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Relationships between Wellbeing and Sustainable Development in a Group of Selected Developed Countries

Relacje między dobrostanem a zrównoważonym rozwojem w grupie wybranych krajów rozwiniętych

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Abstract

This work evaluates the crucial aspects of sustainable development (SD) related to wellbeing and quality of life, which were measured by twenty-two relevant indicators (indices) in a sample of 31 countries over the period 2010 – 2019. All the pillars of SD are reflected, while the indicators applied either reflect one of these dimensions, i.e. the economic, social or environmental pillar of SD, or two/all of them. Several of these indicators also measure specific aspects encompassed by the particular pillars, which are of great importance for SD and have to be included. These include especially health and inequality, which belong to the social pillar of SD, and are reflected in several indicators used. Furthermore, the indicator of subjective happiness is included as well. Principal component analysis (PCA) and parallel factor analysis (PARAFAC) are the main methods used to analyse relationships between twenty-two indicators (composite indices) reflecting crucial aspects of SD, wellbeing, and quality of life in the sample. Three stages of both analyses were carried out. For both of them similar results were identified. Principal component 1 (for PCA)/component 1 (for PARAFAC) divided the sample into the less and the more developed countries, since the positive contribution was predominantly determined by the socioeconomic, wellbeing and the more complex environmental or SD indicators, which are predominantly the highest (high) in the more developed countries. On the contrary, the negative contribution was determined by the pollution damage indicators, which are the highest in the less developed countries. Principal component 2 (for PCA)/component 2 (for PARAFAC) divided the sample according to a crucial aspect of the social pillar of SD, i.e. quality of health, particularly reflected in Healthy life years at birth (HLY), which has also poor results in the many developed countries. At the third stage this component is determined by the environmental indicators reflecting resource depletion/consumption and also pollution damages in monetary values, being crucial for SD, since a number of them had the highest values in the developed countries.

Key words: adjusted savings, Inequality-Adjusted HDI (IHDI), Parallel Factor Analysis (PARAFAC), Principal Component Analysis (PCA), sustainable development, wellbeing

JEL Classification: I15, I31, Q51

Streszczenie

Niniejsza praca ocenia kluczowe aspekty zrównoważonego rozwoju (SD) związane z dobrostanem i jakością życia, które zostały zmierzone za pomocą dwudziestu dwóch odpowiednich wskaźników (wskaźników) w próbie 31 krajów w latach 2010-2019. Uwzględniono wszystkie filary zrównoważonego rozwoju, natomiast zastosowane wskaźniki odzwierciedlają albo jeden z tych wymiarów, tj. filar ekonomiczny, społeczny lub środowiskowy ZR, albo dwa/wszystkie z nich. Niektóre z tych wskaźników mierzą również konkretne aspekty objęte poszczególnymi filarami, które mają ogromne znaczenie dla zrównoważonego rozwoju i muszą zostać uwzględnione. Wśród nich wyróżnić należy zwłaszcza zdrowie i nierówności, które należą do społecznego filaru zrównoważonego rozwoju i znajdują odzwierciedlenie w przyjętych wskaźnikach. Ponadto uwzględniono również wskaźnik subiektywnego szczęścia. Analiza głównych składowych (PCA) i równoległa analiza czynnikowa (PARAFAC) to główne metody stosowane do analizy relacji między dwudziestoma dwoma wskaźnikami (wskaźnikami złożonymi) odzwierciedlającymi kluczowe aspekty SD, dobrostanu i jakości życia. Przeprowadzono trzy etapy obu analiz. Zidentyfikowano podobne wyniki. Komponent główny 1 (w przypadku PCA)/komponent 1 (w przypadku PARAFAC) podzielił próbę na kraje słabiej i bardziej rozwinięte, ponieważ pozytywny wkład był determinowany głównie przez wskaźniki społeczno-ekonomiczne, dobrobyt i bardziej złożone wskaźniki środowiskowe lub zrównoważonego rozwoju, które są przeważnie najwyższe (wysokie) w krajach bardziej rozwiniętych. O ujemnym wkładzie zadecydowały wskaźniki szkód powodowanych przez zanieczyszczenia, które są najwyższe w krajach słabiej rozwiniętych. Komponent główny 2 (dla PCA)/komponent 2 (dla PARAFAC) podzielił próbę według kluczowego aspektu społecznego filaru SD, jakim jest zdrowie, w szczególności Healthy life years at birth (HLY), który wypadł słabo także w wielu krajach rozwiniętych. W trzecim etapie składnik ten jest określany przez wskaźniki środowiskowe odzwierciedlające wyczerpywanie się/konsumpcję zasobów, a także szkody spowodowane zanieczyszczeniami w wartościach pieniężnych, które są kluczowe dla zrównoważonego rozwoju, gdyż wiele z nich miało najwyższe wartości w krajach rozwiniętych.

Słowa kluczowe: skorygowane oszczędności, HDI skorygowany o nierówności (IHDI), Równoległa Analiza Czynnikowa (PARAFAC), Analiza Głównych Składowych (PCA), zrównoważony rozwój, dobrostan

1. Introduction

SD has become a key issue for humanity in the 21st century (Komiyama and Takeuchi, 2006), or even a worldview for the 21st century (Eckersley, 2006). However, its roots go back to the distant past, and it is highly likely it will gain importance in the future or, alternatively, gradually be replaced by more appropriate concepts, perhaps even alternative ones. The relationships between economic performance, wellbeing, quality of life and environmental aspects of human (production/consumption) activities are crucial topics related to the concepts of sustainability and SD. Many studies investigated particular relationships. However, general implications for future development options to achieve SD environmentally and socially at different levels remain a challenging issue for research.
According to the most cited definition of SD from the World Commission on Environment and Development (WCED), SD is development that meets the needs of the present without compromising the ability of future generations to meet their own needs. Two fundamental concepts are involved within this. Firstly, it is the concept of needs, in particular the essential needs of the world's poor, to which essential priority should be given. Secondly, there is the idea of limitations imposed by the state of technology and social organization on the environment's ability to meet present and future needs (WCED, 1987).
The concepts of wellbeing, quality of life and SD are significantly interconnected, and in an analysis of quality of life not only SD, but additional concepts need to be considered. Improving the quality of life of the current generation must not be at the cost of burdening future generations by limiting their quality of life/wellbeing, or even by threatening their very survival. This is in compliance with the basic philosophy of SD. The concept of SD is based on a harmonization of economic growth, social welfare and environmental protection (Asara et al., 2015). However, research has demonstrated the limits of economic growth and the social and environmental problems associated with contemporary consumption-oriented lifestyles. An important challenge is to maintain the sources of people's wellbeing, and it is even more important to find ways of ensuring that this is compatible with environmental limits and that social imbalances are minimized. Improving the quality of life and wellbeing of people in the whole world is a crucial goal and it has become a challenging aim in the world of diminishing resources given by the supply of the planet Earth. This supply has been decreasing due to the socioeconomic activities (trends) of people aimed at increases in their wellbeing and quality of life, often associated with unsustainable production and consumption patterns (consumerism has prevailed in the developed countries) and also continuing population growth in many parts of the world (especially in the developing countries while, on the contrary, their consumption per capita is low). When compared with this supply, people's needs (demand on resources) are unlimited. Due to the deficits in market forces, i.e., non-existing markets for a majority of the environmental services on which wellbeing, quality of life, and even the survival of humanity depend, all these aspects are the subject of sustainability/SD research. Nevertheless, due to deficiencies of these concepts, many alternative concepts have been developed which are more or less in compliance with these concepts, some of them were formed to replace them or even replace the whole economic system in which sustainability and SD should be pursued. Although critiques of sustainability and SD have persisted, these concepts must not be abandoned. On the contrary, they remain critical challenges. SD as originally conceived is still a convincing concept. This work extends the previous authors' work, the aim of which was to identify the crucial factors affecting quality of life, and to discover the relationships between these factors in a sample of 26 developed OECD countries.

The aim of the work is to evaluate performance and relationships between twenty-two indicators (composite indices) indicating crucial aspects of SD, wellbeing, and quality of life in the sample of 31 countries over the period 2010-2019, using principal component analysis (PCA) and parallel factor analysis (PARAFAC). The structure of the remainder of this paper is as follows: Section 2 presents more background to the topic of SD, wellbeing, quality of life, and their interconnections (2.1), and provides information regarding the data (2.2.1) and the statistical methods used (2.2.2); section 3 provides the results and discusses them; section 4 included overall discussions in context; and Section 5 contains the conclusions.

2. Materials and Methods

In this section, the research works related to the performed analysis are introduced. Next, the data and methods used are presented.

2.1. Literature Review

In this subsection the background for the overall topic analysed in this paper and the rationale behind the measures/indicators used in the analysis are provided. Since the essential definition by which SD was conceptualized (WCED, 1987) was accepted, its definition has been explicated and many scholars have provided their definitions. According to WCED (1987), recognizing limits is one of the two lead principles of SD. This can be achieved by reducing the extent of an economy, limiting the total resource quantity it exhausts. Some of the definitions are worth mentioning, such as that referring to SD as a development that generates economic growth, distributes benefits equitably, regenerates the environment, and promotes people (Mosteanu et al., 2014). The concept of SD can be understood as a balance between its three pillars, i.e., the economic, social, and environmental (see more also in: Drastichova, 2018; Drastichova and Filzmoser, 2019). Moreover, the fourth institutional pillar is added due to its essential role in underpinning progress in the previous three pillars and SD in general (United Nations et al., 2003). The relationship to quality of life is obvious. The concept of quality of life was introduced in detail in Drastichová and Filzmoser (2021), including a detailed literature review related to both the concept of SD and quality of life and their relationships. According to Sinha (2019), the concept of quality of life is multidisciplinary and holistic since it incorporates every aspect of daily life. Not only is it economic, but it also contains social, political, cultural, and recreational aspects (among others). The term *quality of life* (similarly to the concept of SD) is difficult to identify, define, categorize and analyse. It is a complex, multidimensional concept. It involves various social, cultural, economic, political, demographic and environmental aspects. The attention should be paid to what determines quality of life, with respect to the philosophy of SD. The concept of SD involves environmental protection, economic vitality, as well as social equity, by assimilating individual concerns into collective ones. As regards quality of life in the context of SD, SD can be interpreted as *a quest for developing and sustaining qualities of life* (see more in: Drastichova and Filzmoser, 2021). The goals of SD, related to the *three E's*, which include economic growth, environmental protection, and social equity, also correlate with the aspects of quality (Cusack, 2019). The quality of life of future generations depends on people's current decisions. The humans fundamentally depend on the flow of ecosystem services which are used in production and consumption in order to increase their wellbeing and quality of life. Therefore, it is necessary to identify these services to determine the relationships between the three distinct dimensions of SD, wellbeing and quality of life. According to La Notte et al. (2017), ecosystem services research faces several challenges stemming from the plurality of interpretations of classifications and terminologies. Some definitions are very similar, including the following ones: the direct and indirect contributions of ecosystem structures and functions (Müller and Burkhard, 2012); the direct and indirect contributions of ecosystems to human wellbeing (Maes et al., 2016; TEEB, 2010); the benefits that people obtain from ecosystems (the outcomes sought through ecosystem management) (Wallace, 2007), among others. Although different scholars can use different classification of ecosystem services, the following one is used as a crucial one. The Millennium Ecosystem Assessment (MEA, carried out in 2001-2005) assessed the consequences of ecosystem change for human wellbeing and established the scientific basis for actions needed to enhance the conservation and sustainable use of ecosystems and their contributions to human wellbeing. It focuses on the linkages between ecosystems and human wellbeing and, in particular, on *ecosystem services*. Ecosystem services are the benefits people obtain from ecosystems (this is in compliance with several definitions used above, especially that of Wallace, 2007). These include *provisioning services*, including food, (fresh) water, timber and fuel; *regulating services*, including climate regulation, flood regulation, disease regulation and water purification; *cultural services*, which provide educational, recreational, aesthetic and spiritual benefits; and *supporting services*, including primary production, soil formation, photosynthesis and nutrient cycling. In this work, the term ecosystem services are generally used to refer to some kinds of natural re/sources or sinks. The MEA investigated how changes in ecosystem services influence human wellbeing, which has multiple constituents. It includes the *basic material for a good life*; *health*; *good social relations*; *security*; and *freedom of choice and action*. The last component is affected by other constituents of wellbeing and other factors, especially education, and is also a precondition for achieving other components of wellbeing, particularly those related to equity and fairness.

In terms of the conceptual framework for the MA, people are the integral parts of ecosystems and a dynamic interaction exists between them and the other parts of ecosystems. Changes in human conditions lead, both directly and indirectly, to changes in ecosystems and subsequently, to changes in human wellbeing. Simultaneously, social, economic, and cultural factors not related to ecosystems alter the human conditions, and many natural processes affect ecosystems. The MA not only emphasized the linkages between ecosystems and human wellbeing, it also recognized that the activities of people that influence ecosystems result not only from the concern about human wellbeing but also from the considerations of the intrinsic value of ecosystems (Millennium Ecosystem Assessment, 2005). It is particularly visible in the MEA classification that ecosystem services are as much a source of wellbeing as a prerequisite for the survival of humanity. Therefore, a direct link to SD is included.

Several scholars have clearly indicated that the system of capitalism has exceeded the biophysical limits of the planet and the environmental crisis has become real. Resulting from the content of the SD concept introduced above, an important concept related to SD, sustainability and alternative concepts in this field, as well as their practical counterparts, and also a way of putting SD and related concepts into operation, is the concept of sustainable consumption and production (SCP). SCP is among the crucial more practical concepts that are necessary to achieve the path of SD and sustainability. This concept is among others reflected in the conception of decoupling economic activity from environmental effects (further: *decoupling*) (see e.g. Wiedmann et al., 2015). Absolute decoupling, including an absolute decrease in resource (ecosystem service) use over time with simultaneous growth of the economy, has not taken place (Fritz and Koch, 2016; O'Neill et al., 2018). The crucial factor responsible for that is the *rebound effect*, which is a general term for a number of mechanisms that reduce the potential energy savings from improved energy efficiency. Nevertheless, it has also been argued that the rebound effect often surpasses 100% and hence, it can eliminate all of the energy savings from an increased energy efficiency. This is known as the Jevons Paradox (Ruzzenenti et al., 2019), according to which an increase in efficiency of resource use in the long term will generate an increase in resource consumption rather than a decrease. Consumption is, to a high degree, a social, rather than an individual act. It is significantly interconnected with the concept of decoupling. The concept of SD embraces two crucial aspects: meeting human needs and respecting the limits imposed by the environment (WCED, 1987). Hence, both underconsumption and overconsumption are unsustainable (Spangenberg, 2014). There are also more practical approaches, which help economies shift towards SD. Political strategies, including the Inclusive Green Economy (GE) and Green Growth (GG have gained ground in political agendas at the inter/national levels. GG is a political catchword, introduced to defeat the reservations of the business sector over all green initiatives, irrespective of the potential economic benefits. It is at the heart of the GE concept (UNEP, 2011). The OECD has made it its underlying phrase (OECD, 2011c). However, it has not been systematically applied. Another more practical concept putting SD into operation is that of circular economy (CE). CE corresponds with the field of biomimicry (see e.g. Geisendorf, and Pietrulla, 2017). It involves elimination of waste, the mimicking of nature, the internalization of externalities, and the emulation of a closed loop cycle. A CE, as opposed to a linear consumption economy, is regenerative. It reuses products and recycles waste rather than disposing of them. The concept of CE is also a crucial concept and system which applies decoupling, is based on SCP, can operate within GE or GG and helps move closer to SD.

Although according to Lorek and Spangenberg (2014), SD is still a convincing concept if its crucial definition (WCED, 1987) is used, it has often been misinterpreted since its formulation and its importance has therefore been weakened. The concept of SD is still nebulous and vague. Hence a number of re/interpretations and alternative conceptions have been adopted which are more suitable to the stakeholders at various analytical levels (at the macroeconomic level: developed vs. developing countries in general; the groups of countries based on their natural endowment, economic and social, environmental, institutional, cultural (and other) conditions and their combinations in particular) or specific communities, such as Buen Vivir and Ecological Swaraj (alternatives to SD as well as GE, and alternatives to growth at local levels (Beling et al., 2018; Kothari, Demaria and Acosta, 2014). Some concepts refuse the deficiencies of the SD concepts or try to fill in the gaps, or only add some important aspect or complement it with important aspects. Particular concepts of sustainability including the human development approach can be included into this group. Development is understood as a process of change that is sustainable, leading to a desirable state of sustainability, while several concepts of sustainability defined by particular criteria can be defined. Some concepts try to put the SD concept into operation, while they are often blamed for similar deficiencies as the SD concept, causing even more confusion. These are especially the concepts of GE, GG, along with the concepts of CE, SCP and decoupling, which can also be applied within the first two concepts. Some of them refuse the recent system of capitalism, with which the concept of SD is connected, at all. This is especially the concept of degrowth.

