quantitative characteristic of the level of *SDI*.

At the fourth stage, it is considered to build a multivariate linear regression using MS Excel. It should be noted that it is necessary to evaluate the adequacy of the proposed multivariate linear regression, based on the validation of the regression parameters.

The fifth step considers a formalization of the condition for determining the minimum acceptable level of *SDI*.

Thus, the condition for providing a minimum level of sustainable development (*SDI*) based on optimization a variable – environmental performance (*ENV*), which contributes to the total creation of the country's sustainable development, can be defined as follows:

$$\frac{\partial SDI}{\partial \varphi_1} = ENV + (NON - ENV)\frac{\partial \varphi_2(\varphi_1)}{\partial \varphi_1} = \\ = ENV + (NON - ENV)(3a_1\varphi_1^2 + 2a_2\varphi_1 + a_3), \quad (9)$$

where $\frac{\partial \phi_2(\phi_1)}{\partial \phi_1} = 3a_1\phi_1^2 + 2a_2\phi_1 + a_3$.

Further, as part of the mathematical formalization of the proposed approach to determining the environmental performance (*ENV*), the following criteria should be optimized:

$$\begin{cases} (\mathrm{CO2})_t = \beta_0 + \sum_{m=1}^{n} \beta_m (\mathrm{CO2})_{t-m} + \\ + \sum_{m=0}^{n} \beta_{m+n} (ENV)_{t-m} + \sum_{m=0}^{n} \beta_{m+2n} (SDI)_{t-m} \to \max \\ SDI = \varphi_1 ENV + \varphi_2(\varphi_1)(NON - ENV) \to \min. \end{cases} \quad (10)$$

Considering the identified relationship between the indicator of the environmental performance (*ENV*) and the indicator of the non-environmental performance (*NON-ENV*), which contribute to the general sustainable development (*SDI*), the abovementioned system takes the following form:

$$\begin{cases} (\mathrm{CO2})_t = \beta_0 + \sum_{m=1}^{n} \beta_m (\mathrm{CO2})_{t-m} + \\ + \sum_{m=0}^{n} \beta_{m+n} (ENV)_{t-m} + \sum_{m=0}^{n} \beta_{m+2n} (SDI)_{t-m} \to \max. \\ SDI = \varphi_1 ENV + (a_1\varphi_1^3 + a_2\varphi_1^2 + a_3\varphi_1 + a_4) \times \\ \times (NON - ENV) \to \min \end{cases} \quad (11)$$

It is suggested that the optimization problem can be solved using method of successive concessions. The essence of this method is as follows: it is needed to select a criterion such as a minimum (*SDI)* and set its maximum value taking into account the environmental performance (*ENV*):

$$SDI(\phi_1) \le (\min SDI(\phi_1) - \Delta F_1) SDI(\phi_1) \quad (12)$$

Formalization of the condition for ensuring the minimum level of of the country's sustainable development (*SDI*) based on optimization of the variable – the level of carbon dioxide emissions (*CO2*) in achieving the desired level of sustainability, and considering the limitations (previously defined), is determined as follows:

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$$(CO2)_t = \beta_0 + \sum_{m=1}^{n} \beta_m (CO2)_{t\text{-}m} + \sum_{m=0}^{n} \beta_{m+n} (ENV)_{t-m} + \sum_{m=0}^{n} \beta_{m+2n} (NON-ENV))_{t-m} \to \max, \quad (13)$$

$$\begin{cases} SDI(\phi_1) \geq (\min SDI(\phi_1) - \Delta F_1) \\ \dfrac{\partial SDI(\phi_1)}{\partial \phi_1} = ENV + (a_1 \phi_1^{\,3} + a_2 \phi_1^{\,2} + a_3 \phi_1 + a_4) \cdot (NON - ENV) \end{cases}$$

If to consider the fact that in this study, the environmental performance *(ENV)* is a control variable, equation (13) can be represented as follows:

$$(CO2)_t = \beta_0 + \sum_{m=1}^{n} \beta_m (CO2)_{t\text{-}m} + \sum_{m=0}^{n} \beta_{m+n} (ENV)_{t-m} + \sum_{m=0}^{n} \beta_{m+2n} (NON-ENV)_{t-m} \to \max,$$

$$\begin{cases} SDI(\varphi_1) \geq (\min SDI(\varphi_1) - \Delta F_1) \\ \varphi_1 = \dfrac{-a_2(ENV) + \sqrt{a_2^{\,2}(NON-ENV)^2 - 3a_1(NON-ENV)\cdot(ENV) - 3a_1 a_3 (NON-ENV)^2}}{3a_1(NON-ENV)} \cdot \end{cases} \quad (14)$$

The final step of the methodological approach should be completed using MS Excel toolkit "Finding Solution".

