

Measuring World Better Life Frontier: A Composite Indicator for OECD Better Life Index

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Abstract The OECD Better Life initiative recently released a comprehensive set of 11 indicators of well-being covering a group of countries. Each individual indicator corresponds to a key topic that is essential to well-being. However, the problem of aggregating them is left to users of this dataset. Using these as individual indicators, we propose a composite indicator of overall well-being, which is intended to measure the performance of each country in terms of providing well-being to its people. The ‘benefit of the doubt’ approach (BOD), a well-known aggregation tool based on a weighed sum, assigns the most favourable weights for each entity under investigation. BOD may also be considered to evaluate the performance of each entity in terms of its efficiency. Regarding individual indicators as outputs, it constructs the benchmark production frontier from observed individual indicators. A composite indicator based on BOD equals the distance between each entity’s individual indicator and the production frontier, indicating its efficiency. It is widely considered that the well-being of a country’s people stems from its productive base, which is characterized by capital assets and social infrastructures. Thus, the productive base can be considered the input used to produce well-being, which is reflected by individual indicators. Therefore, when we apply BOD to aggregate individual well-being indicators across countries, we implicitly assume that all countries have the same productive base, as BOD addresses only the output and neglects the input. This inaccurate assumption leads to a distorted performance measure. Data envelopment analysis (DEA), in which BOD has its roots, is a tool to measure the efficiency of each entity by allowing for differences in inputs as well as outputs across entities. DEA also measures efficiency by using the distance to the production frontier; however, unlike BOD, DEA constructs the production frontier more accurately by utilizing the information of inputs as well as outputs, leading to a better performance measure. We apply DEA to aggregate 11 individual well-being indicators into a composite indicator using the World Bank’s estimates of each country’s productive base. The composite indicator based on BOD is distributed similarly

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to and is highly correlated with the existing Human Development Indicator (HDI). It is also positively correlated with GDP per capita. On the other hand, we show that the composite indicator based on DEA is negatively correlated with HDI as well as GDP per capita.

Keywords Composite indicators · Better Life Index · Data envelopment analysis · Benefit of the doubt approach

1 Introduction

GDP per capita has long been used as a proxy measure of well-being. However, it is now widely recognized that GDP data provide a partial perspective on the array of factors that affect people's lives. The consensus on the deficiency of per capita income as a measure of well-being has led to a search for alternative measures of well-being. Research over the last two decades has considerably improved our understanding of them. The past research and unresolved issues are summarized in the recommendation of the Commission on the Measurement of Economic Performance and Social Progress, appointed by President Nicholas Sarkozy of France (Stiglitz et al. 2009).

The OECD has actively led the research seeking an alternative measure of well-being. On the occasion of the OECD's 50th Anniversary, held under the theme 'Better Policies for Better Lives', the organization launched the OECD Better Life Initiative. Drawing upon the recommendations of the commission (Stiglitz et al. 2009), the OECD identified 11 dimensions as being essential to well-being. The dimensions cover material living conditions, such as income and wealth, as well as quality of life (QOL), such as community, environment and work–life balance. These dimensions are explored and analysed in detail in Organization for Economic Cooperation and Development (2011). The web-based tool *Your Better Life Index*, a key instrument of the OECD Better Life Initiative, profiles the 34 OECD member countries and two non-member countries across the 11 topics of well-being (known as OECD Better Life Index).¹ However, evaluating the overall well-being by summarizing the 11 individual indicators is left to users of the statistics.²

Since each individual well-being indicator may trend in different directions, the set of 11 individual indicators itself is not enough to compare overall well-being of people across countries. A composite indicator is formed by compiling the underlying individual indicators into a single number. Composite indicators can measure multidimensional concepts, which are characterized by multiple individual indicators. Thus, they are used to analyse a wide range of concepts such as competitiveness, single market integration, sustainability and well-being. A composite indicator of well-being based on the 11 individual indicators also enables a comparison of the overall well-being of people across countries.

There exist many composite indicators and, more specifically, composite indicators of well-being. Despite their increasing use, identifying the ideal composite indicators remains controversial. Much criticism associated with indicator construction stems from the fact that the weights assigned to individual indicators are often fixed, and that individual indicators of all countries are aggregated under these fixed weights (Cherchye et al. 2007).

¹ The number of countries covered was 34 in 2011. The revised dataset released in 2012 includes 36 countries, incorporating Brazil and Russia.

² *Your Better Life Index* (<http://www.oecdbetterlifeindex.org/>) was designed as an interactive tool that allows users to assign the importance of each of the 11 topics and track the performance of countries.

Weight plays a crucial role in the construction of a composite indicator; it determines the trade-offs between underlying individual indicators. Moreover, by assigning zero to the other individual indicators, it selects the set of individual indicators actually incorporated. Thus, weights used to construct the composite indicator of well-being reflect a particular value judgement on how 'good' a life is. Schokkaert (2007) reports much interpersonal variation in people's opinions on the 'good life'. Therefore, no matter how elaborately weights are chosen, people across countries, and even within a society, are very likely to disagree on them. In the context of international comparison of well-being, certain countries (i.e. their authorities or experts) are likely to consider the predetermined fixed weights as unfair because undue importance is attached to individual indicators on which they underperform.³

Among a number of construction techniques of the composite indicator, the 'benefit of the doubt' approach (BOD), which has received increasing attention from researchers, avoids subjectivity in the determination of weights (Mahlberg and Obersteiner 2001; Cherchye et al. 2004, 2007, Despotis 2005a, b and Organization for Economic Cooperation and Development 2008). Under BOD, the weights are country-specific and endogenously determined such that they maximize the value of each country's resulting composite indicator. Thus, larger weights are given to the individual indicators (topics of well-being) on which each country performs well. The core idea is that a good relative score of a country on an individual indicator shows that it considers the individual indicator as relatively important. Therefore, a country cannot attribute the lower score of its composite indicator to a harmful or unfair weighting scheme under the international comparison based on BOD.

BOD is rooted in Data envelopment analysis (DEA), which is designed to compute efficiency indexes. DEA is an established technique to measure the relative efficiency of decision-making units based on inputs and outputs of units in a sample. It measures the efficiency of each unit by its distance from the production frontier, which is represented by the best practice units. BOD is formally tantamount to the input-oriented DEA model, with all individual indicators as outputs and a 'dummy input' equal to one for all countries.⁴ As Dasgupta (2001) and Arrow et al. (2004) advocate, it is widely believed that the productive base of economies, which consists of a variety of capital assets and a social infrastructure, determines the well-being of people. Thus, countries' productive bases are reasonably considered as inputs to achieve greater well-being indicators. There is a wide difference in the productive bases among countries. Thus, BOD's assumption that inputs are invariant across units is inappropriate when computing composite indicators of well-being.

