

# Synthetic Indicators of Quality of Life in Europe

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**Abstract** For more than three decades now, sociologists, politicians and economists have used a wide range of statistical and econometric techniques to analyse and measure the quality of life of individuals with the aim of obtaining useful instruments for social, political and economic decision making. The aim of this paper is to analyse the advantages and disadvantages of three possible methodologies for obtaining synthetic indicators for the area of welfare and quality of life. These methodologies are Principal Components Analysis, Data Envelopment Analysis and Measure of Distance  $P_2$ . Furthermore this paper analyses quality of life in the European Union (EU), as a methodological exercise to demonstrate the principles of calculation, implications and differences between the three indicator-construction approaches. This analysis is particularly useful in a scene like the EU, immersed in a deep transformation process and with profound cultural, economic and social inequalities. Therefore, an analysis of the quality of life and well-being of its inhabitants can play a major role in ironing out such differences.

**Keywords** Quality of life · Synthetic indicators · Distance measures · Data envelopment analysis · Principal components analysis

## 1 Introduction

The analysis of quality of life and social welfare is considered one of the main challenges of economic science in view of its important role in political, social and economic areas. In

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this respect, several approaches have been employed, but perhaps the most important and generalized is the social indicators approach through which social welfare is decomposed into several components, each component defining a social indicator and the combination of all the indicators determining the social welfare status. Consequently, synthetic indicators are designed to combine the information provided by each social indicator for the purpose of offering a global synthesis of all such indicators, in other words, to offer a welfare indicator. In this respect, synthetic indicator-construction methods are particularly interesting in this field of research, especially within the European Union (EU) context.

The enlargement of the EU places us in a scene with enormous cultural diversity and large disparities in the living conditions and material resources of the inhabitants of EU countries. To reach economic integration and social cohesion and to adopt measures to improve living conditions and reduce differences between countries, politicians need precise information on how people live and how they perceive their lives.

The Lisbon Summit puts social policy at the centre of EU policy, as opposed to its traditional economic policy focused on quantitative growth. Nowadays, social progress is no longer exclusively associated with higher living standards as the qualitative dimension must also be taken into consideration. Furthermore, the concept of “quality of life” cannot be exclusively defined in terms of objective living conditions (income, house, etc.), as we must also consider subjective aspects like Europeans’ perceptions of their quality of life. In this paper, we combine these subjective perceptions with objective conditions to analyse the quality of life of Europeans using a synthetic indicator of quality of life (QOLI).

In the first part, this paper analyses the advantages and disadvantages of three possible methodologies for obtaining synthetic indicators for the area of welfare and quality of life: Principal Components Analysis, Data Envelopment Analysis and Measure of Distance  $P_2$ , as mechanisms for designing synthetic indicators of quality of life.

*Principal components analysis* (PCA) is a technique included in multivariate analysis, and will be used in the following section to obtain a synthetic indicator of well-being.

*Data Envelopment Analysis* (DEA) has traditionally been used to estimate the relative efficiency of a set of productive units. In recent years, other applications that employ DEA to obtain synthetic indicators of well-being and quality of life have been developed. This method will be used to try to obtain a synthetic indicator of “quality of life”.

Finally, we will introduce the *measurement of the  $P_2$  distance* approach into the concept of “quality of life”, a synthetic indicator that adds the information contained in a set of social indicators which is designed to make inter-spatial and inter-temporary comparisons.

In the second part, this paper analyses quality of life in the EU, as a methodological exercise to demonstrate the principles of calculation, implications and differences of the three indicator-construction approaches.

In particular, we will clarify some aspects of the concept of “quality of life” and select the possible indicators to measure and analyse this concept in the group of European countries.

The proposed indicators do not offer an entirely global vision of the concept of quality of life, but we must remember that this is only an exercise to determine how the different methodologies under analysis operate. In this respect, one can consult Somarriba (2008), this work that offers a complete analysis of quality of life in Europe using a total of 110 indicators.

After applying these methods, we will compare the results obtained by analysing the advantages and disadvantages of each methodology.

## 2 A Review of Methodologies of Composite Synthetic Indicators of Quality of Life

One of the major problems of constructing quality of life indicators is determining an appropriate aggregation method for incorporating multi-dimensional quality of life variables into an overall index. In this section three possible methods of composite synthetic indicators are evaluated and compared, emphasising their advantages and disadvantages.

### 2.1 Principal Components Analysis

The method of principal components has been used by several authors as a tool for constructing synthetic indicators of quality of life (Ram 1982a, b; Slottje et al. 1991, among others).

This method consists of transforming a set of original variables into another set of uncorrelated principal components. The amount of information incorporated into a component depends on the variability in the data. In the synthetic indicator by principal components the weights of the variables are the factorial loads in the first principal component, which we can consider equivalent to welfare.

Compared with other statistical alternatives, the main advantages of this method are that it is computationally easier, has excellent mathematical properties and avoids duplicity of information. In addition, it can be used in comparisons between countries, settings and time, provided that the separate indices are calculated using the same variables.

