Preface

In recent years, handbooks on Data Envelopment Analysis (DEA) have been published. They include *Handbook on Data Envelopment Analysis* (eds, W.W. Cooper, L.M. Seiford, and J. Zhu, 2011, Springer), *Data Envelopment Analysis: A Handbook of Modeling Internal Structures and Networks* (eds, W.D. Cook and J. Zhu, 2014, Springer), *Data Envelopment Analysis: A Handbook of Models and Methods* (ed. J. Zhu, 2015, Springer), and *Data Envelopment Analysis: A Handbook of Empirical Studies and Applications* (ed. J. Zhu, 2016, Springer). It is well known that DEA is a "data-oriented" approach for evaluating the performance of a set of entities called decision-making units (DMUs) whose performance is categorized by multiple metrics. These performance metrics are classified or termed as inputs and outputs. In general, DEA finds an envelopment for a set of data. This envelopment is called efficient frontier (in production theory) or best-practice frontier (in benchmarking terminology). While many DEA applications can be viewed as estimation of production functions, DEA can also be applied to manufacturing as well as service operations where DEA is used as a versatile tool for making various operational decisions.

To complement the existing DEA handbooks, the current handbook focuses on DEA applications in operations analytics which are fundamental tools and techniques for improving operation functions and attaining long-term competitiveness. In fact, the chapters in the handbook demonstrate that DEA can be viewed as Data Envelopment *Analytics*.

Chapter 1, by Ruiz and Sirvent, reviews cross-efficiency evaluation which provides a peer appraisal in which each DMU is evaluated from the perspective of all of the others by using their DEA weights.

Chapter 2, by Zhou, Poh, and Ang, presents a case study on measuring the environmental performance of OECD countries. Environmental performance measurement provides an analytical foundation for environmental policy analysis and decision making.

Chapter 3, by Serrano-Cinca, Mar-Molinero, and Fuertes Callén, demonstrates how to select a set of performance metrics (inputs and outputs) in DEA with an application to American banks.

Chapter 4, by Liu, proposes using a relational network model to take the operations of individual periods into account in measuring efficiencies, and the input and output data are treated as fuzzy numbers.

Chapter 5, by Avkiran and Zhu, shows how the efficient frontier methods DEA and stochastic frontier analysis (SFA) can be used synergistically. As part of the illustration, the authors directly compare locally incorporated foreign banks with Chinese domestic banks.

Chapter 6, by de la Torre, Sagarra, and Agasisti, integrates DEA and multidimensional scaling, with the aim to discuss the potential complementarities and advantages of combining both methodologies in order to reveal the efficiency framework and institutional strategies of the Spanish higher education system.

Chapter 7, by Wu, Kweh, Lu, Hung, and Chang, constructs a dynamic three-stage network DEA model which evaluates the R&D efficiency, technology-diffusion efficiency, and value-creation efficiency of Taiwanese R&D organizations over the period 2005–2009.

Chapter 8, by Wanke and Barros, presents a bootstrapping-based methodology to evaluate returns to scale and convexity assumptions in DEA.

Chapter 9, by Lozano, Hinojosa, Marmol, and Borrero, studies the possibilities of hybridizing DEA and cooperative games. Specifically, bargaining games and transferable utility games (TU games) are considered.

Chapter 10, by Fukuyama and Weber, uses DEA to represent the production technology and directional distance functions to measure bank performance. The performance measure allows the researcher to compare observed inputs and outputs, including undesirable outputs, with the outputs and inputs that might be produced if a producer were able to optimally choose production plans relative to a dynamic benchmark technology.

Chapter 11, by Ke, presents an input-specific Luenberger energy and environmental productivity indicator. DEA is utilized to estimate the directional distance function for composing the Luenberger energy and environmental productivity indicator.

Chapter 12, by Mehdiloozad and Sahoo, addresses the issue of reference set by differentiating between the uniquely found reference set, called the global reference set (GRS), and the unary and maximal types of the reference set for which the multiplicity issue may occur. The authors propose a general linear programming-based approach that is computationally more efficient than its alternatives. The authors define the returns to scale of an inefficient DMU at its projection point that is produced by all—but not some—of the units in its GRS.

Chapter 13, by Lim, Jahromi, Anderson, and Tudori, evaluates and compares the technological advancement observed in different hybrid electric vehicle (HEV) market segments over the past 15 years. The results indicate that the introduction of a wide range of midsize HEVs is posing a threat to the two-seaters and compact

HEV segments, while an SUV segment shows a fast adoption with a significant performance improvement.

Chapter 14, by Ding, Feng, and Wu, provides radial measurements of efficiency for the production process possessing multicomponents under different production technologies. Their approach is based on the construction of various empirical production possibility sets. Then the authors propose a procedure that is unaffected by multiple optima for estimating returns to scale.

Chapter 15, by Harrison and Rouse, considers issues around the use of accounting information in DEA with suggestions on how accounting data can be used in the modeling process and how DEA can be combined with other accounting approaches to improve performance evaluation.

Chapter 16, by Sueyoshi, explains how to use DEA environmental assessment to establish corporate sustainability and discusses that environmental assessment and protection are important concerns in modern business.

Chapter 17, by Sueyoshi and Yuan, summarizes previous works on the research efforts, including concepts and methodologies, on DEA environmental assessment applied to energy in the past three decades.

Chapter 18, by Sarkis, provides an overview of DEA and how it can be utilized alone and with other techniques to investigate corporate environmental sustainability questions. Some future DEA directions that could be used for research and application in corporate environmental sustainability are also defined.

We hope that this handbook, along with other aforementioned DEA handbooks, can serve as a reference for researchers and practitioners using DEA and as a guide for further development of DEA. We thank reviewers who provided valuable suggestions and comments to the chapters. We are also grateful to the authors who make important contributions toward advancing the DEA research frontier.

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