The specification of inputs and outputs enables us to apply the original DEA to evaluating countries' performances in terms of efficiency. Since DEA specifies the best practice countries more appropriately than does BOD, the frontier represented by them correctly describes the benchmark technology of providing well-being. We call this the 'World Better Life Frontier'. This provides an unbiased estimate of efficiency, and thus an accurate measure of countries' performances. The efficiency score on DEA is also the weighted sum of 11 individual indicators, and it defines the DEA composite indicator of well-being. In the present paper, we apply BOD and DEA to compute the composite indicator aggregating 11 individual well-being indicators. A series of studies by the World

³ In addition to the problem of paternalism, Cherchye et al. (2007) also indicate that if weights are fixed, the eventual country ranking depends on the measurement unit and the particular normalization option adopted for individual indicators, such as rescaled scores, distances to goalposts, or z-scores.

⁴ Lovell et al. (1995) interpret the dummy input as a helmsman that pursues several policy objectives.

Bank (Kunte et al. 1998 and World Bank 1997, 2006, 2011) estimates the comprehensive wealth of many countries, which corresponds to their productive bases. Our application of DEA relies on the most recent of these studies (World Bank 2011).

Mahlberg and Obersteiner (2001) was the first study to apply BOD to the construction of a composite indicator of well-being. They revisited the construction procedure of the UN's Human Development Index (HDI) (United Nations Development Program 1990). The existing HDI is a weighted sum of three individual indicators—income, longevity and educational attainment—using the fixed weight. Mahlberg and Obersteiner (2001) propose an alternative HDI based on BOD by endogenizing the weight assigned to the three individual indicators. However, as they admit, the application of BOD does not allow them to distinguish between resources, which differentiate countries' conditions of providing human development or well-being.

Zaim et al. (2001) is an exception that differentiates countries' inputs used for providing well-being to their people.⁵ The production process they consider transforms two inputs (produced capital and labour) into one private good (real GDP) and four social goods (infant survival rate, life expectancy at birth, primary school enrolment rate and secondary school enrolment rate). Although Zaim et al. (2001) construct the frontier more appropriately than does BOD, the constructed frontier is not utilized to evaluate countries' performance in terms of efficiency. Instead, it proposes a measure of QOL called 'achievement index', which aggregates only four social goods and is a quantity index formulated by the frontier. The quantity index is a theoretically well-founded aggregation tool that captures the radial distance between the social goods of a country and the frontier. However, the set of inputs and outputs presented by Zaim et al. (2001) is severely limited relative to the present paper.⁶ Specifically, their index, which aggregates only social goods, fails to capture overall well-being because private goods such as income, wealth and dwellings also affect people's well-being.

There are different approaches to comparing overall well-being across countries, which are also well-founded in economic theory. Fleurbaey and Gaulier (2009) and Jones and Klenow (2010) aggregate several dimensions of well-being by expressing them in monetary units.⁷ The calculation of the former is based on an income equivalent, while that of the latter is based on a consumption equivalent. Both approaches impute the individual preferential attitude to several dimensions of well-being, explicitly using the expected utility function. While they consider several dimensions of well-being as goods being consumed and propose composite indicators (summary statistics in their words) based on consumption theory, we consider them as outputs and propose composite indicators based on production theory.

How would the scores and rankings of countries under our composite indicators based on BOD and DEA differ from those in the previously mentioned studies? Our indicators

⁵ Despotis (2005a, b) also addresses the process of converting countries' resources to well-being or human development. However, they are concerned with countries' capabilities of converting economic prosperity into better lives for their people. Thus, while income is considered as input, life expectancy and adult literacy rate are considered as outputs.

⁶ The definition, based on the ratio of the distance functions, prevents us from interpreting the achievement index as a weighted average of individual indicators of well-being. On the other hand, the index we propose is an efficiency score simply defined by the distance function; it is the weighted average of individual indicators.

⁷ Fleurbaey and Gaulier (2009) deal with leisure, unemployment, health and inequality in addition to income. Jones and Klenow (2010) deal with life expectancy, leisure and inequality in addition to consumption.

compare countries' performance by incorporating more dimensions of well-being, including key dimensions such as environmental equality and health status. Thus, countries showing higher well-being in the dimensions previously missed would be evaluated higher. For example, while countries known for their high environmental quality, such as Luxembourg and the UK, rank relatively low among OECD countries under HDI, Mahlberg and Obersteiner (2001) and Zaim et al. (2001), they might be underestimated and would rank higher under the composite indicator based on BOD.⁸ On the other hand, countries with lower scores in many dimensions of well-being are likely to be economically poor and have a limited productive base. Furthermore, since countries with a smaller productive base are considered to be at a disadvantage in providing well-being to their people, their performance would be more highly valued in terms of efficiency as compared with if inputs are not differentiated. Thus, countries ranked extremely low under HDI or BOD would be valued higher under DEA.

The paper unfolds as follows. Section 2 discusses two approaches to construct a composite indicator. Section 3 explains data of well-being indicators and comprehensive wealth. Section 4 computes composite indicators under different cases and compares them across countries. Section 5 concludes.

2 Methodology

The present paper aggregates 34 countries' 11 individual well-being indicators into composite indicators and compares countries' performance in terms of well-being. We adopt two approaches to construct composite indicators. Since they are sufficiently versatile to be applicable to a variety of problems and situations, we explain them below in a more general setting independent of the number of countries and underlying individual indicators.

We consider that there are K countries and that the well-being of people in a country k is characterized by a set of M individual indicators $\mathbf{y}_k = (y_{1k}, \dots, y_{Mk})$, with y_{mk} representing the value of the m th individual indicator of country k . BOD aggregates these individual indicators using their weighted average. Denoting μ_{mc} as the weight of the m th individual indicator of country c , the composite indicator based on BOD for country c , $CI_{BOD,c}$, is formulated as follows:

$$CI_{BOD,c} = \max_{\mu_{1c}, \dots, \mu_{Mc}} \left\{ \sum_{m=1}^M \mu_{mc} y_{mc} : \sum_{m=1}^M \mu_{mc} y_{mk} \leq 1 \text{ for } k = 1, \dots, K; \mu_{mc} \geq 0 \text{ for } m = 1, \dots, M \right\} \quad (1)$$

For an international comparison, the above procedure is repeated for each country in our sample. The weight $(\mu_{1c}, \dots, \mu_{Mc})$ is endogenously determined to maximize the value of the composite indicator for country c . Thus, a larger weight is assigned to an individual indicator on which the country performs well. In this procedure, the good performance of country c on an individual indicator is considered to indicate that the country prioritizes it. Therefore, countries cannot argue that their poor performance is due to an unfair weighting scheme, because any weight other than that used for their evaluation would not improve their position.

There are two constraints in (1). The first is that every country in a sample has a resulting composite indicator smaller than one when applying the most favourable weights

⁸ Luxembourg also ranks relatively low among OECD countries in Jones and Klenow (2010).

for the evaluated country c . This guarantees that the resulting composite indicator for country c will be below one. The second constraint limits the weights to be non-negative. This means that the composite indicator is a non-decreasing function of individual indicators. Thus, each individual indicator is necessarily formed so that the larger score reflects an improvement in a specific aspect.