However, several authors have criticised Principal Component Analysis as a valid procedure for obtaining synthetic indicators (Pena 1977, Ram 1982a, b, Zarzosa 1996, Mishra 2007, among others). The main criticisms against this methodology as an instrument for constructing synthetic indicators are the following:

The synthetic indicator derived from this procedure is exclusively an ordinal type indicator, and the weights of partial indicators lack socio-economic interpretation.

Additionally, this procedure does not take into account all the non-redundant information as it only explains the variance in the first component and can therefore remove useful information in the synthetic indicator. It also presents some difficulties if one wishes to construct a single index of the variables that are not very highly correlated, the method has a tendency to pick up the subset of highly correlated variables to make the first component and assign marginal weights to relatively poor correlated subsets of variables.

Moreover, the principal components analysis does not allow making inter-spatial or inter-temporary comparisons, except in ordinal comparisons.

In short, rather than its aggregation ability, the interesting aspect of Principal Components Analysis to obtain synthetic indicators is that it is a useful method of selecting variables.

### 2.2 Data Envelopment Analysis

The Data Envelopment Analysis methodology has been traditionally used to estimate the relative efficiency of a set of productive units, DMU (DMU = Decision Making Units). In the last few years, other applications which include DEA as a possible tool for obtaining synthetic indicators have been developed.

Data Envelopment Analysis is in origin a non-parametric technical procedure that uses a technique of linear programming to evaluate the relative efficiency of a set of homogenous productive units. For this, it makes use of the amounts of inputs and outputs consumed and

produced by each unit using linear programming techniques. DEA is constructed based on examples of best practice, i.e., the efficient production frontier, based on which the efficiency of each unit is evaluated.

In our field of study, the last few years have seen several works that employ this method for obtaining synthetic indicators of well-being and quality of life, namely, Hashimoto and Kodama (1997), Despotis (2004a, b), Mahlberg and Obersteiner (2001), among others. However, applications in this field of investigation are still few and far between.

Examples of these initial works are the proposals for estimating an index of social welfare and quality of life put forward in Japan by authors like Hashimoto and Ishikawa (1993) and Hashimoto and Kodama (1997).

Also worth mentioning is the work of Murias et al. (2006), which uses DEA to aggregate partial indicators relative to the Spanish provinces.

As regards restrictions, the work of Cherchye and Kuosmanen (2002), which proposes the use of DEA to obtain a Meta Index of Sustainable Development, is worth mentioning.

The work of Raab et al. (2000), where DEA is used to construct an index of child quality of life in a group of underdeveloped countries, is also very interesting.

Mahlberg and Obersteiner (2001) suggest an alternative method of calculating the HDI (Human Development Index) using the same indicators as in the HDI. Other related work includes Despotis (2004a, b), which develops a reformulation of the HDI for Asia and the Pacific by means of linear programming, and the work of Zhu (2001).

On the following, we will present the principles of this model.

It is a process characterised by constant returns on scale in which  $m$  inputs are used in the production of  $s$  outputs and for which there are  $n$  observations corresponding to  $n$  productive units (DMU), the technical efficiency of a certain unit 0 can be estimated through the following linear program (Murias et al. 2006):

$$\text{Max } h_0 = \frac{\sum_{r=1}^s u_r y_{rj_0}}{\sum_{i=1}^m v_i x_{ij_0}}$$

s.t.:

$$\frac{\sum_{r=1}^s u_r y_{rj}}{\sum_{i=1}^m v_i x_{ij}} \leq 1 \quad j = 1, \dots, n$$

$$u_r, v_i \geq 0 \quad r = 1, \dots, s; \quad i = 1, \dots, m$$

where  $h_0$  is the objective function,  $u_r$  is the weight of the output  $r$ ,  $v_i$  is the weight of the input  $i$ ,  $y_{rj}$  is the amount of the output  $r$  of the unit  $j$  and  $x_{ij}$  is the amount of the input  $i$  of the unit  $j$ .

The objective of this model is to maximise a type of index of total productivity of factors for each unit (units of output produced by each unit of input used). The numerator of the index is the sum of all the outputs; likewise, the denominator is the sum of all the inputs. Nevertheless, for that aggregation a conventional system of prices is not used, instead we use a set of weights ( $u_1, \dots, u_s, v_1, \dots, v_m$ ) whose value is what we are searching in a way that maximises the ratio for each unit.

Two of the main *advantages* are its technical emphasis and *flexibility*, given that it is not necessary for all the units to give the same importance to the same partial indicator. Also, this flexibility can be adjusted with the introduction of additional restrictions that allow the incorporation of additional information into the model.

In addition, the program itself determines the weights, which implies an *absence of value judgements* on the part of the investigator in relation to the relative importance of each variable for determining the efficiency of a unit (DMU).

We will provide *information broken down by units* (countries, cities, individuals, etc.), which can also be used to analyse sensitivity and stability for establishing action guidelines to improve efficiency (welfare).

