Sustainable Development in the EU

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1 Introduction

Having been hit by an economic crisis that revealed weaknesses in its economic and social progress, Europe is confronted by serious problems. Moreover, Europe is part of a fast-changing world managing long-run challenges such as globalisation and limited resources. These issues are reflected in the EU Treaty, Article 3 of which states that the European Union's overarching long-term target is sustainable development. More specifically, the European Union's goal is a "balanced economic growth and price stability, a highly competitive social market economy [. . .], and a high level of protection and improvement of the quality of the environment". Priorities such as improved resource efficiency, greening and increased competitiveness are highlighted in the Europe 2020 Strategy. The resulting call of the United Nations Rio+20 conference for the "development of internationally recognised indicators to measure the green economy" affirms the relevance of this topic.

The close interconnection and complexity of economic, social and environmental aspects requires a new methodology both for performing economic analyses and for measuring economic activities. We face the challenge of how to improve our economic accounting systems to better reflect both economic and ecological issues. Incremental increases in popular GDP are often made at the expense of ecological capital and therefore, GDP provides us with misleading information about where we are and where we should go. Consequently, it is necessary to identify relevant indicators that measure the economic performance of national economies while considering environmental issues.

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This chapter reflects those needs and focuses on the sustainability of economic growth, linking economic issues with environmental quality. Primary attention is paid right to the measurability of the EU countries' economic-environmental performance, which in reality is closely related to the European priorities mentioned above. In particular, various alternatives for measuring sustainable economic performance—together with the evolution of those alternatives—are introduced.

The chapter is structured as follows: First, the concept of well-being is introduced in Sect. 2 and is accompanied by a discussion of the misuse of GDP in that context. Well-being is realised through sustainable development, as explained in Sect. 3. Possible sustainable-development measures are discussed in the remaining part of this chapter (beginning with Sect. 4), which includes a discussion of the widely used indices approach (Sect. 5) and suggests possible alternatives (Sects. 6–8). Section 9 concludes the chapter.

2 From GDP to Well-Being Concept

To explain why the sustainable economic performance indicators were developed, it would be opportune to present a historical overview of economic performance measures, which originated in the post-war period of reconstruction. Many people lived in conditions of misery caused by the destruction of war, and greater production was seen as the key to prosperity. Consequently, gross domestic product was regarded as the main indicator for measuring production and consequently, its growth. In the early 1930s, S. Kuznets implemented this indicator in economic practice at the direct request of the American government. The indicator's primary purpose was to measure the gross output of the American economy, especially its production capacities in strategic industries. Later, this indicator (and particularly its derived version, GDP per capita) became popular for interpreting the successes of economic growth (for GDP per capita progress in the EU countries,[1] see Table 1). Despite continued warnings from the GDP's authors about its unsuitability to measure societal well-being and social progress (Kuznets 1934), frequently this indicator has been interpreted inappropriately.

Standard quantities such as gross national product (GNP) and gross domestic product (GDP) are commonly used to measure a country's level of economic activity. However, experience shows that the broad applications and categorical interpretation of this indicator are not appropriate and do not give a comprehensive picture of societal development, either for the population's social status or for the state of the environment. Simultaneously, many economists have noted that GNP

[1] Countries: **V4:** Czech Republic, Hungary, Poland, Slovakia; **CEEC:** Bulgaria, Croatia, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia, Slovenia; **Periphery:** Greece, Ireland, Italy, Portugal, Spain; **Core:** Austria, Belgium, Denmark, Finland, France, Germany, Luxembourg, the Netherlands, Sweden, United Kingdom.

Table 1 GDP in PPS per capita for the EU countries (Eurostat)

Country	2004	2008	2012	Country	2004	2008	2012
Austria	27,600	31,100	33,100	Italy	23,100	26,000	25,600
Belgium	26,200	28,900	30,700	Latvia	10,100	14,600	16,400
Bulgaria	7,500	10,900	12,100	Lithuania	11,100	16,100	18,300
Croatia	12,500	16,200	15,700	Luxembourg	54,500	65,800	67,100
Cyprus	19,600	24,800	23,400	Malta	17,200	20,300	22,000
Czech Republic	16,900	20,200	20,700	Netherlands	27,900	33,500	32,600
Denmark	27,100	31,100	32,100	Poland	10,900	14,100	17,100
Estonia	12,400	17,200	18,200	Portugal	16,700	19,500	19,400
Finland	25,100	29,700	29,400	Romania	7,500	12,200	13,500
France	23,700	26,700	27,700	Slovakia	12,300	18,100	19,400
Germany	25,000	29,000	31,500	Slovenia	18,700	22,700	21,400
Greece	20,300	23,200	19,500	Spain	21,900	25,900	24,400
Hungary	13,600	15,900	17,000	Sweden	27,300	30,900	32,200
Ireland	30,800	32,900	32,900	United Kingdom	26,900	28,600	26,800
EU	20,514	24,504	25,007	Periphery	22,560	25,500	24,360
V4	13,425	17,075	18,550	Core	26,311	29,944	30,678
CEEC	12,136	16,200	17,255				

and GDP can give a highly misleading impression of both economic and human development (Bell and Morse 2008). It is also important to say that GDP is not bad—rather, it is being misused as an indicator of something that it does not measure.

In light of increasing requirements to capture economic growth in all its complexity, namely, the impact of economic growth on security, health, social, environmental, educational, politics, etc., demand for a new concept referring to an overall condition also increased. Consequently, the concept of well-being was developed. Well-being is composed of the satisfaction of human needs in terms of physiological needs (such as housing, food, etc.) and material standard of living, both of which depend on the ability to provide oneself with the financial and material wealth that enables the purchase of goods and services that satisfy those needs. One important prerequisite to finding a relevant job is access to education. Other crucial aspects of well-being include family, social participation and leisure opportunities. Contentment also depends not only on health and health care but also on a sound living environment. Moreover, without either security or accountable governance and political voice, individual liberties are endangered. Because of its multidimensionality, it is difficult to carefully analyse well-being, and measuring it is even more difficult. Stiglitz et al. (2009) identify key dimensions for economic development and social progress that should be reflected in well-being measures (see Fig. 1).

Fig. 1 Well-being dimensions

3 Sustainable Development

Realising, conserving and developing well-being are goals guided by sustainable development, i.e., "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (United Nations 1987). Sustainable development ensures an individual's well-being by integrating social development, economic development, and environmental conservation and protection (see Fig. 2).

The social dimension is an essential aspects of sustainable development and refers to the fact that human needs such as access to education, health services, food, housing, employment, and fairly distributed income are met by emphasising the necessity of enabling poor, disabled, and minority people to have those needs satisfied. Satisfaction of these needs can be facilitated if human rights are both implemented and enforceable: that is the role of institutions.

The institutional framework creates an environment for all of the mentioned dimensions because it embodies both formal and informal institutions that determine individuals' behaviour and particular markets' functioning. Economic development both preserves and creates work for individuals, assuring an income for their families. The economic dimension incorporates domestic economies within the global economy. Social and economic dimensions are interconnected and reinforce one another. Well-being is definitely influenced by environmental quality. Accordingly, the protection of both the earth and natural resources are important aspects of sustainable development.

