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Research article

Decent Work and Economic Growth in the European Union. A partial order analysis of Eurostat SDG 8 data

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Abstract: Decent work and economic growth are regarded as essential elements for the sustainable development of countries. Thus, the Sustainable Development Goal No. 8 (SDG 8) is specifically devoted to this. The present paper reports on partial ordering-based analyses of the main indicators for the 27 European member states for their complying with SDG 8. The analyses are based on five main indicators, real GDP (GDP), investment share of GDP by institutional sectors (INV), young people neither in employment nor in education and training (NEET), employment rate (EmpR) and long-term unemployment rate (LtUR). The analyses comprise 1) an overall analysis taken all five indicators simultaneously into account, 2) the investment profiles of the countries applying investment from business, government of households as indicators and 3) the employment situation in the single countries with the NEET, EmpR and LtUR as indicators, specifically looking at differences between males and females. The data gives rather clear-cut pictures of the general situation in the European Union as well on the investment profiles and employment situation. In all cases the countries are mutually ranked and compared to the population averaged values for the Union (EU27).

Keywords: sustainability; sustainable development goals; SDG 8; partial ordering; average ranking; indicator importance

JEL Codes: C1, C3, C6

1. Introduction

The Eurostat published yearly data to disclose the development of the single 17 Sustainable Development Goals (SDGs) in Europe (Eurostat, 2020a). Sustainable development comprises the 3

pillars of sustainability, i.e., economically viable decisions, environmentally sound decisions, and socially equitable decisions (Future Learn, 2021). Decent work and Economic growth (SDG 8) have legs in both the economic as well as in the social areas. The development of SDG 8 can be elucidated through the development of five main indicators (Eurostat, 2020a), i.e., Real GDP (Eurostat, 2020b), Investment share of GDP by institutional sectors (Eurostat, 2020c), Young people neither in employment nor in education and training (Eurostat, 2020d), Employment rate (Eurostat, 2020e) and Long-term unemployment rate (Eurostat, 2020f) have been applied. The overall objective of the study is to disclose the mutual state of compliance among the European Union member states about the Sustainable Development Goal No. 8, i.e., Decent work and Economic growth, based on the five main indicators reported by Eurostat. Further it is an aim to provide an analytical tool for decision support that enable authorities, decision makers and regulators to pinpoint for which areas, given by the indicators that needs allocation of resources to increase the compliance with SDG 8 for the country. In Table 1 the Eurostat description of the five indicators is given.

Table 1. Main indicators for SDG 8: decent work and economic growth.

Indicator	Description
GDP	Gross domestic product (GDP) is a measure of economic activity and is commonly used as a proxy for changes in a country's material living standards. It refers to the value of total final output of goods and services produced by an economy within a certain time period. Real GDP per capita is calculated as the ratio of real GDP (GDP adjusted for inflation) to the average population of a specific year and is based on rounded figures.
INV	Investment share of GDP measures the investment for the total economy, government and business, as well as household sectors. The indicator is calculated as the share of GDP used for gross investment. It is defined as gross fixed capital formation (GFCF) expressed as a percentage of GDP for the government, business and household sectors.
NEET	A considerable proportion of young people aged 15 to 29 in the EU are economically inactive. For some this is due to the pursuit of education and training. Others, however, have withdrawn from the labour market or are not entering it after leaving the education system. Those who struggle with the transition from education to work are captured by the statistics on young people who are neither in employment, education nor training (NEET rate).
EmpR	The employment rate is defined as the percentage of employed persons in relation to the comparable total population. The data analysed here focus on the population aged 20 to 64 with the view of monitoring the Europe 2020 strategy target of raising employment rates among this age group to 75 % by 2020.
LtUR	Long-term unemployment is measured for economically active people (which includes both employed and unemployed people) aged 15 to 74 who have been unemployed for 12 months or more. Long-term unemployment increases the risk of falling into poverty and has negative implications for society as a whole. Long-term unemployed people in the EU have about half the chance of finding employment as those who are short-term unemployed.