As Mahlberg and Obersteiner (2001) graphically illustrate, an alternative interpretation of $CI_{BOD,c}$ is possible. Considering individual indicators y as outputs and a dummy input equal to one for all countries, $CI_{BOD,c}$ is considered as evaluating the performance of country c in terms of its efficiency. The dummy input can be considered as a helmsman in each country, which intended to provide the people a better life; this is reflected by the values of individual well-being indicators.⁹

Countries' input and output sample data enable us to construct the production set Ψ_{BOD} , which includes achievable individual well-being indicators, through the minimal extrapolation principle. There, Ψ_{BOD} is constructed as the smallest subset of \mathbb{R}_+^M covering individual indicators y for all countries and satisfying free disposability and convexity.¹⁰ The boundary of Ψ_{BOD} is the production frontier and represents the optimal practices to produce well-being, which is the benchmark to evaluate countries' performances. Countries with individual indicators on the frontier are considered the best performers and are ranked highest under BOD. The farther from the frontier and closer to the origin the individual indicators of a country are, the lower its performance is evaluated. Thus, the distance between individual indicators of a country and the frontier measures its performance. We can relate the composite indicator to the production frontier as follows:

$$CI_{BOD,c} = \min\{\theta : y_c/\theta \in \Psi_{BOD}\} \tag{2}$$

The right hand side of (2) is the smallest proportional contraction of y_c to the best practice frontier, indicating the distance from y_c to the best practice frontier. For countries with individual indicators on the frontier, no contraction is necessary, and thus θ equals one. For countries with individual indicators located farther below the frontier, individual indicators must be well expanded to reach the frontier, and thus θ is less than one.

Figure 1 illustrates what CI_{BOD} measures in the case of two individual indicators— y_1 and y_2 —and four countries— A, B, C and D . Each dot represents the underlying individual well-being indicator of each country. Here the line connecting A, B and C constitutes the best practice frontier. A, B and C on the frontier are classified as the best performing, while D , which lies below the frontier, is classified as the worst performing. To expand D to reach the frontier, its individual indicators need to be divided by a number less than one. Therefore, the composite indicator for country D is also less than one. This leads to $CI_{BOC,A} = CI_{BOC,B} = CI_{BOC,C} = 1$ and $CI_{BOD,D} = OD/OD' < 1$.

Here we highlight the assumption of invariant input associated with BOD. This assumption dismisses the fact that each country faces different conditions for providing well-being to its people. As Dasgupta (2001) and Arrow et al. (2004) advocate, it is widely believed that the productive base of economies, which consists of a variety of assets and a social infrastructure, determines people's well-being. When considering individual well-being indicators as outputs and the productive base as corresponding inputs, is a composite indicator based on BOD still a reasonable performance measure in terms of well-being?

⁹ This interpretation is rooted in Lovell et al. (1995).

¹⁰ Technically speaking, the minimal extrapolation principle constructs Ψ_{BOD} so that $\Psi_{BOD} = \{y \in \mathbb{R}_+^M : y_m \leq \sum_{k=1}^K \lambda_k y_{mk} \text{ for } m = 1, \dots, M; \lambda_k \geq 0 \text{ for } k = 1, \dots, K\}$.

Fig. 1 Frontier constructed by BOD

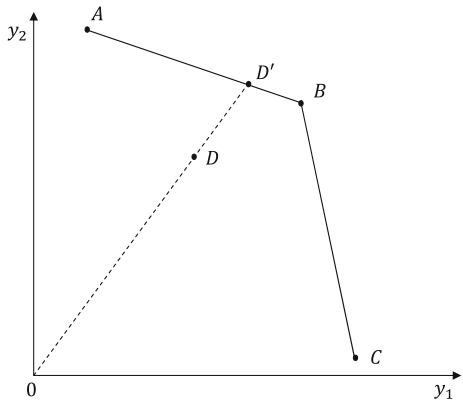
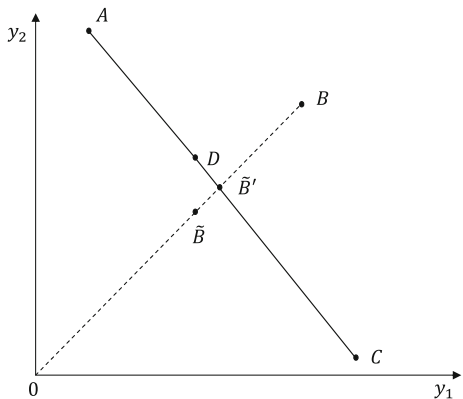


Figure 2 depicts how the inappropriate assumption of invariant input by BOD distorts the calculation of the composite indicators. Suppose a situation where country *B* is endowed with a productive base two times greater than the other three countries, and that the productive bases of the other three countries are equal to each other. As mentioned before, BOD forms the best practice frontier connecting *A*, *B* and *C*, and classifies the three countries on the frontier as the best performing. However, the production frontier in output space coincides with a set of outputs that is attainable from the given input. Hence, once we assume constant returns to scale, individual well-being indicators of country *B* which are attainable from the same level of productive base as the other countries, are indicated by \tilde{B} . Thus, when we appropriately incorporate differences in the conditions that affect countries' abilities to provide well-being to their people, the best practice frontier is formed by connecting *A*, *D* and *C* as drawn in Fig. 2. Thus, while the three countries on the frontier are classified as being the best performing, *B* is classified as being the worst performing. This leads to $CI_{BOD,A} = CI_{BOD,C} = CI_{BOD,D} = 1$ and $CI_{BOD,B} = 0\tilde{B}/0\tilde{B}' < 1$. It suggests that neglecting the differences among the productive bases distorts estimation of the production frontier, leading to a biased performance measure of countries.

Countries endowed with a larger productive base have an advantage in providing well-being to their people compared with those endowed with a smaller one. Since BOD neglects differences in the size of the productive bases, it overestimates countries having a larger productive base. Reasonable performance measures in terms of well-being should

Fig. 2 Frontier constructed by DEA



evaluate countries’ capabilities of converting the productive base to well-being indicators. Therefore, countries’ performances must be evaluated by comparing the combination of inputs and outputs across countries.

BOD’s estimation procedure for composite indicators or efficiency is rooted in DEA (Charnes et al. 1978). The original DEA is the established tool to measure the efficiency of decision-making units based on the comparison of combinations of inputs and outputs across units in a sample. An efficiency score obtained under DEA is the weighted average of outputs of the evaluated country, for which it defines the composite indicator. By applying DEA to the aggregate of individual well-being indicators along with the productive bases, we can more accurately estimate the production frontier. This leads to a more appropriate performance measure for each country. DEA itself is an established tool; however, we describe it in further detail below to contrast it with BOD in terms of calculating the composite indicator.