Sustainable development can be regarded as "a normative concept involving trade-offs among social, ecological and economic objectives," which is determined by the institutional framework and "is required to sustain the integrity of the overall system" (Hediger 2000). Another insight can be presented by the so-called 'sustainability barometer', see Fig. 3, in which a system's particular state is mapped using a two-dimensional structure of human and ecosystem well-being. The reader can see a system's position but cannot discern why that system happens to occupy a particular location in the barometer (Bell and Morse 2003).

In general, the goal of sustainable development is to permanently improve living conditions (i.e., to improve both human and ecosystem well-being); therefore, social and economic developments must be environmentally friendly and set in a suitable institutional framework, thus ensuring both continual development and the availability of natural resources for future generations. As Stiglitz et al. (2009) state, "Active participation in sustainable development ensures that those who are

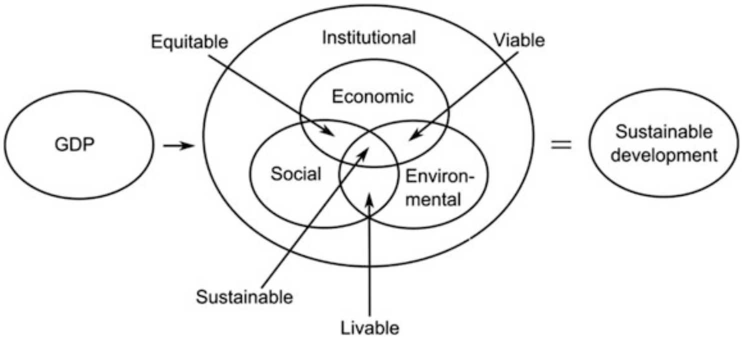

Fig. 2 The dimensions of sustainable development

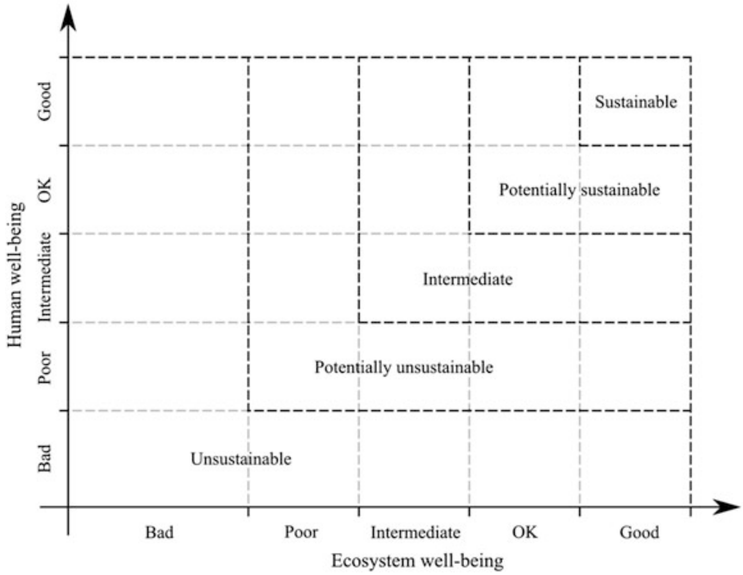

Fig. 3 Barometer of sustainability introduced by the World Conservation Union and the International Development Research Centre (Bell and Morse 2003)

affected by the changes are the ones determining the changes. The result is the enjoyment and sharing of the benefits and products generated by the change. Participation is not exclusive, ensuring equitable input, self-determination and empowerment of both genders and all races and cultural groups."

4 Measurement of Sustainable Development

It is possible to realise improvements in human and ecosystem well-being through the use of measurements of sustainable economic development, which indicate the areas that should perform better. The difficult task of measuring and comparing sustainable economic development among countries can be carried out using several methods. The traditional method consists of constructing indices that can cover different aspects of economic, ecologic, social or institutional aspects of well-being. This chapter is dedicated to general issues related to indices, for example, their history and construction. Sections 5, 6, 7 describe particular indices, whereas Sect. 8 introduces data envelopment analysis (DEA), an operational research tool that enables a comparison of countries according to their efficiency. More specifically, this section aims to assess how a particular level of GDP is achieved based on natural resources depletion and environmental pollution. Another method to compare countries with respect to sustainable development is that of multi-output production functions, which can be viewed as a special operational research technique and will not be further discussed because DEA can be viewed as a more general approach.

A number of methods of measuring national-level progress have been proposed, developed, and implemented to address sustainable development or less general areas. The most common method is to construct indices. Those indices can be generally placed into the following categories:

1. Indices that address the issues described above by making 'corrections' to existing GDP and SNA accounts (e.g., the human development index, the genuine progress indicator, green GDP, genuine savings, etc.)
2. Indices that directly measure aspects of well-being (e.g., ecological footprint, the environmental performance index, subjective well-being, gross national happiness, etc.);
3. Composite indices that combine the aforementioned approaches (e.g., the better life index, the living planet report, the happy planet index, etc.)
4. Indicator suites (e.g., national income satellite accounts, the Calvert-Henderson quality of life indicators, the millennium development goals and indicators, etc.)

As stated in Costanza et al. (2009), all of the indicators mentioned so far, including GDP, are based on the aggregation of a large number of variables into a single composite index. Many new measures of progress do not attempt this final aggregation step, but simply report many indicators separately: we call these "indicator suites". Such systems omit the final aggregation step, which answers the question of "what does this all mean?" to the user.

Numerous scientists and practitioners have discussed the desirability of integrating a suite of indicators into a single index for sustainable development (i.e., Stirling 1999). Experts are divided between those who see indicator suites as a good thing and those who stress their dangers.

According to the OECD (2008), aggregation is useful to summarise complex real systems with a view to supporting decision-makers. Aggregated information is easier to interpret than a battery of many separate indicators. It is possible to assess countries' progress over time. Aggregation can facilitate communication with the public (i.e., citizens, the media, etc.), promote accountability and enable users to compare complex dimensions effectively.

However, there are also some negative aspects of aggregating information. For example, aggregation may send misleading policy messages if poorly constructed or misinterpreted. It may induce simplistic policy conclusions. Aggregation can be misused, e.g., to support a desired policy, if the construction process is not transparent. The selection of underlying data and weights can be the subject of political dispute. Aggregation may disguise serious failings in some dimensions and increase the difficulty of identifying proper remedial action, if the construction process is not transparent. It also may lead to inappropriate policies if difficult-to-measure dimensions of performance are ignored. In reality, the lack of transparency caused by highly aggregated indicators is a serious problem.

Sustainability indices are quite prominent in the literature. The basis upon which these devices are founded—clarity for users—is bound up with the uses to which they will be put. Scientists and technicians are interested not only in data presented in tables or graphs but also in raw data. Decision-makers and managers require some degree of data condensation, particularly in terms related to goals and targets. Individual users (public) prefer highly aggregated data (such as an index) and visual devices (Bell and Morse 2003). This division can be illustrated by a "pyramid of indicators set" as shown in Fig. 4.