A focus on the concept of human development (HD) together with several alternative (transformation) concepts has also prevailed recently. The concept of HD is considered in this work. It is still connected with the concepts of SD and sustainability, i.e. economic growth is not abandoned. In the HD approach, the focus on the economic, environmental and social dimensions of SD must be expanded so as to cover a human dimension. People and their opportunities and choices are at a centre of attention. This is a crucial part of the overall concept of SD, and must be considered when analysing quality of life. Ideas of HD have become significantly associated with the work of the United Nations Development Programme (UNDP), presented in its annual reports. The HD paradigm supports a need for understanding development as being *development of the people by the people, for the people* (UNDP, 2022). The contribution of HD can be understood as a consideration of development that has moved away from a merely economic-based understanding (measured in GDP) and from an exclusively state-centred understanding to one based on people as the main agents of development.

Another more practical advanced concept, which can embody a HD approach and also quality of life, is worth mentioning. The Economy for the Common Good (ECG) is an economic model where the primary goal is the common good, which is a good life for everyone on a healthy planet. The ECG shapes a new economy based on dignity, social justice and environmental sustainability. It supports an ethical market economy, whose goal is a good life for all people, rather than an increase in monetary capital. The ECG focuses on the real mission of business, which is meeting human needs. That is fully in compliance with the SD concept. The ECG fundamentally involves building prosperous relationships, which are a requirement for happiness and a requirement for the common good. On the other hand, money is only a means of economic activity. Economic output, expressed in money, does not reflect the change of common good. Other indicators, in addition to monetary ones (including GDP), are required (see more on ECG, 2021).

It must be added that from the point of view of economics as a science, mainstream neoclassical environmental economics is regarded as the basic scientific (theoretical) approach for addressing environmental issues in economics. Other important approaches in economics, including alternative approaches, are also considered. Beeks (2016) summarized fourteen economic concepts (systems). They include environmental, circular, green, resilience, ecological, complexity, feminist, compassionate, caring, degrowth, steady-state, no-growth, ecosocialism, and anarcho-ecosocialism systems. Although there are significant differences in the understanding of the relationships of these systems with SD between Beeks (2016) and the authors of this work, it can be concluded that the ECG also significantly reflects the features of compassionate system, which can represent a potential economic model for the future. Compassionate economics has its origins in 1955, having a philosophical basis in Buddhism (Schumacher, 2011). This approach focuses on the complex relationships between society, personal needs, and the environment in relation to economic needs. It also endeavours to establish the foundation of a social democracy, emulating the governments of the Nordic nations. The environmental sustainability of economic growth has been a concern in relation to the concept of SD and sustainability in general. More generally, two alternatives to the economic growth paradigm have been presented: namely, a-growth and degrowth. The first concept considers neglecting GDP as an indicator of welfare/progress and addressing instead reasonable environmental, social, and economic policies independently of their impacts on economic growth (van den Bergh, 2011). Degrowth involves the deliberate downscaling of the economy to achieve its operation within biophysical boundaries (Kallis, 2011).

The relationships between economic prosperity, quality of life, and environmental aspects of production and consumption patterns are an important subject of sustainability debates. Regarding the relationships between SD, wellbeing and quality of life, it must be emphasised that they involve many similar aspects and accordingly, they can be measured by similar indicators (or at least some of their aspects) (see more in: Drastichová, 2021). In measuring quality of life of the people by quantitative and qualitative indicators, Singh (1993) involved income, employment, health, education, physical environment, human dignity and freedom. Sarma et al. (1993) considers the indicators of quality like life expectancy at birth, infant mortality rate, crude death rate, literacy rate, per capita income, number of hospitals and dispensaries, telephone exchange, post and telegraph office, per capita availability of food grains, or population covered by radio, TV. Hussain (1994) also considered population characteristics, such as infant mortality, expectancy of life and literacy as crucial factors of physical quality of life. He also used GNP per capita, education and health in evaluating physical quality of life of the targeted population. Methods of measurement in the field of SD, wellbeing and quality of life have also been developing. Cusack (2019) showed that quality of life follows a general economic trend. The countries with the greatest declared life satisfaction and scoring toward the top of the ladder are generally those having very high human development. The correlation between HDI scores and self-assessed wellbeing scores was recognized. Life satisfaction is positively correlated with both HDI and environmental performance. Hence, neither the environment nor the economy can be sacrificed at the expense of the other. This has significant policy implications. Moreover, increases in income alone have played only a limited role in happiness. Other variables affect perceptions of wellbeing, including health, environment, family, or freedom (de Vries and Petersen 2009). In recent times there is no confirmation that GDP in high-income countries correlates with jobs (the quality of which has decreased), or with poverty, or, more broadly, with wellbeing and life satisfaction (Cattaneo and Vansintjan, 2016).

In the World Happiness Report (WHR), the WELLBY approach is also presented. It provides a reasonable method of combining wellbeing with length of life. For the evaluation of social progress and preparation of effective policies, both quality of life, and length of life need to be considered. In the wellbeing approach, total wellbeing experienced by everyone and for whatever reason are considered. The authorities should aim at maximizing Well-Being-Adjusted Life-Years (or WELLBYs) of all born and should include the life-experiences of future generations, which are subject to a small discount rate.

To sum up, it is confirmed that a number of the relevant aspects of wellbeing, quality of life and SD are difficult to quantify economically, including the intrinsic value of nature. The presented works inspired this study in terms of the selection of factors and indicators (variables) reflecting SD, wellbeing, or quality of life. The indicators presented significantly determined the selection of indicators in this work (or they were directly used).

2.2. Data and Methods Applied

The fundamental framework of the methodology, the indicators used and data sources are defined in this section.

2.2.1. Data Applied

On the basis of the knowledge included in subsection 2.1, 22 indicators were selected for measuring crucial aspects of SD along with wellbeing. Those indicators are often composite indicators, i.e. indices, which contain several indicators reflecting crucial dimensions of SD or important factors of wellbeing. They are described in this subsection (in succession). Their inclusion is justified by the relevant research works (see section 2.1). All the variables (indicators, indices) are included in Table 1 where their official names as well as the abbreviations used in this work are indicated in the brackets.

Table 1. The 22 variables (indicators/indices) chosen for the analysis, source: UNDP (2022), World Bank (2021), Eurostat (2021)

Human Development Index (HDI)	Adjusted net national income per capita (constant 2010 USD) (ANNIpcco)	Adjusted savings: particulate emission damage (% of GNI)
Inequality-adjusted HDI (IHDI)	Adjusted net national income per capita (annual % growth) (ANNIpccog)	Adjusted savings: particulate emission damage (current USD)
Real GDP per capita (GDPpc)	Adjusted net savings, including particulate emission damage (current USD) (ANSP)	Adjusted savings: energy depletion (% of GNI)
Healthy life years at birth (HLY)	Adjusted net savings, including particulate emission damage (% of GNI) (ANSPperc)	Adjusted savings: energy depletion (current USD)
Happiness Index – Life Ladder (HI/LL)	Circular material use rate (CMUR)	Adjusted savings: mineral depletion (current USD)
Inequality-adjusted life expectancy index (IALE)	Fossil fuels MF tonnes/Population on 1 January (FFMFpop)	Adjusted savings: carbon dioxide damage (% of GNI)
Adjusted savings: net national savings (% of GNI) (NNSperc)	Adjusted savings: natural resources depletion (% of GNI)	Adjusted savings: carbon dioxide damage (current USD)
	Adjusted savings: education expenditure (% of GNI) (EEperc)	Adjusted savings: natural resources depletion (% of GNI)

Notes: Data not available for: HLY – AT, IT (2010); SE (2012), FI (2013), IS, UK (2019); ANNIpcco: MT, IS (all years); ANNIpccog: EE (2010), IS (2010, 2011), UK (2019); ANS (both indicators: IS (2010), UK (2019); CMUR: IS, NO, CH (each year); FFMFpop: for all countries in 2018-2019); NRD – MT (all the years), UK (2019).

The first five socioeconomic and wellbeing indicators (highlighted in bright grey in Table 1) were applied at the first stages of the analysis. The indicators added at the second stage include one macroeconomic indicator, i.e., Adjusted savings: net national savings (% of GNI) (NNSperc), and two environmental indicators reflecting the movement towards SD/sustainability, i.e., Circular material use rate (CMUR), and Fossil fuels material footprint in tonnes (The International Resource Panel, 2021) (FFMFpop). They are highlighted in dark grey in Table 1. These two indicators were applied to reflect the environmental dimension of SD as well as sustainability in more general, considering principal concepts related to these concepts, including the alternative ones. They complete the environmental indicators included in the ANS indicators, which reflect both resource depletion and environmental impacts.

CMUR is a measure of the share of material recovered and fed back into the economy in overall material use. It is the ratio of the circular use of material to the overall material use. The overall material use is calculated as a sum of the aggregate domestic material consumption (DMC) and the circular use of materials. DMC, as defined in economy-wide material flow accounts (Eurostat, 2021), indicates the application of CE in the country, which is one of the key concepts that can help shif economies towards SD (see subsection 2.1 and e.g. Kirchherr et al., 2017). The circular use of materials is approximated by the amount of waste recycled in domestic recovery plants minus imported waste destined for recovery plus exported waste destined for recovery abroad. The higher the CMUR value, the more secondary materials are substituted for primary raw materials, reducing the environmental impacts of extracting primary material. Fossil fuels material footprint in tonnes (The International Resource Panel, 2021) is divided by population on 1st January (Eurostat, 2021) to create the indicator per capita (FFMFpop). Population on 1 January measures the number of persons having their usual residence in a country on 1 January of the respective year. When resident population is not available, countries report legal/registered residents. In FFMFpop crucial aspects related to the global environmental problem of climate change are captured. The compliance with resource efficiency and planetary boundaries is also reflected. All the indicators chosen have some relations to the selected concepts introduced in subsection 2.1. The remaining indicators involve socioeconomic (including one indicator reflecting the aspects of inequality and health (IALE)) and environmental indicators (those included in the ANS indicators), as well as the overall SD indicator, ANS, and one indicator reflecting both economic and environmental aspects together, namely ANNI.

As regards the indicators added in the second stage, the first indicator, NNSperc is a macroeconomic indicator reflecting national saving and it forms the basis for the calculation of ANS. The remaining two indicators are the environmental indicators not included in ANS reflecting crucial aspects of SD, i.e. the first one indicates the engagement of CE and the second one is the footprint indicator reflecting the consumption of fossil fuels and hence also the extent of unsustainable trends in relation to climate change. UNDP's widely recognized HDI and its inequality-adjusted alternative, IHDI, represent economic and social development/human wellbeing. These indicators reflect the HD approach described in subsection 2.1. IHDI is an even more advanced than HDI because it reflects the social dimension of SD more precisely, in particular, the aspects of inequalities in distribution are included. A country's average achievements in health, education and income are combined with the distribution of those achievements among country's population by discounting each dimension's average value according to its level of inequality (UNDP, 2020). Hence IHDI reflects the human development when inequality is considered. The IHDI goes beyond the average achievements of a country in health, education and income to show how these achievements are distributed among its residents (UNDP, 2015). Hence, the relative difference between a country's HDI and IHDI is equal to the losses due to inequality in distribution of the HDI. IHIDI can thus better reflect the aspects of SD, wellbeing, and quality of life. The HDI is computed as a geometric mean of the three dimensions indices according to Eq. (1):

$$HDI = (I_{Health} . I_{Education} . I_{Income})^{1/3}, \quad (1)$$

where the symbol I reflects the corresponding dimension index. The cut-off points used for the four categories of HD achievements are: very high HD: ≥0.800; high HD: 0.700–0.799; medium HD: 0.550–0.699; and finally, low HD: below 0.550 (UNDP, 2015). The dimensional indices (I) from Eq. (1) are calculated as:

$$I = \frac{Actual\ value - Minimum\ value}{Maximum\ value - Minimum\ value}. \quad (2)$$

The IHDI is a geometric mean of the three dimensions indices adjusted for inequality:

$$IHDI = (I^*_{Health} . I^*_{Education} . I^*_{Income})^{1/3} = [(1 - A_{Health}).(1 - A_{Education}).(1 - A_{Income})]^{1/3}.HDI, \quad (3)$$

where A is the inequality indicator applied. The inequality-adjusted dimension indices (I*) are calculated for three dimensions of HDI. The overall formula from Eq. (3), which is multiplied by HDI, reflects the loss in HDI due to inequalitiea. The IHDI is based on the Atkinson (1970) group of inequality measures (see more about this measure in Drastichová and Filzmoser, 2021; Drastichová, 2018). For the measurement of the first dimension, which is health, the indicator of life expectancy (LE, years; see below) is used. For the second dimension, which is education, the indicators of expected years of schooling and mean years of schooling, and the third one – standard of living, Gross National Income (GNI) per capita (2011 purchasing power parity (PPP) USD), are used. Overall IHDI is computed as the geometric mean of the values in the inequality-adjusted life expectancy index (IALE), inequality-adjusted education index and inequality-adjusted income index (see more in Drastichová and Filzmoser (2021). IALE (the third index applied in this work) is HDI life expectancy index value adjusted for inequality in distribution of expected length of life. Life expectancy (LE) at birth is defined as the mean number of years that a new-born child can expect to live if subjected throughout his life to the current mortality conditions. LE is one of the most commonly used health status indicators. The LE indicator is included in the SDG 3 topic: *good health and wellbeing*, of the EU Sustainable Development Goals (SDG) indicator set (see more in Drastichová and Filzmoser, 2019). It is used as one of the explanatory variables reflecting health status in the analysis of this work. On the contrary, the fourth variable, Healthy Life Years (years) in absolute value at birth (HLY) is measured as the number of remaining years that a person of specific age is expected to live without any severe or moderate health problems. HLY is a composite indicator that combines mortality data with health status data. Health as a productive or economic factor is also considered. LE is not able to reflect whether extra years of life gained through increased longevity are spent in good or bad health. Hence, indicators of health expectancies, such as HLY have been developed. HLY reflects the quality of life spent in a healthy state, rather than the quantity of life, as measured by LE. If HLY grows quicker than LE, people are expected to live more years in better health (Eurostat, 2022). It was decided to use both IALE and HLY in the analysis to reflect the social dimension of SD and quality of life from different points of view. Both are objective indicators, but while LE refers to quantitative aspects of life, HLY also reflects qualitative aspects. However, the inequality-adjusted version of LE was applied to reflect another crucial aspect of social dimension of SD, which is the extent of in/equality.

As the fifth variable, we used a subjective index of wellbeing and happiness, which is referred to as the Happiness Index (HI). Regarding the rationale behind HR, happiness score or subjective wellbeing, i.e., the measure entitled Life Ladder (LL), applied in the WHR 2021 (Helliwell et al., 2021), is also used. Three main indicators, i.e. life evaluations, positive and negative emotions, are used in Helliwell et al. (2021). The happiness ranking based on life evaluations is supposed to be a more stable measure of the quality of people's lives (the Gallup World Poll (GWP) – the main source of data in WHR 2021, covering the years 2005-2020). Respondents are asked to evaluate their current life as a whole using the image of a ladder, whereby the best possible life for them is 10 and the worst possible is 0. Each respondent provides a numerical response on this scale, referred to as the *Cantril ladder*. In particular, the English wording of the question stated is *Please imagine a ladder, with steps numbered from 0 at the bottom to 10 at the top. The top of the ladder represents the best possible life for you and the bottom of the ladder represents the worst possible life for you. On which step of the ladder would you say you personally feel you stand at this time?* Weighted average values are used to build a representative population from national averages for each year in each country (around 1000 responses for each country annually). Hence, the national average response to the question of life evaluations is created. As indicated above, this variable is also referred to as Cantril life ladder, or LL in the WHR 2021 (Helliwell et al., 2021) and in this analysis. The above presented indicators (included in the first row of Table 1, except for GDPpc and NNSperc) reflect several aspects of SD, wellbeing and quality of life. The HD approach is directly reflected in the first two indicators. Particular aspects of SD, wellbeing and quality of life are embraced in each of them, including the subjective aspects of wellbeing in HI. Nevertheless, the environmental dimension is not included in these indicators.