One of the *disadvantages* of this procedure is that the programme can assign a zero or very low weight to a specific factor which, from a theoretical point of view, is very important.

Furthermore, this method does not define in a sufficiently precise manner which the data is output and which is input within the context of measurement of quality of life, therefore when the variables are defined by the investigator as input or output some arbitrariness may be introduced into the model.

On the other hand, this method can show multiple virtual solutions [virtual inputs and outputs] and the existence of restrictions could cause problems of non-feasibility.

### 2.3 P<sub>2</sub> Distance

The P<sub>2</sub> distance, defined by Professor Pena (1977), is a synthetic indicator that adds the information contained in a set of social indicators and it is designed to make *inter-spatial* and *inter-temporary comparisons*.

A theoretical country that reaches the worse variable values of the object of study is taken as a reference. The DP<sub>2</sub> indicator calculates the distances of each country with respect to that theoretical country of reference.

The P2 distance is defined as follows:

$$DP_{2j} = \sum_i \left\{ \left( \frac{d_i}{\sigma_i} \right) \left( 1 - R_{i,i-1,\dots,1}^2 \right) \right\};$$

with  $R_1^2 = 0$ ; where  $d_i = d_i(r^*) = |x_{ri} - x_{*i}|$  and the reference base is  $X_* = (x_{*1}, x_{*2}, \dots, x_{*n})$ , where  $m$  is the number of countries,  $n$  is the number of variables,  $x_{ij}$  is the value of the variable  $i$  in the country  $j$ ,  $\sigma_i$  is the standard deviation of the variable  $i$ ,  $R_{i,i-1,\dots,1}^2$  is the coefficient of determination in the regression of  $X_i$  over  $X_{i-1}, X_{i-2}, \dots, X_1$ .

This indicator satisfies the properties of non-negativity, commutativity and triangular condition as well as such properties as existence, determination, monotony, unicity, transitivity, invariance to change of origin and/or scale of the units in which the variables are defined as invariances to a change in the general conditions and exhaustiveness of the reference base [See Pena (1977), Zarzosa (1996)].

Besides these properties, the indicator solves a large number of problems such as the aggregation of variables expressed in different measures, arbitrary weights and duplicity of information.

The order of entrance of the partial indicators and the determination of the weights of each variable is determined through an iterative algorithm that reaches convergence when the indicator fulfils a set of desirable properties. The order of entrance of the partial indicators is obtaining in accordance to the absolute values of the coefficients of linear correlation between the values of the indicators and the synthetic indicator.

In addition, by means of a correction factors  $\left( 1 - R_{i,i-1,\dots,1}^2 \right)$ , the new information is retained by incorporating the only new information and avoiding the duplicated one. These factors are the weights of the partial indicators.

In order to guarantee the fulfilment of the properties of the synthetic indicator certain variables whose increase implies a worsening of the quality of life were multiplied by  $-1$  so that an increase in the value of any variable might mean an improvement in the quality of life. As in the case of DEA, the requirement of this method to classify the indicators as inputs or outputs could introduce some subjectivism into the procedure.

### 3 The Concept of Quality of Life and Selection of Indicators

In recent years many papers have been written about the concept of “quality of life”. Nevertheless, there is no consensus on a universally accepted definition. Research into “quality of life” has been approached in different ways by European researchers. These approaches respond to the variety of definitions present in the different cultures.

In this paper, we are adopting the approach of “having, loving and being”. This approach was introduced into quality of life research by Allardt through the Scandinavian Welfare Survey. This survey was conducted in Denmark, Finland, Norway and Sweden (Allardt 1975) and belongs to the so-called Scandinavian approach to quality of life.

Allardt invented his famous “having, loving and being” to give a more complete description of the human condition. His work is based on Galtung’s “basic needs approach”:

- “Having” has to do with the material conditions of human development and existence. This dimension is closer to the resources approach and it refers to material living conditions.
- “Loving” is related with the necessity to be related to other people and to form social identities. This dimension is related to the family, friends and neighbours.
- “Being” refers to the necessity of integrating ourselves in society and living in harmony with nature.

Apart from incorporating the dimensions of having loving and being, another interesting aspect of Allardt’s approach is that it uses subjective measurement. In our empirical analysis this proposal has a double interest because it introduces subjective information and provides a panoramic picture of the principal components of the concept of quality of life from the point of view of the individual.

Many scholars and researchers have used this approach in their investigations because it is more simple and intuitive.

In our case, the following definition of quality of life is adopted:

*“Quality of life is the result of complex interactions between a set of objective and subjective factors: the first refers to external conditions of an economic, socio-political, environmental and cultural nature, whilst the subjective factors refer to the individual’s perception of his life and the satisfaction reached in the diverse dimensions of his life”* [Somarriba (2008), p. 14].

One of the objectives of this paper is to design a synthetic indicator of quality of life in European Union countries and Turkey. Our work includes a total of 28 countries and each country is the basic unit of analysis.