In this case, the maximum level of carbon dioxide emissions (*CO2*) is taken as the target function. As a limitation, the minimum level of *SDI* and the relationship between ϕ_1 and ϕ_2 is accepted.

Thus, the calculation of this parameter gives the opportunity to gain advantages within decision-making management regarding the tactical and strategic goals of the companies' development and the segment as a whole.

3. RESULTS AND DISCUSSION

As mentioned earlier, the country's sustainability framework considers the criteria in the economic, social, environmental, and governance dimensions, which consist of a series of indicators. Thus, using equations (1-3), the general assessment of sustainable development has the following form (Table 2).

The results, depicted in Table 2, reveal that for developed countries, economic direction has the highest results, while for emerging economies, social dimension has better score. It should be highlighted that countries in transition still have the weakest side of their development – governance, and the political part is really fragile and unstable.

Generally, the results of calculations of sustainable development general assessment for the sampling groups of countries depicted in Figure 2, and it can show us how each factor (economic, environmental, social, and governance) can pose a sustainable development of the investigated group of countries.

Hence, these results primarily reflect the problems of governance and economics direction of countries, which belong to emerging economies, in the period 2004–2018. Furthermore, all average sub-indices of SDI of the advanced economies characterized with better level rather than the countries with emerging economies. These results allow us to state that top-15 leaders according to HDI-2018 remain the main forerunners in achieving 17 SDG, and the tendency is positive.

It is important to pay attention that the general level of the sustainability of both group of countries has been improving during the last decade (Figure 3).

It can be seen that advanced economies perform better and have a sufficient level of sustainability,

Table 2. General assessment of the sustainable development

Source: Compiled by the author.

Period	ECO	+/–, %		SOC	+/–, %		ENV	+/–, %		GOV	+/–, %	
Advanced economies												
2004	0.91	–	–	0.86	–	–	0.73	–	–	0.82	–	–
2005	0.91	100.00	||||	0.87	101.16	↑	0.75	102.74	↑	0.84	102.44	↑
2006	0.92	101.10	↑	0.89	102.30	↑	0.74	98.67	↓	0.85	101.19	↑
2007	0.91	98.91	↓	0.90	101.12	↑	0.76	102.70	↑	0.86	101.18	↑
2008	0.92	101.10	↑	0.91	101.11	↑	0.77	101.32	↑	0.86	100.00	||
2009	0.89	96.74	↓	0.87	95.60	↓	0.79	102.60	↑	0.80	93.02	↓
2010	0.91	102.25	↑	0.86	98.85	↓	0.80	101.27	↑	0.79	98.75	↓
2011	0.92	101.10	↑	0.88	102.33	↑	0.83	103.75	↑	0.82	103.80	↑
2012	0.91	98.91	↓	0.89	101.14	↑	0.85	102.41	↑	0.84	102.44	↑
2013	0.90	98.90	↓	0.89	100.00	||	0.85	100.00	||	0.84	100.00	||
2014	0.90	100.00		0.90	101.12	↑	0.88	103.53	↑	0.85	101.19	↑
2015	0.91	101.11	↑	0.90	100.00	||	0.90	102.27	↑	0.81	95.29	↓
2016	0.90	98.90	↓	0.91	101.11	↑	0.92	102.22	↑	0.85	104.94	↑
2017	0.91	101.11	↑	0.93	102.20	↑	0.94	102.17	↑	0.81	95.29	↓
2018	0.91	100.00	||	0.95	102.15	↑	0.97	103.19	↑	0.81	100.00	||
Emerging economies												
2004	0.77	–	–	0.83	–	–	0.79	–	–	0.41	–	–
2005	0.78	101.30	↑	0.84	101.20	↑	0.80	101.27	↑	0.42	102.44	↑
2006	0.78	100.00	||	0.85	101.19	↑	0.77	96.25	↓	0.44	104.76	↑
2007	0.79	101.28	↑	0.87	102.35	↑	0.76	98.70	↓	0.45	102.27	↑
2008	0.82	103.80	↑	0.87	100.00	||	0.76	100.00	||	0.48	106.67	↑
2009	0.73	89.02	↓	0.87	100.00	||	0.83	109.21	↑	0.49	102.08	↑
2010	0.74	101.37	↑	0.86	98.85	↓	0.83	100.00	||	0.48	97.96	↓
2011	0.77	104.05	↑	0.86	100.00	||	0.78	93.98	↓	0.49	102.08	↑
2012	0.74	96.10	↓	0.89	103.49	↑	0.77	98.72	↓	0.51	104.08	↑
2013	0.70	94.59	↓	0.90	101.12	↑	0.82	106.49	↑	0.51	100.00	||
2014	0.68	97.14	↓	0.91	101.11	↑	0.81	98.78	↑	0.54	105.88	↑
2015	0.66	97.06	↓	0.92	101.10	↑	0.81	100.00	||	0.52	96.30	↓
2016	0.68	103.03	↑	0.93	101.09	↑	0.82	101.23	↑	0.53	101.92	↑
2017	0.68	100.00	||	0.94	101.08	↑	0.81	98.78	↓	0.54	101.89	↑
2018	0.68	100.00	||	0.95	101.06	↑	0.82	101.23	↑	0.55	101.85	↑