Previous studies have focused on the development within the single indicators over the years (Eurostat, 2020a). However, analyses taking all 5 main indicators simultaneous have not previously been reported. The present study takes its onset in analyses for the years 2010, i.e., 5 years prior to the adoption of the 17 SDGs, 2015, i.e., the year the SDGs were adopted and 2019, the latest year where

a virtually complete data set is available (Eurostat, 2020a). The datasets analyzed comprises 27 EU member states plus population averaged values for the EU (EU27) and the five main indicators for all 28 entries. Thus, we are dealing with a multi-indicator system (MIS). Over time MISs have been analyzed by various approaches, like ELECTRE (Roy and Bouyssou, 1986; Colorni et al., 2001) and PROMETHEE (Brans and Vincke, 1985). However, none of these method takes into account all indicators simultaneously without any pretreatment. In contrast to this partial ordering constitutes an advantageous method that allows to take into account all indicators without any pretreatment (Brüggemann and Patil, 2011; Carlsen and Brüggemann, 2018), like, e.g., aggregation thus avoiding loss of information about the role of the single indicators, e.g., due to compensation effects (Munda, 2008). In a recent paper (Carlsen, 2021) the advantageous use of partial ordering compared to the use of aggregated indicators has been elucidated.

In the following section the theoretical background for the methodology is briefly described. For further deepening the given references should be consulted.

The analyses comprise overall analyses including all 5 indicators using the total value for each indicator. Further specialized analyses comprising the employment situation for males and females as well as various investment profiles, i.e., business, government, and household contributions. The 27 European Union (EU) members as well as the values for the EU, EU27, have been included in the single analyses (Appendix 1 for the applied ISO 3166-1 country codes).

2. Methods

2.1. Partial ordering—the basics

Partial ordering is a relation among the objects to be ordered. In mathematical terms the only relation is "≤" (Brüggemann and Patil, 2011; Carlsen, 2018; Carlsen and Brüggemann, 2018). Hence, the "≤" relation is the basis for a comparison of objects and constitutes a graph, the so-called Hasse diagram (see below). Two objects are connected to each other if and only if the relation "x ≤ y" holds. A given object, x, is characterized by the a set of indicators r_j (x), j = 1,...,m, and can thus be compared to another object y, characterized by an identical set of indicators r_j (y), if

$$\mathrm{ri}(x) \leq \mathrm{ri}(y) \text{ for all } i = 1, \ldots, m \quad (1)$$

It is obvious that Equation 1 is a rather strict requirement for having a comparison as at least one indicator value of object x must be lower (the remaining lower or at least equal) to those of object y. In technical terms: Let X be the group of objects studied, i.e., X = {O1, O2, O3, ……, On}, then object Oy will be ranked higher than object Ox, i.e., Ox < Oy if at least one of the indicator values for Oy is higher than the corresponding indicator value for Ox and no indicator for Oy is lower than the corresponding indicator value for Ox. On the other hand, if r_j (Oy) > r_j (Ox) for some indicator j and r_i (Oy) < r_i (Ox) for some other indicator i, Oy and Ox will be called incomparable (notation: Oy ‖ Ox) due to the mathematical contradiction expressed by the conflicting indicator values. A set of comparable objects are called a chain, whereas a set of mutually incomparable objects is called an antichain. In cases where all indicator values for two objects, Oy and Ox, are equal, i.e., r_j (Oy) = r_j (Ox) for all j, the two objects will be considered as equivalent, i.e., Ox–Oy, which in terms of ranking means that they will have the same rank.

2.2. The hasse diagram

The Equation 1 is the basis for the so-called Hasse diagram technique (HDT) (Brüggemann and Patil, 2011; Brüggemann and Carlsen, 2006). Hasse diagrams are visual representations of partial orders. In a Hasse diagram comparable objects are connected by a sequence of lines (Brüggemann and Patil, 2011; Brüggemann and Münzer, 1993;). Thus, sets of comparable objects, i.e., fulfilling Equation 1 are called chains that in the diagram are connected with lines, whereas sets of mutually incomparable objects, i.e., not fulfilling Equation 1 are called antichains.

In the diagram the single objects are positioned in levels, typically arranged from low to high (bottom to top in the diagram). It is a general rule that objects are located as high in the diagram as possible. Thus, isolated objects will, by default be located at the top level of the diagram. It is important to make sure that the orientation of the single indicators is identical, e.g., that high values correspond to good whereas low values correspond to bad. In practice this is done by multiplying indicator values by –1 in case where high and low values correspond to bad and good, respectively (cf. 2.5). In the present study the highest located object/country will be assigned rank 1 indicating the best.

The module mHDCl7_1 of the PyHasse software (vide infra) was used for the basic partial ordering calculations and the associated construction of the Hasse diagrams.