We consider the general case that each country k is bestowed with a productive base characterized by a set of N types of wealth $\mathbf{x}_k = (x_{1k}, \dots, x_{Nk})$, with x_{nk} the value of n th wealth in country k .¹¹ Countries’ individual well-being indicators are considered as being produced from this wealth vector. As with BOD, DEA constructs the production set Ψ_{DEA} through the minimal extrapolation principle. However, unlike Ψ_{BOD} , Ψ_{DEA} deals with input and output pairs. While the minimal extrapolation principle requires Ψ_{BOD} to include individual indicators \mathbf{y} for all countries, it requires Ψ_{DEA} to include pairs (\mathbf{x}, \mathbf{y}) for the same.¹² Inclusion of the productive base changes the shape of the production set, leading to a different frontier. Efficiency is calculated as follows:

$$CI_{DEA,c} = \min\{\theta : \mathbf{y}_c/\theta \in \Psi_{DEA}\} \tag{3}$$

As formulated in (3), $CI_{DEA,c}$ radially measures the distance from individual well-being indicators of country c , \mathbf{y}_c , to the benchmark production frontier. An alternative formulation of $CI_{DEA,c}$ is given below to compare $CI_{DEA,c}$ and $CI_{BOD,c}$ from the viewpoint of an endogenous weighting scheme.

$$CI_{DEA,c} = \max_{\mu_{1c}, \dots, \mu_{Mc}, \nu_{1c}, \dots, \nu_{Nc}} \left\{ \begin{aligned} &\sum_{m=1}^M \mu_{mc} y_{mc} : \sum_{m=1}^M \mu_{mc} y_{mk} \leq \sum_{n=1}^N \nu_{nc} x_{nk} \quad \text{for } k = 1, \dots, K; \\ &\sum_{n=1}^N \nu_{nc} x_{nc} = 1; \mu_{mc} \geq 0 \quad \text{for } m = 1, \dots, M; \nu_{nc} \geq 0 \quad \text{for } n = 1, \dots, N \end{aligned} \right\} \tag{4}$$

Both DEA and BOD select country-specific weights that maximize the composite indicator for each country under evaluation. However, we find a difference in constraint between DEA and BOD in (1) and (4). The constraints in (1) and (4) state that when we apply favourable weights for the evaluated country c , the resulting composite indicators of other countries are under the upper bounds. While (1) sets one as the upper bound across countries, (4) sets $\sum_{n=1}^N \nu_{nc} x_{nk}$ as the upper bound for each country k , which varies across countries. Weights assigned to the wealth vector $(\nu_{1c}, \dots, \nu_{Nc})$ are optimally chosen for the evaluated country c under the assumption that $\sum_{n=1}^N \nu_{nc} x_{nc} = 1$. Thus, if the evaluated country c has a relatively small productive base, the upper bound of the constraint for many

¹¹ Social infrastructures of country k , such as law and community ties, also constitute its productive base. They are considered social capital, which is a component of the wealth vector \mathbf{x}_k .

¹² Technically speaking, the minimal extrapolation principle constructs Ψ_{DEA} so that $\Psi_{DEA} = \{(\mathbf{x}, \mathbf{y}) \in \mathbb{R}_+^{M+N} : y_m \leq \sum_{k=1}^K \lambda_k y_{mk} \text{ for } m = 1, \dots, M; x_n \geq \sum_{k=1}^K \lambda_k x_{nk} \text{ for } n = 1, \dots, N; \lambda_k \geq 0 \text{ for } k = 1, \dots, K\}$.

countries becomes greater than one so that $\sum_{n=1}^N v_{nc}x_{nk} > 1$, relaxing the constraint of the optimization problem and making the composite indicator of the evaluated country c greater than 1. It indicates that between two countries with the same well-being indicators, the one with the smaller productive base will be more highly evaluated. Generally, countries with smaller productive bases raise their ranking when changing from BOD to DEA. These are the properties that we believe a reasonable composite indicator should satisfy.

3 Data

3.1 OECD Better Life Index

In the midst of growing concerns about identifying an alternative approach to measuring well-being, in 2011, the OECD launched the Better Life Initiative and released a set of 11 well-being indicators covering the 34 OECD member countries, comprising advanced and emerging economies. The data have been updated in 2012 to include the latest figures and add more dimensions to calculate indicators. Moreover, the country coverage has been expanded beyond the OECD to include Brazil and Russia. We use the most recent data covering individual indicators drawn from *Your Better Life Index*. Unfortunately, since the data of the productive base, which are necessary for computing the composite indicator in the present paper, are missing for Estonia and Slovenia, we focus on the remaining 34 countries.

The 11 individual well-being indicators evaluate topics that the OECD considers essential to people's well-being. Each individual indicator corresponding to each topic is based on one to four secondary indicators. These underlying secondary indicators are expressed in different units such as dollars, years or number of people. To compare and aggregate values expressed in different units, the values are normalized. The normalization is done according to a standard formula which converts the original values of the individual indicators into numbers between 0 and 10 as follows: $\frac{\text{value to convert} - \text{minimum value}}{\text{maximum value} - \text{minimum value}} \times 10$. Within each topic, the secondary indicators are averaged with equal weight. For example, while the topic of environment is constructed using two secondary indicators, *water quality* and *air pollution*, their scores are first normalized in a range between 0 and 10. They are then aggregated as follows: $\frac{\text{water quality score} + \text{air pollution score}}{2}$. The 11 individual indicators and their corresponding 24 secondary indicators are shown below.

- (1) Income (Household income; Household financial wealth)
- (2) Jobs (Employment rate; Personal earnings; Job security; Long-term unemployment rate)
- (3) Housing (Rooms per person; Housing expenditure; Dwellings with basic facilities)
- (4) Work–life balance (Employees working very long hours; Time devoted to leisure and personal care)
- (5) Health (Life expectancy; Self-reported health)
- (6) Education (Educational attainment; Years in education; Students' skills)
- (7) Community (Social network)
- (8) Civic engagement (Consultation on rule-making; Voter turnout)
- (9) Environment (Water quality; Air pollution)

- (10) Safety (Homicide rate; Assault rate)
- (11) Life Satisfaction (Life Satisfaction)

Among the 11 individual indicators, the first three topics are categorized under material living conditions and the remaining eight are categorized as QOL. According to the file released by the OECD Better Life Initiative, the data years of the underlying detailed indicators range from 2005 to 2011. Averaging them with each topic equally weighted suggests a year close to 2009. Thus, we consider that the 11 indicators of each country measure the socioeconomic situation of people around 2009.

Table 1 summarizes the statistics of the 11 indicators. As Organization for Economic Cooperation and Development (2011) finds, these tables show that while life is good in many dimensions in countries such as Australia, Canada, Sweden, New Zealand, Norway and Denmark, it is significantly less so in countries such as Turkey, Mexico, Chile, Estonia, Portugal and Hungary. While the latter countries are characterized by their lower per capita income, the former are not necessarily the richest countries, that is, those with the highest per capita income.

From here onwards, we group countries based on per capita GDP to consider the link between well-being and economic development, which is well reflected in per capita GDP. The grouping is as follows: nine high-income countries with per capita GDP greater than USD 40,000, 18 middle-income countries with per capita GDP between USD 20,000 and 40,000 and seven low-income countries with per capita GDP below USD 20,000. Table 1 suggests that people's well-being improves as income grows in every aspect apart from work–life balance. In this respect, on average, people in middle-income countries enjoy a better life than do those in high-income countries.