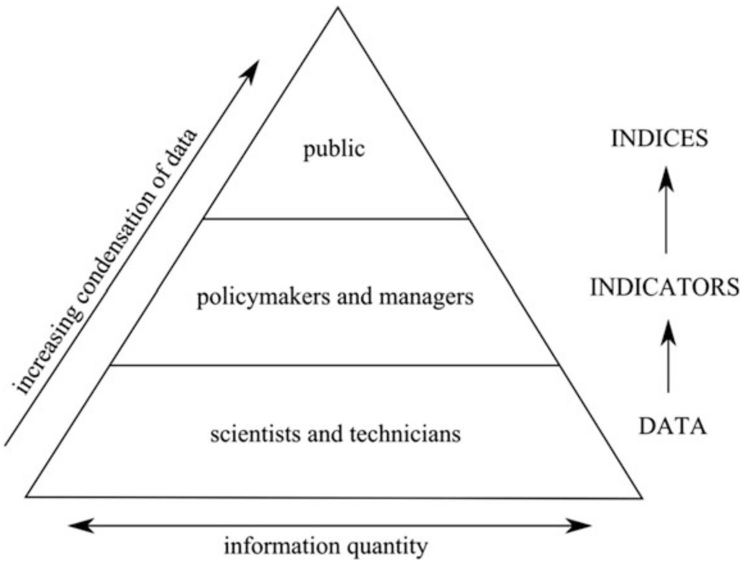

Fig. 4 Data condensation degrees related to different users (Bell and Morse 2003)

Like GDP, numerous measures comprise abstracted indicators that show an overall view, not comprehensive reports. However, some measures can be used to inform local and regional decisions. This represents an improvement on the misuse of GDP and economic growth as a proxy for well-being.

One question is whether GDP should be improved on, replaced by these other approaches, or supplemented. A case can be made for relying on measures that improve GDP because it would be rather straightforward to rearrange the accounting protocols to recognise that some expenditures now counted as beneficial should actually be counted as either harmful or defensive. However, it is worth reemphasising that GDP is not an appropriate measure of welfare and was never meant to serve that purpose. Advocates for supplementing GDP with these other measures note that although GDP is a poor measure of welfare, it nonetheless "serves crucial and helpful roles in macroeconomic policy" and is "unique in that it combines simplicity, linearity, and universality as well as carries the objectivity of the observable market price as its guiding principle" (Goossens and Mäkipää 2007).

Well-being metrics can provide a new, broader perspective to policymakers in the areas that matter to people. Such expanded sets of indicators can also open new horizons in traditional policy areas by providing new types of information, such as information about how people behave and how they feel about their lives (OECD 2013). For correct usage of well-being indicators, it is necessary to explore them in detail.

Therefore, we present and evaluate a set of tools that allow the measurement and evaluation not only of the results of economic growth but also of its complex social and environmental impacts. The professional and academic literature offers many newly developed alternative methodologies and indicators that attempt to measure the impacts of economic growth on societal development (broadly understood), including respect for the rules and requirements of environmental protection and sustainable development. These tools are based on newer approaches to the measurement of economic progress. This class of indicators contains e.g., the human development index (HDI), the genuine progress indicator (GPI), the index of sustainable economic welfare (ISEW), gross national happiness (GPH), the happy planet index (HPI), the better life index (BLI), the social progress index (SPI), etc.

An exclusive focus on economic performance is often tightly accompanied by pollution and wastefulness as negative by-products of economic performance that burden quality of life. For this reason, it is necessary to consider both economic and environmental indicators. Alternative indicators are often used to measure these types of sustainable economic performance, taking GDP as a base and modifying it to compensate for its shortcomings. This group of indicators includes the following indices: adjusted net savings (ANS), the genuine progress indicator (GPI), the index of sustainable economic welfare (ISEW), ecological footprint (EF), environmentally sustainable national income (ESNI), the better life index (BLI), etc. These indicators take into account environmental damage and the exploitation of natural resources, both of which are viewed as costs. This focus on environmental measurements of economic activity is relatively new. Note that interest in including the environment in economic performance began in the 1970s and 1980s, see Fig. 5.

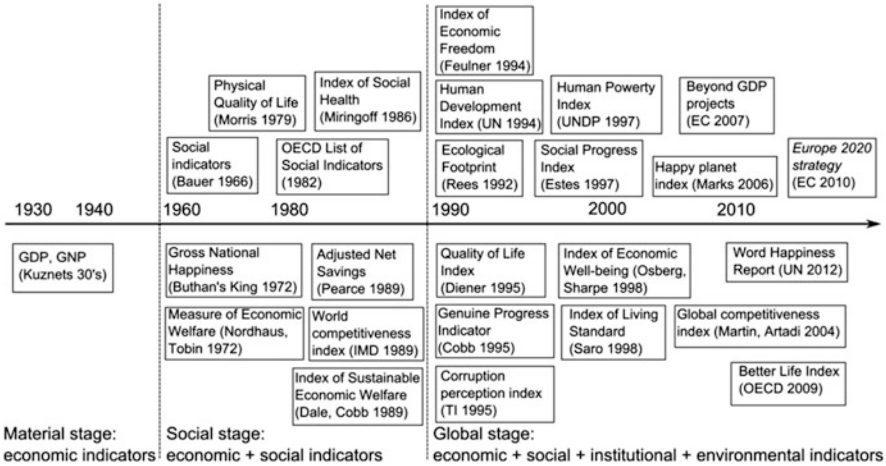

Fig. 5 Chronology of life-quality indicators introduction

Measuring the sustainability of well-being is key to ensuring that we will not undermine people's future well-being by improving well-being today. Even if we cannot predict the future precisely, we can measure some of the factors that are more or less likely to contribute to better lives in the future. This measurement begins by monitoring the resources (economic, environmental, human and social) that generate well-being over time and are passed on to future generations.

Significant efforts are still needed to develop a set of internationally comparable indicators for each type of capital, although metrics already exist for some of them (economic capital) and efforts are underway for others (environmental capital, human capital). Measuring the sustainability of well-being also requires assessing both the distribution of these resources across the population and whether these resources are managed efficiently, with a particular focus on the risks that may weigh on them.

As stated in OECD (2013), measuring better lives has become even more important today as many of our economies and societies have been stricken by the global financial and economic crisis. Understanding how people's lives have been affected and designing the best strategies to help them seems to be crucial. Therefore it is important to have information that is as accurate as possible about how both economic and noneconomic well-being have evolved during the crisis.

Many workers have lost their jobs since the beginning of the crisis in 2007, and many households have registered stagnating or declining levels of income and wealth. In 2013, there were nearly 16 million more unemployed people in the OECD area than before the crisis, and the number of people out of job for more than a year reached 16.5 million. Meanwhile, between 2007 and 2010, relative income poverty rose in most OECD countries, especially among children and young people (OECD 2013).

5 Environmental and Sustainable Development Indicators

Environmental and sustainable development indicators proliferated in the wake of the Rio Earth Summit's call for indicators of sustainable development (United Nations 1994, Agenda 21, Chap. 40). However, there is no universal set of environmental indicators. Although many indicators appear to be the same, most indicators are developed narrowly by an agency or organisation for specific, mission-oriented needs.

Most environmental and sustainable indicators are based on the idea of green national accounts or simply environmental accounting; in both cases, environmental costs are incorporated into measurements of economic activities. Environmental accounting is defined in the System of Environmental and Economic Accounts 2003 (SEEA-2003), which describes four basic approaches to environmental accounting (Smith 2007):

1. Measuring the relationships between the environment and the economy in both directions
2. Measuring environmental economic activities
3. Environmental asset accounts
4. Adjusting existing accounting measures to account for natural capital degradation

In the next sections, we provide a detailed description of widely used indicators that reflect both environmental performance and sustainable development.

