

Chapter 5

Composite Indicators Construction by Data Envelopment Analysis: Methodological Background

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ABSTRACT

Composite indicators (CIs) are seen as an aggregation of a set of sub-indicators for measuring multi-dimensional concepts that cannot be captured by a single indicator (OECD, 2008). The indicators of development in different areas are also constructed by aggregating several sub-indicators. Consequently, the construction of CIs includes weighting and aggregation of individual performance indicators. These steps in CI construction are challenging issues as the final results are significantly affected by the method used in aggregation. The main question is whether and how to weigh individual performance indicators. Verifiable information regarding the true weights is typically unavailable. In practice, subjective expert opinions are usually used to derive weights, which can lead to disagreements (Hatefi & Torabi, 2010). The disagreement can appear when the experts from different areas are included in a poll since they can value criteria differently in accordance with their expertise. Therefore, a proper methodology of the derivation of weights and construction of composite indicators should be employed. From the operations research standpoint, the data envelopment analysis (DEA) and the multiple criteria decision analysis (MCDA) are proper methods for the construction of composite indicators (Zhou & Ang, 2009; Zhou, Ang, & Zhou, 2010). All methods combine the sub-indicators according to their weights, except that the MCDA methods usually require a priori determination of weights, while the DEA determines the weights a posteriori, as a result of model solving. This chapter addresses the DEA as a non-parametric technique, introduced by Charnes, Cooper, and Rhodes (1978), for efficiency measurement of different non-profitable and profitable units. It is lately adopted as an appropriate method for the CI construction due to its several features (Shen, Ruan, Hermans, Brijs, Wets, & Vanhoof, 2011). Firstly, individual

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performance indicators are combined without a priori determination of weights, and secondly, each unit under observation is assessed taking into consideration the performance of all other units, which is known as the ‘benefit of the doubt’ (BOD) approach (Cherchye, Moesen, Rogge, & van Puyenbroeck, 2007). The methodological and theoretical aspects and the flaws of the DEA application for the construction of CIs will be discussed in this chapter, starting with the issues related to the application procedure, followed by the issues of real data availability, introducing value judgments, qualitative data, and non-desirable performance indicators. The procedure of a DEA-based CI construction will be illustrated by the case of ranking of different regions of Serbia based on their socio-economic development.

INTRODUCTION

The purpose of this chapter is to introduce theoretical and methodological aspects of using a quantitative technique (Data envelopment analysis – DEA) in constructing composite indicators (CI). Composite indicators have recently become very popular and useful tools for comparing performance of countries. These indicators allow „simple comparisons of countries that can be used to illustrate complex and sometimes elusive issues in wide-ranging fields, e.g., education, environment, economy, society, or technological development” (OECD, 2008, p. 13). It often seems easier for the general public to interpret composite indicators than to identify common trends across many separate indicators; they have been also proven as a useful tool for benchmarking of the country performance (Saltelli, 2007). Numerous indicators have been constructed and introduced to cover all important areas of human and social development. A list of 178 composite indices can be found in the survey made by Bandura (2008).

However, composite indicators can send misleading messages if they are not properly constructed or calculated. Besides others techniques, such as multiple criteria decision analysis techniques of the equal weighted sum (Cherchye, Moesen, Rogge, & van Puyenbroeck, 2007), a statistical technique of composite I-distance indicator (Dobrota, Bulajic, Bornmann, & Jeremic, 2016), DEA is considered a suitable technique for constructing composite indicators. Detailed and structured literature reviews (Mariano, Sobreiro, & Rebelatto, 2015) indicate that DEA-based CIs are used in different areas covering different aspects of life, from economy and transportation to happiness.

The methodological and theoretical aspects, advantages and drawbacks of the DEA application to a CI construction will be discussed in detail in this chapter. The DEA theoretical background along the basic DEA models is given in the next two sections. The main focus of this chapter is put on the DEA-based CI discussed in the section “DEA-based composite indicators”, followed by the models constructed for overcoming the DEA drawbacks. The procedure of a DEA-based CI construction is illustrated by the case study of the ranking of different regions of Serbia based on the socioeconomic development indicators. Finally, the concluding remarks are given.

BACKGROUND

Composite indicators (CIs) represent an aggregation of a set of sub-indicators for measuring multi-dimensional concepts that cannot be captured by a single indicator *e.g.* competitiveness, sustainability, single market integration, etc. (OECD, 2008). Dobrota, Savic, and Bulajic (2015) gave the example of using 12 single indicators for evaluating the European countries’ educational structure development is

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