2.3. Sensitivity—indicator importance

The relative importance of the single indicators in play can be determined through a sensitivity analysis (Brüggemann et al., 2001). The basic idea is to construct partial ordered sets (posets) excluding the single indicators one at the time. Subsequently, the distances from these posets to the original poset are determined. The indicator, whose elimination from the original poset leads to the maximal distance to the original one, in other words causing the highest degree of changes in the Hasse diagram is most important for the structure of the original partial order. As the effect of elimination single indicators is studied, this kind of sensitivity analysis can be called indicator-related sensitivity. The sensitivity values were calculated by the sensitivity23_1 module of the PyHasse software (vide infra).

2.4. Average ranking

Looking at the Hasse diagram, the level structure constitutes a first approximation to ordering. However, as all objects in a level automatically will be assigned identical orders such an ordering will obviously cause many tied orders. Obviously, it is desirable with a degree of tiedness as low as possible. Hence, ultimately a linear ordering of the single objects is desirable. However, when incomparable objects are included in the ordering, this is obviously not immediately obtainable. Partial order methodology provides a weak order, where tied orders are not excluded, which is obtained by calculating the average order of the single objects as, e.g., described by Brüggemann and Carlsen (2011) and Brüggemann and Annoni (2014).

The average rankings were calculated applying the LPOMext8_5 (Brüggemann and Carlsen, 2011) of the PyHasse software (vide infra).

2.5. Software

All partial order analyses were carried out using the PyHasse software (Brüggemann et al., 2014). PyHasse is programmed using the interpreter language Python (version 2.6). Today, the software package contains more than 100 specialized modules and is available upon request from the developer, Dr. R. Brüggemann (brg_home@web.de). A web-based version (PyHasse, 2020) is under construction.

It should be noted that the partial ordering methodology is under constant development and is used in a varity of disciples (Brüggemann and Carlsen, 2006; Brüggemann et al., 2014; Fattore and Brüggemann, 2017; Silan et al., 2021).

2.6. Indicators and data

The indicators applied for this study have been summarized in Table 2. It is noted that the indicator describing the investment profiles is subdivided into total investments and investments from business, governments, and households, respectively, whereas the indicators describing employment profiles are subdivided into total, males, and females, respectively. The total investments equal the sum of the investments from business, governments and households and the total employment indicators equals the sum of the indicators for males and females, respectively.

In the appendices 2–6 the data for the partial ordering analyses are shown. It should be noted (cf. Table 2) that to have a joint orientation of all indicators, i.e., ranging from bad (low values) to good (high values) negative values for NEET and LtUR are used.

Table 2. Indicators applied for the SDG 8 analyses.

ID	Description	Subdivision	Orientation
GDP	Real GDP	Total	the higher the better
INV	Investment share of GDP by institutional sectors	Total	the higher the better
		Business	
		Government	
		Household	
NEET	Young people neither in employment nor in education and training	Total	the lower the better
		Males	
		Females	
EmpR	Employment rate	Total	the higher the better
		Males	
		Females	
LtUR	Long-term unemployment rate	Total	the lower the better
		Males	
		Females	

3. Results and discussion

Decent work and economic growth are both important elements in legs in both the economic as well as in the social areas of sustainable development.

3.1. Overall analyses

The first set of analyses comprises all 27 EU member states plus the European Union (EU27) as a reference for comparison applying the total values for the five main indicators, i.e., GDP, INV, NEET, EmpR and LtUR (cf. Table 1) for the years 2010, 2015 and 2019, respectively, the indicator values are shown in Appendix 2. In Figure 1 the corresponding Hasse diagrams (cf. sect. 2.3) are shown.