5.1 The Better Life Index

One of the most famous quality-of-life indices is the Better Life Index, introduced by OECD's Better Life Initiative (OECD Better Life Initiative 2014). Life quality is verified through 12 key dimensions essential to well-being (see Fig. 1), which range from traditional measures such as income and jobs, health, education and the local environment, to personal safety and overall satisfaction with life. This variety of dimensions enables the identification of the relative strengths and weaknesses in a country's well-being (OECD 2013). One the BLI's primary advantages is that OECD also focuses on measuring inequality among societal groups with respect to different aspects of well-being.

The BLI is a composite indicator composed of various "dimensions" of well-being such as material living conditions (housing, income, jobs) and quality of life (community, education, environment, governance, health, life satisfaction, safety and work-life balance) (OECD Better Life Initiative 2014). However, the BLI has recently been criticised for not reflecting societal inequalities. Therefore, future editions of the index are planned to account for inequalities (e.g., between men and women or between people with low and high socio-economic status).

Values of BLIs ranging from 0 to 10 are presented in Table 2. It is evident that higher values are found in core countries. In contrast, CEE and periphery countries

Table 2 Better life index, 2011, EU countries/OECD members (OECD)

	Housing	Income	Jobs	Community	Education	Environment	Governance	Health	Life Satisfaction	Safety	Work-life balance	Overall
Austria	7.40	3.71	8.32	8.40	6.19	6.37	6.26	7.08	8.39	9.19	7.00	7.02
Belgium	9.27	4.13	5.20	7.34	6.84	7.89	5.88	7.30	7.10	7.02	8.46	6.95
Czech Republic	6.46	1.38	6.15	5.37	7.32	8.44	4.23	5.20	4.84	8.35	7.76	5.91
Denmark	8.33	2.63	8.41	9.57	6.75	8.87	6.72	6.54	10.00	8.46	9.11	7.57
Estonia	2.82	0.90	2.97	3.09	8.13	9.59	2.11	2.32	1.29	5.49	7.34	4.27
Finland	8.10	2.60	7.29	7.77	9.07	9.15	6.43	6.58	8.71	8.55	8.50	7.42
France	7.82	3.65	5.68	8.03	6.41	9.53	4.60	7.59	6.77	8.09	7.71	6.76
Germany	7.43	3.75	6.98	7.82	7.71	8.89	4.45	6.49	6.45	8.83	8.05	6.93
Greece	5.86	2.14	3.91	3.88	5.14	5.79	5.13	7.38	3.55	8.63	6.65	5.42
Hungary	3.76	0.95	3.29	5.21	7.13	9.00	4.81	2.17	0.00	8.46	6.99	4.82
Ireland	8.80	2.72	3.41	9.84	6.37	9.60	5.68	8.01	8.39	8.65	6.63	6.75
Italy	6.89	3.49	4.37	3.83	4.67	7.49	5.02	7.10	5.48	8.25	6.65	5.82
Luxembourg	8.10	...	7.23	8.62	5.22	9.59	2.98	7.51	7.74	8.27	7.32	7.01
Netherlands	8.61	3.89	8.72	8.51	7.24	6.03	5.59	7.85	9.03	8.23	8.76	7.51
Poland	4.43	0.85	5.65	7.13	8.00	5.19	5.20	3.37	3.55	9.18	6.65	5.46
Portugal	6.52	2.03	4.70	2.39	2.81	7.95	4.07	4.63	0.65	7.69	7.95	4.83
Slovak Republic	5.79	0.95	2.23	5.74	7.21	9.49	3.12	0.66	4.52	8.48	7.67	4.84
Slovenia	5.94	2.02	6.32	6.33	6.83	6.37	5.92	5.22	4.52	8.85	7.45	6.09
Spain	8.33	2.51	1.90	8.14	4.28	6.66	5.65	7.48	4.84	8.57	6.95	5.90
Sweden	8.06	3.43	8.32	9.26	7.70	10.00	8.27	8.27	9.03	8.19	8.16	7.86
United Kingdom	7.91	4.07	7.18	8.56	6.32	9.58	6.39	7.18	7.42	8.69	7.03	7.11

(continued)

Table 2 (continued)

	Housing	Income	Jobs	Community	Education	Environment	Governance	Health	Life Satisfaction	Safety	Work-life balance	Overall
EU	6.98	2.59	5.63	6.90	6.54	8.17	5.17	6.00	5.82	8.29	7.56	6.30
V4	5.11	1.03	4.33	5.86	7.42	8.03	4.34	2.85	3.23	8.62	7.27	5.26
CEEC	4.87	1.18	4.43	5.48	7.44	8.01	4.23	3.15	3.12	8.14	7.31	5.23
PERIPHERY	7.28	2.58	3.66	5.62	4.65	7.50	5.11	6.92	4.58	8.36	6.97	5.74
CORE	8.10	3.54	7.33	8.39	6.95	8.59	5.76	7.24	8.06	8.35	8.01	7.21

have lower values, primarily due to visibly lower values of income and health. Moreover, compared to the other countries in the EU, the periphery countries have remarkably severe problems related to jobs and education.

5.2 The Ecological Footprint

The Ecological Footprint (EF) measures human demand on the Earth's ecosystems. Therefore, EF accounting measures the extent to which the ecological demand of human economies either remains within or exceeds the capacity of the biosphere to supply goods and services. Based on this assessment, it is possible to estimate how much of the Earth it would take to support humanity if everybody followed a particular lifestyle. In other words, it measures the extent to which humanity is using nature's resources faster than they can regenerate.

Both the ecological footprint concept and its calculation method were developed by M. Wackernagel and W. Rees at the University of British Columbia in 1994—for more detail see Rees (1992), Wackernagel (1994) and Global Footprint Network (2012). The EF is measured in global hectares (*gha*), an indication of the proportion of the earth's surface required to support a particular activity. This unit takes into account the different bio-capacities of each land type for each country/area. The EF's primary advantage is that it is relatively easy to calculate the ecological footprint of individual nations and other geographically defined groups because we usually know their consumption levels and therefore we can easily calculate the impact of that consumption on the earth's resources. Conversely, the EF's weakness is its failure to include any economic, political or cultural factors such as well-being. Another weakness of the EF relates to destruction of bio-capacity by long-term processes such as climate change and the fact that a large proportion of the earth's surface represents deserts, mountains and deep oceans, which reduce its bio-capacity.

The latest results show that the United States, China and India have the largest ecological footprints. Of the EU countries (see Table 3), Denmark, Belgium and Estonia place the highest demand on resources. Moreover, the greatest positive differences between bio-capacity and ecological footprint, called ecological reserve, are found in Finland, Sweden and Latvia due to those countries' high bio-capacities, whereas the worst ecological positions are found in Belgium, the Netherlands and Italy. There are also obvious, considerable differences in the ecological footprints of the core and the CEE countries.

