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## Editorial

### Recent developments on the use of DEA in the Public Sector

Heinz Ahn, Mohsen Afsharian, Ali Emrouznejad, Rajiv Banker

There has been continuous and rapid growth in the field of Data Envelopment Analysis since it was operationalized by Charnes et al. (1978) and further developed by Banker et al. (1984) on the basis of the seminal work of Farrell (1957). There is now a considerable amount of theoretical articles in measuring various notations of efficiency, such as technical efficiency, cost efficiency and revenue efficiency, in both static and dynamic frameworks. The family of DEA models is also employed routinely in areas that range from assessment of public organizations such as health care systems, educational institutions and governmental bodies to private organizations such as banks and service providers.

The papers comprising this special issue of the *Socio-Economic Planning Sciences* contribute to the theory and applications of *DEA in the public sector*. This special issue has its origin in the 13<sup>th</sup> *International Conference on Data Envelopment Analysis (DEA2015)*. The conference was organized by the *Institute of Management Control and Business Accounting* of the *Technische Universität Braunschweig* and took place in Braunschweig, Germany, between August 24<sup>th</sup> and 27<sup>th</sup>, 2015. The scope of this issue was extended beyond that of the papers presented at the conference via an open invitation to the broader academic community working in the area of theory and applications of efficiency and productivity analysis. As a result of the rigorous refereeing process, 9 papers were accepted for inclusion in this special issue. This set of papers represent only a small fraction of the total number of submitted manuscripts, but can still offer a well balanced mix of topics of DEA in the public sector.

Further to this, a feature paper, as invited by the Editor-in-Chief, on reviewing DEA literature has also been included in this issue. Hence, the issue opens with a survey and analysis of the first 40 years of scholarly literature in DEA. *Ali Emrouznejad and Guoliang Yang* report that until the end of 2016, the total number of journal articles has reached 10,300 and the distinct authors reached 11,975 in total. Based on the statistics of journal articles, the authors have revealed that *European Journal of Operational Research*, *Journal of the Operational Research Society*, *Journal of Productivity Analysis*, *Omega* and *Annals of Operations Research* are the most utilized journals in this field, while *journal of Socio-Economic Planning Sciences* has been recognized as the first choice journal for DEA papers with applications in the public sector. In terms of the subject areas, environmental efficiency, directional distance function, network DEA, benchmarking and bootstrapping as well as analyzing returns to scale are the main fields of current studies. Moreover, agriculture, banking, supply chain, transportation and public policy are the top 5 application fields of DEA with the greatest numbers of journal articles published in 2015 and 2016.

The second paper of this issue deals with economic interpretations of DEA. *Finn Førsund* explores some basic issues in the efficiency literature with a focus on differences between economic interpretations and more operations-research based formulations of efficiency. More precisely, the definitions of efficiency measures in the two seminal papers by Farrell (1957) and Charnes et al. (1978) are reviewed and the differences in the approaches are pointed out. The author also investigates the interpretations of the shadow prices (dual variables or weights) in DEA problems to give a clear understanding of the concept. Therefore, this work can not only be seen as a tool for researchers not so familiar with efficiency analysis and DEA but can also be especially useful for those DEA researchers who wish to have a new perspective on the foundation of DEA models.

*Pegah khoshnevis and Peter Teirlinck*, the authors of the third paper in this issue, evaluate the performance of R&D active firms in Belgium using DEA models with ratio data. The input-oriented constant and variable returns to scale DEA models (CRS- and VRS-based models) are applied. Scale efficiency and the respective types of returns to scale have been examined. The firms have also been evaluated based on global, size and sector frontiers. The results of this paper highlight that on average R&D active firms suffer from both technical inefficiency and scale size problems while the average of scale efficiency is modest. According to the size, small-sized firms suffer from scale and technical inefficiency. Medium-sized firms endure scale inefficiency rather than technical inefficiency. Large firms, however, present a higher average scale efficiency and technical efficiency. Concerning the sector of activity, firms in specialized supplier industries tend to outperform other firms in terms of average scale efficiency and average technical efficiency. Firms in science-based industries are also found to underperform on average in terms of VRS and scale efficiency.