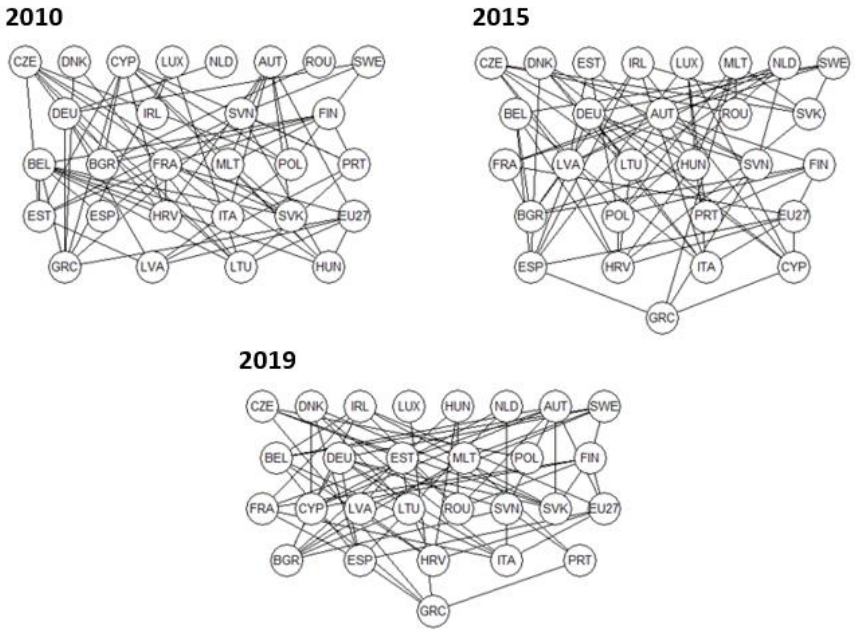

Figure 1. Hasse diagrams displaying the mutual ration between the 27 EU member states, the population averaged values for the European Union (EU27) being included as a reference.

From Figure 1 it is immediate noted that countries like CZE, DNK LUX, NLD and SWE for all 3 years are found in the top level of the diagrams indicating that these countries have among the highest level of decent work and economic growth within the EU, whereas, e.g., GRC are found in the bottom of the diagrams. Further the significant drop of CYP from 2010 to 2015 should be mentioned. It should in this connection be noted that the level structure of the Hasse diagrams (Figure 1) only gives a first indication of the mutual ranking of the countries as all countries at the same level will be ascribed identical rank.

A more elaborate disclosure of the mutual ranking of the 27 EU member states are obtained by estimating the average rank (cf. sect. 2.5) of the single countries (Table 3).

From the data in Table 4 it is immediate noted that EU27 appears stable with an average rank of 13, 14 and 14 for the three years, indicating that on an overall basis only little have happened in the European Union over the years. Countries being ranked higher (lower values) apparently on an average basis are doing better that the European average whereas countries with lower ranks than the EU27 (higher values) are doing worse than the average and as such appear to be challenged to reach at least the average level within the EU. Sweden (SWE) is found in the top for all three years closely followed by Austria (AUT) apart from 2015 where the second place was taken by NLD.

Table 3. Average rank of the 27 EU member states for the years 2010, 2015 and 2019, including the European Union (EU27) as reference.

ID	2010	2015	2019
AUT	2	3	2
BEL	9	12	13
BGR	24	26	27
CYP	4	22	20
CZE	5	4	3
DEU	14	9	7
DNK	11	6	5
ESP	19	23	23
EST	20	8	10
EU27	13	14	14
FIN	3	11	8
FRA	7	13	15
GRC	26	27	28
HRV	22,5	28	26
HUN	25	17	9
IRL	17	7	4
ITA	21	25	25
LTU	27	20	19
LUX	8	10	12
LVA	28	16	17
MLT	15	5	11
NLD	6	2	6
POL	18	21	18
PRT	16	24	21
ROU	12	18	24
SVK	22,5	19	22
SVN	10	15	16
SWE	1	1	1

As the ranking of the countries is based on the five main indicators, it is of obvious interest to disclose the relative importance of the single indicators and hereby give authorities and decision makers a further tool to pinpoint specific areas for improvement. In Figure 2 the relative importance of the five indicators for the three studied years are displayed. It is (Figure 2) immediate noted, not surprising, that the indicators GDP and INV have the highest influence on decent work and economic growth with a combined relative importance of 0.7–0.9, whereas the remaining three indicators, reflecting various aspects of employment (cf. Table 1) apparently are of less importance in achieving the SDG 8. This may be found surprising as on increased labor force would be expected to have a positive influence on the two economic indicators, GDP and INV. A further somewhat surprising finding is that, especially for the years 2010 and 2019, the calculations disclosed that the INV indicator for LUX is unexpected low compared to the general trend among the 27 member states plus EU27, even though the GDP for LUX is the highest within the EU27 (cf. Appendix 2).