Our sources include the Candidate Countries Eurobarometer (CCEB), the Standard Eurobarometer Surveys (EB), The European Social Survey (2002) and the reports of the European Foundation for Improvement of Living and Working Conditions, among others.

In view of the absence of a European Survey on Quality of Life common to all the countries under analysis, combining different sources of data is the best solution for approaching this analysis. However, this choice has its problems. For example, the surveys refer to different periods of time, therefore time comparisons are restricted.

Based on the information available, we suggest working with the following indicators that reflect aspects like work, accommodation, education, leisure time, etc. We have also included such dimensions as income and health and individuals' self-assessment of their lives.

Unfortunately, the lack of indicators for all 28 countries means that certain dimensions are not well represented.

As an indicator of access to *employment*, we have selected the specific country's employment rate. Also, as an indicator of job quality, we have considered the individual's assessment of his/her job satisfaction rather than other traditional indicators, such as wages. As another indicator, we have considered the percentage of individuals who perceive their job as stressful, observing that many individuals consider their jobs both satisfying and stressful. As one of the main problems of today's society, stress has a very negative impact on quality of life.

Access to decent *accommodation* in a good area is a sign of material resources and status. In this respect, we decided to incorporate two indicators of perception: the individual's satisfaction with his/her house and the individual's satisfaction with his/her area.

The *education dimension* indicators cover the individual's satisfaction with the education received, school life expectancy and distance to the nearest primary school. These three indicators offer a good picture of quality of education. It is worth bearing in mind the large heterogeneity that exists between the different countries in the area of education.

As for *leisure*, given the absence of indicators for the group of European countries, we have only selected one indicator that covers insufficient time for hobbies and interests.

As regards *income*, the three variables considered are income, measurement of inequality and the individual's satisfaction with his/her standard of living.

Another dimension considered as an essential indicator of welfare is *health*. On this point, the indicators considered are life expectancy at birth, life expectancy at the age of 65, the percentage of individuals who are very or fairly satisfied with their health, and the individual's assessment of the quality of the health system.

We have also included aspects like the individual's *family*, *friends*, and *social life*. We must remember that having a partner was one of the aspects most valued by Europeans. We have selected indicators like the individual's satisfaction with his/her family, the individual's satisfaction with his/her social life and people's capacity to trust other people.

Furthermore, we have selected an indicator that reflects the climate of confidence and the safety of the individual's environment, namely, whether the individual feels unsafe when walking in the street at night and his/her confidence in the judicial system.

Finally, two other indicators of a broader nature have been considered: *general satisfaction with one's life* and *happiness*, as they both represent the so-called subjective well-being.

#### 4 Synthetic Indicators of Quality of Life, an Empirical Case for Europe

In this section, through the set of indicators defined above, we will assess and compare the results of each of the three methods described previously. This empirical example will allow us study some of the advantages and disadvantages of each of the methodologies.

**Table 1** Ranking of countries in the synthetic indicator by principal components analysis

Country	Ranking
Denmark	1
Luxembourg	2
Sweden	3
Finland	4
Belgium	5
Netherlands	6
UK	7
Germany	8
France	9
Austria	10
Ireland	11
Italy	12
Cyprus	13
Malta	14
Spain	15
Slovenia	16
Portugal	17
Czech Republic	18
Greece	19
Poland	20
Hungary	21
Turkey	22
Slovakia	23
Estonia	24
Lithuania	25
Latvia	26
Romania	27
Bulgaria	28

#### 4.1 Principal Component Index

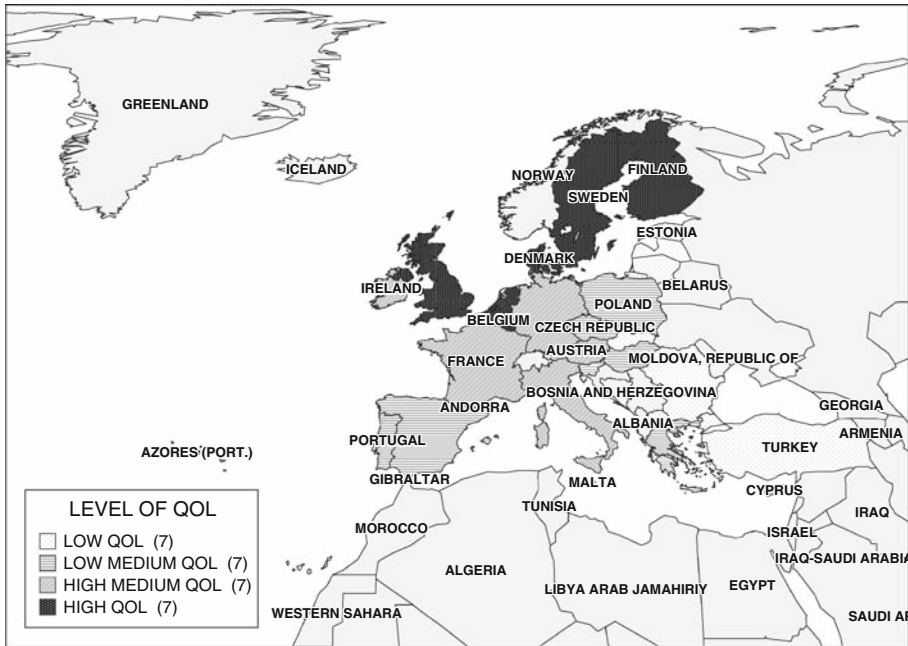
Table 1 shows the ranking of countries obtained when we apply the principal components analysis to our variables (23). The first of the components explains only 56% of the total variance; the percentage of information that this procedure does not take into account, all non-redundant information, is very high, 44% of the total variance.