Source: Compiled by the author.

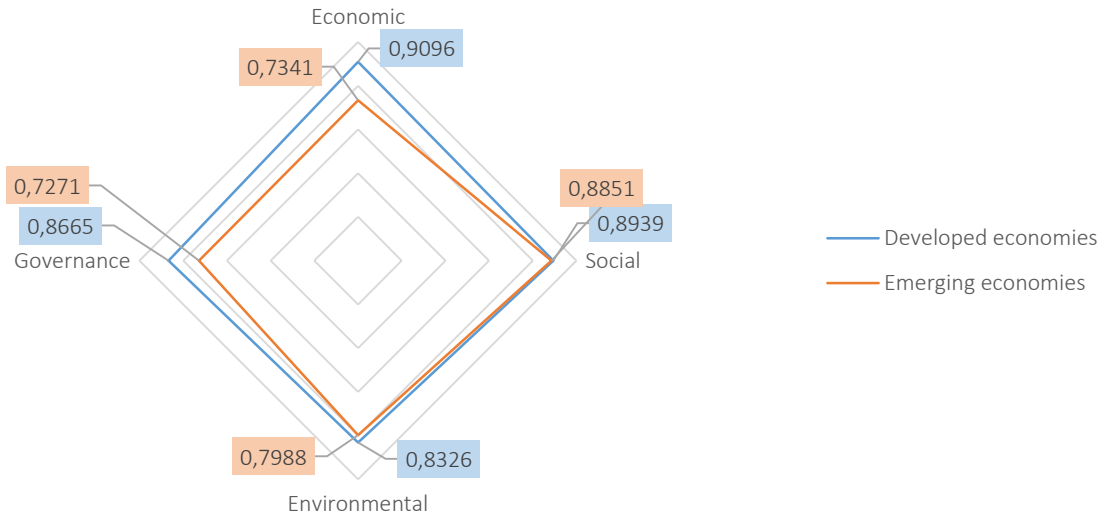

Figure 2. The value of the sub-indices of SDI of the advanced and emerging economies

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Source: Compiled by the author.