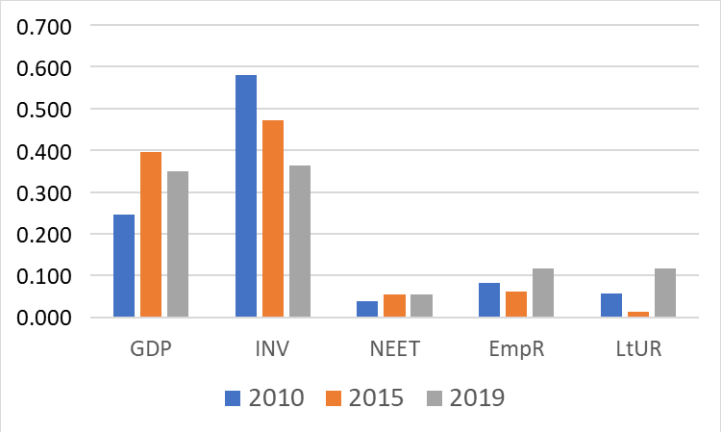

Figure 2. Relative importance of the five indicators.

3.2. Analyses of the investment profiles

The investment profiles for the single countries consist of three elements, i.e., business investments (INV-bus), government investments (INV-gov) and private household investments (INV-hh), respectively. Based on these three indicators (cf. Table 5) a partial ordering analysis were performed for the three years included in the study. In Table 5 the overall ranking of the investments for the 27 countries plus EU27 is shown for the three years investigated.

It is immediately noted that the average rank of the EU27 is decreasing from rank 10 in 2010 to 11,5 in 2015 and 16 in 2019, which is indicative that an increasing number of countries have increased the investments to a level higher that the average EU27 level. Thus, significant increases in the investments are, e.g., EST that increased from 19 to 3 to 1 for the years 2010, 2015 and 2019, respectively. Surprisingly, some of the so-called rich-countries like DNK, SWE and LUX (cf. discussion above) are found well below the EU27 level.

Further it is interesting to disclose which of the three indicators that have the more pronounced influence on the investment picture (Figure 3).

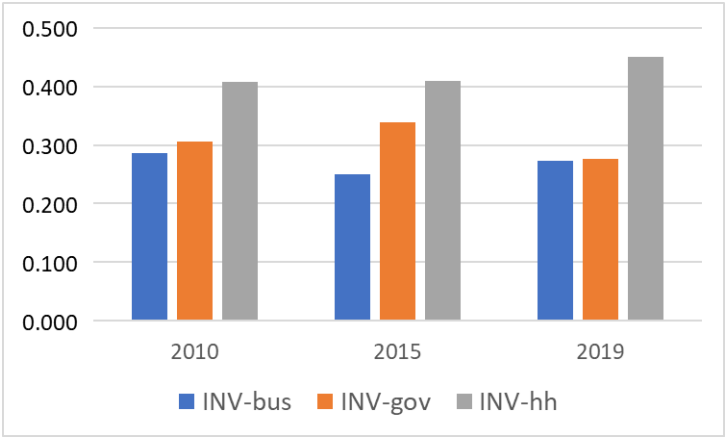

Figure 3. Relative importance of the three investment indicators.

Table 4. Average ranking of the 27 EU member states plus EU27 based on the three investment indicators INV-bus, INV-gov and INV-hh.

ID	2010	2015	2019
AUT	19	8	6
BEL	16.5	6	7
BGR	11	16	na
CYP	7	26	11
CZE	1	2	3
DEU	24	16	8
DNK	26	18.5	10
ESP	5	24	22
EST	19	3	1
EU27	10	11.5	16
FIN	4	6	4
FRA	3	7	5
GRC	21	25	25
HRV	14	21	17
HUN	14	9	2
IRL	27	16	13
ITA	12	23	23
LTU	23	18.5	19
LUX	25	22	na
LVA	19	14	9
NLD	22	11.5	12
POL	8	10	21
PRT	6	27	24
ROU	2	1	14
SVK	14	4	18
SVN	9	20	20
SWE	16.5	13	15

It is immediately noted that the private, household, investment (INV-hh) for all three years is the most influential indicator that even further increases over the years, followed by the business and government investments that more or less play identical roles. Although the absolute value for, e.g., INV-bus are significantly higher that for the private investment (INV-hh) the relatively high importance of the INV-hh should be noted and should probably be further encouraged (for data cf. Appendix 3).

3.3. Analyses of the employment situation

The employment situations, total as well as for males and females, respectively, in the studied countries are summarized in Appendix 4–6 based on the three employment indicators NEET, EmpR and LtUR (cf. table 2). The lower the values mare for NEET and LtUR the better, whereas higher values reflect a better state for EmpR. In Table 5 the average rankings are summarized for 2010, 2015 and 2019, respectively.