In view of the ranking, the countries have been classified into four groups,<sup>1</sup> as shown in Fig. 1.

We must stress the fact that the indicator, obtained through the principal components analysis, is only an ordinal measurement and the weights, which are factorial loads of the first component, do not have an economic interpretation.

The first group comprised of the Nordic countries (Sweden, Finland, Denmark), the Netherlands, Luxembourg, Belgium and the UK, heads the ranking.

<sup>1</sup> The countries have been grouped in 7 to 7 simply to facilitate comments.



**Fig. 1** Synthetic indicator by principal components analysis

The second group is made up of France, Ireland, Germany, Austria, and Italy (from the EU 15) and two recent accession countries, Malta and Cyprus (Mediterranean countries).

The third group includes Spain, Portugal, Poland, Czech Republic, Hungary, Slovenia and Greece (three Mediterranean countries of the EU 15 and four Eastern European countries).

The last group is made up of the rest of the recent accession countries, i.e., the Baltic countries (Estonia, Lithuania and Latvia) and Slovakia, together with Turkey, Romania and Bulgaria.

#### 4.2 DEA Index

We will now apply the DEA of our set of indicators to all the above-mentioned 28 countries.

As a prior step, we must classify the partial indicators of a negative nature as inputs (the smaller the value the better) and those of a positive nature as outputs (the greater the value the better). This process introduces some arbitrariness into the method.

With the objective of adding realism to our analysis, we will introduce information about the individual's experiences and/or expert opinions by incorporating additional restrictions into the model. Although each DMU weighs the indicators differently, we can assign the importance of one indicator as greater than or equal to the other indicator; this variant of the DEA is widely known as Assurance Region [DEA/AR]. Therefore, we can discriminate the importance of social indicators by bounding the ratios of weights in accordance with the answers to the following question, which provide information on what aspects people consider as essential to enjoying a good life:

**Table 2** The percentage of answers from the question Eurobarometer 56.1

Having a good job	91
Having sufficient accommodation	89
Having a good education	84
Having sufficient leisure time	83
Going out with friends and family	79
Having at least one holiday a year	69
Living with a partner	80
Seeing friends regularly	72
Being on friendly terms with neighbours	69
Having children	60
Being able to be useful to others	80
Feeling recognised by society	67
Having a successful career	54
Participation in associations, etc.	23

Source CCEB, EB 56.1, quoted in Delhey (2005)

Eurobarometer 56.1: “*Not everybody has the same idea about what are the necessities of good life. Please tell me if each of the following is absolutely necessary for leading a good life?*”

The question has 14 possible answers; the Table 2 shows the percentage of answers.

In order to obtain our DEA indicator a linear variant of the previously presented model has been calculated for each of the countries and completed with the indicated restrictions about the preferences.

We work with an input orientation. This is our system of preferences:

- $W[\text{having a good job}] \geq W[\text{having a good home}]$
- $W[\text{having a good home}] \geq W[\text{having a good education}]$
- $W[\text{having a good education}] \geq W[\text{leisure time}]$
- $W[\text{leisure time}] \geq W[\text{family}]$
- $W[\text{family}] \geq W[\text{Social life}]$

There are not any restrictions in relation to “health” and “income”.

Table 3 shows the values of the DEA synthetic indicator for each country and the weights of the indicators.

Only seven out of twenty-eight countries are judged DEA inefficient. The number of countries with unitary indicator is so high that it leads us to believe that the indicator overvalues the quality of life of the countries, offering little information to our analysis.

These inefficient countries can be better observed in Fig. 2.

Of the seven inefficient countries, four are Eastern European (Bulgaria, Estonia, Poland and Romania), two are Southern European (Italy and Portugal) and one is Central European (France), although the value of the indicator is very close to one.

Of course, the values of the weights depend on the restrictions that we have previously imposed on them, although some components like “income” and “health” have not been restricted.