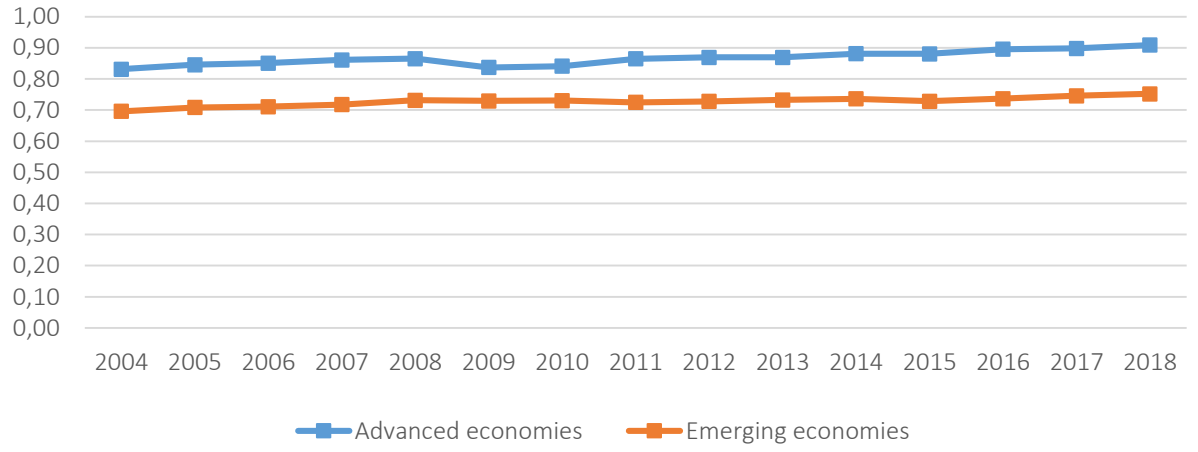

Figure 3. The dynamics of the level of the sustainability during the analyzed period (2004–2018)

while the level of SDI of the emerging economies does not exceed 0.75. Also, it is important to pay attention that there was one significant trough, happened after 2008 until 2011.

The obtained results reveal that since 2015, developed countries have been showing better results. Obviously, the reason was the Paris Agreement, adopted on December 12, 2015 under the UN Framework Convention on Climate Change (UN, 2015b), which regulates measures to reduce carbon dioxide emissions in the atmosphere since 2020. The agreement was prepared in place of the Kyoto Protocol during the Paris Climate Conference.

The agreement aims to "step up the implementation" of the UN Framework Convention on Climate Change, in particular, "to keep the global average temperature rise "much lower" than 2° C and "make efforts" to limit the temperature increase to 1.5° C". The parties to the agreement announced that the peak of CO2 emissions should be achieved "as soon as possible." The participating countries determine their contributions to the achievement of the declared common goal individually and review them once every five years.

It is worth paying attention that environmental management systems were developing under the influence of various factors – historical, cultural, political, economic, etc. Therefore, they developed in different countries the different approaches to environmental management and environmental protection using different methods and tools. However, they can all be divided into three main groups:

- nature conservation management methods;
- administrative regulation;
- system of economic mechanisms;
- formation of market relations in the field of environmental management.

Obviously, administrative regulation is quite important for getting established 17 SDGs, based on the introduction of relevant regulatory standards and restrictions, as well as on direct control and licensing of environmental management processes. All this aims to determine the framework that manufacturers must adhere to. In this area, approximately, standards, prohibitions, and certificates and licenses can be distinguished. Economic mechanisms aim at creating such conditions that would enable the producers to engage in the rational use of natural resources and involve in the introduction of pollution payment systems, environmental taxes, subsidies, etc. Economic regulatory mechanisms ultimately come down to the "greenhouse" tax free. In the very beginning of the 1990s, before the adoption of the UN Framework Convention on Climate Change, a carbon tax was introduced in the countries of Scandinavia (Sweden, Norway).

Hence, it proves the importance of the governance factor in the overall sustainability framework.

Source: Compiled by the author.

