A MEASURE OF WELL-BEING ACROSS EUROPEAN COUNTRIES: AN INTEGRATED DEA-ENTROPY APPROACH

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Background: The analysis of quality of life and well-being is deemed an important area of economic science in view of its relevant implications in the political, social and economic spheres. Research into this field has been approached in different ways. For many years the Gross-Domestic Product (GDP) has been used as a proxy measure of well-being and employed as a benchmark in assessing and comparing the development of countries and regions. Despite its extensive use, many scholars have called growing attention about the limitations of GDP as a simple and intuitive measure in guiding the progress of societies. Accordingly, several researchers have proposed different sets of variables to evaluate the well-being and the quality of life, recognizing that they are a result of complex interactions between objective and subjective factors (see, for an overview, Costanza et al. 2009). A valuable alternative to the above mentioned traditional economic-based measure is offered by the Better Life Index (BLI), provided in 2011 by the OECD, which measures well-being along different socio-economic dimensions, covering material conditions (such as income and wealth) as well as quality of life (community, environment and work life balance).

Objectives: Relying on the latest BLI data (2014), this paper aims at evaluating the well-being across 21 European countries via Data Envelopment Analysis (DEA). Through this well-known mathematical programming technique, the performance of each country in terms of providing well-being to its people will be benchmarked on the basis of empirical observations of "best practice" countries. Starting from the sensible assumption that communities want to maximize their desirable goals and minimize the undesirable community attributes or resources to be efficiently rationalized, the DEA approach provides a meaningful identification of efficient and inefficient countries. Besides, in a second stage of our analysis, to improve the discriminative power of DEA, we construct a composite efficiency index, based on Shannon’s entropy formula, which allows us to combine the results of different models and viewpoints.

Methods: Let us consider \( n \) Decision Making Units (DMUs) under evaluation. Each DMU \( j (j=1,2,...,n) \) is assumed to produce \( s \) outputs by using \( i \) inputs. There is a wide variety of DEA models for assessing these units. A taxonomy and a general model framework can be found in Cook and Seiford (2009).

According to the classic DEA model, the evaluation of the technical efficiency of a DMU is addressed by a ratio of a weighted sum of desirable outputs to a weighted sum of inputs, such that no DMU’s efficiency scores can exceed one (Charnes et al. 1978).
The efficiency of the j-th DMU \( E_j \) can be obtained by solving the following linear fractional CCR DEA formulation:

\[
\begin{align*}
\text{Max} \quad & E_j = \frac{\sum_{s=1}^{\bar{S}} u_s o_{sj}}{\sum_{i=1}^{\bar{I}} v_i i_{ij}} \\
\text{s.t.} \quad & \frac{\sum_{s=1}^{\bar{S}} u_s o_{sm}}{\sum_{i=1}^{\bar{I}} v_i i_{in}} \leq 1 \quad \forall n \\
& u_s \geq 0 \quad \forall s \\
& v_i \geq 0 \quad \forall i
\end{align*}
\]

where \( \bar{S} = 1, 2, \ldots, S \) are the inputs used, \( \bar{I} = 1, 2, \ldots, I \) the output variables and \( \bar{n} = 1, 2, \ldots, \bar{n} \) the DMUs. Furthermore, in this model specification, \( o_{sj} \) denotes the amount of the \( s \)-th output for the \( j \)-th DMU, \( i_{ij} \) is the amount of the \( i \)-th input for the \( j \)-th DMU while \( u_s \) and \( v_i \) are the weights assigned to the \( s \)-th output and \( i \)-th input, respectively, objectively determined.

In the present study, the efficiency of the selected OECD countries in providing well-being to their citizens is computed by specifying a DEA (output oriented-CCR) model for all possible different combinations of inputs and outputs.

In other terms, the units under considerations have been evaluated by a set of different models, say:

\[ M = \{ M_1, M_2, \ldots, M_k \} \]

and the efficiency scores presented in the matrix form:

\[
\begin{bmatrix}
    E_{11} & E_{12} & \cdots & E_{1k} \\
    E_{21} & E_{22} & \cdots & E_{2k} \\
    \vdots & \vdots & \ddots & \vdots \\
    E_{n1} & E_{n2} & \cdots & E_{nk}
\end{bmatrix}
\]

To achieve a more balance ranking of DMUs, the efficiency scores of various DEA models have been combined using Shannon's entropy method and the degree of importance of each model calculated via some established steps (Soleimani-damaneh and Zarepisheh, 2009), as detailed below.

**Step 1**: normalization of the efficiency matrix by setting

\[
e_{jk} = \frac{E_{jk}}{\sum_{j=1}^{n} E_{jk}}, \quad k = 1, 2, \ldots, K
\]

**Step 2**: calculate entropy

\[
f_k = -(\ln n)^{-1} \sum_{j=1}^{n} e_{jk} \ln(e_{jk}), \quad k = 1, 2, \ldots, K
\]
Step 3: compute the degree of diversification of $M_k$ as $d_k = 1 - f_k, \quad k = 1, 2, \ldots, K$

Step 4: set

$$W_k = \frac{d_k}{\sum_{k=1}^{K} d_k}, \quad k = 1, 2, \ldots, K$$

such that $\sum_{k=1}^{K} W_k = 1$

as degree of importance of model $M_k$

Step 5: calculate a comprehensive efficiency score as:

$$\theta_j = \sum_{k=1}^{K} W_k E_{jk}, \quad j = 1, 2, \ldots, n$$

If $\theta_j = 1$ then DMU$_j$ $(j = 1, 2, \ldots, n)$ is comprehensive DEA efficient.

Results: Adopting the above specified DEA-Shannon entropy integrated approach we derive the comprehensive efficiency scores for the European OECD countries, selected for the present analysis. A total of 21 output-oriented constant return to scale DEA models were constructed, choosing two input variables (environmental pollution and employment rate) and three output indicators (satisfaction with life, life expectancy and income). According to the empirical findings the best performance in terms of well-being is observed in the Northern European countries (Sweden, France, Norway, Germany, United Kingdom) whereas the bottom positions in the ranking are occupied by Poland, Slovenia, Hungary, Greece and Czech Republic. It is worth noting that, in this calculation process of the comprehensive efficiency score, Italy lies in the middle of ranking, with a better performance compared to other Mediterranean countries, like Spain, Portugal and Greece.

Conclusions: Typically, in a DEA-based model, the measure of technical efficiency and the ranking of units obtained is strictly dependent on the choice and number of the input and output variables considered. The integrated DEA-Shannon entropy approach employed in this study permits us to increase the discriminatory power of DEA procedure and attain a more reliable profiling of European well-being efficiencies.

Main references