A macro level index of SD, constructed by the World Bank – Adjusted Net/Genuine Saving (ANS) is the sixth index (variable) used. However, there are also partial indices used for the evaluation of performance in particular dimensions of SD, which are reflected by these partial indices. Moreover, for several of them, including the overall ANS, two measurement units are applied, while they usually indicate various developments. The units applied are % of GNI (relative, percentage value) and current USD (absolute, monetary values). Despite the importance of relative impacts, in terms of environmental effects, the absolute amount of savings is critical in the field of SD in the relation to environmental limits of the planet – i.e., planetary boundaries (see subsection 2.1). Regarding the rationale behind this measure, ANS extends the conventional net saving by adding human capital accumulation and subtracting natural resource depletion (Gnègnè, 2009). Pearce and Atkinson (1993) presented an index which builds on the concept of Hicksian income. ANS is based on that and it is an indicator of weak sustainability. The capital stock of societies consists of man-made capital (physical or produced capital), human capital (such as knowledge and skills) and natural capital. Thus, the theoretical background results from the idea that weak sustainability requires the maintenance of a constant stock of extended wealth, which does not only include natural resources, but physical capital and human capital as well. ANS is the change in this total wealth during a given time period. This concept is an appropriate economic representation of the concept of sustainability (Fitouss et al., 2011). Although explained from the slightly different perspective, the theoretical foundation of the ANS is obvious (see more in Drastichová, 2018). ANS is calculated from gross national saving (GNS), while several adjustments are made. GNS represents the difference between gross national income (GNI) and public and private consumption, plus net current transfers. Next, net national savings (NNS) are calculated as the difference between GNS and the estimates of fixed capital consumption of produced assets (CFC). ANS is computed as NNS plus education expenditure (EE) and minus energy depletion (ED), mineral depletion (MD), net forest depletion (NFD), and carbon dioxide (CD) and particulate emissions damage (PED). NR is the sum of NFD, ED, and MD. NFD is unit resource rents times the excess of roundwood harvest over natural growth. NFD is calculated as the product of unit resource rents and the excess of roundwood harvest over natural growth. If growth exceeds harvest, this figure is zero. ED is expressed as the ratio of the value of the stock of energy resources to the remaining reserve lifetime. It involves coal, crude oil, and natural gas. MD is the ratio of the value of the stock of mineral resources to the remaining reserve lifetime. It contains tin, gold, lead, zinc, iron, copper, nickel, silver, bauxite, and phosphate. Cost of damage due to CD emissions (CO_2) from fossil fuel use and the manufacture of cement, are estimated to be 40 USD per ton of CO_2 (the unit damage in 2017 US dollars for CO_2 emitted in 2020) multiplied by the CO_2 emissions in tons. CD is also applied in our analysis separately, not only as part of ANS, because it is related to the global environmental problem of climate change. It is used in both current USD and in % of GNI to indicate both its absolute and relative effects. Particulate emissions (PM) damage, which reflects local environmental impacts, is a damage caused by exposure of a population of a country to ambient concentrations of particulates measuring less than 2.5 microns in diameter (PM2.5), ambient ozone pollution, and indoor concentrations of PM2.5 in households cooking with solid fuels. Damages are calculated as foregone labour income due to premature death (estimates of health effects: from the Global Burden of Disease Study 2019; data for other years: extrapolated from trends in mortality rates). EE refers to the current operating expenditures in education, including wages and salaries and excluding capital investments in buildings and equipment. This indicator is used in % of GNI in the analysis to present the relative effects in the countries analysed. In ANS, public education expenditures are understood as savings. Nevertheless, there is a wide variability in the effectiveness of public education expenditures and they cannot be simply regarded as the value of investments in human capital. The calculation should also involve private education expenditure, but data are not available for certain countries. Since the calculated values of resource depletion and pollution damages are often low and those of EE often higher, the ANS can be higher than the NNS. To sum up, ANS reflects the change in values of defined assets, excluding capital gains. On the basis of economic theory, if the present value of an economy's social welfare is increasing, net savings are positive. On the contrary, continuously negative ANS reflects an unsustainable trajectory. NNS is used in the analysis even before the ANS indicator is applied, although the first one is only an economic indicator (index), while the second one is an indicator (index) of SD (weak sustainability). The rationale behind this lies in an effort to discover how it behaves in the sample in a relationship with selected socio-economic, wellbeing and environmental indicators. ANS also has a number of limitations/deficiencies. Among other things, the methodology of the accounting of natural resource depletion/pollution costs determines the results. Important pollutants affecting human health and/or economic assets are excluded, since internationally comparable data are not widely available. Moreover, the final values are affected by the methods used. ANS can indicate the SD capability in dynamic way. If a country's income is only growing by exploitation of nature resource capital and uses the income obtained for consumption instead of investment, this country will reach negative saving. This also indicates that its sustainability and the opportunities of development for future generations will be limited. Conversely, a country can raise net wealth through positive saving. The ANS can be used as an effective instrument to quantify dynamic development of wealth (Guomei et al., 2006). According to Gnègnè (2009), positive, significant, but weak, relationship exists between ANS and aggregate welfare. At least, it applies that negative ANS rates implying declines in extended wealth indicate non-sustainability (Fitouss et al., 2011). The ANS is an indicator of sustainability and it serves as a policy indicator as well. Negative ANS values imply that total wealth of the economy is in decline and therefore policies leading to persistently negative ANS can be regarded as policies for unsustainability (World Bank, 2012). To sum up, the negative ANS values indicate unsustainability. Nevertheless, the ANS values are generally affected, to some extent, by pricing method used to estimate economic values of natural resources and environmental damage. Hence, a certain degree of subjectivity is present.

Adjusted net national income (ANNI) is GNI less CFC and NR (GNI - CFC - NR). ANNI enhances the measurement by means of gross national income (GNI) in assessing economic progress, since it is an extended measure of national income which incorporates the depletion of natural resources (Hamilton and Ley 2010). The deduction for the depletion of NR, involving NFD, ED, and MD, represents diminishing asset values connected with the natural resource extraction/harvesting of. It is equivalent to the depreciation of produced (fixed) assets. However, the adjustments made in the calculation of ANS involve accounting for investments in human capital and damage from pollution, which ANNI does not. Although this indicator is especially important in monitoring low-income, resource-rich economies, it was used to complete this analysis. The rates of ANNI's growth are computed from constant price series deflated by means of the gross national expenditure deflator (the World Bank, 2021). In particular, ANNI per capita (constant 2010 USD) (ANNIpcco) and annual % growth of ANNI (ANNIpccog) are used in this work to reflect both the state, as well as the development. In quantitative macroeconomic indicators, including GDP, the more developed countries with the higher values often exhibit lower growth rates. Hence, both units are also applied for ANNI, since it reflects the economic and environmental dimension of SD. It is desirable to determine whether the trends in the development are similar to GDP.

If high/low values of an indicator are referred to in the text, it means that the countries have had high/low values of that indicator for some time and/or relatively high/low average values (if not stated otherwise).

2.2.2. Methodology Applied

Principal component analysis (PCA) and Parallel factor analysis (PARAFAC) are the crucial methods applied in this work. PCA is a dimension-reduction tool and it is used to reduce a large set of variables to a small set, which still comprises most of the information. PCA is a mathematical procedure that transforms a number of (possibly) correlated variables into a (smaller) number of uncorrelated variables named principal components. The first principal component explains as much of the variability in the data as possible, and each succeeding component accounts for as much of the remaining variability as possible (Johnson and Wichern, 2007). This method was used in a previous joint work by the authors (Drastichová and Filzmoser, 2019). As regards the concrete procedure applied in this work, replacing the country and year columns with one, a general model for PCA over all the years (2010-2019) and countries (the sample of 31 countries) is created. Country plus year identify one observation uniquely.

PARAFAC simultaneously fits multiple two-way arrays or *slices* of a three-way array in terms of a common set of factors with differing relative weights in each slice (Harshman and Lundy, 1994). Parafac analysis and models were chosen, because this allows to model the country effect and the time effect separately. Thus, it will be possible to identify the main structure in the time trend, the main structure in the country behaviour, as well as deviations from these main trends. As regards the analysis carried out in this work, the unnecessary columns from the dimension with variables were removed to be examined in the 3D array.

When necessary, the Pearson correlation coefficient (r) is applied to quantify the extent of a linear association between two variables, while the value of 1 means a perfect positive correlation and that of -1 indicates a perfect negative correlation. This statistical indicator, reflecting a degree of linear correlation between two variables, can be significantly sensitive to outliers. When the concrete values of indicators or their changes are indicated, they are usually ordered from highest to lowest for the highest values/increases/decreases and from lowest to highest for the lowest values of the indicators.

3. Results

Section 3.1 presents the relationships among the variables included, followed by the results of the PCA. Section 3.2 contains the results of PARAFAC. A deeper analysis of the results and discussion is included in section 3.3.

3.1. Results of Principal Component Analysis

Using a PCA, crucial relationships between the indicators over time and also similarities/differences between countries were identified. In the first stage, only the objective socio-economic and wellbeing indicators and one subjective indicator of happiness are included, particularly GDPpc, HDI, IHDI, HLY, and HI. GDPpc reflects only the economic performance, i.e. the economic pillar of SD, while the other indicators included also reflect selected aspects of quality of life and wellbeing, i.e. also the social pillar of SD, including health (HLY, HDI and IHDI), education (HDI and IHDI) and the aspects of inequality (IHDI). PC1 is interpreted as an average of HDI, IHDI, HI, and GDPpc. PC2 is determined by HLY. With only the first two PCs 93.75% of the variance of the chosen six variables for the first stage can be explained, which means that a significant dimension reduction can be achieved. Figure 1 shows the results of the first two PCs. The left plot shows the scores, and the right plot the loadings. The first component, PC1, explains 75% and component 2, PC2, explains 18.75% of the variance. It must be emphasised that the least and less developed countries, exhibiting low levels of GDPpc, HDI, IHDI, and HI, are placed on the left side. Those having low levels of HLY are placed in the upper part. All these are the new member countries of the EU. In the results with the segments which are displayed in Figure 1, the movement of countries over the years is exhibited. This is done by connecting subsequent years for a country in the plot where the most recent year is highlighted with a circle. Most of the countries move towards the right side, which indicates that the average values of their indices included in PC1 have increased over the years. Some, but not all, countries, move downwards, meaning that their HLY increases.

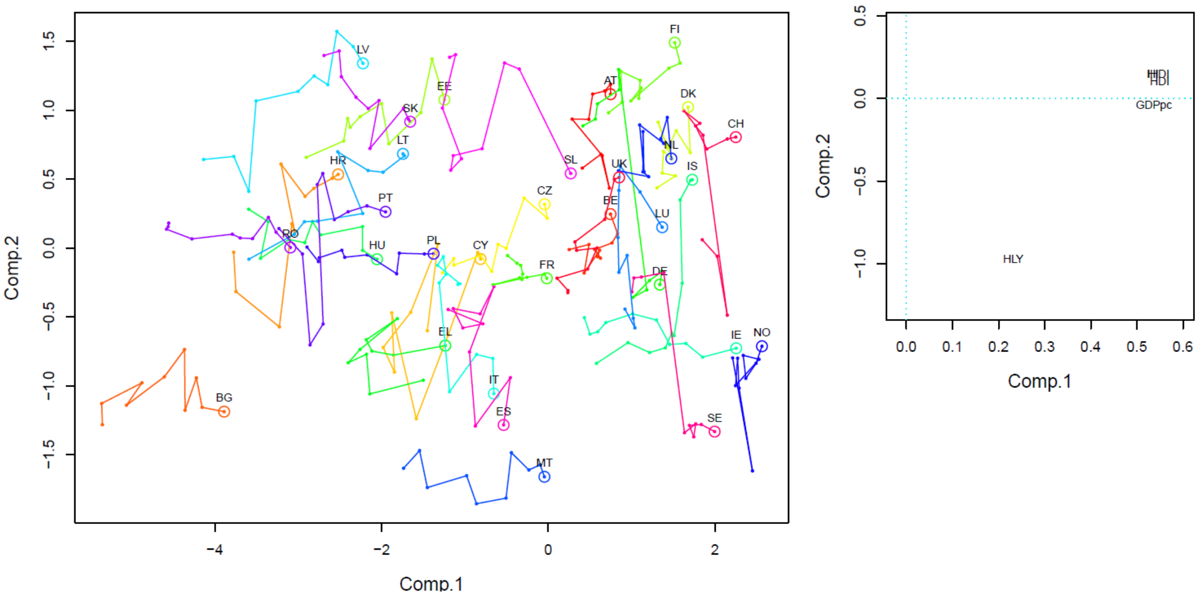

Figure 1 Plot of the scores (left) and loadings (right) of the first two PCs after the first stage PCA along with time development for each country; source: author's calculations

The PCA loadings reveal that the variables GDPpc, HDI, HI and IHDI are highly associated, while HLY clearly is different. It results from the loadings plot. It is clear that HDI and IHDI are correlated to the highest extent, although r decreased from 0.962 (2010) to 0.934 (2019). HLY is correlated with the remaining indicators only slightly. The correlation is the highest between HLY and IALE (around 0.4, in 2010-2012 and 2015: above 0.5), which is justified, since IALE reflects the aspects of health as well. However, it is often higher between HLY on the one hand and GDPpc or HDI on the other, although the r values are often slight (often around 0.3, 0.4). Nevertheless, GDPpc is highly correlated with all the remaining variables included in PC1. The coefficient also substantially decreased between HLY and HI (from 0.392 in 2010 to 0.157 in 2019). During the period under the examination (2010–2019), HDI and GDPpc increased in all the countries included. IHDI declined only very slightly in one country (in Spain by -0.004). This also took place for HI in nine countries (from the highest to the lowest decline: CY, NO, FR, AT, SE, BE, DK, NL, IE). Apart from Cyprus, which is placed in the middle part of Figure 1 (left), all the remaining countries with the decrease of HI are placed in the right part. These are the more and the most developed countries having GDP, HDI/IHDI above the average level of the sample (for IHDI with the exception of France whose values are slightly below the average level). Nevertheless, HLY decreased in sixteen of them (from the highest to the lowest decline: IS, UK, CH, DK, LU, AT, LT, CY, FI, LV, HR, CZ, EL, BE, EE, NO). In Figure 1, this is illustrated by a shift to the upper part. HI decreased in different groups of countries according to their levels of development. In 2010, HLY was less than 60 years in twelve countries (eight new/three older member countries (PT, FI, DE, AT); the AT's value is from 2011). It is remarkable that three new member countries had relatively high values: Cyprus, Bulgaria and Malta achieved the tenth highest, the eighth highest and the highest values in the sample respectively. It is clearly visible that Bulgaria and Malta are placed on the bottom of Figure 1, although on different sides, while Cyprus can be found in the middle. In Cyprus significant fluctuations took place in almost all the indicators, except for HDI, which grew almost continually (there were major drops in IHDI in 2016, in HI between 2011 and 2013, in GDPpc between 2010 and 2014, and in HLY in 2011 and every year since 2015), it finally shifted to the right side slightly. Its HI exhibited the highest decrease. An increase of GDPpc was also relatively low (below the average of the sample). The only increases above the average increase of the sample occurred for HDI and IHDI. Nevertheless, a decrease of its HLY was also relatively high over the monitored period. The least developed EU country (with the lowest GDPpc), Bulgaria, exhibited increases in all the indicators, although they were slight, apart from HI (the third highest increase). Nevertheless, a relatively high shift to the right part occurred, and in 2019, its HLY was even the eighth highest. It can be concluded that in this country, the development towards higher wellbeing was more significantly based on increases of subjective well-being and quality of life, including health. Sweden followed by Malta, Spain, Norway, Ireland, Italy, Germany, Bulgaria, and Greece achieved the highest values in 2019 (starting from Greece at 66 years, rising to Sweden at 73.3 years) (the highest increases, i.e., over five years occurred in: DE, SE, SL, ES, IT (2011-2019) (in order from the highest to the lowest increase). In Figure 1, this is confirmed by significant shifts upward.

It can be clearly seen that a significant shift to the right took place within the given time period (Figure 1, left). This shift is especially visible for the countries on the very left, with some exceptions, such as Ireland, which is on the very right. It moved to the right part substantially. The countries on the left had lower values for most of the variables analysed. This results from the loadings of the first two PCs. The indicators included in PC1 mostly increased in the sample (the exceptions were summarized above). Although several drops occurred in HI, the only new member country in which this occurred was Cyprus, which is, however, a medium-developed country. Nevertheless, the least developed countries had low values for all or some of GDPpc, HDI and IHDI, and very low values for HI (apart from Czechia and a few others, such as Cyprus at the beginning and Malta at the end of the period). In particular, Bulgaria, Romania, Croatia and a majority of new member countries often exhibited low increases in several indicators. Bulgaria and Romania achieved significant increases in HLY and HI only, which again confirms improvements in qualitative and subjective aspects of health and wellbeing, while the objective socio-economic and wellbeing indicators did not increase very significantly. However, IALE, the indicator included in the third stage, increased significantly in both, which confirms again improvements in the aspects of health and inequality. This indicator is part of IHDI, so positive effects on objective wellbeing can also be assumed (however, in 2019, the lowest values persisted: Bulgaria was followed by Latvia, Romania, Lithuania and Hungary; all these countries exhibited among the highest increases in the monitored period).

As already analysed, significant drops in HLY occurred in the sample. Since the values in the majority of new member countries were critically low, and in several of them decreased further. These countries, including the three Baltic countries, Croatia and Slovakia are placed in the upper-left sector. Low values also persisted in the more developed countries, such as Finland, Austria, Denmark, the Netherlands and Switzerland (placed in the upper-right sector), but in the group of the Southern countries, these values were low only in Portugal. The three Baltic countries exhibited drops in HLY, as did Croatia (upward shifts), but not Slovakia (a downward shift). However, Estonia experienced increases in all the remaining indicators and ended up mostly in the middle. Moreover, Malta, Cyprus and Bulgaria are exceptions with higher values, but as indicated above, Cyprus experienced a significant drop. The value was also around the average in Poland in 2019 after an increase of 2.1 years. As regards the more developed countries, in 2010 Switzerland's HLY of 64.5 was higher than average, and also higher than those of France and Belgium. Since then, Switzerland's HLY has dropped significantly, while Belgium's has decreased slightly, but France's has increased. Another interesting kind of development is that which occurred in Spain, whose HDI increased significantly (in relative values), but whose IHDI decreased. This could indicate an increase in inequality, which is clearly a negative phenomenon.