Several striking features can be seen from the data in Table 8. Hence, first it can be noted that the

ranking of EU27 appears fairly stable although relatively decreasing especially for females. At the top ranks we find, e.g., SWE, NLD and DNK, whereas ESP, SVK, GRC and ITA are found at rather low ranks, GRC even decreasing over the years, which probably can be ascribed to the economic crisis in the country. Thus, GRC and ITA are found at the very bottom in the 2019 analysis for in total as well as for males and females. It is further noteworthy that in the case of CZE a significant increase over the years develops and for CZE-males even appears at rank 1 for both 2015 and 2019.

It turns out that relative importance of the three indicators is rather similar although a slight tendency, especially in the case of females that the long-term unemployment rate (LtUR) is slightly dominating on the expense of NEET and EmpR in the ranking of the employment situations. Hence, based on these analyses it appears not surprising that the task to fight unemployment and getting young people on the labor market is still an important task, especially in, e.g., the South European countries.

Table 5. Average ranking of the 27 EU member states plus EU27 based on the three employment indicators NEET, EmpR and LtUR.

	2010			2015			2019		
ID	Total	Males	Females	Total	Males	Females	Total	Males	Females
AUT	3	4	4	5	7	4	8	9	11
BEL	12	16.5	10	18	22	17	20	23	18
BGR	22	25	24	24	23	23	23	22	22
CYP	6	5	8	22	24	22	19	15	19
CZE	10	6	16	7	1	11	3	1	5
DEU	7	8	9	3	4	2	4	6	3
DNK	4	7	1.5	2	3	3	6	7	4
ESP	27	23	25	25.5	26	24.5	26	26	25
EST	18	24	15	8	8	9	7	5	9
EU27	16	15	13	20	16	21	18	19	20
FIN	8	9	6	9	11	7	9	16	6
FRA	11	16.5	11	15	20	12	22	24	21
GRC	19	13	28	28	28	28	27.5	28	27
HRV	23	22	22	25.5	27	24.5	25	25	23
HUN	25	21	23	16	10	19	16	10	17
IRL	21	26	19	17	15	14	14	12	13
ITA	24	19	26	27	25	27	27.5	27	28
LTU	20	27	12	10	13	8	13	18	8
LUX	5	2	5	6	5	6	10	14	10
LVA	28	28	20	12	18	10	15	21	12
MLT	17	11	21	11	9	18	5	4	7
NLD	1	1	3	4	6	5	2	2	2
POL	14	14	17	14	12	15	12	8	16
PRT	15	18	14	19	21	16	17	13	15
ROU	13	12	18	21	19	20	24	17	24
SVK	26	20	27	23	17	26	21	20	26
SVN	9	10	7	13	14	13	11	11	14
SWE	2	3	1.5	1	2	1	1	3	1

4. Conclusions and outlook

Based on five main indicators, real GDP (GDP), investment share of GDP by institutional sectors (INV), young people neither in employment nor in education and training (NEET), employment rate (EmpR) and long-term unemployment rate (LtUR) the paper has described the mutual relation between the 27 European Union member states using the population averaged values for the European Union (EU27) as a reference in order to disclose the state of the single countries within the Union in their attempt to comply with the Sustainable Development Goal No. 8 (SDG 8), Decent work and Economic growth. Three set of analyses, applying partial order methodology have been performed: (1) an overall analysis taken all five indicators simultaneously into account (Table 3). (2) the investment profiles of the countries applying investment from business, government of households as indicators (Table 4) and (3) the employment situation in the single countries with the NEET, EmpR and LtUR as indicators (Table 5). This analysis for carried out for the total population, the male population, and the female population.

In all cases the average ranking of the 27 member states plus the EU27 were derived as well as the more important indicators for the actual ranking. Rather clear-cut pictures developed and as such the results constitute a potentially valuable decision support tool for politicians, authorities, and regulators in attempts to focus on specific areas that eventually will bring the given country in compliance with the SDG 8. Further the results give an indication of the actual situation within the EU, i.e., which countries are higher (or better) than the average Union and which countries are lower (worse) and gain valuable support to specific focus areas for the single countries to improve their relative state within the EU.

The partial order methodology that allows inclusion of several indicators simultaneously without any pretreatment such as aggregation has here been demonstrated to constitute a highly advantageous decision support tool not only to mutually rank the single countries but, possibly from a decision makers perspective even more important to disclose the relative influence of the single indicators as this is not disguised through some more or less subjective aggregation, which is often seen in studies analyzing multi-indicator systems.

The method can without difficulties be applied to other multi-indicator systems (MIS).

Conflict of interest

The author declares no conflicts of interest in this paper.

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