One of the disadvantages of the method of DEA for composite synthetic indicators is that the programme can assign a zero or very low weighting to factors which, from a theoretical point of view, are very important to this analysis. Indicators like “leisure time”, “satisfaction with education”, “school life expectancy”, “satisfaction with one’s family”

**Table 3** Ranking of countries in the synthetic indicators by DEA/AR

	Country	Score
1	Austria	100.00
2	Belgium	100.00
3	Bulgaria	96.74%
4	Cyprus	100.00
5	Czech Republic	100.00
6	Denmark	100.00
7	Estonia	87.13%
8	Finland	100.00
9	France	98.41%
10	Germany	100.00
11	Greece	100.00
12	Hungary	100.00
13	Ireland	100.00
14	Italy	91.48%
15	Latvia	100.00
16	Lithuania	100.00
17	Luxembourg	100.00
18	Malta	100.00
19	Netherlands	100.00
20	Poland	89.07%
21	Portugal	96.86%
22	Romania	93.19%
23	Slovakia	100.00
24	Slovenia	100.00
25	Spain	100.00
26	Sweden	100.00
27	Turkey	100.00
28	UK	100.00

and “satisfaction with one’s social life” are not used in the construction of DEA indicators in our example.

#### 4.3 $P_2$ Distance Index

To ensure the fulfilment of the properties of the synthetic indicator, certain variables whose increase implies a worsening of the quality of life were multiplied by  $-1$ , so that an increase in the value of any variable might mean an improvement in quality of life; remember that this was the only inconvenience of this methodology.

In Table 4, the variables have been ordered in accordance with their order of entrance, namely, according to the absolute values of the coefficients of linear correlation between the values of the indicator for each country and the synthetic indicator ( $|r|$ ). The table shows the variables in order, the relevance of each variable and the correction factor  $(1 - R^2)$  which indicates the new incorporated information of each variable. Remember



**Fig. 2** Synthetic indicator by DEA

**Table 4** Ranking of the variables according to order of entrance in the DP<sub>2</sub> and correction factors

Variables	r	1 - R <sup>2</sup>
Satisfaction with standard of living	0.95912	1
Happiness	0.935751	0.75672
Life satisfaction	0.908742	0.282711
Home satisfaction	0.902438	0.107096
Social life satisfaction	0.896977	0.133518
Income	0.882134	0.253226
Job satisfaction	0.8668	0.251388
Health system satisfaction	0.863417	0.212143
Living satisfaction area	0.832107	0.239626
Health satisfaction	0.814873	0.213639
Life expectancy at birth	0.804973	0.262129
Unsafety	0.797519	0.242063
Trust people	0.742118	0.31871
Life Expectancy at the age of 65	0.726429	0.07724
Family satisfaction	0.69298	0.142613
Schoolife expectancy	0.620929	0.235036
Employment	0.612227	0.318191
Education satisfaction	0.601613	0.101605
Leisure time	0.550477	0.310349
Trust in judicial system	0.486091	0.244698
Inequality	0.451193	0.2146
Distance to school	0.227183	0.287309
Stress	0.18028	0.237719

that this procedure only eliminates the redundant information, which was one of the advantages.

The first variable in order of entrance is “satisfaction with the standard of living” which has a correction factor of 100%. This means that 100% of the information of this indicator is introduced in the measurement of welfare. The next variable in order of entrance is “happiness”, which retains ~75% of the information.

Traditional variables in welfare studies such as “income” and “inequality” lose importance in the presence of subjective information. We can see how “income” is in position six and retains only 25% of the information, and “inequality” is in position 21 and retains also only 21%.

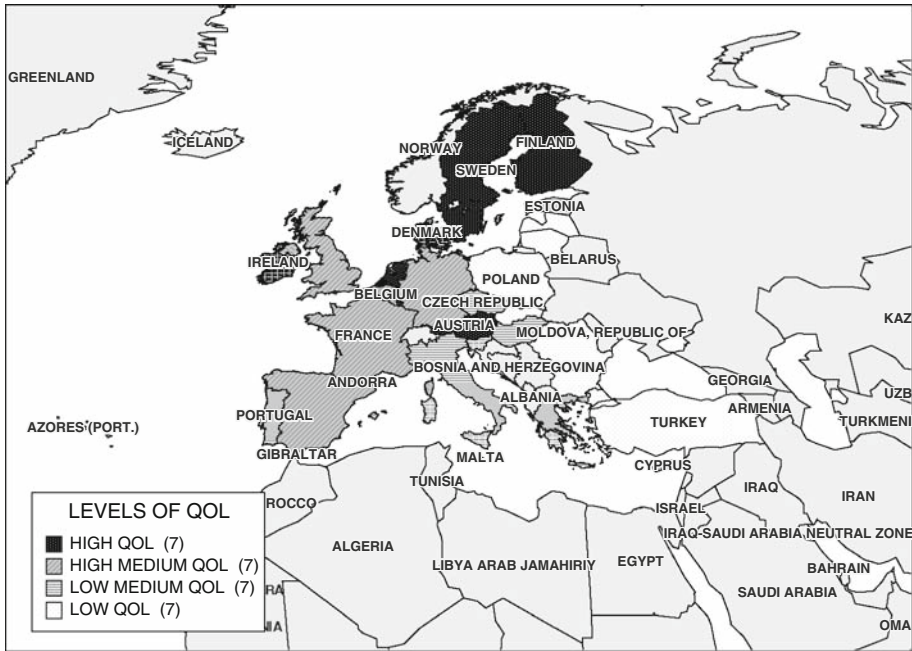
Now we can see the ranking of the countries in the  $DP_2$  in the Table 5 and in Fig. 3:

Based on the results obtained in the  $DP_2$  measure, we have classified the countries into four groups:

- Group 1: includes the Nordic countries, Finland, Denmark and Sweden as well as the area formed by the Netherlands, Luxembourg, Ireland and Austria.