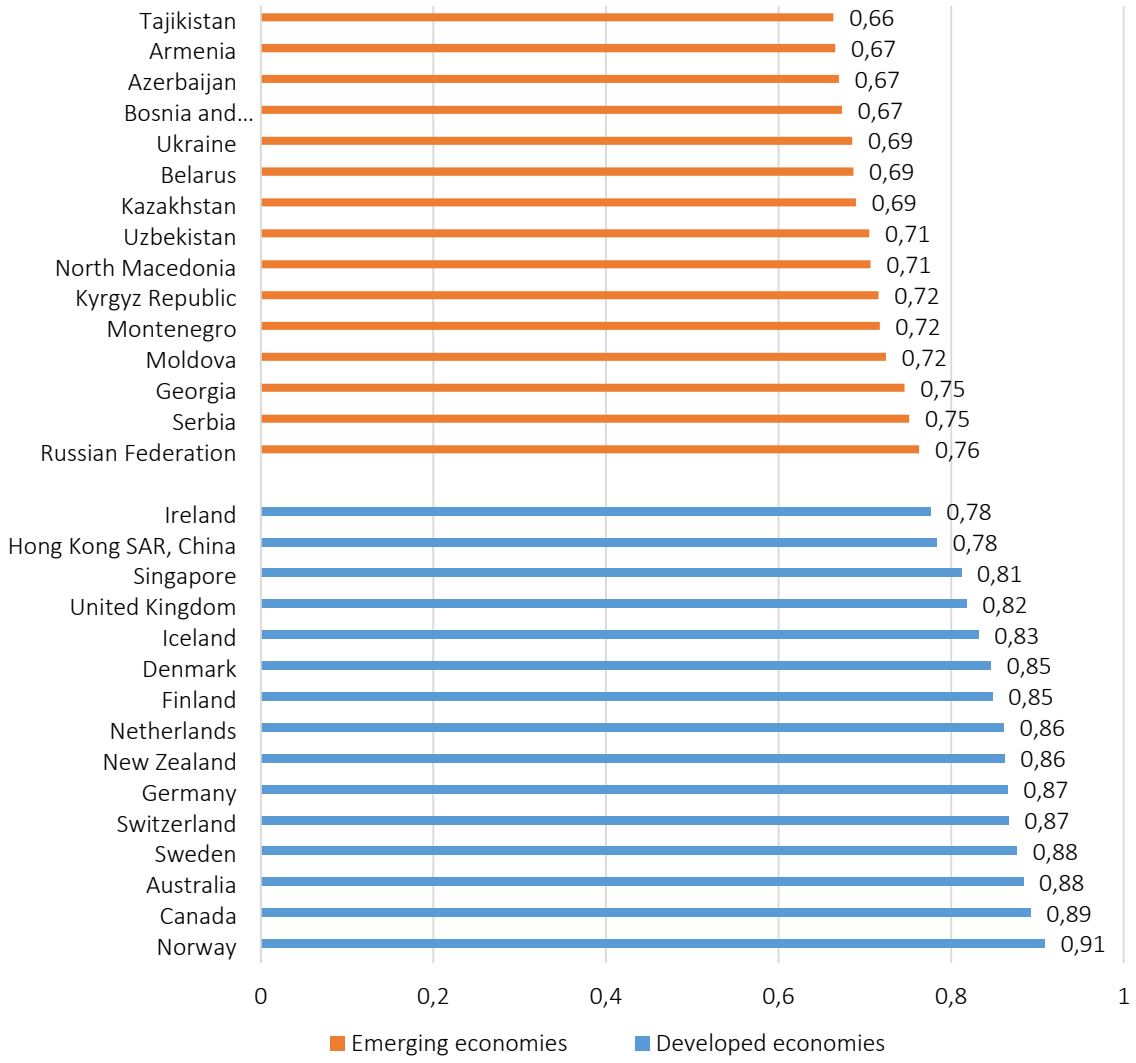

Figure 4. Average countries' SDI score

The SDI scores, presented in Figure 4, reveals that across economies, the highest score of sustainability is in Norway, which is constantly working to improve sustainability in all spheres of activity, followed by such countries as Canada, Australia, Sweden, Switzerland, and Germany. It should be noted that all advanced economies accelerate the transition towards a truly sustainable global society (Koilo, 2019). Moreover, these countries are engaged in different supporting projects and nowadays they are the members of organizations that take certain actions towards, and beyond, economic, environmental, social, and governance sustainability. Hence, each country has its scientific, systemic, and strategic approach to sustainability, in other words, the framework for strategic sustainable development.

Data from Figure 4 also reveal that emerging economies still have lower level of sustainability: the weakest results are presented in Tajikistan, Armenia, Azerbaijan, some countries have sufficient level of SDI, such as Russian Federation, Serbia, and Georgia.

A look at plot diagram, which is presented in Figure 5, maps the correlation between the level of the economic growth and composite Sustainable Development Index, and reveals that the term of development is wider than growth, and nowadays it is more important if one considers the level of living standards, preserving nature resources, and well-being of future generation.

The level of general economic growth does not differ a lot between these two groups of countries;

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Source: Compiled by the author.