Overall, Sweden, Norway and Ireland are placed mostly in the bottom-right part (SE: more at the bottom, NO and IE: more in the right part). They exhibited among the highest values of all the indicators included both at the beginning and the end of the monitored period, except for Ireland in the HDI and IHDI values, where the highest and the second highest increase (respectively) occurred (they were slightly lower at the beginning of the period). Hence, Ireland is an exception, with a significant shift to the right side, although it has already achieved a high level of socio-economic performance and wellbeing as measured by several of the indicators included, while two indicators increased significantly. There are other developed countries, including Switzerland, Denmark, Finland, Iceland, the Netherlands and Austria, exhibiting high values of HDI, IHDI and GDPpc (Iceland's GDPpc and HDI were lower at the beginning of the period, but significant increases occurred). Nevertheless, this group is in the upper-right part of Figure 1 due to relatively low values of HLY of the countries included. However, Iceland, which occupied the bottom-most position in this group, had a relatively high HLY, especially at the beginning of the monitored period, although a very significant drop occurred between 2010 and 2019 (-6.4 years). Moreover, these countries had among the highest values of HI, especially in 2019 (top ranked in 2019: FI, CH, DK, IS, NO, NL; top ranked in 2010: DK, NO, CH, NL, SE, FI, AT, IE, IS). The values of Ireland and Austria are often lower when compared to those of the remaining countries in these two groups, and only Finland, Switzerland and Iceland experienced an increase during the monitored period.

In the second stage all the variables from the first stage and three additional variables were used. They include NNSperc, CMUR (data not available in IS, NO and CH) and FFMFpop (see Table 1). The rationale behind the application of NNSperc, which is the economic index, before ANSperc, which is the index of SD, was explained in the section 2.2.1. The additional two measures were incorporated to reflect important aspects of the environmental pillar of SD, with a focus on the implementation of a CE (CMUR) and the consumption of crucial non-renewable resources (FFMFpop). Since there were NA values in columns CMUR and FFMFpop we had to impute these values. Cross-validation was needed for determining the optimal number of dimensions for PCA, this information was further used for imputation in *imputePCA() function*. The first two PCs explain 69.41% of the variance (53.11%for PC1 and 16.3% for PC2). PC1 involves the same indicators as in the previous stage, i.e. GDPpc, HDI, IHDI, and HI. Moreover, NNSperc and CMUR contribute positively to PC1. PC2 is represented by FFMFpop (positively) and HLY (negatively). As regards the new indicators included, NNSperc dropped in four countries (LU, NO, CH, SE), CMUR in eight (LU, FI, RO, SE, PL, DK, ES, IE) and FFMFpop in fifteen countries (between 2010 and 2017).

The highest values of NNSperc are in compliance with the values and the development of GNS and CFC (NNSperc in order from the highest to the lowest – 2010: NO (20.482%), CH, LU (over 15%), SE (11.93% of GNI); 2019: MT (16.45% of GNI), NL, DK, NO, IE (over 14% of GNI), EE, CH (over 13% of GNI), as are the lowest values. NNSperc was negative in six countries in 2010 (IS, EL, PT, LV, UK, IT) and two countries in 2019 (EL, UK). This means that GNS is not sufficiently high to cover the value of CFC. The reason for this is either that the first indicator is too low or the second is too high. CFC (% of GNI) dropped in eighteen countries (IS, RO, LV, HU, HR, EE, EL, LT, CY, SK, CZ, SL, DK, MT, BG, NL, BE, IT) over the monitored period. In the sample, several countries exhibited very high values of CFC (in order from the highest to the lowest – 2010: LV, CZ, IS, CH, SL (above 20% of GNI); 2019: IE, LV, CH, CZ (above 20% of GNI, IE – to as much as 31.126% of GNI) and several very low values (in order from the lowest to the highest – 2010: PL (11.676%), CY (12.278%), LT, MT, UK (over 14% of GNI); 2019: (CY (10.477%), PL (11.872%), LT (12.52%), MT (13.292%), RO, BG, HR (over 14% of GNI). The highest increase occurred in Ireland (14.143 p.b), followed by Norway (1.75 p.b.), a number of countries experienced increases below 1 p.b., while the highest drops occurred in Iceland (-6.918 p.b), Romania (-3.575 p.b), and Latvia (-3.511 p.b). It must be emphasised again that when monetary values are used for this indicator, the small countries have lower values than the more populated countries, with Germany, France, the UK, Italy, Spain and Switzerland having the highest values. On the other side are Malta, Cyprus, Iceland, the three Baltic countries and Luxembourg. They are followed by the majority of the new member countries, as well as Greece and Portugal. However, the values of Czechia and Poland were also higher. Regarding the countries with the lowest NNSperc values, the UK, had low GNS values, but also relatively low CFC values. Greece and Portugal had low GNS values, but those of CFC are medium (slightly below/above the average in Greece/Portugal respectively). On the contrary, Latvia had the medium values of GNS, but high CFC values.

The values of GNS decreased in Luxembourg, Norway, Romania, Switzerland and Latvia (by 5.9, 4.345, 3.52, 2.297 and 0.2 p.b. respectively). Both at the beginning and the end of the monitored period they were the lowest in Greece, although they increased (from 4.733 to 10.187% of GNI). Switzerland and Norway had among the highest values in 2010 (over 36%). Greece was followed by Iceland (5.345%) and Portugal (10.96%) in 2010 and the UK (13.62%) and Cyprus in 2019 (14.175%). Nevertheless, Ireland surpassed both Switzerland and Norway in 2019 after the highest increase of 25.49 p.b. Luxembourg, which had the third highest GNS in 2010 (32%) experienced the highest drop in the sample (followed by Norway). hence, in 2019, other two countries had among the highest values, i.e. the Netherlands (31.107%) and Denmark (30.66% of GNI) (following IE, CH and NO). From the relationships between GNS and CFC, the rationale behind the development of NNS can be derived. To sum up, the best results in NNSperc for Norway, the Netherlands, Switzerland, Estonia, Malta and Sweden are predominantly associated with higher values of GNSperc (except for Malta in mainly until 2013). The CFC values are often lower, apart from Switzerland, whose values are among the highest (the fourth highest average value in the sample), while the values of Malta among the lowest. Those values of the remaining four countries were slightly below the average of the sample.

For CMUR, which reflects a shift towards CE, it is difficult to specify a group in which high/low values prevail. Nevertheless, many new member countries exhibited low values, especially in Romania, Bulgaria (there was a higher increase in 2016 to a share of 4.4%, but then the values decreased again) and Cyprus, as well as Ireland and two of the Southern countries, Portugal and Greece. Although two Baltic countries, Latvia and Lithuania, exhibited low values (but with a relatively high increase in Latvia), the values are relatively high in Estonia, which even exhibited the third highest increase during the monitored period (6.8 p.b). Two Benelux countries, Belgium and the Netherlands, had very high values (see below), even achieving increases in the monitored period, while Luxembourg had the second highest value in 2010 (24.1%) but experienced a high drop of -13.6 p.b. in the monitored period. France and the UK also had among the highest values, with slight increases over the monitored period, while Finland exhibited high drops from 2013, having had the highest values until that year among the Northern countries where the data were available and also among the highest values in the sample (the highest average values were for: NL, FR, BE, UK, IT, LU, EE, DE, PL; the lowest average values were for: IE, RO, PT, CY, EL, BG, LT, LV; the highest values in 2019: NL (30), BE (24.2) FR (20%), IT, UK, EE, DE, AT, SL; the lowest values in 2019 were for: RO, IE, PT, BG, CY, LT, GR, LV)

For FFMFpop, there is again no clear rule for particular groups of countries. This is also one of the crucial indicators reflecting an effort towards SD, decoupling, and respecting planetary boundaries, i.e. it is one of the crucial indicators reflecting the use of resources and environmental impacts, and has significant implications for SD. Croatia had the lowest value in each year of the monitored period, while Slovakia, followed by Luxembourg, Estonia and Norway, exhibited the highest values. The next lowest values were displayed by Ireland and Bulgaria, which interchanged positions over the years. The next highest values were achieved by Finland and Greece (only in 2010, 2011 and 2012 was the value of Greece higher than that of Finland). Malta, Portugal, Cyprus, Poland, Belgium and Latvia had among the lowest values each year as well (the values usually in the interval of (2.8-3.9) (the highest average values were for: SK, LU, EE, NO, FI, EL, LT, CZ; the lowest average values were for: HR, IE, BG, MT, PT, CY, LV, PL; the highest values in 2017: SK, LU, EE, NO, FI, EL, LT, CZ; the lowest values in 2017 were for: HR, IE, BG, MT, PT, CY, PL, BE).

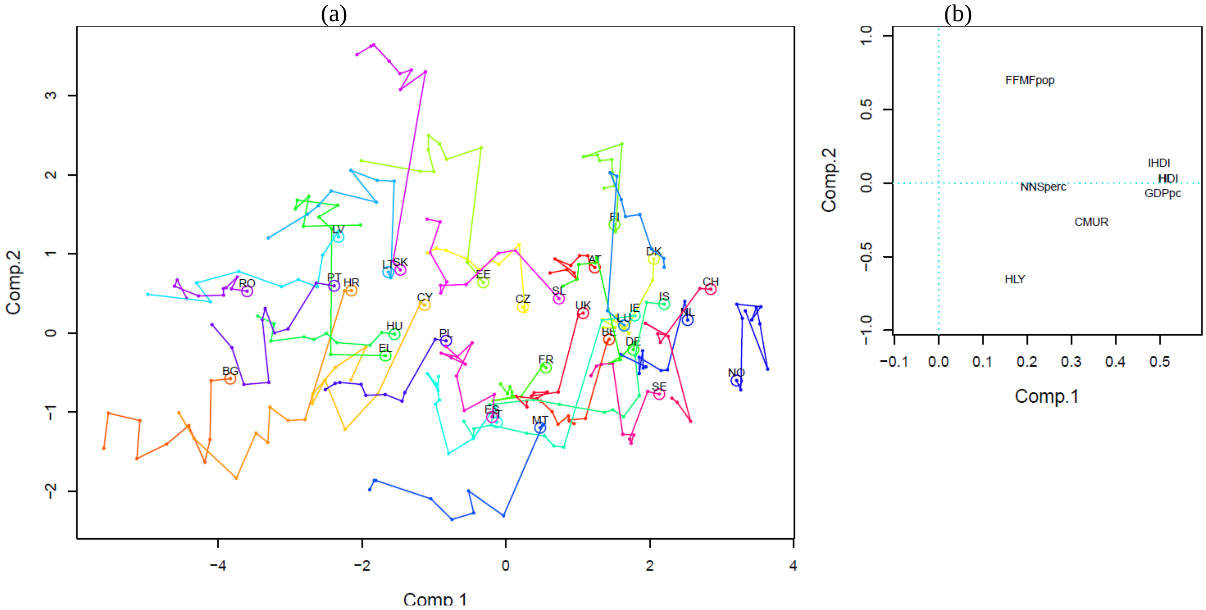

Figure 2. Plot of the scores (a) and loadings (b) of the first two PCs after the second stage, source: author's calculations

It results from the analysis in Figure 2 that a substantial shift to the right part took place within the given time period. This shift is especially visible for the countries on the far left, such as BG, HR, LV, HU, MT, or SL. These are the countries, which had lower values in most of the variables HDI, IHDI, HI and GDPpc (in SL the values are often higher). Several shifts over time are also visible along PC2 towards zero, starting from the upper part (especially for SK, EE, but also for CZ, EL, ES, SL, LT, LU, SE, FI, NO, DE) or from the lower part (especially for CH, DK, HR, MT, BE, BG, IE, IS, LV, PL, PT, UK, CY). If the countries move towards zero in PC2, the values for FFMFpop decrease and those for HLY increase. This means that the indicators FFMFpop and HLY got less pronounced over time. A deeper rationale behind these shifts can be found above, by the description of the HLY and CMUR developments. For example, Iceland had a relatively high increase of FFMFpop and the highest decline of HLY (an upward shift), the UK high decreases of both (a final upward shift), Lithuania and Slovakia the highest increases of FFMFpop, while in the first HLY decrease and in the second HLY increased (final downward shifts, while in Slovakia, it is much higher). In Malta, CMUR and HLY increased and FFMFpop decreased and the shift to the upper-right part prevailed in the second stage. In Poland, the opposite is true for CMUR and FMFpop. Both increased in Slovakia and Estonia (substantially, apart from CMUR in Slovakia – only a slight increase occurred), but HLY decreased in Estonia and increased in Slovakia. In one of the most developed countries, Norway, the vertical shifts also differ between the first and the second stage. Its HLY slightly decreased and FMFpop slightly increased in the monitored period (for CMUR data were not available). The comparison of developments in a vertical direction of Romania, Hungary, France, and Sweden in the second stage is also worth mentioning. It is visible that the highest shift to the right part occurred for Hungary (especially due to the highest increase of HI in the sample; the increases of the remaining 1st stage PC1 indicators were also relatively high, although in this group those of Sweden were higher; however, the fourth highest increase of the 2nd stage PC1 indicator, NNSperc, occurred in the sample. Nevertheless, in all of them only slight final changes in a vertical direction occurred, but with different levels of fluctuations between 2010 and 2019. Hungary had the highest fluctuations and both CMUR and FMFpop slightly increased, but HLY increased substantially.

When compared to Figure 1, opposite shifts prevailed due to the presence of additional indicators in the second stage (for the first stage – the shifts from the upper part: SL, SK, ES, DE, FR, SE, HU, MT, RO, FR (slight shifts in the last four countries); the shifts from the lower part: AT, BE, DK, CH, EE, FI, HR, EL, IS, CY, CZ, LU, LT, LV, NO, UK (this complies with the development of HLY). Although the final shift might be small, in some countries a more erratic development took place in comparison to others. A clear example can be identified in the first stage. The development was much more erratic in Portugal, when compared with Bulgaria and Malta, since Portugal experienced more erratic changes in HLY, but the final extents of the vertical shifts are comparable. All experienced an increase in the monitored period (by 1.2, 1.3 and 2.5 years respectively). To sum up, in the first stage the upward shifts are more frequent, since HLY decreased in sixteen countries, while in the second stage these shifts are balanced when FFMFpop develops in the opposite direction.

In the third stage all the variables were used. The first two PCS explain 50.6% of the variance, while component 1 explains 36.5% and component 2 explains 14.1% (Figure 3, left). There is a stronger positive contribution to PC1 by HI, IHDI, HDI, GDPpc, IALE, ANNIpcco, ANSP, ANSPperc, EEperc, HLY, NNSperc and CMUR, and a negative contribution to PC1 from CDperc and PEDperc. As regards PC2, there is a positive contribution from MD, CD, PED and FFMFpop and a negative contribution from ED, EDperc and NRperc. ANNIpccog is close to zero and thus it is not relevant for either of PC1 or PC2 (Figure 3, right). So, the highest number of variables contribute positively to PC1, while those indicators applied at the first stage, reflecting the socioeconomic aspects (including health, inequality and education) and happiness, contribute most. As regards other indicators which positively contribute to PC1, these are the indicators added at the second stage, i.e., NNSperc (the macroeconomic indicator reflecting national saving) and CMUR (the indicator reflecting environmental (CE) aspects related to SD), and at the third stage, i.e. the indicators which predominantly reflect socioeconomic aspects and overall SD (such as saving, education expenditure, health, and inequalities). The overall ANS indicator in both units, which is not only a socioeconomic, but a SD indicator, belongs to this group as well. This is also the case for ANNI in both units, which predominantly reflects macroeconomic aspects (income), but natural resources depletion as well. Hence, it is closer to SD indicators as well. A number of indicators included at the third stage are component indicators of ANS, which were included to reflect particular aspects of SD, such as the social aspects (education expenditure, EE) and environmental aspects (the indicators of pollution damage (CD, PED) and natural resource depletion (ED, MD, NR), both in different units), while NNS reflecting economic aspects was already included at the second stage. Next, these indicators added in the third stage are briefly analysed.