**Table 5** Ranking of countries in the synthetic indicator by  $DP_2$  measure

Country	$DP_2$	Means by group
Denmark	19.942	17.525
Luxembourg	17.636	
Sweden	17.351	
Netherlands	17.2226	
Austria	17.118	
Finland	16.839	
Ireland	16.568	
United Kingdom	16.431	14.761
Belgium	16.049	
Malta	14.481	
Germany	14.376	
Spain	14.194	
France	14.095	
Cyprus	13.702	
Slovenia	13.174	11.436
Italy	13.172	
Portugal	11.520	
Czech Republic	11.305	
Greece	11.207	
Hungary	10.26	
Estonia	9.406	
Poland	8.754	7.811
Lithuania	8.7022	
Slovakia	8.485	
Romania	8.464	
Latvia	8.414	
Turkey	6.845	
Bulgaria	5.013	



**Fig. 3** Synthetic indicator by  $DP_2$  measure

- Group 2: contains the strip formed by Spain, France, Germany and Belgium and the UK, along with two Mediterranean countries, Malta and Cyprus, which present surprisingly high quality of life levels. The results of these countries are similar to those of the principal components analysis.
- Group 3: this group includes Italy, Slovenia, Czech Republic, Hungary and Estonia and two traditional countries of the EU, Portugal and Greece.
- Group 4: this last group includes Latvia, Lithuania, Poland, Slovakia, Romania, Bulgaria and Turkey. These countries form a strip that delimits the Eastern area of Europe.

Compared with the principal components analysis, this method presents many advantages because it satisfies a large number of interesting properties, it is a cardinal measurement and the weights have a clearer interpretation. We will go back to this point in the last section of this paper.

The following Tables 6 and 7 show the distances between the resources of the groups of countries, in units and percentages. The tables show large differences between North and Central European countries and Eastern European and candidate countries.

**Table 6** Distance units

	g1	g2	g3	g4
g1	–	2.7641	6.0894	9.7142
g2	–	–	3.3253	6.9500
g3	–	–	–	3.6248
g4	–	–	–	–

**Table 7** Distance %

	g1	g2	g3	g4
g1	–	0.8423	0.6525	0.4457
g2	–	–	0.7743	0.5291
g3	–	–	–	0.6830
g4	–	–	–	–

**Table 8** Comparison of the synthetic indicators PCA, DP<sub>2</sub>, DEA/AR

Country	PCA	DP <sub>2</sub>	DEA/AR
Austria	2	1	
Belgium	1	2	
Bulgaria	4	4	4
Cyprus	2	2	
Czech Republic	3	3	
Denmark	1	1	
Estonia	4	3	4
Finland	1	1	
France	2	2	4
Germany	2	2	
Greece	3	3	
Hungary	3	3	
Ireland	2	1	
Italy	2	3	4
Latvia	4	4	
Lithuania	4	4	
Luxembourg	1	1	
Malta	2	2	
Netherlands	1	1	
Poland	3	4	4
Portugal	3	3	4
Romania	4	4	4
Slovakia	4	4	
Slovenia	3	3	
Spain	3	2	
Sweden	1	1	
Turkey	4	4	
UK	1	2	

#### 4.4 Comparison of Results

Table 8 shows the classification of the different countries in relation to the results obtained in the three synthetic indicators [PCA, DP<sub>2</sub>, DEA/AR]. The countries had been classified on the basis of their quality of life levels (1 = high, 2 = high-medium, 3 = low-medium and 4 = low).

The classifications according to the PCA and the  $DP_2$  indicators coincide in a percentage of 71. In the case of the DEA indicator, the results are contradictory: on three occasions its classification does not agree with any of the other two indicators, on one occasion it agrees with indicator PCA, on one occasion with  $DP_2$  and on two occasions with both simultaneously. This result, together with the low discrimination power of this indicator (DEA), raises doubts about its quality.

## 5 Conclusions

The evaluation of quality of life involves assessing multiple aspects of society and implies the simultaneous use of many social indicators. In this multidimensional evaluation, defining an appropriate aggregation method to combine multi-dimensional quality of life variables in an overall index is extremely important.

In this paper, three possible methods of composite synthetic indicators are evaluated and compared through an empirical example in the context of the EU.

The method of *principal components*, which is considered representative of the family of factorial analysis methods, raises a number of problems as a method for composite synthetic indicator of quality of life:

- Its application only allows ordering cases; it is an ordinal measure, whereas the measurement of welfare requires cardinal type measures.
- In this synthetic indicator by principal components, the weights of the variables are the respective factorial loads in the first component. From a mathematical point of view, the meaning of these weights is clear, but it makes little sense in relation to our objective of measuring well-being.
- This method solves the problem of correlations but the resulting synthetic indicator does not include all the non-redundant information of the variables.
- The principal components analysis does not allow making inter-spatial and inter-temporary comparisons, only ordinal comparisons, as opposed to the DEA and  $DP_2$  methods.