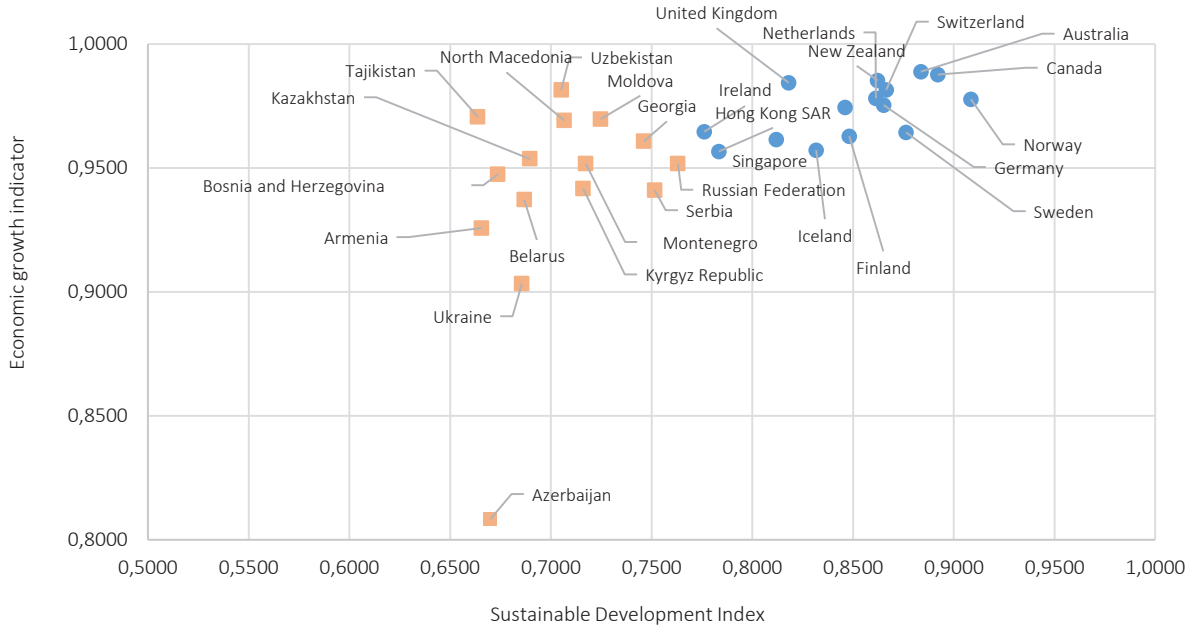

Figure 5. Correlation matrix between the level of the economic growth and composite Sustainable Development Index of the investigated countries

nevertheless, there is a strong tendency that in advanced economies during the investigated period, the general level of sustainability is increasing.

As mentioned earlier, the current index of HDI simplifies and captures only a part of what human development should include. Figure 6 prominently features the countries' performance (the relationship between HDI and SDI).

This graph exemplifies strong positive relationship between indexe; moreover, countries with very high human development level have better score of SDI. Nevertheless, parameter R^2 is 0.74 (while $R^2 = 1$ can be maximum result), which means there is a room to grow, in other words, human welfare is also critically dependent on healthy environmental assets. Hence, HDI can be improved, and proposed SDI can form the research backbone for the construction of new indicator, which can wider explore the level of human development of the nations.

It should be noted that Norway has been ranked as number one according to HDI, not surprisingly that this country is playing a leading role in achieving SDGs. According to Irvine (2016), this requires strategic engagement". The same statement can be found in a work of Grytten and Minde (2019), where authors investigate the relationship between the motivation and companies' management in Norway during the period from the early 1800s until present times: "Christian stewardship has been always central in Norwegian business ethics, it was imperative to do business to reinvest accumulated capital in productive measures to create work and values for the common good of the society".

In this paper there was also used a compound annual growth rate (CAGR). CAGR is a specific term for the geometric progression ratio, that smoothes the calculations due to volatility in year-to-year growth and provides a constant rate. CAGR is defined as follows:

$$CAGR = \frac{Ending\ result}{Start\ result}^{\frac{1}{(t_n - t_1)}} - 1. \qquad (15)$$

Despite the constant incremental progress demonstrated by the majority of countries on the SDI during the investigated period, nevertheless, several countries have negative compound annual growth rate (Table 2).