5.3 Environmental Performance Index

The Environmental Performance Index (EPI) represents a method of quantifying the environmental performance of a state's policies. In other words, "the EPI ranks

Table 3 Ecological footprint, 2007 (National Footprint Accounts 2010 Edition)

	Ecological footprint in gha/pers	Bio-capacity in gha/pers	Ecological reserve/deficit (if positive) in gha/pers
Austria	5.30	3.31	−1.99
Belgium	8.00	1.34	−6.66
Bulgaria	4.07	2.13	−1.94
Croatia	3.75	2.50	−1.24
Czech Republic	5.73	2.67	−3.07
Denmark	8.26	4.85	−3.41
Estonia	7.88	8.96	1.08
Finland	6.16	12.46	6.31
France	5.01	3.00	−2.01
Germany	5.08	1.92	−3.16
Greece	5.39	1.62	−3.77
Hungary	2.99	2.23	−0.76
Ireland	6.29	3.48	−2.82
Italy	4.99	1.14	−3.85
Latvia	5.64	7.07	1.43
Lithuania	4.67	4.36	−0.31
Netherlands	6.19	1.03	−5.17
Poland	4.35	2.09	−2.26
Portugal	4.47	1.25	−3.21
Romania	2.71	1.95	−0.76
Slovakia	4.06	2.68	−1.38
Slovenia	5.30	2.61	−2.70
Spain	5.42	1.61	−3.81
Sweden	5.88	9.75	3.86
United Kingdom	4.89	1.34	−3.55
EU	5.30	3.49	−1.81
V4	4.28	2.42	−1.87
CEEC	4.65	3.57	−1.08
PERIPHERY	5.31	1.82	−3.49
CORE	6.09	4.34	−1.75

how well countries perform on high-priority environmental issues in two broad policy areas: protection of human health from environmental harm and protection of ecosystem” (Hsu et al. 2014). The EPI was developed by Yale University (Yale Center for Environmental Law and Policy) and Columbia University (Center for International Earth Science Information Network) in collaboration with the World Economic Forum and the Joint Research Centre of the European Commission.

The EPI usually aggregates 20 indicators reflecting national-level environmental data, which are consequently combined into the following 9 categories (see Hsu et al. 2014):

1. Health impacts
2. Air quality
3. Water and sanitation
4. Water resources;
5. Agriculture
6. Forests
7. Fisheries
8. Biodiversity and habitat
9. Climate and energy

The EPI ranges from the worst to the best performers between 0 and 100. For a more detailed discussion on the EPI, see Hsu et al. (2013) and Hsu et al. (2014).

The EPI's main advantage is that an aggregated index is more complex than looking at each indicator separately. In addition, a single number or a score is more user friendly. Conversely, the EPI's weakness is that it consists of a difficult interpretation of composite indicators. Users should be concerned about real environmental performance rather than the index number as such.

Table 4 presents the EPI 2012 and 2014 values of the EU countries. Primarily due to low emissions, the top five EU countries were Latvia, Luxemburg, France, Austria and Italy in 2012 and Luxemburg, the Czech Republic, Germany, Spain and Austria in 2014.

5.4 Happy Planet Index

The Happy Planet Index (HPI) is an index of human well-being and environmental impact that was introduced by the New Economics Foundation (NEF) in July 2006. The HPI is designed to improve well-established development indices, such as GDP and HDI, which do not take sustainability into account. The HPI measures the extent to which countries enable their residents to live long, happy, sustainable lives. The index ranks countries according to the length (based on life expectancy) and happiness (questionnaire-based well-being measured on the scale 0–10) of the lives that they enable per unit of environmental input, measured by ecological footprint (see Abdallah et al. 2012). The HPI's main weakness is that it does not consider human rights issues.

Table 5 presents the HPI and the corresponding well-being values for the EU countries in 2012. The top three EU countries are the United Kingdom, Germany and Austria, and the worst three EU countries are Lithuania, Bulgaria and Luxembourg. The latter results are primarily attributable to the worst three countries' high ecological footprint, causing low well-being.

Table 4 Environmental performance index in EU countries (http://epi.yale.edu/)

	EPI 2012			EPI 2014		
	Value	World ranking	EU ranking	Value	World ranking	EU ranking
Austria	68.92	7	4	78.32	8	5
Belgium	63.02	24	17	66.61	36	22
Bulgaria	56.28	53	25	64.01	41	25
Croatia	64.16	20	14	62.23	45	26
Cyprus	57.15	44	23	66.23	38	23
Czech Republic	64.79	18	12	81.47	5	2
Denmark	63.61	21	15	76.92	13	9
Estonia	56.09	54	26	74.66	20	14
Finland	64.44	19	13	75.72	18	12
France	69.00	6	3	71.05	27	18
Germany	66.91	11	8	80.47	6	3
Greece	60.04	33	20	73.28	23	17
Hungary	57.12	45	24	70.28	28	19
Ireland	58.69	36	21	74.67	19	13
Italy	68.90	8	5	74.36	22	16
Latvia	70.37	2	1	64.05	40	24
Lithuania	65.50	17	11	61.26	49	27
Luxembourg	69.20	4	2	83.29	2	1
Malta	48.51	87	27	67.42	34	21
Netherlands	65.65	16	10	77.75	11	7
Poland	63.47	22	16	69.53	30	20
Portugal	57.64	41	22	75.8	17	11
Romania	48.34	88	28	50.52	86	28
Slovakia	66.62	12	9	74.45	21	15
Slovenia	62.25	28	18	76.43	15	10
Spain	60.31	32	19	79.79	7	4
Sweden	68.82	9	6	78.09	9	6
UK	68.82	9	6	77.35	12	8
EU	62.67	27.36	...	72.36	24.36	...
V4	63.00	24.25	15.25	73.93	21.00	14.00
CEEC	61.36	32.64	16.73	68.08	34.55	19.09
PERIPHERY	61.12	30.00	17.40	75.58	17.60	12.20
CORE	66.84	12.60	8.40	76.56	14.20	9.10

Table 5 Happy planet index, 2012 (www.happyplanetindex.org/)

	Value	World ranking	EU ranking		Value	World ranking	EU ranking
Austria	47.09	48	3	Italy	46.35	51	5
Belgium	37.09	107	22	Latvia	34.87	118	25
Bulgaria	34.15	123	27	Lithuania	34.55	120	26
Croatia	40.62	82	15	Luxembourg	28.99	138	28
Cyprus	45.51	59	7	Malta	43.10	66	9
Czech Republic	39.35	92	19	Netherlands	43.09	67	10
Denmark	36.61	110	23	Poland	42.58	71	12
Estonia	34.95	117	24	Portugal	38.68	97	20
Finland	42.69	70	11	Romania	42.18	75	14
France	46.52	50	4	Slovakia	40.13	89	18
Germany	47.20	46	2	Slovenia	40.17	87	17
Greece	40.53	83	16	Spain	44.06	62	8
Hungary	37.40	104	21	Sweden	46.17	52	6
Ireland	42.40	73	13	United Kingdom	47.93	41	1
EU	40.89	82.07	...	Periphery	42.40	73.20	12.40
V4	39.87	89.00	17.50	Core	42.34	72.90	11.00
CEEC	38.27	98.00	19.82				

6 Data Envelopment Analysis: A New Approach to Sustainability Measuring

This section offers an alternative perspective on the measurement of sustainable development that is based on data envelopment analysis (DEA). DEA's original goal was to evaluate the relative efficiency of decision-making units (DMUs) in a multi-input/multi-output context. Although DEA is typically applied to micro-economic agents such as banks or firms, we use to conduct an efficiency assessment of countries.