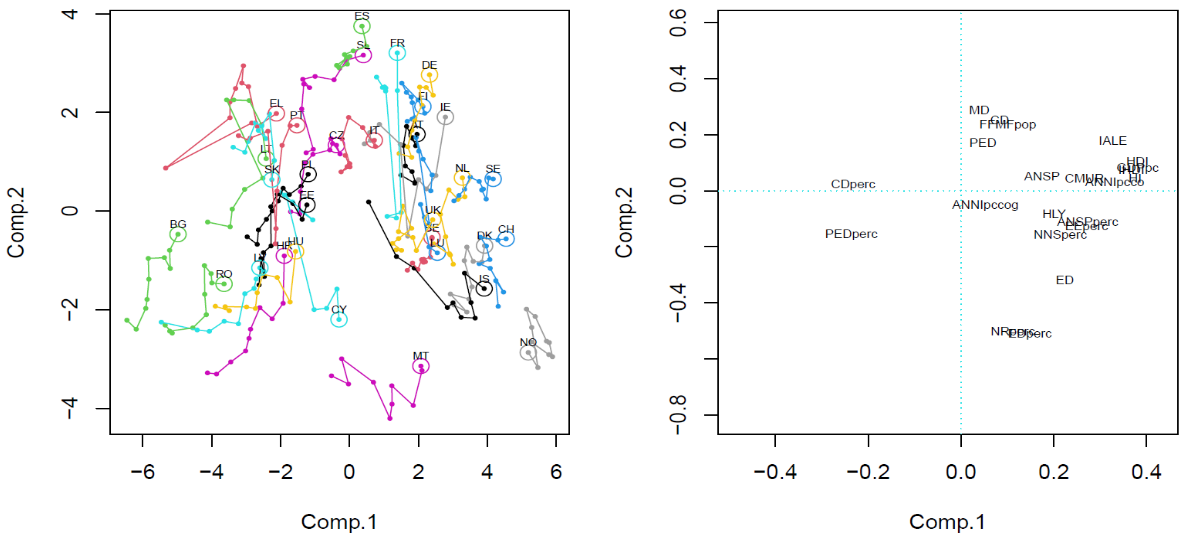

Figure 3. Plot of the scores of the first two PCs after the first stage PCA along with time development for each country (left) and Loadings plot of the first two PCs (right), source: author's calculations

IALE reflects the social aspects (health and inequality) (the highest average values were for: IS, CH, IT, ES, SE, NO, FR; the lowest average values were for: BG, RO, LV, LT, HR, SK; the highest values in 2019: ES, CH, IT, IS, SE, NO, NL; the lowest values in 2019 were for: BG, LV, RO, LT, HU) and ANNI reflects economic and environmental aspects (ANNIpcco: the highest values in 2019 were for: NO, CH, LU, DK, SE, NL; the lowest values were for: EE, LT, BG, RO, HU, HR; the lowest average numbers were for: EE, BG, LT, RO, HU, HR; the highest average numbers: NO, CH, LU, DK, SE, NL; ANNIpccog: the highest average values were for: LV, RO, IS, BG, PL, HU, IE, SK; the highest values in 2019 were for: RO, BG, IE, IS, LT, HU, PL, HR, EE; the lowest average values: EE, LT, EL, IT, CY, NO; the lowest values in 2019: NO, UK, NL, DE, ES, FR). So, some similarities for these indicators in the sample are visible. For IALE the lowest values were exhibited by a number of the new member countries, high values for the Northern countries (except for Denmark), two Benelux countries – Luxembourg and the Netherlands, Switzerland, France and Ireland. Nevertheless, IALE values were high for some Southern countries, such as Spain, Italy and also in Greece (slightly lower than in the previous two). In the group of the new member countries, the values are relatively high in Malta and due to relatively high increases over the monitored period also in Slovenia. For ANNIpcco the values are clearly low/lower in the new member and the Southern economies and high in the more developed countries.

The annual growth rates of ANNI are often high in several new member countries, such as the Baltic countries, Romania, Bulgaria, Poland, Hungary, Croatia, Slovakia, Czechia, and Cyprus, also Iceland and Ireland, albeit with huge fluctuations (i.e., higher rates in some years are interchanged with lower rates or falls). They are often low in the more developed countries (apart from 2010) and the Southern countries. Although they were often high in all three Baltic countries, the average growth rates of Estonia and Lithuania were negative. This is also the case for Greece. While each of the Baltic countries had a high decrease in specific year (EE: -92.98% in 2011; LT: -70.602 in 2015; LV: -11.851 in 2010), the rates of Greece were negative until 2013 and then they continued being relatively low. The development of r values between ANNIpcco and ANNIpccog should be emphasised. They developed from relatively high positive values in 2010 (0.624), to the negative values in 2019 (-0.516), which seem to be decreasing again (the values between 2011-2018: 0.229, -0.074, -0.309, -0.241, 0.167, -0.725, -0.724, -0.578). Macroeconomic convergence should occur, i.e. the less developed countries should have higher growth rates. From these values it looks more like a cyclical development, but more likely, the first two years of the monitored period were still affected by the impacts of the economic crisis, which also caused huge drops in growth rates in the less developed countries. The above-indicated huge drops in the Baltic countries, which could be associated with immediate economic problems, could also be responsible for the development, since these are among the less developed countries. However, many countries also experienced changes in increases and falls between the years (Ireland, Iceland, Cyprus, etc.). In 2011 and 2012, many falls occurred in both the more and less developed countries. In 2010, there were several decreases, predominantly in the new member countries, Greece, and Spain. In 2013-2016 fewer decreases than in the previous two years occurred, and they were predominantly in the more developed countries (in 2013 also in Cyprus, Italy, Spain, Greece, and Slovenia, in 2014 also in Cyprus, in 2015 also in Lithuania). In the last years, the positive correlation is more justified, since few lower decreases occurred (2016: CH, NO, LU; 2017: CH, AT; 2018: IS, SE; 2019: NO). Despite the above-described importance of this indicator, ANNIpccog is close to zero and is not relevant for both PC1 and PC2.

EEperc, representing the social dimension of SD, had the highest average values in the Northern countries (IS, DK (over 7%), SE, NO, FI and BE (over 6% of GNI) respectively) and the lowest values in the new member and the Southern countries (RO, EL, SK, BG, IT, LT, HR, ES respectively). In 2019, the order of the first four countries with the highest values was the same, the following two interchanged their positions. The lowest values in 2019 had Romania (2.81%) (as well as in each year; in 2019 – followed by EL, CZ, LT, SK, HR, LV, IT, ES (over 3% and below 4% of GNI). Sweden followed by Norway and Switzerland experienced the highest increases and Ireland (exceeding 2 p.b.) followed by Malta and Lithuania the highest decreases (both exceeding 1 p.b.). Nevertheless, the values of some developed countries, including Germany and Switzerland, are also lower (below the average values in each year). On the contrary, Malta (especially until 2014), Cyprus, and also Portugal (in several years, with the lowest value in 2012) and Czechia (in 2015 and 2016) exhibited higher values.

Next, the results of the overall ANS indicator, measured in % of GNI, as well as in current USD, are analysed, since both versions also contribute to PC1 (positively). It is a critical indicator used in this work, because it represents a justified macro level index of SD. However, the values differ according to the units used. When current USD are used, the more developed and more populated countries show the highest values, the less developed countries and small economies lower values. This indicator is influenced by the overall performance of countries, which is also affected by their population and relevant macroeconomic features, such as price level, that affects it. Low values of ANS in % of GNI (ANSPperc) were often exhibited by the new member and the Southern countries (the highest values in 2019: DK, SE, NL, IR, CH, IS, EE, NO, HU; the lowest values in 2019: EL, UK, LV, PT, RO, IT, SK, CY, CZ).. Three Northern countries – Norway (19.077%), Sweden and Denmark (over 17% of GNI), followed by Switzerland (16.516), two Benelux countries – the Netherlands and Luxembourg (15.814 and 14.985 of GNI respectively) had the highest average values. They were followed by Ireland, Germany and Austria (over 13% of GNI). As an only country, Greece, had a negative average value of ANSPperc. Accordingly, it is the lowest average value, followed by Portugal and the UK (above 2%), Latvia (3.064), Italy and Romania (over 4%) and Cyprus (5.882% of GNI). The results also indicate that Iceland, followed by Hungary and Ireland, had the highest increases. On the contrary, Luxembourg, followed by Norway and Switzerland, had the most significant drops. Iceland had also negative values in 2011 and 2012, then the value increased annually except for 2017 and 2018. Some more developed countries, which are more populated, including the UK, France and Germany, had considerably worse average results, when the units of percentage of GNI rather than current USD are applied. Conversely, certain less populated developed countries, such as Luxembourg, as well some new member countries, including Estonia, Hungary, Bulgaria and Lithuania, had a significantly higher performance.

Next the focus is shifted to the environmental indicators included in ANS. There is a negative contribution from ED, EDperc and NRperc to PC2 (energy depletion - ED in two different units (% of GNI and current USD), and the third is overall natural resources depletion (NR), available only in % of GNI). As regards NR, the values in each year (the average value: 6.024%) are the highest in Norway (significantly surpassing those of other countries). It is followed by Denmark in 2010, the UK in 2019 and Romania in the other years. These countries exhibited the highest NR each year, together with Estonia, Croatia, the Netherlands and Bulgaria (apart from Bulgaria in 2019) (the average values: 0.927% in Romania, 0.799% in Denmark, and over 0.5%. in the remaining four countries). In 2019, Bulgaria was surpassed by other countries, including Hungary, Czechia, Poland and Sweden which, along with Slovakia (following Bulgaria in 2019) also had relatively high values. All these countries experienced decreases, with the highest drop in Norway (over 1 p.b.), followed by Denmark, Estonia, Bulgaria and Romania (below -0.5 p.b.). The lowest average numbers were in Iceland and Latvia (the zero values in each year), followed by Switzerland (close to zero; the zero values in 2015-2019), Belgium (0.001; the zero value in 2010), France (0.008), Cyprus and Spain (the last two: 0.013%). NR increased in only three countries in the monitored period, which were Portugal, Spain and Belgium. These increases meant that their positions worsened at the end of the period, especially for Portugal. Another component part of NR as well as the overall ANS indicator, reflecting natural resource depletion, is net forest depletion, which was not included separately because of too many zero values. As regards NFD in percentage of GNI, the only non-zero value in 2010 was exhibited by Slovakia. Subsequently, non-zero values have also been exhibited since 2011 in Belgium, since 2015 in the Netherlands, since 2016 in Portugal, and since 2017 in Czechia and Estonia (Estonia went back to zero in 2019) (the highest average non-zero values were in: SK, CZ, EE, PT, BE, NL; and in 2019: CZ, SK, PT, NL, BE). There were rarely any values over 0.1% of GNI (SK: in 2010, 2011, 2017, 2018; CZ: in 2019). Apart from Belgium and Portugal, these countries also have higher values of NR.

Zero values in all the years and, hence, the zero-average value of ED (% of GNI) were exhibited in ten countries (MT, BE, CY, FI, IS, LV, LU, PT, SE, CH). The values were highest in Norway (6.021%), followed by Romania (0.917%), Denmark (0.798% of GNI), and then the UK, Estonia, Croatia, and the Netherlands, all exceeding 0.5% of GNI). In 2019, Norway (5.102%) was followed by the UK, Romania (both over 0.5%), Denmark, Croatia (both over 0.3%), Estonia, Hungary, and the Netherlands (all three over 0.2% of GNI). The lowest average non-zero was typical of Spain (0.002%). In 2019 Ireland also achieved a zero value (for both countries this also applies when the units of current USD are used). In all countries with the non-zero values, the values decreased (with the highest drops for: NO, DK, EE, RO; and the lowest decreases for: ES (-0.002), FR, IE, SK, IT (-0.028)). When current USD are used as the units in the ED indicator, the ten above indicated countries exhibit zero values for each year and, hence, zero average values. The highest average value was exhibited by Norway again, but for this unit, the more populous countries, particularly the more developed countries - although also some less developed ones (for the average numbers: NO is followed by the UK, NL, DK, IT, DE, RO, PL, HU) - showed worse results in terms of higher values. However, these countries also showed the highest drops (NO, followed by the UK, NL, DK, DE, IT, PL, CZ, RO, HR). Overall, as with the previous units used, all countries, except for those showing zero values, experienced drops in ED values (with the highest drops for: NO, UK, NL, DK; and the lowest decreases for: LT, IE, SK, SL, ES).

The average MD measured in % of GNI values were typical of Bulgaria (0.294%), followed by Poland (0.133), Sweden (0.11) and Finland (0.065). The following non-zero values are close to zero and nine countries had the zero values in each year and thus, the average zero values (MT, BE, CZ, EE, IS, LV, LT, NL, SL). It applies again, that the countries with the highest values had the highest decreases (BG, followed by PL, SE, IE, FI, LU, CY). In 2019, Sweden had the highest value and it was followed by Poland, Bulgaria and Finland (0.107; 0.074; 0.052; 0.045% of GNI respectively). When current USD are used, zero values are achieved by the same countries, but the countries with the highest values differ to some extent again. The highest average value was exhibited by Poland, followed by Sweden, Finland, Bulgaria, Spain, Ireland, and Germany. Germany and Spain are the only two countries experiencing increases in the monitored period, the remaining countries with the highest values achieved significant drops in the value. Besides the countries with the zero values in each year, in 2019, Croatia, France, Hungary, the UK (but also in 2014 and 2015), Luxembourg and Switzerland from 2015, Italy from 2012 and Norway from 2016. The highest values in 2019 were exhibited by Sweden, followed by Germany, Poland, Spain, Finland, Portugal and Greece.

There is a positive contribution of both the CD and PED indicators in current values to PC2. This is also the case for the MD indicator, reflecting resource depletion, while its version in % of GNI was not finally used because of too many zero values in the sample. For both indicators, there are similarities in the values. Again, the less populated countries exhibit lower values and the more populated countries higher values in the case of current USD used as the units. For the PED indicator in percentage of GNI, high values were in the new member and the Southern economies, while the lowest values were exhibited by the Northern countries, but also by two countries from the aforementioned group – Estonia and Spain (the highest average values were for: BG, RO, HU, PL, LV, HR, EL; the lowest average values were for: SE, FI, NO, IS, IE, ES, FR; the highest values in 2019 were for: BG, HU, PL, RO, LV, SK, EL; the lowest values in 2019: SE, FI, NO, IS, IE, EE, ES, LU). When PED in current USD is used, the results are different, since the smaller countries typically have lower values and the more populous countries usually have higher values. Hence, high values were exhibited by several developed countries and more populous countries, such as Germany, the UK, Italy, France, Poland, Spain, the Netherlands, Romania and Switzerland, which had the highest average values in that order (the lowest average values were for: IS, MT, EE, LU, CY, SL, FI; the highest values in 2019 were for: DE, UK, IT, FR, PL, NL, ES, RO; the lowest values in 2019 were for: IS, MT, EE, LU, CY, FI, SL). Bulgaria experienced the highest increase and Germany the highest decrease. Similarly, for CD in current USD, the average numbers are the highest in the more populated, especially developed countries, but also from the other groups. Concerning the average numbers, Germany is followed by the UK, Italy, France, Poland, Spain and the Netherlands. The lowest ones were in Malta, followed by Iceland, Cyprus, Latvia, Luxembourg and Lithuania. The order does not differ significantly over the monitored period, it is highly similar to the average numbers. Nevertheless, Iceland exhibited the lowest value until 2014 and from 2015 the lowest value was achieved by Malta, which had the second highest decrease in the sample following Denmark. The remaining countries of the sample experienced increases, with the highest ones shown by Germany, Poland, France and the Netherlands. This is a substantial difference to the changes of CD in % of GNI.

3.2. Results of Parallel factor analysis (PARAFAC)

First, only the variables of the first stage PCA are used: HDI, IHDI, HLY, HI and GDPpc. The PARAFAC model is applied with 2 factors, resulting in plots for the countries (A-mode), for the variables (B-mode), and for the years (C-mode). Component 1 represents an average of HDI, IHDI, HLY, HI and GDPpc. Component 2 represents HLY (negative). Hence, the explanation of the results related to the first stage of PCA (Figure 1) is also relevant for this part of the analysis. Nevertheless, additional results are obtained by means of this analysis. In Figure 4 there is a clear separation between four groups of countries. The first of these is in the upper-left quadrant and includes several new member countries. There are also two closer sub-groups here (the first: SK, EE and LV; the second: LT, HU, HR, PT and RO). In the lower-left quadrant there are four Southern counties close to the middle (ES, IT, CY and EL), Bulgaria in its left and Malta in its very low-left part. In the lower-right quadrant there are a number of Northern (NO, SE, IS), Belgium, France and Ireland. Belgium and the UK are very close to one another in the upper-right part of this quadrant (the UK is partly in the upper one), while Czechia is in the very upper-left part (practically in the middle of the whole Figure). In the upper-right quadrant there are other developed countries, including the remaining Northern countries (FI, DK) and Benelux countries (LU, NL). Denmark and the Netherlands are closest to one another.