3.2 Comprehensive Wealth Accounts

Acknowledging the deficiency of GDP as a measure for tracking sustainable development, the World Bank has been developing comprehensive wealth accounts along with statistics addressing genuine saving. Their wealth accounts are reported in a series of publications (World Bank 1997, 2006, 2011). The concept of comprehensive wealth in its wealth account is broad, and it includes produced capital, natural capital, human capital, social capital and institutional capital. It corresponds to the productive base as a source of well-being of both the present and future generations. Among their publications, we use the data in the most recent publication (World Bank 2011), which covers more than 120 countries. We use the estimates of comprehensive wealth and its subcomponents by country for 2005.¹³ We use the following primary subcomponents.

- Comprehensive wealth = produced capital + natural capital + intangible capital.
- Produced capital, comprising machinery, structures and equipment.
- Natural capital, comprising agricultural land, protected areas, forests and subsoil

¹³ Since individual well-being indicators are considered to be data from 2009, there is a difference in data periods between individual well-being indicators and the productive base. Because of data limitations, we omit this problem. One justification is that the magnitude of the comprehensive wealth of each country is significantly large because of the accumulation of past investment; thus, it is rather stable over several years. We leave extending the data of well-being indicators or the productive base in order to match their data period to future research.

Table 1 Descriptive statistics, OECD well-being indicators

	Housing	Income	Jobs	Community	Education	Environment	Civic engagement	Health	Life satisfaction	Safety	Work-life balance
Mean											
Overall	5.6	4.0	6.4	7.6	6.3	7.5	5.3	6.9	6.1	7.9	6.7
High-income	6.8	6.3	8.3	8.7	6.9	8.7	6.2	8.5	8.3	8.8	6.9
Middle income	5.8	4.1	6.3	7.9	6.8	7.8	5.3	7.2	6.0	8.5	7.1
Low-income	3.7	1.0	4.5	5.5	4.1	5.3	4.4	4.3	3.5	5.5	5.4
Median	6.0	4.0	6.5	8.0	7.0	7.9	5.5	7.6	7.0	8.5	6.9
Std. Dev.	1.6	2.3	1.6	2.0	2.0	1.9	1.6	2.0	2.8	2.1	1.8
Max	7.8	10.0	9.0	10.0	9.4	10.0	9.4	9.5	10.0	9.9	9.7
Min	1.3	0.2	2.6	0.0	0.9	3.6	1.8	0.1	0.0	0.8	1.6

assets.¹⁴

- Intangible capital, comprising human capital, social capital and institutional capital. The rule of law and government, which contribute to an efficient economy, are also included in institutional capital.

Comprehensive wealth is estimated as the present value of future consumption. Produced capital is derived from historical investment data using a perpetual inventory method. The stock value of natural capital is based on country data of physical stocks and estimates of natural resource rents based on prices and costs data. Intangible capital is measured as the difference between comprehensive wealth, produced capital and natural capital. Thus, since all the measurement errors associated with comprehensive wealth, produced capital and natural capital are drawn into the measure of intangible capital, intangible capital data must be cautiously interpreted.

All estimates are as per the US dollar in 2005. Table 2 summarizes the statistics of comprehensive wealth and its subcomponents. World Bank (2011) finds that intangible capital represents the largest share of the wealth of all countries, and that its share increases as per capita income grows. In addition, the important role of natural capital is highlighted. In the early stage of development, countries are relatively dependent on natural capital such as agricultural land, subsoil assets and forests. Countries use these to build produced capital and intangible capital in the course of economic development.

Table 2 reveals a similar pattern between wealth and development even among our sample, which have relatively higher incomes compared with other countries included in World Bank (2011). Intangible capital has the largest share in all the country groups. Natural capital has the smallest share among the three types of capital; however, natural capital of low-income countries is 11 % on average, much higher than that of the other groups.¹⁵

4 Result

We compute composite indicators based on BOD formulated by (1) (CI_{BOD}) and DEA formulated by (4) (CI_{DEA}).¹⁶ CI_{DEA} measures countries' performances by incorporating the individual indicators of well-being as well as the productive bases for countries in a sample. Although the productive base of each country consists of its produced, natural and intangible capital, we compute CI_{DEA} under three compositions of the productive base. The comparison of the composite indicator calculated under the three different conditions reveals the impact of including each asset into the productive base for composite indicator construction. Denoting produced, natural and intangible capital by x_p , x_n and x_{in} , respectively, we consider the following cases of the input vector \mathbf{x} , which corresponds to the productive base:

¹⁴ The 11 subcomponents of natural capital are as follows: (1) Crop, (2) Pasture land, (3) Timber, (4) Non-timber forest, (5) Protected areas, (6) Oil, (7) Natural gas, (8) Hard coal, (9) Soft coal, (10) Coal and (11) Minerals.

¹⁵ The fact that the share of intangible capital is higher in middle- than high-income countries seems to contradict the finding by World Bank (2011), which indicates that its share increases as an economy grows. Since middle- and high-income countries in our sample are considered as high-income countries in World Bank (2011), the differences in per capita income and the level of economic development between these two groups are neglected in that study.

¹⁶ All calculations are done in R using the 'Benchmarking' package. See Bogetoft and Otto (2011, 2012).

Table 2 Descriptive statistics, World Bank comprehensive wealth accounts

	Comprehensive wealth	Produce capital	Natural capital	Intangible capital
Mean				
Overall	457,361 (100 %)	84,443 (18 %)	15,693 (3 %)	357,226 (78 %)
High-income	708,331 (100 %)	135,950 (19 %)	27,890 (4 %)	544,491 (77 %)
Middle income	464,774 (100 %)	83,794 (18 %)	10,584 (2 %)	370,396 (80 %)
Low-income	115,625 (100 %)	19,888 (17 %)	13,147 (11 %)	82,590 (71 %)
Median	528,751	89,836	8,752	405,853
Std. Dev.	251,919	49,614	20,283	202,336
Max	917,529	213,425	110,163	753,128
Min	73,167	11,330	2,095	24,137

- Case 1: $\mathbf{x} = (x_p)$
- Case 2: $\mathbf{x} = (x_p + x_n)$
- Case 3: $\mathbf{x} = (x_p + x_n, x_{in})$

Case 3 is ideal for using the comprehensive set of produced, natural and intangible capital. In cases 1 and 2, as the second best, the productive bases are approximated by part of the productive bases, such as produced capital or tangible capital. In case 3, we differentiate intangible capital from produced and natural capital, rather than summing up all three forms of capital into a single measure of the productive base.¹⁷ This is because intangible capital differs considerably in character from produced and natural capital.

Table 3 presents the full empirical result, containing the scores of composite indicators and corresponding rankings along with existing HDI and GDP per capita, which is denoted by *income* in the table. To ensure comparability with composite indicators, we rescale HDI score so that its maximum value is one. It is shown that composite indicators and HDI fail to completely discriminate among all the countries in our sample, and that some countries are ranked equally. While HDI indicates ties among at most three countries a between the lowest score zero and highest score one, a larger number of countries are equally ranked highest in BOD and DEA. However, comparing the number of countries equally ranked (19 out of 34 for BOD, six for DEA case 1, eight for DEA case 2, 10 for DEA case 3), we note the better discriminating power of CI_{DEA} than CI_{BOD} . Incorporating the information about the productive base as well as individual well-being indicators allows us to distinguish countries' performances in greater detail.