*Data Envelopment Analysis* is useful for constructing synthetic indicators and it facilitates spatial and temporary comparisons.

This method can guarantee impartiality in the weights and allows the introduction of expert opinions and individuals' perceptions of their welfare. Each analysis of country or unit can determine their weight in an objective manner and this freedom can be controlled with the introduction of additional restrictions.

By contrast, this method presents disadvantages, since it can show multiple virtual solutions [virtual inputs and outputs] and the existence of restrictions can cause problems of non-feasibility. Furthermore, this method fails to define in a sufficiently precise manner which data is output and which is input within the context of measurement of quality of life. As a result, when the investigator defines the variables as inputs or outputs, some arbitrariness is introduced into the model. Additionally, in this study, this method overvalues the level of quality of life and lacks discrimination power to classify the countries.

In our opinion, of the three methods analysed, the synthetic indicator of the  $P_2$  distance (Pena 1977) has shown that it is the optimal method of obtaining synthetic indicators of well-being:

- This measurement verifies a set of properties that guarantee that the weight of the partial indicators is determined in a non-arbitrary manner.
- The obtained weights have an economic interpretation, whilst the weights derived from the principal components analysis did not.
- In addition, as a cardinal measurement, it is a distance measurement, which allows us to make comparisons in time and space.

The only disadvantage of this method is that introduces certain subjectivism into the procedure when classifying the indicator as positive or negative, since an increase in the value of any variable might mean an improvement of the quality of life.

Based on this indicator, Europe displays a strong polarization between, on the one hand, Nordic countries and Austria and, on the other hand, Eastern European and the new accession countries. The distance between the averages of both groups is 9.71 units in relation to the reference base. The rest of the countries are between those extremes.

### **Appendix: Description of the Indicators**

The indicators are the following:

- Satisfaction with the job: percentage of employed people who are not very or not at all satisfied with their job [Working Conditions Survey].
- Employment ratio [European Commission].
- Find work stressful, percentage of employed people who often or always find work stressful [Eurobarometer].
- Satisfaction with the house, proportion of individuals aged 15 and over who are not very satisfied or not at all satisfied with their house [Eurobarometer].
- Satisfaction with the area you live, percentage of individuals aged 15 and over who are not very or not at all satisfied with the area they live in [Eurobarometer].
- Satisfaction with one's education, mean value on a scale of 1 (very dissatisfied) to 10 (very satisfied) with their own education [European Quality of life].
- Distance to the nearest primary school, proportion of people aged 15 and over who don't live within walking distance or within 20 min of the nearest primary school [Eurobarometer].
- School life expectancy, percentage of survival rates [UNESCO].
- Too little time for hobbies and interests, percentage of people aged 18 and over having too little time for hobbies and interests [European Quality of Life].
- Satisfaction with the standard of living. Mean value on a scale of 1 (very dissatisfied) to (very satisfied) with the own present standard of living [European Quality of Life Survey].
- Inequality of income distribution, the ratio of the total received by the 20% of the population with the highest income (top quintile) to that received by the 20% of the population with the lost income (lowest quintile) [European Commission].
- Income, monthly household income [Eurobarometer].
- Life expectancy at birth, it is the average number of years a person would live if, for the time period, the observed age-specific mortality rate remains constant (years) [Eurostat].
- Life expectancy at the age of 65, it is the average number of further years a person at the age of 65 would live if, for the time period, the observed age-specific mortality rates remains constant (years) [Eurostat].

- Satisfaction with the National Health Care System, percentage of individuals who are not very or not at all satisfied with their national health system [Eurobarometer].
- Satisfaction with one's health, percentage of individuals who are very or fairly satisfied with their health [Eurobarometer].
- Satisfaction with the family, mean value on a scale from 1 (very dissatisfied) to 10 (very satisfied) with the family life [European Quality of Life Survey].
- Trust in people, mean value on a scale of 1 (you can't be too careful in dealing with people) to 10 (most people can be trusted) [European Social Survey].
- Satisfaction with social life, percentage of the population aged 15 and over who are very or fairly satisfied with their social life [Standard Eurobarometer]
- Safety: safe to walk around at night, percentage of individuals aged 18 and over who think that it is very unsafe or rather unsafe to walk around the area they live at night [European Quality of Life Survey]
- Confidence in the judicial system, percentage of people aged 15 and over who have not very much confidence or none at all tends in the justice [World Values Survey]
- Satisfaction with one's life, share of individuals aged 15 and over who are very satisfied or fairly satisfied with the family they lead [Eurobarometer].
- Happiness, share of individuals aged 15 and over who are very or fairly satisfied with the life they lead [Standard Eurobarometer].

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