More specifically, DEA analyses the relative efficiency of the EU countries, which transform multiple inputs into multiple outputs in economic, environmental and social dimensions. DEA is a convenient tool for this purpose because it uses data observations to evaluate relative sustainable development by inferring information directly from the data set. Indeed, the need to work with physical indicators is addressed by Stiglitz et al. (2009) to develop "a clear indicator of our proximity to dangerous levels of environmental damage" that is in line with having sustainable development as one of its dimensions. DEA is actually a well-developed nonparametric technique for evaluating the relative efficiencies of DMUs with multiple inputs and outputs (Ramanathan 2003). Nonetheless, the adoption of DEA in the context of environmental performance measurements is still scarce. There are only a few studies that focus on sustainable development, including, e.g., Färe et al. (1996), Zofio and Prieto (2001), Färe and Grosskopf (2004), Zaim (2004), and Zhou et al. (2008).

The text below is dedicated to the direct approach to environment-economic performance evaluation based on DEA. This technique has various advantages. First, a multi-dimensional perspective or independence on individual preferences can be stated. In contrast to sustainable development indicators, DEA can elaborate multiple inputs and outputs measured even on different scales without any requirement for functional relationships between inputs and outputs or market value assessment. It enables the identification and quantification of economic growth's multi-factor impacts on social development and environment. Finally, DEA is a technique that measures the relative efficiency of DMUs, showing which inputs and outputs cause the inefficiency of a DMU and the extent to which they do so.

In an economy, inputs are consumed to produce desirable outputs accompanied by undesirable outputs. DEA then either maximises the output subjected to a given amount of inputs or minimises the amount of inputs for a given output. Because the set of goods and services produced using a given number of inputs is often accompanied by socially undesired resource depletion and pollution, DEA in an ecological framework must be carefully applied when addressing environmental impact. In this context, DEA is intended not only to maximise the economic goods and services output but also to consider negative environmental effects at the same time.

According to Allen (1999) there are four possibilities for coping with pollutants:

1. Converting pollutants by taking their reciprocal or by subtracting the pollutant from a maximal value regarding the converted pollutant as usual output
2. Considering the pollutant as an input that—together with other inputs—should be minimised
3. Considering pollutants as the only type of input, factors subtracted from the value of a product
4. Considering pollutants as indirectly subtracting from the product

Because negative environmental effects of production should be minimised, we are interested in the second possibility how to treat pollutants. Therefore, we apply the input-oriented BCC model (Banker et al. 1984), adding undesirable pollutant as an input.

Now, a more detailed list of indicators related to 3 dimensions of DEA must be established. Country-level data for 2004, 2008 and the most recent period are used, which allows us to compare efficiencies, thus providing a type of dynamic analysis. Measuring the environmental efficiency of the EU countries, we follow Dyckhoff and Allen (2001), Halkos and Papageorgiou (2014), Halkos and Tzeremes (2014), Korhonen and Luptacik (2004), and Mandal and Madheswaran (2010) in treating undesirable pollution as input. It is worth noting that DEA is sensible to entry of data from which information is directly inferred. In our case, 3 inputs and 1 output are used in the input-oriented DEA. More specifically, the following proxies of dimensions of our interest are chosen: CO_2 emissions (kt, per USD current GDP), energy use (in constant 2005 PPP, kg of oil equivalent) and the poverty rate. These

Table 6 DEA: the EU countries' relative efficiency

	2004	2008	2012		2004	2008	2012
Austria	0.7965	0.7873	0.7437	Italy	1.0000	0.9598	0.9587
Belgium	0.5480	0.5428	0.5005	Latvia	0.5937	0.6777	0.5821
Bulgaria	0.3608	0.3940	0.3698	Lithuania	0.4594	0.5346	0.6021
Croatia	0.6991	0.7197	0.6629	Luxembourg	0.6768	0.7304	0.6867
Cyprus	0.7842	0.7021	0.7319	Malta	1.0000	1.0000	1.0000
Czech Republic	0.4205	0.4808	0.4613	Netherlands	0.7397	0.7359	0.6734
Denmark	0.8614	0.8485	0.8118	Poland	0.5310	0.5685	0.5557
Estonia	0.3764	0.4003	0.3610	Portugal	0.8114	0.8140	0.7861
Finland	0.4072	0.4431	0.4022	Romania	0.4727	0.5363	0.5236
France	1.0000	1.0000	1.0000	Slovakia	0.4195	0.5127	0.5173
Germany	1.0000	1.0000	1.0000	Slovenia	0.6000	0.6073	0.5774
Greece	0.8457	0.8391	0.7541	Spain	0.8934	0.8990	0.8948
Hungary	0.5912	0.5776	0.5482	Sweden	0.7212	0.7761	0.6079
Ireland	1.0000	1.0000	1.0000	United Kingdom	1.0000	1.0000	1.0000
EU	0.7004	0.7174	0.6898	Periphery	0.9101	0.9024	0.8787
V4	0.4906	0.5349	0.5206	Core	0.7751	0.7864	0.7426
CEEC	0.5022	0.5463	0.5238				

indicators are used as inputs to produce current GDP in US$ because they generally provide proxies of environmental, social and economic dimensions, the aspects of sustainable development that we want to assess.

The results of DEA for all dimensions—i.e., environmental, economic and social—and sustainable development aspects for all explored time periods—2004, 2008 and 2012—are shown in Table 6.

As observed, the best-performing countries are the largest old EU members, plus Ireland and Malta. All of these countries lie on the production frontier, which means that the given amount of output is produced with minimal requests on inputs, including pollution. These countries have a relatively high output and produce a small amount of pollution. In contrast, the relatively least-efficient countries overall are overall the CEE countries, namely, Bulgaria, Czech Republic, Estonia, Lithuania, Romania, and Slovakia. These countries' primary problem is their relatively high pollution. Thus, we call for precautions related to pollution abatement to increase these countries' relative efficiency and their support for sustainable development in the EU.

Moreover, the scope of this study was to offer an alternative to widely used indices that we believe are provided in the form of DEA results—i.e., efficiencies. After introducing this new indicator, it would be opportune to explore its relationship to other indices mentioned above. For this purpose we use both numerical and graphical analyses, which comprise the content of the following sections.

7 Are Indices and DEA Results Related?

First, we address the linear dependency of the analysed indicators. Thus, Table 7 reports the Pearson and Spearman correlation coefficients of both the mentioned indicators and GDP. The relationship between the abovementioned indicators and GDP in PPS per capita for 2012 is also presented in Fig. 6. The table and figures imply a strong relationship between the indicators and GDP in PPS per capita. The highest values of the Pearson correlation coefficients between GDP and BLI also support the theoretically formulated expectation because the BLI is derived from GDP. The weakest GDP relationships are those between GDP and EPI, GDP and DEA, and GDP and HPI. This is primarily because the EPI and HPI are not based on GDP and are focused primarily on issues such as environmental health or ecosystem vitality. Finally, a low Pearson correlation is observed between BLI and EF, BLI and DEA, HPI and EF, HPI and EPI, EF and EPI, EF and DEA and EPI and DEA. The low correlation between EF and EPI is particularly surprising. The primary reason for this finding may be that EF only measures human demand on the Earth's ecosystems, whereas EPI is more general because it focuses not only on ecosystem protection and resource management but also on the protection of human health from environmental harm. Note that these findings are mostly reinforced by Spearman correlation coefficients.