As expected, CI_{BOD} is evaluated higher than the previous studies for countries that achieve high scores in dimensions of well-being other than *income*, *education* and *health*. For example, the scores of Luxembourg and the UK are one, which is the highest under CI_{BOD} , while they are ranked relatively low among OECD countries by HDI, Mahlberg and Obersteiner (2001) and Zaim et al. (2001). The well-being of people in the UK is close to the highest level in multiple dimensions such as *community*, *environment* and *safety*. Luxembourg records decent scores of well-being in all dimensions except *education*, leading to a lower evaluation under HDI. On the other hand, countries that lose their ranking largely because of switching from HDI to CI_{BOD} have relatively low scores in dimensions of QOL other than *education* and *health*.

¹⁷ Note that cases 1 and 2 adopt DEA with single input while case 3 adopts DEA with two inputs.

Table 3 Composite indicator with HDI and per capita income

	BOD	DEA			HDI	Income	Productive base
		Case 1		Case 3			
		Case 1	Case 2	Case 3			
Australia	1.0000 (1)	0.4964 (27)	0.4793 (29)	0.6836 (26)	0.9841 (2)	47,566 (3)	518,805 (18)
Austria	0.9894 (20)	0.5405 (22)	0.6062 (24)	0.7232 (23)	0.9341 (18)	41,063 (7)	570,655 (12)
Belgium	1.0000 (1)	0.7001 (12)	0.8339 (14)	0.8680 (15)	0.9384 (16)	38,580 (11)	562,365 (14)
Brazil	0.7877 (31)	1.0000 (1)	1.0000 (1)	1.0000 (1)	0.7524 (33)	10,521 (34)	79,143 (33)
Canada	1.0000 (1)	0.7485 (10)	0.6751 (21)	0.8099 (16)	0.9596 (7)	40,023 (9)	538,697 (17)
Chile	0.7053 (33)	0.9069 (7)	0.8496 (13)	1.0000 (1)	0.8480 (30)	13,689 (31)	101,900 (32)
Czech Republic	0.9450 (22)	0.6563 (13)	0.8911 (10)	1.0000 (1)	0.9171 (22)	25,553 (25)	180,821 (26)
Denmark	1.0000 (1)	0.3850 (33)	0.4447 (32)	0.4716 (33)	0.9469 (13)	37,377 (12)	742,955 (4)
Finland	1.0000 (1)	0.4831 (28)	0.5490 (27)	0.5692 (30)	0.9320 (19)	34,765 (17)	570,255 (13)
France	0.9236 (28)	0.6320 (16)	0.7273 (16)	0.7308 (21)	0.9352 (17)	34,385 (18)	586,448 (11)
Germany	1.0000 (1)	0.5893 (20)	0.7270 (17)	0.7510 (18)	0.9564 (8)	36,226 (14)	547,200 (16)
Greece	0.9418 (23)	0.5169 (25)	0.6188 (23)	0.6631 (27)	0.9171 (22)	30,201 (22)	392,814 (22)
Hungary	0.9260 (27)	0.6396 (15)	0.8848 (11)	0.8888 (13)	0.8618 (27)	18,001 (29)	173,008 (27)
Iceland	1.0000 (1)	0.3934 (32)	0.4784 (30)	0.4784 (32)	0.9532 (11)	40,096 (8)	902,961 (2)
Ireland	1.0000 (1)	0.4016 (30)	0.5467 (28)	0.54811 (31)	0.9617 (5)	35,878 (15)	599,116 (9)
Israel	0.9391 (25)	1.0000 (1)	1.0000 (1)	1.0000 (1)	0.9394 (15)	28,452 (23)	327,471 (23)
Italy	0.9148 (29)	0.6410 (14)	0.7234 (18)	0.7925 (17)	0.9245 (21)	30,895 (20)	498,277 (19)
Japan	1.0000 (1)	0.4599 (29)	0.5650 (25)	0.7289 (22)	0.9511 (12)	35,011 (16)	548,751 (15)
Korea	0.9455 (21)	0.5826 (21)	0.8064 (15)	0.9124 (12)	0.9447 (14)	26,675 (24)	248,180 (25)
Luxembourg	1.0000 (1)	0.3937 (31)	0.4612 (31)	0.6014 (29)	0.9171 (22)	93,388 (1)	917,529 (1)
Mexico	0.7043 (34)	0.8364 (8)	1.0000 (1)	1.0000 (1)	0.8098 (31)	12,887 (32)	131,384 (30)
Netherlands	1.0000 (1)	0.5926 (19)	0.6558 (22)	0.7414 (19)	0.9617 (5)	44,583 (5)	593,546 (10)
New Zealand	1.0000 (1)	0.5194 (24)	0.4279 (33)	0.6071 (28)	0.9628 (3)	30,797 (21)	414,114 (20)
Norway	1.0000 (1)	0.2653 (34)	0.2355 (34)	0.3393 (34)	1.0000 (1)	56,499 (2)	861,798 (3)

Table 3 continued

	BOD	DEA			HDI	Income	Productive base
		Case 1					
		Case 1	Case 2	Case 3			
Poland	0.9895 (19)	1.0000 (1)	1.0000 (1)	1.0000 (1)	0.8576 (28)	18,366 (28)	135,941 (29)
Portugal	0.8528 (30)	0.6016 (18)	0.8563 (12)	0.8685 (14)	0.8555 (29)	22,339 (26)	305,831 (24)
Russian Federation	0.9368 (26)	1.0000 (1)	1.0000 (1)	1.0000 (1)	0.7938 (32)	15,704 (30)	73,167 (34)
Slovak Republic	0.9406 (24)	0.7383 (11)	1.0000 (1)	1.0000 (1)	0.8810 (26)	21,414 (27)	142,372 (28)
Spain	1.0000 (1)	0.5369 (23)	0.7206 (19)	0.7228 (24)	0.9288 (20)	30,908 (19)	408,384 (21)
Sweden	1.0000 (1)	0.6259 (17)	0.7008 (20)	0.7008 (25)	0.9543 (10)	39,295 (10)	627,951 (8)
Switzerland	1.0000 (1)	0.5033 (26)	0.5625 (26)	0.7386 (20)	0.9554 (9)	44,375 (6)	736,795 (5)
Turkey	0.7617 (32)	1.0000 (1)	1.0000 (1)	1.0000 (1)	0.7333 (34)	10,886 (33)	114,830 (31)
United Kingdom	1.0000 (1)	0.7763 (9)	0.9207 (9)	0.9207 (11)	0.9139 (25)	37,001 (13)	662,625 (7)
United States	1.0000 (1)	1.0000 (1)	1.0000 (1)	1.0000 (1)	0.9628 (3)	45,614 (4)	734,195 (6)

Table 4 Descriptive statistics, composite indicator with HDI and per capita income

	BOD	DEA			HDI	Income
		Case 1	Case 2	Case 3		
Mean	0.9472	0.6519	0.7338	0.7900	0.9131	33,206
Median	1.0000	0.6137	0.7252	0.7717	0.9346	34,575
Std. Dev.	0.0857	0.2108	0.2125	0.1852	0.0641	15,595
Max	1.0000	1.0000	1.0000	1.0000	1.0000	93,388
Min	0.7043	0.2653	0.2355	0.3393	0.7333	10,521

We compare the distribution of CI_{BOD} , CI_{DEA} and HDI among countries. According to Table 4, the mean, the variation characterized by the standard deviation and the range of the distribution characterized by the difference between the maximum and minimum scores are similar for CI_{BOD} and HDI. In contrast, CI_{DEA} is distributed in a wider range and has a higher mean than CI_{BOD} and HDI, which improves discriminating power by reducing the number of equally ranked countries, which has already been mentioned.