Of six most worsened countries, there were both advanced and emerging economies, namely,

Source: Compiled by the author based on World Bank (2018) and UNDP (2018).

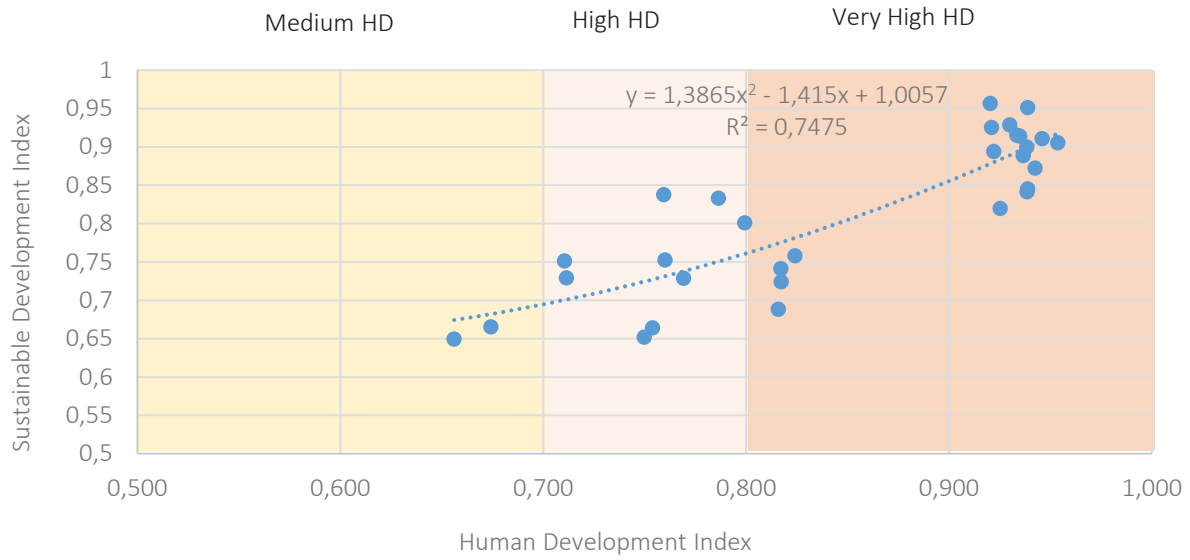

Figure 6. Correlation of the Human Development Index and Sustainable Development Index

Table 3. Compound annual growth rate of SDI, %

	Most worsened countries	CAGR, %	
1	Finland	–0.39	↓
2	Kyrgyz Republic	–0.37	↓
3	Ukraine	–0.30	↓
4	Montenegro	–0.25	↓
5	Russian Federation	–0.19	↓
6	Sweden	–0.10	↓
	Most improved countries	**CAGR, %**	
1	Iceland	0.07	↑
2	Norway	0.12	↑
3	Tajikistan	0.13	↑
4	Canada	0.17	↑
5	Azerbaijan	0.18	↑
6	New Zealand	0.26	↑
7	Australia	0.38	↑
8	Uzbekistan	0.49	↑
9	Kazakhstan	0.81	↑
10	Switzerland	0.85	↑
11	Georgia	0.95	↑
12	Armenia	1.02	↑
13	Moldova	1.06	↑
14	Netherlands	1.10	↑
15	Denmark	1.15	↑
16	Belarus	1.23	↑
17	Bosnia and Herzegovina	1.34	↑
18	Ireland	1.40	↑
18	Singapore	1.45	↑
20	Serbia	1.52	↑
21	Germany	1.61	↑
22	Hong Kong SAR. China	1.62	↑
23	United Kingdom	1.91	↑
24	North Macedonia	2.32	↑

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Finland and Sweden, which at the beginning of the investigated period, had better score, rather than in 2018. Kyrgyz Republic, Ukraine, Montenegro, and Russian Federation are also in the same group with negative CAGR.

The final step of current study would be the investigation a maximum level of carbon dioxide emissions (CO2), taking into account the Sustainable Development Index (SDI). Excel Solver allows us to find optimal solutions. As a result of using this tool, there was determined a maximum level of carbon dioxide emissions for each group of countries: for advanced economies, it was defined as 9.40 $MtCO_2$ per capita and for emerging economies – 4.87 $MtCO_2$ per capita. These results provide a conclusive evidence that developed countries have already achieved the sufficient level of SDI; nevertheless, emerging economies still have to improve it; thus, the maximum acceptable level of CO2 is lower for these countries.