The domain of the next two papers is the public transport sector. In the first paper, *Anand Venkatesh and Shivam Kushwaha* evaluate the cost efficiency of those State Transport Undertakings (STUs) which are key players in providing mass road transport in India. The cost efficiency is decomposed into technical efficiency and allocative efficiency, allowing for further analyzing the causes of inefficiencies. The authors have found out that STUs are not only sub-optimally utilizing the inputs at their disposal, but also seem to be operating with inappropriate input mixes from the standpoint of cost minimization. According to the results and in order to optimize costs, this study gives a number of practical and managerial recommendations. In the second paper, *Giovanni Cesaroni* introduces a new DEA-based approach for measuring the structural efficiency. From a theoretical level, a decomposition of the industry measure is determined, which establishes the relationship between group and individual measures. The proposed approach also highlights the relationship between the industry measure and different returns-to-scale characterizations of the technology. From a practical point of view and in the context of the Italian local public transit sector, an algorithm is designed, which provides the decision maker with a method to compute the optimal industry structure and the corresponding efficiency components.

The following paper by *Roxani Karagiannis and Giannis Karagiannis* deals with intra- and inter-group composite indicators using the so-called Benefit-of-the-Doubt (BoD) model (i.e. the radial DEA model with a single constant input) with an application in public and private hospitals in Greece, using the data from the 2012 fiscal year. The BoD model is extended in such a way that it can account for environmental or contextual differences. Accordingly, three types of composite indicators are developed, namely the pooled that uses the entire sample of the evaluated units, the intra-group that accounts for within-group differences, and the inter-group that reflects between group differences. The application of the proposed methodology reports that, e.g., public and private hospitals seem on average to be equally well-managed in terms of liquidity financial ratios, but the former seem to have an advantage in achieving higher financial liquidity standards. It has also been revealed that the between-groups differences are more pronounced than the within-group differences and the private hospitals with relatively high values of the intra-group composite indicators tend to achieve relatively lower values of the inter-group composite indicators, and vice versa.

The next two papers are related to education. The key question to answer in the first paper by *Chiara Masci, Kristof De Witte and Tommaso Agasisti* is to identify which among the aspects that relate to the composition of the student body, school (district) size, management practices and the school principals' own characteristics are associated with the performance of Italian students at grade 8 in 2013/2014, measured through standard test scores in reading and mathematics. The core methodology is based on DEA and uses the bootstrap method. The results show that the most influential variables relate to the composition of the student body, while the students' performance in mathematics is partly correlated with the management practices adopted by the school principal/head teacher. It is shown that schools and schooling can only explain a minor part of the variance in achievement scores, while the characteristics of the students themselves play the most significant role. The authors, *Madjid Tavana, Ali Ebrahimnejad, Francisco J. Santos-Arteaga, Seyed Mehdi Mansourzadeh and Reza Kazemi Matin*, study the equivalence relationship between multi objective linear programming problems and combined-oriented DEA models using a direction distance function designed to account for desirable and undesirable inputs and outputs together with uncontrollable variables. They have applied this to a case study where the performance of high schools in the City of Philadelphia is evaluated.

The last two papers in this special issue deal with the evaluation of the efficiency in the domain of local governments. In the first study, *Sepideh Abolghasem, Juliana Gómez-Sarmientoa, Andres Medaglia, Olga L. Sarmiento, Andrés González, Adriana Díaz del Castillo, Juan F. Rozo-Casas and Enrique Jacoby* develop a DEA-centric Decision Support System (DSS) that facilitates the evaluation of community-based programs. These programs are those open street programs by which people can enjoy safe and free space in their city for cycling, skating, walking, jogging, or cultural activities. The authors have demonstrated how policy makers can benefit from their DSS to, e.g., find benchmark programs, identify sources of inefficiencies and extract recommendations for

improvement. Finally, the last paper by *Giovanna D'Inverno, Laura Carosi and Letizia Ravagli* presents an application of DEA on studying the efficiency of Tuscan municipalities' public expenditure. The overall expenditure composition of each municipality and the global spending efficiency have been studied by a proposed composite indicator. The main determinants affecting the municipalities' efficiency have also been further investigated. The study, among others, reveals that the bigger the municipality, the greater its level of public expenditure efficiency.

To conclude, we are grateful to all the authors and to the many reviewers who made this special issue a success. Although it was not possible to include all submitted manuscripts, the editors of this special issue hope that all authors found the feedback helpful for their future work. We also extend our thanks to Professor Vedat Verter, Editor-in-Chief of the Socio-Economic Planning Sciences, for giving us the opportunity and for providing full support during preparation of this special issue.

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