Table 5 shows the correlation of composite indicators with HDI score and GDP per capita. It shows that CI_{BOD} and HDI, which share a similar pattern of distribution, are highly correlated with each other. The quest for an alternative welfare measure stems from an acknowledgement of the limitations of GDP per capita as a welfare measure. We now consider the relationship between composite indicators and GDP per capita. While CI_{BOD} is positively correlated with GDP per capita, CI_{DEA} is negatively correlated with it. Table 1 suggests that GDP per capita and the scores of individual well-being indicators are directly proportional. Larger values of individual indicators raise the composite indicator CI_{BOD} , of which they are components. Therefore, the positive correlation between CI_{BOD} and GDP per capita is straightforward. While the correlations between CI_{BOD} and HDI and between CI_{BOD} and GDP per capita are 0.7859 and 0.6314, respectively, the corresponding

Table 5 Correlation among composite indicators

	BOD	DEA			HDI	Income
		Case 1	Case 2	Case 3		
Correlation coefficient						
BOD	1.0000	-0.5289	-0.5273	-0.5424	0.7859	0.6314
DEA: case 1		1.0000	0.8977	0.0894	-0.6658	-0.5989
DEA: case 2			1.0000	0.9520	-0.6799	-0.6623
DEA: case 3				1.0000	-0.6348	-0.6144
HDI					1.0000	0.6604
Income						1.0000
Spearman rank correlation coefficient						
BOD	1.0000	-0.5868	-0.6493	-0.6367	-0.7689	-0.8136
DEA: case 1		1.0000	0.9235	0.9243	-0.5443	-0.5832
DEA: case 2			1.0000	0.9470	-0.6507	-0.6736
DEA: case 3				1.0000	-0.5918	-0.6422
HDI					1.0000	0.7790
Income						1.0000

Table 6 Correlation among composite indicators and underlying statistics

	BOD	DEA			HDI	Income
		Case 1	Case 2	Case 3		
Productive base	0.6689	-0.6641	-0.7298	-0.7604	0.7489	0.8539
Produced capital	0.6449	-0.7737	-0.8194	-0.7880	0.7246	0.9109
Natural capital	0.1783	-0.2850	-0.5277	-0.4849	0.2869	0.2453
Intangible capital	0.6568	-0.6086	-0.6549	-0.7049	0.7259	0.8153

correlations of the composite indicator in Mahlberg and Obersteiner (2001) are 0.893 and 0.565. Incorporating more dimensions of well-being than HDI and Mahlberg and Obersteiner (2001), CI_{BOD} further deviates from HDI. Consequently, CI_{BOD} more closely approaches GDP per capita.

Interpreting the negative correlation between CI_{DEA} and GDP per capita is not as intuitive. It exhibits a marked contrast to the previous studies. Strikingly, all the countries in the low-income group, except Hungary, are ranked highest under CI_{DEA} . Before we continue the detailed analysis of CI_{DEA} , we compare the computed scores of CI_{DEA} under the three different cases. In Table 5, the largest correlation coefficient is approximately 0.95, which is found between cases 2 and 3 of CI_{DEA} in terms of score values as well as ranking. The most difficult aspect of implementing CI_{DEA} is preparing the productive bases of countries, especially the intangible capital. The similarity between cases 2 and 3 suggests that integrating the natural capital into the productive base is the most critical step in calculating CI_{DEA} . Thus, even when estimates of intangible capital are unavailable, by using produced and natural capital, we approximate the result that should be obtained under the most appropriate definition, which states that the productive base consists of produced, natural and intangible capital.

The source of this negative correlation between CI_{DEA} and GDP per capita can be inferred from Table 6.¹⁸ The productive base strongly correlates negatively with CI_{DEA} and positively with GDP per capita, leading to negative correlation between CI_{DEA} and GDP per capita. High-income countries can afford to invest a variety of assets that are accumulated into their large productive base. However, these countries are likely to fail in providing the level of well-being appropriate for their large productive base. This leads to larger correlations between the productive base and CI_{DEA} and between the productive base and GDP per capita in absolute terms than the correlation between CI_{DEA} and GDP per capita.

The large negative correlation between CI_{DEA} and the productive base does not necessarily imply that their country rankings are in reverse order. The US and Canada raise their CI_{DEA} ranking compared with their ranking based on the productive base. In particular, the US is ranked highest, with countries having the lowest GDP per capita and the smallest productive base. Although the large productive bases of the US and Canada are advantageous to these countries, their people enjoy a better life than is explained by their large productive base, leading to a higher evaluation of their performance. Similarly, Belgium and the UK, whose productive bases are comparably large, are also ranked

¹⁸ From now onwards, CI_{DEA} refers to the composite indicator based on DEA under case 3, which ideally assumes the productive base comprising produced, natural and intangible capital.

Table 7 Average weight for composite indicators

	Housing	Income	Jobs	Community	Education	Environment	Civic engagement	Health	Life satisfaction	Safety	Work-life balance
BOD	0.0100	0.0076	0.0011	0.0076	0.0061	0.0109	0.0065	0.0208	0.0139	0.0209	0.0104
DEA: case 1	0.0009	0.1218	0.0001	0.0004	0.0024	0.0044	0.0076	0.0115	0.0066	0.0044	0.0003
DEA: case 2	0.0184	0.0881	0.0039	0.0008	0.0020	0.0113	0.0109	0.0026	0.0057	0.0024	0.0045
DEA: case 3	0.0044	0.1213	0.0005	0.0001	0.0011	0.0082	0.0074	0.0177	0.0052	0.0063	0.0022

relatively high under CI_{DEA} among the high-income countries, indicating the significant well-being their people enjoy, which is balanced with their large productive bases. On the other hand, countries that lose their country ranking are not always endowed with a large productive base. The productive bases of Greece, New Zealand and Spain are approximately USD 40,000, below the average of USD 45,000. However, their country rankings based on CI_{DEA} are even lower than those based on the productive base. This indicates that the well-being of their people is even lower than that expected from their relatively modest productive base.