Thus, the calculation of this parameter gives an opportunity to gain advantages within the limits of managerial decision-making regarding the tactical and strategic goals of the sustainable development policy of the country in a balanced and systematic manner.

4. PRACTICAL IMPLICATION AND FUTURE RESEARCH

The results derived from the study can help policymakers to determining the priorities for early action and monitor progress in achieving SDGs. Sustainability ranking also can give insights concerning countries' SDI profile whether it is improving or deteriorating.

Besides, the current study reveals, that human welfare is also critically dependent on healthy environmental assets and existing HDI simplifies and captures only part of what human development should include. Thus, SDI can be an instrument, which forms the research backbone for the construction of new human development index.

Moreover, this composite index might be a useful tool, while calculating optimal level of CO2 emissions for emerging markets and developed economies based on the countries' total sustainability scores.

CONCLUSION

The present study proposes a new approach for dealing with uncertainties in determining the level of sustainability at the national level and provides a complete picture of sustainable development of the countries. Composite Sustainable Development Index is a tool designed to assess comprehensively the progress made by 15 advanced economies and 15 emerging economies since 2004–2018 towards achieving sustainable development goals.

This method considers a set of indicators, which are arranged into four categories of sustainable development: economic, social, governance, and environmental. The analyses show that for developed countries, economic direction has the highest results, while for emerging economies, social dimension has better score. It should be highlighted that countries in transition still have the weakest side of their development – governance, and the political part is really fragile and unstable.

In general, during the analyzed period, advanced economies had a satisfactory level of sustainability, while the level of SDI of the emerging markets does not exceed 0.75. Also, it is important to pay attention that there was one significant trough, happened after 2008 until 2011. The obtained results reveal that since 2015, developed countries have been showing better results. Obviously, the reason was the Paris Agreement, adopted on December 12, 2015 under the UN Framework Convention on Climate Change.

The present study reveals that across economies, the highest score of SDI is in Norway, which is constantly working to improve sustainability in all spheres of activity, followed by such countries as Canada,

Australia, Sweden, Switzerland, and Germany. Also, obtained results show that emerging economies still have lower level of sustainability: the weakest results are presented in Tajikistan, Armenia, Azerbaijan, some countries have sufficient level of SDI, such as Russian Federation, Serbia, and Georgia.

Besides, it was proved that the current human development index simplifies and captures only part of what human development should include. This paper analyzes the relationship between HDI and SDI. The results reveal a strong positive relationship between indexes; moreover, countries with very high human development level have better score of SDI. Nevertheless, human welfare is also critically dependent on healthy environmental assets. Hence, HDI can be improved, and proposed SDI can form the research backbone for the construction of new indicator, which can wider explore the level of the nations' human development.

Moreover, proposed composite index was used to find an optimal level of carbon dioxide emissions, taking into account the Sustainable Development Index. The author determines a maximum level of carbon dioxide emissions for each group of countries: for advanced economies, it was defined as 9.40 $MtCO_2$ per capita and for emerging economies – 4.87 $MtCO_2$ per capita. These results provide a conclusive evidence that developed countries have already achieved a sufficient level of SDI; nevertheless, emerging economies still have to improve it; thus, the maximum acceptable level of CO2 is lower for these countries.

The calculations show, first of all, the effectiveness of the assessment methodology. Nevertheless, SDI is heavily dependent on quality of information supplied, i.e., on how well is the monitoring organized. Hence, to have more adequate results or performance of the proposed assessment model, the methodology can be used in combination with other models (e.g., expert method, which will confirm or refine the results of sustainable development areas assessment).

AUTHOR CONTRIBUTIONS

Conceptualization: Viktoriia Koilo.
Data curation: Viktoriia Koilo.
Formal analysis: Viktoriia Koilo.
Investigation: Viktoriia Koilo.
Methodology: Viktoriia Koilo.
Project administration: Viktoriia Koilo.
Validation: Viktoriia Koilo.
Visualization: Viktoriia Koilo.
Writing – original draft: Viktoriia Koilo.
Writing – review & editing: Viktoriia Koilo.

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