Chapter 13
Using Data Envelopment Analysis to Construct Human Development Index

Paulo Nocera Alves Junior
University of São Paulo (USP), Brazil

Enzo Barberio Mariano
São Paulo State University (UNESP), Brazil

Daisy Aparecida do Nascimento Rebelatto
University of São Paulo (USP), Brazil

ABSTRACT

This chapter addresses problems related to methodological issues, such as data normalization, weighting schemes, and aggregation methods, encountered in the construction of composite indicators to measure socio-economic development and quality of life. It also addresses the use of several Data Envelopment Analysis (DEA) models to solve these problems. The models are discussed and applied in constructing a Human Development Index (HDI), derived from the most recent raw and normalized data, using arithmetic and geometric means to aggregate the indices. Issues related to data normalization and weighting schemes are emphasized. Kendall Correlation was applied to analyze the relationship between ranks obtained by DEA models and HDI. Recommendations regarding the advantages and disadvantages of using DEA models to construct HDI are offered.

INTRODUCTION

This chapter describes problems related to methodological issues in constructing composite indices. It also assesses the use of data envelopment analysis (DEA), a quantitative method, to solve them. Many factors can influence the construction of composite indicators. These include data normalization and weighting schemes. Accordingly, if the methods used to construct composite indicators are inconsistent, they may well lead to diverse rankings, thus increasing the probability of erroneous results (Booysen, 2002).

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Many methods can be used to construct composite indicators, but DEA is one of the principal quantitative methods suitable for this purpose, because it enables nonarbitrary weighting, avoiding this methodological issue (although it comes from the application of a constrained optimization algorithm and this application of that algorithm itself is arbitrary), and it is invariant to the measurement unit, then DEA does not require data normalization (Cherchye, 2006). The DEA application used to construct composite indicator is known as the benefit of the doubt (BOD) model and it is be described at the "Data Envelopment Analysis and Composite Indicators" section.

While there are several composite indicators used to measure socio-economic development and quality of life (QOL), the most frequently used is the human development index (HDI). A general practical implication of composite QOL indices is its usefulness for decision makers, e.g., making political decisions based on the evolution of composite indicators over the past years or establishing residency on a place with higher QOL (Hagerty & Land,2007).

Focusing on the HDI together with its weights for each indicator of each country, other practical implications are that it shows the priorities of the countries, it can attract external investment and orientate the concession of international help. Also, it can help policy makers to prioritize public expenditures to improve QOL of the population, stimulating government policies about human development.

As presently constructed, HDI's data normalization and weighting schemes are arbitrary, giving rise to substantive criticism (Neumayer, 2001; Klugman, Rodríguez, & Choi, 2011). Since 1990 when HDI was first created, its calculation methods have been revised constantly, as shown in the survey conducted by Morse (2014). The most radical methodological alteration, a change in its aggregation method of indices, from an arithmetic to a geometric mean in 2010, did not save the index from further controversy (Klugman et al., 2011). The HDI construction and some other detail are presented at the "Data Envelopment Analysis and Composite Indicators" section.

With this history in mind, it is important to note that a slack-based measure (SBM) DEA model was not previously used to recalculate the HDI (Mariano, Sobreiro, & Rebelatto, 2015), so it is used in this regard, comparing its results to HDI's, where it lays the main contribution of this chapter, and those of other DEA models, viz., Charnes, Cooper and Rhodes (CCR) and geometric/multiplicative, in their standard and inverted forms.

The chapter describes and correlates the results of DEA models in calculating the HDI and provides recommendations regarding their respective advantages and disadvantages in constructing socio-economic composite indicators.

DATA ENVELOPMENT ANALYSIS AND COMPOSITE INDICATORS

The first data envelopment analysis model was created by Charnes, Cooper, and Rhodes (1978). The CCR model is a nonparametric mathematical programming method used to measure the relative efficiency of decision-making units (DMUs) in a system with multiple inputs and outputs. The original was an input-oriented fractional programming model formulated as follows:

$$\max P_0 = \frac{\sum_{i=1}^{m} u_i y_{i0}}{\sum_{j=1}^{n} v_j x_{j0}}$$