All the countries in the right half have achieved high GDPpc and those in the left half low (or relatively low) GDPpc values. That of Czechia is also lower than the average of the sample, although this country seems to be situated mainly in the upper-right quadrant. All the countries in the right half have achieved high (or relatively high) HI values for each year. Although at the beginning of the monitored period HI was lower in Czechia, in 2019 it was higher than those of Belgium and France. Moreover, in 2019 France was also surpassed by Malta, and is also closely followed by Slovenia. Malta is closest to the average value for HI, and slightly higher values were achieved by Czechia and France (In France a relatively high decrease, and in the remaining three countries relatively high increases occurred). This is reflected by the positions of these four countries close to the middle of Figure 4. The opposite is true for the countries in the right half (the highest average GDPpc: LU, NO, CH, DK, IE, SE; the highest average HI: DK, CH, NO, FI, IS; the lowest average GDPpc: BG, RO, LV, PL, HR, HU; the lowest average HI: BG, HU, EL, PT, LV, HR, RO). This is reflected in Figure 4. The same applies to the values of HDI/IHDI in each year (the highest average HDI/IHDI: NO, CH, DE, NL, DK, SE, IS/NO, CH, IS, FI, DK, SE, DE; the lowest values of HDI/IHDI: BG, RO, HR, HU, LV, PT, SK/BG, RO, HR, PT, LV, LT, EL). Nevertheless, the countries placed closest to the middle of Figure 4 (SL, CZ, FR, MT) also achieved around average values for HDI and IHDI (although the values for IHDI in Czechia and Slovenia are slightly higher than average). From 2015, France had the lowest value of IHDI in this group and in the previous years it only surpassed Malta, but not Czechia and Slovenia. Moreover, apart from 2012 and 2015, Slovenia surpassed France in HDI as well. In the monitored period, Malta achieved one of the highest increases of HDI and Slovenia one of the highest increases of IHDI. Hence, it can be concluded that these three new member countries have the potential to move closer towards the more developed countries.

All the countries with high HLY values can be found in the lower half and those with low values in the upper half. (The order of those in the lower half (average values 2010 – 2019): MT (mostly in the low part), NO, SE, IE, IS, GR, BG, IT, CY, UK, BE, FR, LU, CZ, DE etc. The order of those with the lowest values: LV, SK, EE, SL, FI, AT, LT, RO etc.). Thus, Malta followed by Norway had the highest average values in the sample, while Latvia followed by Slovakia had the lowest. Czechia was right in the middle, and Bulgaria had the highest value of the new member countries. All this is also reflected by the vertical positions of these countries in Figure 1. Switzerland experienced a significant drop in 2013, having a high value before this year (overall the third highest drop in the sample). On the other hand, Germany achieved the highest increase over the monitored period (particularly in

2015; the seventh highest value in 2019 along with Bulgaria). It was followed by Sweden and Slovenia. Sweden, which also had high values in the previous years, achieved the highest value in the sample in 2019, while Slovenia's value is still relatively low. Poland's value also substantially increased and was already higher than the values of some countries in the lower quadrant (BE, UK, IS, but also CZ). It is again reflected in the positions of these countries in Figure 4. Although the positions of the countries with the highest and lowest HLY values significantly copy the vertical position, by those which are close to the medium values it is not that clear (e.g. the average value of Poland is lower than that of Switzerland and Germany). As indicated, major changes occurred in certain countries in certain years, substantially changing their positions. This is reflected in Figure 5, where two cluster of years are clearly visible. So, when comparing Bulgaria, Slovenia and Slovakia, the first is one of the least developed in terms of GDPpc, HDI/IHDI and HI, but has achieved high HLY values. Conversely, Slovenia has achieved relatively high values of HDI/IHDI but has low values of HLY. Slovakia also has low values of HLY but has relatively low values of HDI, and its IHDI is slightly higher (but below average). Both of these countries have often had similar HI values (often below the average values of the sample). Since Slovenia achieved a higher overall increase in the monitored period than Slovakia, it has a value close to the average in 2019 (similar to France and Malta – see above).

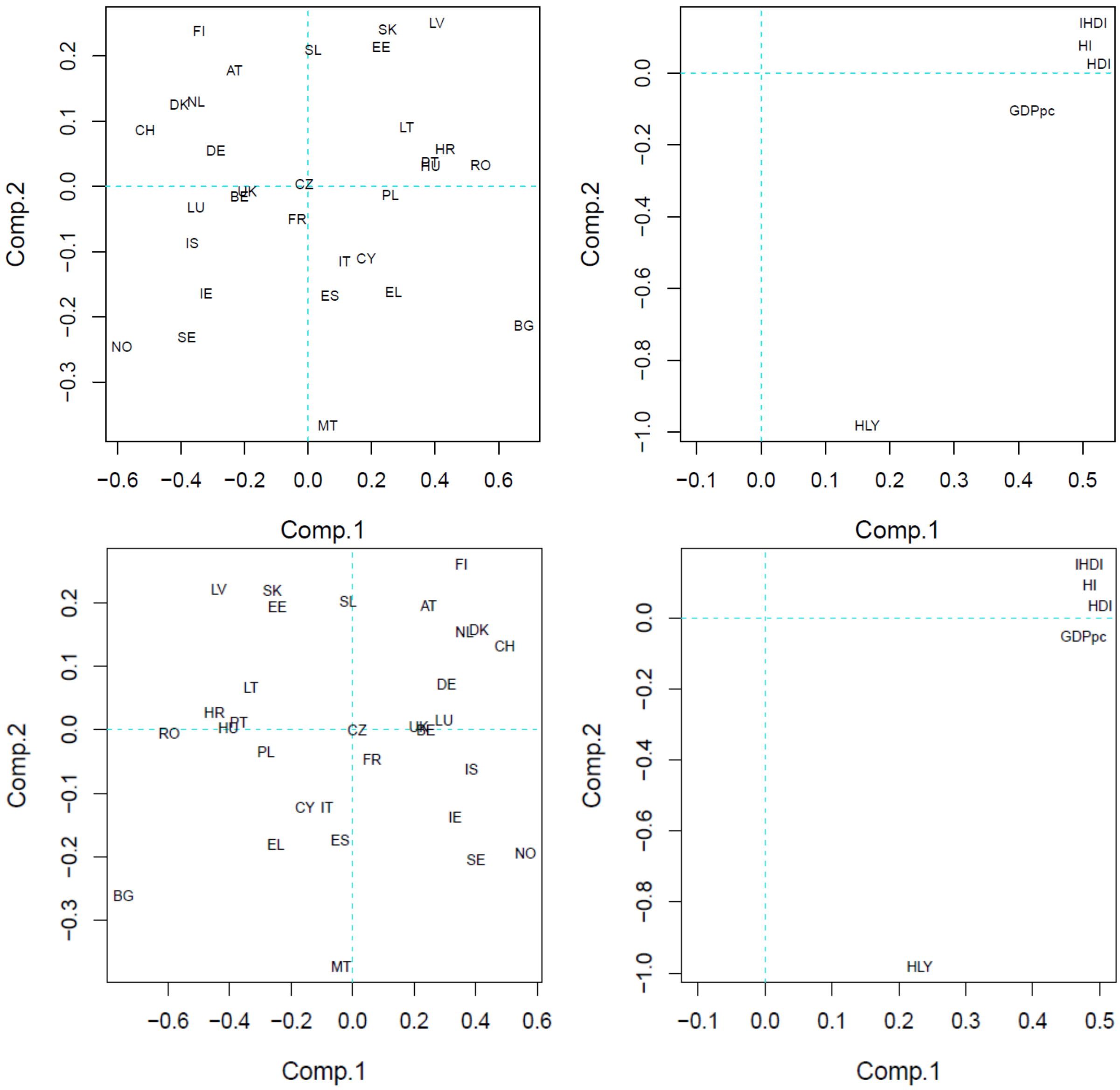

Figure 4. Orthonormalized A-mode (left)/ B-mode (right) component plot (the first stage of PARAFAC), source: own calculation

To sum up, those countries with high GDPpc, HI, HDI and IHDI values (representing component 1) as well as high HLY values (representing component 2) are found in the lower-right quadrant (three Northern countries, two

Benelux countries, the UK, Ireland and France). Those having high values of the four indicators included in component 1, but lower values of HLY are found in the upper-right quadrant. These highly developed countries often exhibited lower values of HLY than some new EU member countries (nevertheless, with a substantial increase of the HLY value in Germany). The countries with high HLY values, but lower/low values for the indicators comprising component 1, are found in the lower-left quadrant (Malta, Cyprus and other three Southern countries, along with Bulgaria). Those countries with lower/low values for all the indicators comprising both component 1 and component 2 can be found in the upper-left quadrant. It includes the less developed and the least developed new member countries, and Portugal.

In Figure 5, two clusters of years are visible in 2010-2013 and 2014-2019. The average values of all five indicators increased over time. There is a certain jump visible from the period 2010-2013, and for the years 2014-2019, where all indicators progressed to a certain extent.

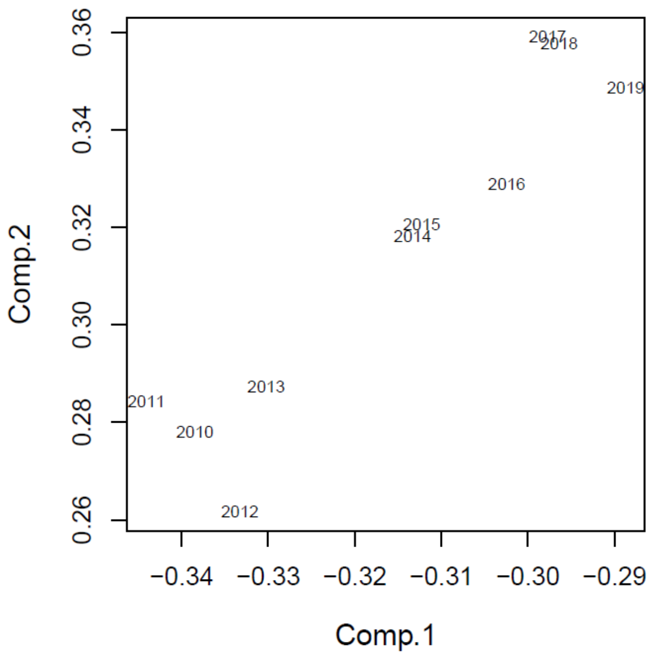

Figure 5. Orthonormalized C-mode component plot (the first stage of PARAFAC), source: own calculation

Next, there are the results of the second stage of PARAFAC (using the second stage array). Three indicators were added to the analysis, similarly to the second stage of PCA. They include NNSperc, CMUR and FFMFpop. Component 1 involves the same indicators as in the previous stage, i.e. GDPpc, HDI, IHDI, and HI. Moreover, NNSperc and the CMUR indicator positively contribute to component 1 in this stage. Component 2 is represented by FFMFpop (positive) and HLY (negative). Figures 6 and 7 display the main results. In Figure 6 left (A-mode component plot) the (more) developed countries are situated in the left part and the less and least developed ones in the right part. The values on the NNS indicator have already been outlined as well. Higher values were often achieved by some Northern and other more developed countries, but also by some new member countries). Lower values prevailed in a number of the new member and the Southern economies. The average values in the monitored period were the highest in Norway and the lowest (negative) in Greece. (the highest average values were for: NO, NL, CH, EE, MT, SE, DK, LU; the lowest average values were for: GR, PT, UK, LV, IS, CY, IT; the highest values in 2019 were for: MT, NL, DK, NO, IE, EE, CH, HU; the lowest numbers in 2019: EL, UK, LV, PT, IT, CY, SK, RO). Since this indicator is dependent on GS and CFC, many macro-characteristics of economies are crucial, as well as micro-characteristics, and a division into the usual groups of countries is not that straightforward. As regards NNSperc, substantial changes occurred in countries during the monitored period, with the highest increases in Iceland, followed by Malta, Ireland and Hungary. Malta achieved the highest value in 2019 (see more in subsection 3.1), but Iceland has the eight lowest value since its value was the lowest (negative) in 2010. So, apart from Iceland, the UK (negative values), Ireland, France, Finland and Belgium, the countries in the right part of Figure 7 had the highest values in 2010 (the order in 2010: NO, CH, LU, SE, NL, AT, DE). There were substantial increases in several countries over the monitored period, including the new member countries. These were in Iceland (27.053 p.b.), followed by Malta, Ireland, Hungary and Croatia (from 11.741 to 8.62 p.b.). So, a higher number of the countries from the left part, including the less/least developed ones, achieved higher values in the more recent period. As analysed in subsection 3.1., the value of NNS is dependent on GNS and CFC. The UK and Greece had negative NNS values each year (although they are situated in different parts of Figure 6). Greece had the lowest and the UK the second lowest GNS values (in % of GNI; the average values were 8.032% and 13.052% respectively), while the average CFC of Greece was around the average of the sample (17.003%), and that of the UK was 14.743%.

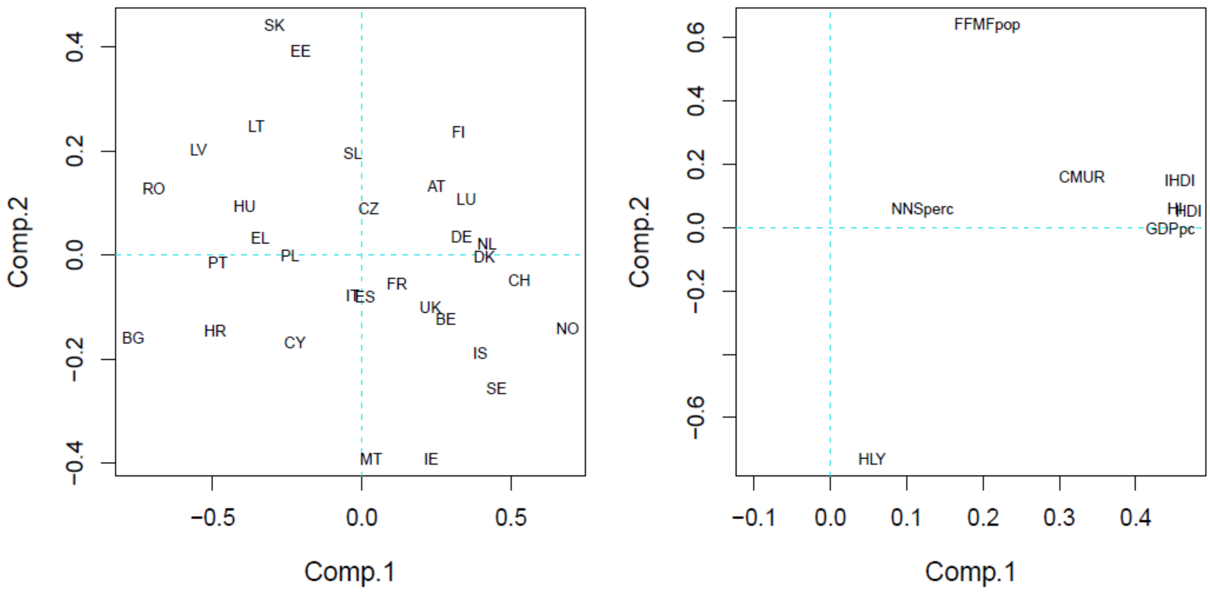

Figure 6. Orthonormalized A-mode (left)/ B-mode (right) component plot (the second stage of PARAFAC), source: own calculation

Both non-ANS environmental indicators, CMUR and FFMFpop, have already been analysed in terms of the PCA. These two indicators along with the overall ANS indicator and its components provide crucial information about the level and progress towards SD. Their values and changes were analysed in more detail in subsection 3.1. The Netherlands, France, Belgium and the UK, having the highest annual and average values of CMUR are all situated in the right part of Figure 6. However, the other successful countries in this field, such as Italy and Estonia, which achieved significant increases in the monitored period (Estonia especially in 2012, then a fall occurred), are at the boundaries (IT) and still in the left part (EE) due to the values of other component 1 variables. Not only the group of the less developed (Romania, Bulgaria, Cyprus etc.) and Southern countries (Portugal, Greece) exhibited low values, but also Ireland (the lowest average value and a decrease over the monitored period). The highest decreases of Luxembourg and Finland must be emphasized again. Data were available for FFMFpop in 2010-2017, and in each year the values were the highest for Slovakia, followed by Luxembourg, Estonia, Norway, Finland and Greece (the last two interchanged their positions in 2010 and 2011). Apart from Norway, all these countries can be found in the upper part of Figure 6. Croatia, Ireland, Bulgaria, Malta, Portugal and Cyprus, having the lowest average values (in this order) and among the lowest values each year, are all situated in the lower part of Figure 6. Of the three countries with the next lowest average values, i.e. Latvia, Poland and Belgium, the first one is situated in the upper part, since it achieved the fourth highest increase in the sample, and in 2017 its value was the highest in this group, also exceeding that of the UK.