Relationships among the indices can also be assessed through principal component analysis (PCA, for more details, see e.g., Jolliffe 2002). Running the PCA on all indices (results reported in Table 8), we obtain PC1 carrying 52.8 %, PC2 carrying 27.7 % and PC3 carrying 12.1 % of total information (92.6 % overall). Component loadings show that indices GDP, BLI, HPI, EPI and DEA are positively correlated to PC1; EF and GDP are positively correlated and HPI and DEA are negatively correlated to PC2; HPI and DEA; EPI is positively correlated and DEA is negatively correlated to PC3 positively. Based on previous findings, we can state that with respect to PCA, some indices are related to GDP, including BLI, HPI, EPI and DEA.

Table 7 Pearson (below the diagonal) and Spearman (above the diagonal) correlation, analysed for either 2012 or the most recent year

	GDP	BLI	HPI	EF	EPI	DEA
GDP		0.85*	0.58*	0.65*	0.41*	0.50*
BLI	0.91*		0.43	0.49*	0.57*	0.23
HPI	0.54*	0.50*		−0.03	0.38	0.63*
EF	0.59*	0.39	−0.15		0.11	0.04
EPI	0.44*	0.60*	0.26	0.22		0.25
DEA	0.47*	0.29	0.63*	0.01	0.13	

Note Correlation coefficients are computed based on the dataset without Luxembourg because that country's GDP is an outlier; significance varies due to the various sample sizes of the analysed indicators (i.e., BLI and EF); * p-value < 0.05

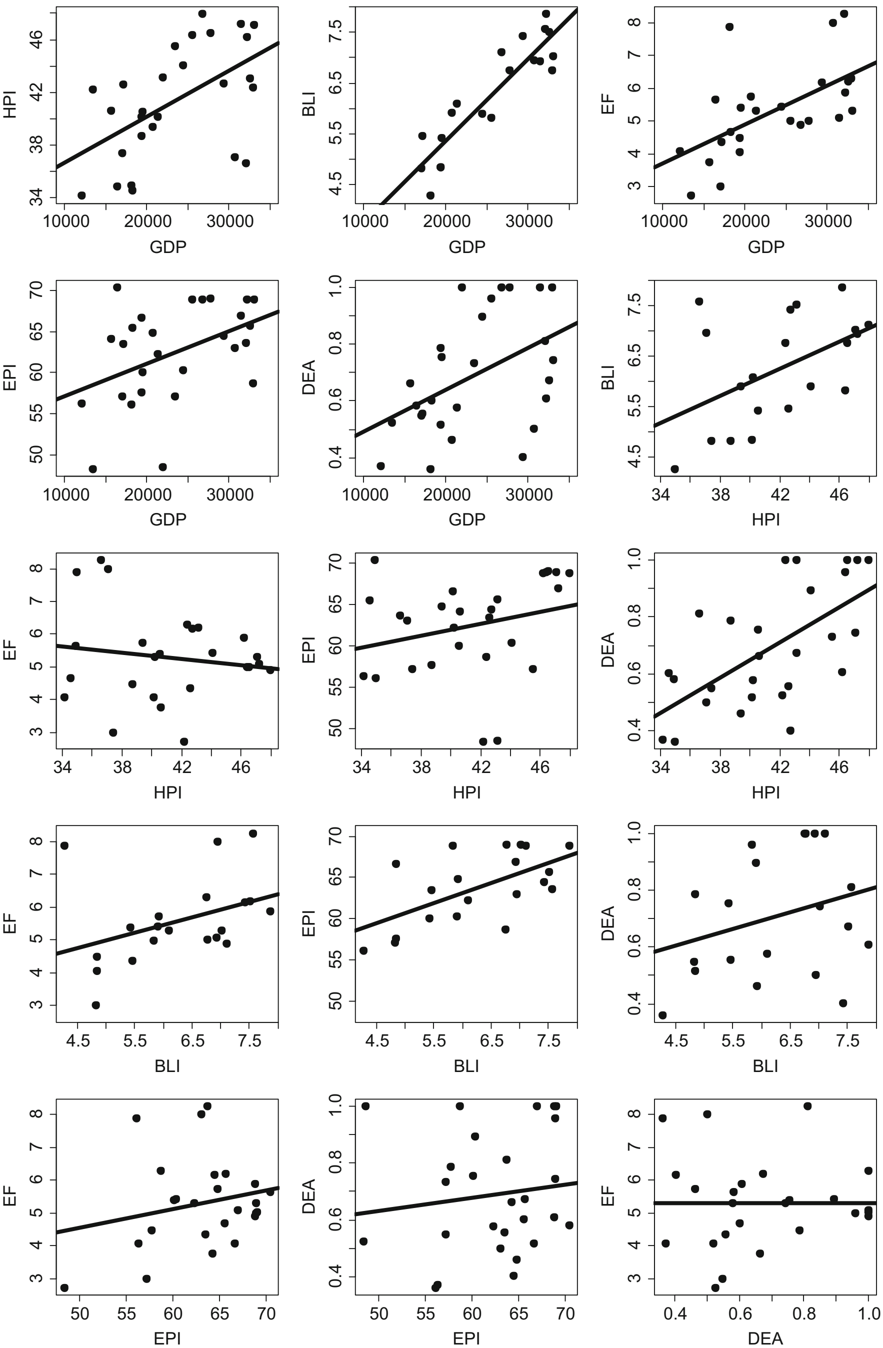

Fig. 6 Scatter plots of analysed variables, analysed for either 2012 or the most recent year (*Note* Constructed scatter plots are based on the dataset without Luxembourg due to outlier in GDP)

Table 8 Principal components analysis

Eigenanalysis of the correlation matrix				Eigenvectors (component loadings)						
Component	Eigenvalue	Proportion	Cumulative	Index	PC1	PC2	PC3	PC4	PC5	PC6
1	3.176	0.528	0.528	GDP	0.483	0.334	−0.127	−0.325	−0.010	0.730
2	1.662	0.277	0.805	BLI	0.489	0.298	0.118	−0.443	−0.230	−0.639
3	0.724	0.121	0.926	HPI	0.456	−0.395	0.073	−0.007	0.788	−0.101
4	0.248	0.041	0.967	EF	0.068	0.725	−0.154	0.564	0.325	−0.147
5	0.124	0.021	0.988	EPI	0.447	−0.165	0.558	0.555	−0.373	0.118
6	0.071	0.012	1.000	DEA	0.339	−0.301	−0.793	0.267	−0.286	−0.110

8 Similarity of the EU Countries: Cluster Analysis

All of the abovementioned indices tend to qualify particular aspects at both the micro and macro levels. At the state level (in our case, that of the EU members), indices can help us assess how aspects either are similar or how they evolve in particular areas. One appropriate technique used to explore the overall dis/similarity of the EU countries is cluster analysis; we employ the Ward method and Euclidean distance (for details see e.g., Everitt et al. 2001). Thus, Fig. 7 presents