CI_{BOD} and CI_{DEA} choose the country-specific weights that maximize the resulting composite indicator score of each country under evaluation. Therefore, higher weights are assigned to the individual indicators on which each country performs well. Therefore, it is possible to conclude that the composite indicators reflect the policy priority of each country on country-specific weights. Table 7 shows the average of the weight for each individual indicator in Eqs. (1) and (4). Widely distributed weights indicate that policy priority encompasses a spectrum covering 11 dimensions, revealing the importance of increasing dimensions in measuring countries' performance. A clear distinction in relative weights is found between CI_{BOD} and CI_{DEA} , indicating that neglecting the productive base distorts the inference of policy priorities of countries. Three individual indicators characterizing material living conditions—*housing*, *income*, and *jobs*—have relative priority in CI_{BOD} . Especially, the components of *health* and *safety* have the largest weights. On the other hand, the remaining individual indicators characterizing QOL have relative priority in CI_{DEA} . Especially, the largest weight is attached to a component of *income*. *Civic engagement* retains a constant role in every composite indicator. This might reflect that institutional characteristics in the productive base which affect *civic engagement* are not captured by capital assets considered in this paper.

5 Conclusion

Well-being is a multidimensional concept. The OECD recently specified 11 topics that are essential to people's well-being. However, the fact that the OECD leaves their aggregation to the user motivates our research. We adopt two approaches, BOD and DEA, to construct a composite indicator from 11 individual indicators of well-being. Unlike HDI, both approaches aggregate individual indicators by investigating country-specific weights that maximize the composite indicator of each country.

The composite indicator based on BOD is distributed similarly to and is highly correlated with the existing HDI. It is also positively correlated with GDP per capita. On the other hand, the composite indicator based on DEA is negatively correlated with HDI as well as GDP per capita. Especially, the group of countries with the least GDP per capita is now ranked highest under DEA. Although these countries have very low well-being indicator scores, the volume of their productive base is further limited. Thus, once we consider that they find it difficult to provide well-being to their people, even though scores of their individual indicators of well-being are relatively low among a sample of countries, their performances are highly appreciated. Many countries with a larger productive base fail to provide an adequate level of well-being and are devaluated under DEA, leading to a significantly negative correlation between the DEA composite indicator and the productive base. Nevertheless, there are exceptional countries. Although the US and UK have high GDP per capita and larger productive bases, they successfully ensure a sufficiently high level of well-being for their people. Thus, they are highly ranked even under DEA. On the

other hand, while the productive bases of Greece, New Zealand and Spain are relatively modest in size, they are ranked very low under DEA. This reflects a significantly low level of well-being that is unjustifiable considering their productive base.

This study has certain limitations. First, we consider an aggregation across 11 individual indicators, but we do not address how to construct each individual indicator. There are between one and four secondary indicators underlying each individual indicator. By merely utilizing indicators released by OECD, we do not consider the aggregation of these secondary indicators into a single individual indicator. The resulting composite indicators, which aggregate the 11 individual indicators, are easily influenced in this preliminary stage of aggregation. It is important to verify that the construction process of OECD's 11 individual indicators is appropriate. Second, the 11 individual indicators of each country measure national average well-being in a specific aspect of people's lives. Thus, the composite indicators we propose do not incorporate the distribution of well-being within each country in any dimension. When comparing two countries with the same national average of well-being, the one with a more equitable distribution of well-being people is likely to be evaluated higher. These shortcomings invite further investigation to establish a more comprehensive framework for international comparison of well-being that covers all the secondary indicators as well as distributional measures such as income inequality and leisure inequality.

While our analysis is preoccupied with comparing countries' current performances, how their performance changes over periods is also important. There is significant DEA literature that measures the change in efficiency and divides it into several components. Once individual well-being indicators become available for multiple periods, they can easily be used to consider the change in countries' abilities to ensure their people's well-being based on their productive base. We leave this exercise to future research.

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References

- Arrow, K., Dasgupta, P., Goulder, L., Daily, G., Ehrlich, P., Heal, G., et al. (2004). Are we consuming too much? *Journal of Economic Perspectives*, 18(3), 147–172.
- Bogetoft, P., & Otto, L. (2011). *Benchmarking with DEA, SFA, and R*. New York: Springer.
- Bogetoft, P. & Otto, L. (2012). Benchmarking package. *Technical Report, R*.
- Charnes, A., Cooper, W. W., & Rhodes, E. (1978). Measuring the efficiency of decision making units. *European Journal of Operational Research*, 2(6), 429–444.
- Cherchye, L., Moesen, W., Rogge, N., & Van Puyenbroeck, T. (2007). An introduction to 'benefit of the doubt' composite indicators. *Social Indicators Research*, 82(1), 111–145.
- Cherchye, L., Moesen, W., & Van Puyenbroeck, T. (2004). Legitimately diverse, yet comparable: On synthesizing social inclusion performance in the EU. *JCMS: Journal of Common Market Studies*, 42(5), 919–955.
- Dasgupta, P. (2001). *Human well-being and the natural environment*. Oxford: Oxford University Press.
- Despotis, D. K. (2005a). A reassessment of the human development index via data envelopment analysis. *Journal of the Operational Research Society*, 56(8), 969–980.
- Despotis, D. K. (2005b). Measuring human development via data envelopment analysis: the case of Asia and the Pacific. *Omega*, 33(5), 385–390.

- Fleurbaey, M., & Gaulier, G. (2009). International comparisons of living standards by equivalent incomes. *Scandinavian Journal of Economics*, 111(3), 597–624.
- Jones, C. I. & Klenow, P. J. (2010). Beyond GDP? Welfare across countries and time. *NBER Working Paper*, WP16352.
- Kunte, A., Hamilton, K., Dixon, J. & Clemens, M. (1998). *Estimating national wealth: Methodology and results*. Environment Department, World Bank.
- Lovell, C. A. K., Pastor, J. T., & Turner, J. A. (1995). Measuring macroeconomic performance in the OECD: A comparison of European and non-European countries. *European Journal of Operational Research*, 87(3), 507–518.
- Mahlberg, B. & Obersteiner, M. (2001). Remeasuring the HDI by data envelopement analysis. *International Institute for Applied Systems Analysis Interim Report*, 01–069.
- Organization for Economic Cooperation and Development. (2008). *Handbook on constructing composite indicators: Methodology and user guide*. Paris: OECD Publishing.
- Organization for Economic Cooperation and Development. (2011). *How's life?: Measuring well-being*. Paris: OECD Publishing.
- Schokkaert, E. (2007). Capabilities and satisfaction with life. *Journal of Human Development*, 8(3), 415–430.
- Stiglitz, J. E., Sen, A. & Fitoussi, J.-P. (2009). *Report by the commission on the measurement of economic performance and social progress*. Available at: http://www.stiglitz-sen-fitoussi.fr/documents/rapport_anglais.pdf.
- United Nations Development Program. (1990). *Human development report 1990: Concept and measurement of human development*. New York: Oxford University Press.
- World Bank (1997). *Expanding the measure of wealth: indicators of environmentally sustainable development*. Environmentally Sustainable Development Studies and Monographs Series No. 17. Washington, DC: World Bank.
- World Bank. (2006). *Where is the wealth of nations?: Measuring capital for the 21st century*. Washington, DC: World Bank Publications.
- World Bank. (2011). *The changing wealth of nations: Measuring sustainable development in the new millennium*. Washington, DC: World Bank Publications.
- Zaim, O., Färe, R., & Grosskopf, S. (2001). An economic approach to achievement and improvement indexes. *Social Indicators Research*, 56(June), 91–118.