The values of FFMFpop and CMUR in the sample are correlated only slightly (for the average values of the indicators, r = 0.013; 2010-2012: above 0.2; 2013: 0.09; 2014-2017: slightly negative, above -0.1, except for 2016 (-0.106). As regards correlation of FFMFpop and CMUR with NNSperc, in the first instance, it decreased from slightly positive to slightly negative values (2010: 0.187; 2011: 0.192; 2012-2014: above 0.2; 2015: 0.053; 2016: -0.035; 2017: -0.065; the average value: 0.111), and in the second it decreased from 0.516 in 2010 to 0.104 in 2019 (the values were between these end-point values in the monitored period; the average value: 0.266). For moving closer towards SD, CMUR and NNS should achieve as high values as possible and the opposite should apply to FFMFpop. In the sample a higher positive correlation between CMUR and NNSperc decreased, that between NNSperc and CMUR on the one hand and FFMFpop on the other became negative. Although the situation can change significantly based on new challenges that have arisen, this development of the correlation can indicate that lower NNSperc can be balanced by higher CMUR and a higher FFMFpop became more significantly associated with lower NNSperc and lower values of CMUR, which is unsustainable. On the contrary, lower values of the first indicator and higher values of the second two can shift economies closer towards SD. The combination of high CMUR values and low FFMFpop values reflects high performance in crucial aspects of the environmental dimension of SD. Belgium can be evaluated as the best performing country in this field, followed by the UK, and Italy. Many less developed countries often exhibit low values for both indicators (BG, LV, HR, HU, CY, PT, but also IE (the worst results in this field), among others), whereas the more developed countries exhibit relatively high values for both indicators (DE, LU, AT). Moreover, some countries exhibit relatively high FFMFpop and relatively low CMUR values, such as Slovakia, Lithuania, and Greece, which is least sustainable. The highest r values between CMUR and FFMFpop in 2010-2017 were identified for Cyprus, the UK, the Netherlands, Italy, Czechia and Belgium (from CY: -0.746 to BE: -0.446). Apart from Cyprus and Czechia, all the reaming countries are those showing the best results in relation to SD in this field.

Overall, the years 2018 and 2019 created a common cluster, while the other years in the monitored period are clearly separated from them and form two more distinct clusters in Figure 7. It shows 3 clusters of years: 2010-2013, 2014-2017 and 2018-2019. All indicator values increased over time, with a certain jump from 2013 to 2014. However, 2018 and 2019 were an exception especially for the indicators determining component 2, thus FFMFpop and HLY. Those developed against the trend in the preceding years.

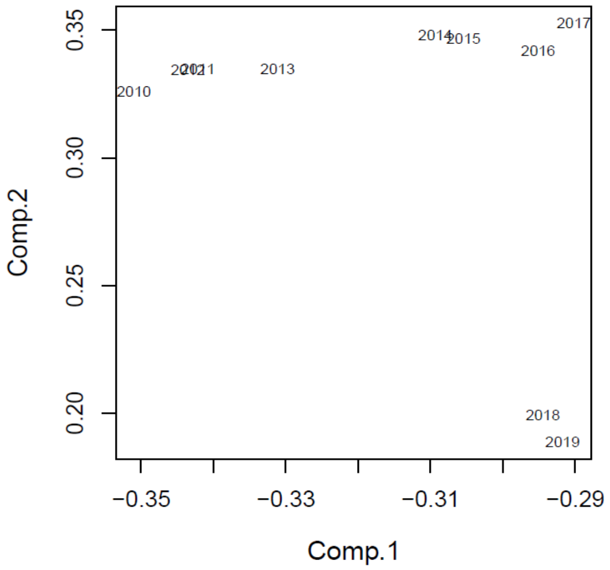

Figure 7. Plot Orthonormalized C-mode component plot (the second stage of PARAFAC), source: own calculation

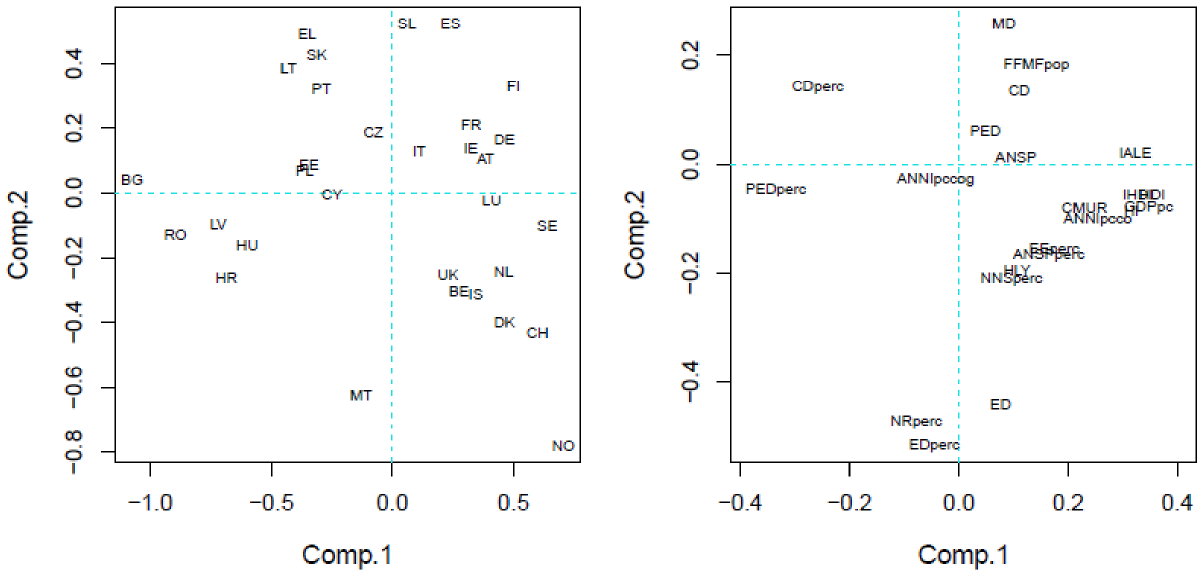

Figure 8. Orthonormalized A-mode (left)/ B-mode (right) component plot (the third stage of PARAFAC), source: own calculation

In the second stage of the analysis, the position of countries was different due to the involvement of three additional indicators contributing to both component 1 and component 2. Several obvious differences between figures 4 and 6 can be highlighted. Luxembourg, Greece (to the upper-left quadrant), Slovakia, Estonia, Bulgaria, Hungary, Lithuania, Poland, and Romania shifted upward, and Spain and Italy from left to right to the middle (the boundary between the left and right halves). The UK, Austria, Finland, the Netherlands, Denmark, Germany, Ireland, and Iceland shifted to the lower part. Hence, for the more developed countries in the right part, downward shifts, and for the less developed countries in the left part, upwards shifts, prevailed. Slovakia, Luxembourg, Estonia, Greece and Lithuania exhibited among the highest average values of FFMFpop, but Poland and Romania among the lowest. From the group of three countries with the lowest values, Croatia, Ireland and Bulgaria, the first two shifted downward.

Next, we carried out PARAFAC with all the variables. From the orthonormalized B-mode component plot (Figure 8, right) it is again visible which variables contribute to components 1 and 2. The highest number of variables contribute positively to component 1, while those indicators applied at the first stage, reflecting the socioeconomic aspects (including health, inequality and education) and happiness, contribute most. Then, there are the indicators added at the second stage, i.e., NNSperc (the macroeconomic indicator reflecting national saving) and CMUR (the indicator reflecting environmental (CE) aspects related to SD), and at the third stage, which predominantly reflect socioeconomic aspects and overall SD (such as saving, education expenditure, health, and inequalities). Overall, the positive contribution on component 1 is from HI, IHDI, HDI, GDPpc, IALE, ANNIpcco, ANNIpccog, CMUR, ANSP, ANSPperc, NNSperc, HLY, EEperc and ED, and the negative contribution is from CDperc and PEDperc. The distribution and the development of the indicator values in the sample has already been described in subsection 3.1. In this subsection the description is completed with some aspects which are especially related to the position of countries in Figure 8 (left) and the years of the monitored period in Figure 9.

For IALE, relatively high values among the new member countries were achieved by Malta and Slovenia, while Slovenia is also situated in the upper-left quadrant of Figure 8 (left), where Italy and Spain are also situated, and which also had among the highest values. The lowest values among the more developed countries were exhibited by Denmark, Belgium and the UK (situated in the lower-right quadrant of Figure 8, left). For ANNIpcco the division is more unambiguous and the more developed countries showing good results in the first stage of both PCA and PARAFAC (situated in the right part of Figure 4, left) achieved the highest (higher values) and the Southern and the new member countries low/lower values. So, the values of countries being situated in the right part at the third stage are lower as well, i.e. those of Italy, Spain (slightly above, below the average values respectively) and Slovenia. Nevertheless, each year, the values of Italy and Spain are on the boundary between the more and the less developed countries. Those of Slovenia are also surpassed by Cyprus in each year. The values of Czechia are also lower. The countries which exhibited negative average growth rates of ANNIpcco, including Estonia, Lithuania and Greece, are all situated in the upper-left quadrant of Figure 8, left). Nevertheless, the contribution of this indicator is very weak.

EEperc predominantly exhibited higher values for the countries in the left of Figure 8, left). However, this was not the case for countries shifted to this part at the third stage, i.e., Italy, Spain, and Slovenia (although they were higher in Slovenia in the first years, but starting from 2012 several higher decreases occurred). Moreover, the values are lower in Switzerland and Germany and higher in Malta and Cyprus, along with Czechia (2015, 2016). The latter three countries are situated in the right part of their quadrants (see subsection 3.1).

The values of ANSPperc of the majority of the more developed countries situated in the right part of Figure 8 (left) were high, with some exceptions, particularly the UK (situated more to the left) and in the more recent period, France and Finland also show relatively low values, despite increasing slightly. However, in the sample, much higher increases occurred, particularly in Iceland (21.797 p.b.), Hungary, Ireland (the last two – over 9 p.b.), Croatia, Denmark (the last two – over 8 p.b.), Estonia, Portugal, and Greece (the last three – over 7 p.b.). The values for Slovenia are also higher in the more recent period after an increase of 5.435 p.b. over the monitored period but are lower in the remaining two Southern countries (ES, IT) also situated in the right part. Iceland improved its situation significantly from negative values to the sixth highest value in 2019. The improvements in Ireland, Estonia, and Hungary are also worth mentioning, while values decreased only in Luxembourg, Norway, and Switzerland (-6.564, -3.741, -2.142 p.b., respectively). The first two still appear among the highest values, but Luxembourg's position deteriorated more significantly (from the third highest value in 2010 to the thirteenth highest value in 2019). The values of ANSP were high in the countries situated in the right part, except for Iceland, Luxembourg (mainly recently) and Slovenia (previously in the left part), and low in those situated in the right part, apart from Poland, whose values were higher than the values of the less populated countries in the right part (especially Iceland, Luxembourg, Finland and Ireland in each year). Since these values are in current prices, the population and macroeconomic indicators reflecting the level of development (including price level) play a significant role.

Next, the focus is moved to the environmental indicators included in ANS. Concerning the environmental indicators included in ANS, it can be concluded that there is a positive contribution of both the CD and PED indicators in current values (reflecting pollution) to component 2. This is also the case of the MD indicator, reflecting resource depletion, while its version in % of GNI was not finally used because of too many zero values in the sample. Apart from the component indicators of ANS, FFMFpop has the positive contribution as well. The ED indicator in both units, along with NRperc (used only in % of GNI), contribute negatively to component 2. The first important conclusion is that component 2 is only determined by the environmental indicators, which have either positive or negative contribution. The remaining environmental indicator not included in ANS, CMUR, positively contributes to component 1. Firstly, the resource depletion indicators are analysed. As regards the overall NR, there is no clear division between the more and the less developed countries. This is related to its negative contribution to component 2. Norway had significantly higher values than the remaining countries in the sample, and it is the country occupying the lowest position in Figure 8 (left). The other countries which have among the highest values, including Romania, Denmark, the UK, Croatia, the Netherlands, and Hungary, are situated in the lower part, or in the upper part, but close to the boundary, which was the case for Bulgaria, Poland and Estonia. However, many countries with the lowest values are also situated in the lower part, but some are from the upper part, such as Slovenia, Lithuania, Portugal, France and Spain.

In the ANS indicator, pollution impacts are represented by two crucial environmental problems of recent times. There are differences in the contribution of both the CD and PED indicator, depending on the units used. PED and CD in current prices contribute positively to component 2, while CDperc and PEDperc contributes negatively to component 1. The highest average values of PEDperc are typical of Bulgaria (0.34%), Romania, Hungary, Poland (over 0.18%), Latvia and Croatia (over 0.15%), followed by Greece, Slovakia, Lithuania and Czechia (over 0.1%), which are all the less developed countries of the sample. For CDperc, the highest average value is in Bulgaria again (2.652%), followed by Estonia, Poland (over 2%), Czechia, Romania, Slovakia, Hungary, Croatia, Greece and Lithuania (over 1%).

The countries exhibiting high PEDperc values are predominantly situated in the right part of Figure 8 (left) (in the lower-left part: RO, HU, LV, HR (they created a closer group); BG and PL – close to the lower boundary in the lower-left part). The majority of the developed countries from the right part exhibited low values, except for Germany (but it was slightly below the average value in each year). This is in compliance with the negative contribution of this indicator to component 1.

The countries exhibiting high CDperc values are predominantly situated in the right part of Figure 8 (left), but in comparison to PEDperc the highest values are exhibited by countries in the upper-left part. The countries with the lowest CDperc values predominantly include those in the right part of Figure 8 (left), and a higher number of countries can be found in the lower-right quadrant. Hence the positive contribution to component 2 is obvious. Switzerland had the lowest value in each year and was followed by Sweden, except fom 2011, when it was followed by Norway and Sweden had the third lowest value. The following countries interchanging their positions between the years are Norway, Denmark, Iceland and France (the lowest average values: CH, SE, NO, DK, IS, FR, AT, UK, IE). Relatively low values were also in Malta, especially in the more recent period (the highest drop in value over the monitored period (over 0.5 p.b), followed by RO, EE (over 0.2 p.b.), IS (0.151 p.b.). In 2016, it had the lower value than France and in 2019, the fourth lowest value (following CH, SE and DK). Bulgaria showing the highest value almost each year, being exceeded by Estonia in 2010 and 2013 (which has the second highest value in the remaining years) achieved a very slight decrease in this indicator. Greece had the highest increase (0.447 p.b.) followed Cyprus (0.304 p.b.), Portugal, Poland and Croatia (over 0.2 p.b.) experienced the highest increases.

The values of these indicators, CD and PED, in monetary values, are higher in the more populated countries, such as Germany, the UK, Italy, France, Poland, Spain, but also the Netherlands, etc, which had the highest average numbers for both indicators and (followed by Czechia for CD, and Romania and Switzerland for PED (the first two countries had among the highest values for both indicators, while the values of CD in Switzerland were relatively low). The values are lower in the small countries, such as Malta, Iceland, Cyprus, Luxembourg, Estonia, Latvia (the las one – especially for CD) etc. Then for CD the countries with the four lowest values are those from the lower part of Figure 8 (left) (MT, IS, CY, LV; the values of Estonia are slightly higher).

When the groups of less developed countries with the highest values in Figure 8 (left) are compared, for PEDperc, the countries from the lower-left quadrant prevail, apart from Poland, which is close to the boundary; and for CDperc, those from the upper-left quadrant prevail, with the exception of Hungary and Romania. So, it can be concluded that for the part of the environmental pillar of SD reflecting the pollution damages, the less developed EU countries and one Southern country – Greece, exhibited the poorest results. Bulgaria exhibited the worst results. For PEDperc, it had the highest value in each year and the highest average value and it is the only country which experienced an increase in this indicator over the monitored period. For CDperc, the similar results were exhibited, but a very slight decrease was achieved over the monitored period and in two years, Bulgaria's value was exceeded by Estonia (2010 and 2013) (which has the second highest value in the remaining years) achieved a very slight decrease in this indicator. The absolute values of these indicators (in current prices) also substantially depend on the population of the countries.

Concerning the natural resource depletion issue, ED had zero values in ten countries each year plus Ireland in 2019, which had among the lowest values until 2015 (then relatively high values). For both units used for this indicator, there are several developed countries on the top, predominantly situated in the lower part of Figure 8 (left), especially Norway, the UK, the Netherlands, Denmark, Italy and Germany. Only the last two are situated in the upper part and their highest average values are only for EDperc. Hence, the remaining countries with the highest ED values in current USD are all situated in the lower part. There are also several less developed countries, having the front positions especially for ED in current USD, especially Romania, Croatia, Estonia and Hungary. For EDperc, it is especially Romania, Poland and Hungary (apart for Poland and Estonia, the highest values are also typical of the countries situated in the lower part). The similarities of values and the prevalence of higher values in the lower part for both indicators are evidence of a negative contribution of both ED and EDperc to component two, which was not typical for both PED and CD. For MD the highest values are especially typical of Bulgaria, Poland, Sweden, Spain (the last country – especially for current USD), Finland, Ireland, and Greece, and also Germany in 2019, situated in the different parts of Figure 8 (left). More generally, higher values were exhibited by more countries from the upper part, with the most significant exceptions of Romania, Cyprus (higher values until 2014) and Sweden (all three are close to the boundary between the upper and lower part). Although MDperc was not finally used, there are often similarities in the order of values in both units for the countries in the sample, with some more significant exceptions represented by the small countries. Nevertheless, Luxembourg and Cyprus had among the highest percentage values and also higher absolute values of MD. As regards the overall depletion of resources, it is reflected by the NR indicator, which had the highest values in Norway in each year, significantly exceeding the remaining countries, followed by Romania, Denmark, the UK, Estonia, Croatia, the Netherlands, Bulgaria, Poland and Hungary in the average values (with some changes in the order, these countries exhibited the highest values each year). Except for Estonia and Poland (on the boundary), all these countries are situated in the lower part. The lowest values, including two zero values in each year (IS, LV) and the following very low values (CH, BE, FR, CY, ES, LU) are also achieved by countries predominantly situated in the lower part of Figure 8. The prevailing positions of the countries confirm the contribution of MD and NR to component 2 in opposite directions.