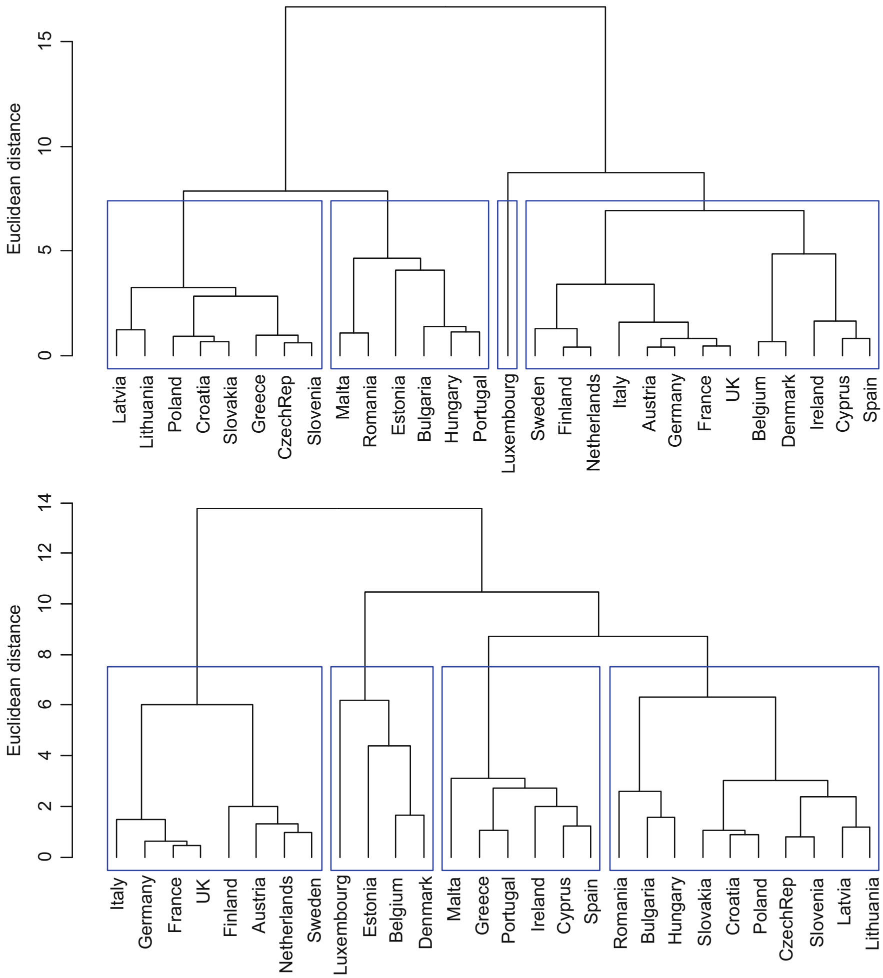

Fig. 7 Dissimilarity of the EU members with respect to economic, environmental and sustainable indicators (*Note* The top dendrogram is based on the GDP, BLI, HPI, EF and EPI indicators; the bottom dendrogram is based on the GDP, BLI, HPI, EF, EPI and DEA indicators; the Ward method and Euclidean distance are used for this figure's construction)

a dendrogram based on the selected economic, environmental and sustainable indicators in 2012 that show the dissimilarity of the EU members' attitudes towards the environment. In the comparative analysis of the economic, environmental and sustainable indicators, special attention is given to those indicators' ability to classify the individual countries/economies into generally accepted, homogenous groups.

First, we construct a dendrogram based on commonly used indicators, i.e., GDP, BLI, HPI, EF and EPI. There is a clear segmentation of the EU members into two main clusters. The first cluster generally consists of the core states; the better-performing periphery countries of Ireland, Italy, and Spain; and Cyprus. These countries have higher GDP in PPS per capita as well as BLI and HPI than the other countries. The second main cluster consists of the CEE countries and the southern states (except for Ireland, Italy and Spain). This second cluster can be further divided into two sub-clusters. The first sub-cluster consists of better CEE countries plus Greece. These countries have similar EPI values. The second sub-cluster consists of the South-Eastern EU states, plus Portugal, Malta and Estonia—i.e., states with relatively lower values of GDP in PPS per capita, EF and EPI than the other EU countries.

Second, for the dendrogram construction we use the indicators mentioned above plus the efficiency obtained from DEA. In comparison to the first dendrogram, we can see that core EU members (with the exception of Luxembourg, Belgium and Denmark) plus Italy, as better performing periphery countries create a separate cluster. The second main cluster can be divided into three sub-clusters. These clusters can be identified as small core EU countries, Estonia, periphery countries (with the exception of Italy), Malta, Cyprus, and CEE countries.

9 Concluding Remarks

Previous sections of this chapter introduced the concept of sustainable development and its measurement, which are important for the corresponding policy decisions. "Useful scientific information [. . .] improves [. . .] decision-making by expanding alternatives, clarifying choice and enabling decision makers to achieve desired outcomes" (McNie 2007). The first section is devoted to the indicators that measure economic and socio-economic progress and environmental quality in terms of the context (in terms of benefits and weaknesses) in which indices should be used without misinterpretations. The second part offers the alternative of using DEA for measuring sustainable development.

The goal of indicators is to provide information that separates relevant content from noise—to synthesise complex data. If properly presented, indices can enable understanding of the described complex phenomenon, can improve the situation that they describe, can diagnose problems by analysing trends, can identify patterns in the units analysed, can identify performance gaps, and therefore hold decision makers accountable (de Sherbinin et al. 2013).

Conversely, if interpreted incorrectly, decisions based on misinterpreting indices can lead to biased or even undesired results. Another weakness of indices is that many indices are tightly connected to projects that only last for a limited time, thus causing limited data availability and therefore a limited possibility of making inter-temporal comparisons. Moreover, the methodology of many indices' construction changes over time, which also reduces the possibilities of conducting dynamic analyses. This implies that it is important to pay serious attention to the statistical methods and construction of aggregate indices, especially to the time-series perspective (Ebert and Welsch 2004). Because normalisation and weighting procedures significantly affect the resulting aggregate index, a contrasting outcome on an actual state can be obtained independently by different approaches. Thus, insufficient attention to the statistical methods of index construction can result in useless, if not misleading, information (Böhringer and Jochem 2007).

DEA shows a high potential for applications in the fields of environmental management and ecological control. It can be regarded as an objective tool that measures the relative efficiencies of DMU and therefore their positions within the set of DMUs. The goal of DEA is to directly infer information from available data. Accordingly, it does not separate desired from non-desired content but instead aims to assess the relative efficiencies of DMUs based on its data set. The advantage is that no piece of information is lost, although the data must be carefully chosen. In the sustainable development context, DEA provides a quantification that can be considered as a background for both economic development and environmental-protection activities.

In summary, the combination of indices and DEA provide a more complex picture of the described reality. We demonstrate this fact in the context of the EU countries. For example, the sustainable development indices can be used to find potential differences in sustainable economic performance among the EU Member States. Compared to the CEE and the periphery countries, the EU's core countries generally demonstrate higher values for all studied indices. Conversely, the core countries have bigger ecological footprints than the other countries, primarily due to their high proportion of heavy industry. When the DEA alternative is considered, ecological burden relative to output is more visible in the CEE countries, which implies a less optimistic perspective on sustainable performance. In contrast to indices, DEA explains how inputs are used to produce outputs and does not purely evaluate aspects. If this relationship is considered, the originally less-problematic CEE countries are revealed as less efficient. Consequently, we call for the appropriate use of indices—possibly accompanied by DEA to report the most relevant information.

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