Based on the values of all the indicators included in the analysis, four quadrants of countries were identified again. Except for Slovenia, all the new member countries are in the right part. In the upper-left quadrant, two Southern countries (EL, PT) can also be found with the new member countries (BG, CZ, EE, LT, SK, PL). In the lower part, the new member countries, including two small island states, Malta and Cyprus (at the edge of upper-left and lower-left part) are situated. All the non-EU countries and the developed EU countries are in the lower-right quadrant (CH, the Norther countries – DK, NO, IS, SE; the Benelux countries). The remaining more developed EU countries (AT, DE, FI, FR, IE), two Southern countries (IT, ES) and Slovenia are situated in the upper-right quadrant.

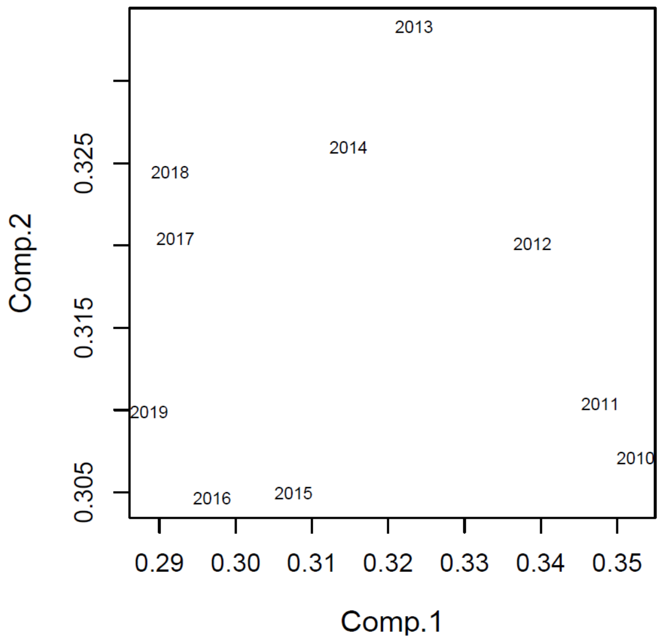

Figure 9. Orthonormalized C-mode component plot, source: own calculation

As results from Figure 9, the values along component 1 are always decreasing, but for component 2 there was an increase until 2013, then a decrease until 2016, and increase for 2017 and 2018, and finally a decrease in 2019.

4. A detailed interpretation of the Results and Discussion

Three stages of PCA and PARAFAC were carried out with the same indicators. Some conclusions in relation to SD and wellbeing can be adopted. In figures 1, 2 and 3, summarizing the results of PCA, the positions and shifts of countries between the years were identified, and in figures 4, 6 and 8, summarizing the results of PARAFAC, four quadrants were created with the same countries (if not indicated, the description of positions/shifts is related to all the figures). However, different positions of countries in particular figures of each group depend on the stage of PCA/PARAFAC and hence, the indicators used. PC1s/components 1 divided the sample into two clusters of the less (left) and the more developed countries (right), since the positive contribution is predominantly determined by the socioeconomic, wellbeing indicators (I/HDI, HI, GDPpc; NNSperc; EEperc, IALE – added in the second and the third stage respectively) or the more complex environmental/SD indicators, such as CMUR, ANS and also ANNI (added in the third stage, while all reflecting and extent of shift towards SD). The negative contribution is determined by the environmental pollution indicators included in ANS in percentage values (PEDperc, CDperc). Since the PC1s/components 1 determined the horizontal clustering, the vertical one was determined by the PC2s/components 2. In the first and the second stages of PCA/PARAFAC the strongest negative contribution of HLY to the PC2/component 2 was identified that also divided the group of the most developed countries situated in the right parts of all the figures. The reason is that many of them have exhibited very low HLY values (see below). There is no indicator with a positive contribution in the first stage, however, in the second stage, a crucial indicator affecting the path towards SD, FFMFpop, has the positive contribution. In the third stage PC2/components 2 is given by the environmental indicators reflecting resource depletion/consumption and also pollution damages in monetary values, being crucial for SD. The highest (high) values were typical of a number of the more developed countries as well.

Finland, Austria and Germany are always placed in the upper-right quadrant of figures 4, 6 and 8 (PARAFAC). Denmark and Switzerland are situated there in the first stage, Luxembourg and France, Ireland and two Southern countries, Italy and Spain, in the third stage only. In the lower-right quadrant, Belgium, the UK (but both on the boundary in the first stage), Norway and Sweden can be found. In the first stage of both PCA and PARAFAC the low values of HLY are only responsible for the vertical position of the countries in all the figures indicated. Since many of the more developed countries exhibiting high values of I/HDI, HI, GDPpc had low HLY, they were separated in the upper-right quadrant (FI, AT, NL, DK, PL, CH, DE) from the remaining ones having all the values high (lower-right quadrant). The same applies to the less developed/new member countries in the left part of figures 4, 6 and 8, where the new member and the Southern economies can be found (the highest values in MT; high values in BG and CY; the lowest values in LV, SK, EE and SL). Hence, Slovakia, Estonia are in the upper-right quadrant and Cyprus and Bulgaria in the lower-right quadrant in each year.

Czechia is exactly in the middle of Figure 4 (the first stage) and Italy, Spain, Slovenia and Malta are at the boundaries of the lower-left and lower-right quadrant in the second stage (Figure 6). Although the position of countries differs based on the stage of the analysis, it applies that the new member countries with the Southern countries are mainly grouped in the left part of figures 4, 6 and 8, with the exception of Slovenia, Spain and Italy in the third stage, while also in the second stage these three countries are on the boundaries between the left and right part. This is also visible in the results of PCA (Figures 1,2 and 3), where the majority of the new member countries (except for Malta and Slovenia), along with two Southern countries – Greece and Portugal, are predominantly grouped in the left part of these figures. However, Poland, Cyprus, Estonia and especially Czechia, which is often most in the right part, are close to the middle of these figures. Spain and Italy are also placed approximately in the middle of these figures, while this is also the case for Greece in the first stage. However, for all three Southern countries their positions in figures for both PCA and PARAFAC significantly moved to the upper part in the third stage. In the first stage, high HLY values in these countries are responsible for their positions in the lower part, but there were poor results in the several environmental indicators, i.e. PD, CD in all three countries, PDperc in Greece, MD in Spain and Greece, ED and also EDperc (slightly lower) in Italy (which also supports its substantially lower position in Figure 8 (left) when compared to Spain) The remaining more developed EU and non-EU countries are grouped in the right parts of all the six figures.

Norway is a country which ended up most in the right part in all the figures 1, 2, 3, and 4, 6 and 8, while Malta is a country, which ended up most in the bottom (in the third stage of PARAFAC (Figure 8): Norway is situated lower; in the second stage of PARAFAC: Ireland is at the same level, but more in the right). For the first and the second stage of both PCA and PARAFAC the position of Sweden is also among the lowest and in the very right parts of figures 1, 2, 4 and 6. However, it is situated more in the upper parts in the third stages of PCA and PARAFAC (figures 3 and 8) since it had among the highest MD values. Nevertheless, it had substantially better results in the remaining environmental indicators when compared to Norway (including ED, NR, FFMFpop). Norway achieved among the highest values of all the indicators included in the first as well as the second stage (but the values of CMUR were not available). It has also the highest values of ED and overall natural resources depletion (NR) in the sample, significantly surpassing other countries, and also the fourth highest FFMFpop which is clearly related to such depletion levels. Since the countries in the lower-right part of all the figures based on both PCA and PARAFAC exhibit best results on average, higher values for particular natural resource depletion indicators prevail, i.e., energy and overall natural resource depletion. High values of energy and resource consumption can be typical for the more developed countries, especially those which have high endowment with such resources There is a clear discrepancy between the values of particular indicators when used in monetary values on the one hand and in percentages on the other. This could be the case for a number of SD indicators, including those composing the ANS index. This is generally associated with the multidimensionality of the SD concept and the resulting difficulties related to its measurement, since multidimensional aspects measured in different units must be captured. In this case, those environmental effects which are part of ANS are often higher in the more developed and more populated countries when measured in current USD (PED, MD, CD) and in the less developed countries when measured in % of GNI, especially for the pollution indicators (PEDperc, CDperc). For some environmental indicators, especially some kinds of resources, consumption and depletion can be typical of the most developed countries and even in monetary values it can be higher in smaller economies. This was exhibited by the overall natural resource depletion (NR) and energy depletion (both ED and EDperc exhibited more similar values in comparison to pollution indicators where both units were also used).

It is also taken into account that many other indicators both at a macroeconomic level and at lower levels could be included. The indicators used were selected carefully to reflect the relevant aspects of SD, wellbeing and quality of life and their most relevant factors, including the subjective aspects related to them, which reflect life satisfaction and happiness. It is likely that the focus in the area of SD could shift to alternative, more radical concepts, which focus more significantly on wellbeing. What's more, because of planetary boundaries, and more generally the limits of the planet to provide humans with the ecosystem services that are sources of wellbeing for them, the concept of economic growth could be gradually abandoned. Alternative and complementary concepts need to be considered when dealing with SD, wellbeing and quality of life. Innovative strategies but also systemic changes in the longer-term period must be introduced. Besides the concept of Human Development, additional concepts should be considered. Ecological economics should provide a platform for a transformation of economies towards new socio-economic models respecting the environment (biophysical planetary boundaries) and improving wellbeing and quality of life. In doing so, current forms of economic growth should be challenged and the ideas of the above-mentioned concepts incorporated. Recent developments have shown that functioning health and social systems are essential for SD, wellbeing and quality of life. They also represent crucial challenges for the future. Nevertheless, currently this seems to be a utopian ideal due to significant impacts on the crucial variables in the social pillar of SD. Hence, the functioning of labour markets would have to be completely restructured. The concept of ECG, the ideas of compassionate economics (systems), as well as the HD approach seem to be more realistic for the near future.

It is also highly likely that many indicators related to SD, wellbeing, and quality of life will change substantially in relation to the most recent pandemic and security situations. These include economic (economic recession, economic problems generally etc.), social mainly with regard to health, poverty, social inclusion, and quality of life generally), and environmental indicators, as well as those indicators generally related to wellbeing/quality of life. The concepts of SD, including the alternative concepts to SD, wellbeing and quality of life, as well as policies towards them, must further deal with these aspects.

5. Conclusions

The main aspects of SD, which are related to wellbeing and quality of life, were evaluated in this work. They were measured by twenty-two relevant indicators (indices) in a sample of 31 countries in the period 2010-2019. All the dimensions of SD were included, while the indicators used either reflect one of these dimensions, i.e. the economic, social or environmental pillar of SD, or two/all of them. Several of these indicators also measure specific aspects included in the particular pillars, which are of great importance for SD and have to be included. These include especially health and inequality, which belong to the social pillar of SD, and are reflected in several indicators used. Furthermore, the indicator of subjective happiness is included as well. PCA and PARAFAC were the main methods applied in this work to analyse relationships between twenty-three indicators (composite indices) reflecting crucial aspects of SD, wellbeing, and quality of life.

Both PCA and PARAFAC led to similar results, which has significant implications for SD and wellbeing. At the first PCA/PARAFAC stage, the socioeconomic and wellbeing indicators, which reflect standard of living as well as the overall stage of a country's development, were included. It was detected that the applied variables, including GDPpc, HDI, HI and IHDI are highly associated, while HLY clearly is different. To sum up, those countries with high GDPpc, HI, HDI and IHDI values (representing PC1/component 1) as well as high HLY values (representing PC2/component 2) are found in the lower-right parts of all the relevant figures 1, 2, 3, 4, 6 and 8. Those having high values of the four indicators included in PC1/component 1, but lower values of HLY were in their upper-right parts. The countries with high HLY values, but lower/low values for the indicators comprising PC1/component 1 are found in the lower-left parts (Malta, Cyprus and another three Southern countries, along with Bulgaria). Those countries with lower/low values for all the indicators can be found in the upper-right parts, including the less developed and the least developed new member countries, and Portugal. In the second stages all the variables from the first stage and three additional variables were used, i.e. NNSperc, CMUR and FFMFpop. All the twenty-two relevant indicators were applied in the third stages. In the third stages of PCA/PARAFAC there is a negative contribution to PC1/component 1 by the pollution damage indicators, PEDperc, CDperc, which are often low in the more developed and higher in the less developed countries (including the new member and the Southern economies, except for Spain and Italy (but for Italy, the values are higher, especially in the more recent period, for PED it is mainly in the relative expression). The absolute values of these indicators (in current prices) also substantially depend on the population of the countries. In the third stage, PC2/component is determined by the environmental indicators reflecting resource depletion/consumption and also pollution damages in monetary values, being crucial for SD.

To summarize the results of PCA and PARAFAC, on the basis of all countries, indicators and years included, the best results are achieved by Sweden and Norway. Sweden and Norway can be evaluated as the best performing countries in the sample. Although Norway often achieved better results in the socioeconomic and wellbeing indicators, Sweden had better results in the natural resource consumption/depletion indicators. This is the area where many developed countries still have had significant defficiencies. For small countries, either more significant shifts to the right part (MT), to the upper part (IE, IS), or high fluctuations were typical (CY). Although some of them exhibited very good results in several aspects, they cannot be evaluated as the best performing countries due to the significant fluctuations. Nevertheless, especially the first three can shift closer towards the SD path and closer to the more developed countries. It can occur in Cyprus as well, but in this country, there were worse results for a higher number of the indicators included. Based on both analyses and the positions and the development of countries, of the new member countries, Malta, Czechia, and Slovenia seem to have the highest potential to move closer to the more developed countries.

The worst results were exhibited by the least developed EU country (with the lowest GDPpc), Bulgaria. It exhibited increases in all the indicators of the first stage, although they were slight, apart from HI (the third highest increase). On the basis of PCA, a relatively high shift to the right part towards the more developed countries was identified. In 2019, its HLY was even the eighth highest. Nevertheless, it had the worst results for both CD and PED in % of GNI. In the monetary values, these values are slightly lower. It had also relatively high NR, MD, ED values (especially in % of GNI), while MDperc is again the highest in the sample. It can be concluded that in this country, the development towards higher wellbeing was more significantly based on increases of subjective wellbeing and quality of life, including health, but it must concentrate on the remaining socioeconomic and wellbeing indicators, and especially, on the environmental indicators.

The combination of high CMUR values and low FFMFpop values reflects high performance in crucial aspects of the environmental dimension of SD. Belgium, followed by the Netherlands, the UK and Italy, were the best performing countries in this area of SD/sustainability, exhibiting highest negative correlation coefficients between these two indicators over the monitored period, with relatively high CMUR and relatively low FFMFpop values. Slovakia is the least sustainable country in this area, with the highest FFMFpop and relatively low CMUR values.

All three pillars of SD are equally important and should be balanced. It is obvious that the less developed countries show worse results in the environmental pillar of SD in the field of pollution. The depletion of resources is also dependent on other features of economies, including their endowment with these resources. Hence, high values of energy and resource consumption can be typical of the more developed countries, especially those having high endowment with such resources. This was exhibited by the overall natural resource depletion (NR) and energy depletion (both ED and EDperc exhibited more similar values in comparison to pollution indicators where both units were also used). The most developed countries situated in the lower-right parts of all the relevant figures summarizing the results of PCA/PARAFAC (figures 1,2,3/4, 6, 8) exhibited higher values). The more populated countries have higher overall impacts on the ecosystem services, although they can achieve better results in the relative expression. Nevertheless, since planetary boundaries give limits to increasing our wellbeing and moreover, determine our very survival (because of basic ecosystem services inevitable for our survival), the absolute extent of the environmental impacts must be considered carefully and the relevant environmental indicators were used in both absolute and relative values.

Knowledge of the SD concept and the capacity for using and applying it must be improved by all stakeholders at all levels, from global to local, while applying both the top-down and the bottom-up approaches. Future economic systems should adjust their systems to get on the SD path and move towards sustainability, constantly evolving over time, taking into account the complexity of the interactions between the economy, people, and the environment. It cannot be assumed that any given system can be adopted uniformly across the world, and in a particular country. Compassionate economic systems or the Economy for the Common Good involving the human development approach appear to be good systems for future development for a number of countries. Certain regional alternatives can also be applied. Concerns are shifting increasingly to the pursuit of wellbeing and quality of life, while respecting environmental limits (planetary boundaries), whereas the pursuit of economic growth may gradually be abandoned. However, degrowth, involving a shift from pursuing economic growth and full employment is still a utopian concept at present.

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