Preface

This new edition updates previous editions of the *Handbook on Data Envelopment Analysis*. As noted in preceding editions, data envelopment analysis (DEA) is a "data-oriented" approach for evaluating the performances of a set of entities called decision-making units (DMUs) which convert multiple inputs into multiple outputs. As will be seen from the chapters in this (and the preceding) editions, DEA has been used in evaluating the performances of many different kinds of entities engaged in many different kinds of activities in many different contexts. It has opened up possibilities for use in cases which have been resistant to other approaches because of the complex and often unknown nature of the relations between the multiple inputs and outputs involved in many of their activities (which are often reported in noncommensurable units). See Emrouznejad et al. (2008) who "have identified more than 4,000 research articles published in journals or book chapters.... To provide some sense of the field's ongoing expansion, has had we included unpublished dissertations, working/research manuscripts, the bibliography count would have exceeded 7,000 entries!" All this occurred in the 30 years since the publication of the originating article by Charnes et al. (1978) and the pace continues to accelerate. DEA has also been used to supply new insights into activities and entities that have previously been evaluated by other methods.

This handbook is intended to represent another milestone in the progression of DEA. Written by experts, who are often major contributors to the topics to be covered, it includes a comprehensive review and discussion of basic DEA models, extensions to the basic DEA methods, and a collection of DEA applications in many different areas such as banking, service industries, health care and education as well as evaluations of country and regional performances, and engineering and science applications.

Handbook chapters are organized into two categories (1) basic DEA models, concepts, and their extensions and (2) DEA applications. The first category consists of 12 chapters. Chapter 1, by Cooper, Seiford and Zhu, covers the various models and methods for treating "technical" and "allocative" efficiency. It also includes the "additive" model for treating "allocative" and "overall" efficiency that can be used when the usual "ratio" form of the efficiency measure gives unsatisfactory or misleading results. Chapter 2, by Banker and Cooper, deals with returns to scale (RTS) and the ways in which this topic is treated with different models and methods. The emphasis in this chapter is on relationships between models and methods and the RTS characterizations that they produce. This chapter also introduces a method for determining "exact" elasticities of scale in place of previous approaches, which are limited because they can only establish "bounds" on the elasticities. Chapter 3, by Cooper, Li, Seiford and Zhu, describes ways to determine the "sensitivity" and "stability" of DEA efficiency evaluations in the presence of stipulated variations in the data. The sensitivity analyses covered in this chapter extend from variations in *one* "data point" and include determining the sensitivity of DEA efficiency evaluations when *all* data points are varied simultaneously.

In Chap. 4, Cooper, Ruiz, and Sirvent describe different approaches with no need for a priori choices of weights (called "multipliers) that reflect meaningful trade-offs. It also shows how to incorporate prices or other value information and managerial goals, making a choice among alternate optima for the weights, avoiding the need for zero weights and avoiding large differences in the values of multipliers, improving discrimination and rankings of performances. Chapter 5, by Färe, Grosskopf, and Margaritis, provides an overview of recent work on DEA and Malmquist productivity indexes. It also reviews the construction of static and dynamic DEA technologies. Based on these technologies it shows how DEA can be used to estimate the Malmquist productivity index. Chapter 6, by Cook, discusses how to treat qualitative data in DEA. The emphasis is on cases in which the data are ordinal and not cardinal. This extends DEA so that it can treat problems in which the data can be ordered but the numbers utilized to represent the ordering do not otherwise lend themselves to the usual arithmetic operations such as addition, multiplication, etc.

Chapter 7, by Cooper, Deng, Seiford, and Zhu, treats "congestion" and discusses modeling to identify the amounts and sources of this particularly severe form of "technical" inefficiency. Chapter 8, by Tone, introduces a slacks-based model and its extensions. This is followed by three chapters directed to probabilistic and statistical characterizations of the efficiency evaluation models discussed in Chap. 1. Chapter 9, by Cooper, Huang, and Li, turns to probabilistic formulations as in "chance-constrained programming." It also treats "joint" chance constraints, as well as the more customary types. All of this is accompanied by discussions of uses of both types of constraints in some of the applications where these chance-constrained programming formulations of DEA have been used. Chapter 10, by Simar and Wilson, utilizes "bootstrapping" and shows how these methods may be used to obtain statistical tests and estimates of DEA results. Chapter 11, by Banker and Natarajan, is directed to the more classical methods of "statistically consistent estimates." Hence, both classical and more recently developed approaches are brought to bear on statistical characterizations that are now available for use with DEA.

The final chapter in the first category is written by Cook, Liang, and Zhu. An important area of development in recent years in DEA has been applications wherein internal structures of DMUs are considered. For example, DMUs may consist of subunits or represent two-stage processes. One particular subset of such processes is those in which all the outputs from the first stage are the only inputs to the second stage. Chapter 12 reviews these models and discusses relations among various approaches. The focus here is the approaches based upon either Stackelberg (leader–follower) or cooperative game concepts.

The second category of the topics covered in this handbook involves four DEA applications. Chapter 13, by Paradi, Yang, and Zhu, provides a detailed discussion of DEA applications to banking with an emphasis on factors, circumstance, and formulations that need to be considered in actual applications. It also includes a comprehensive list of DEA bank branch models in the literature. Chapter 14, by Triantis, discusses DEA applications in engineering and includes a comprehensive bibliography of published DEA engineering applications. As this chapter shows, engineering uses of DEA have been relatively few but this is a field that is rich with potential applications of DEA ranging from engineering designs to uses of DEA to evaluate performances and to locate deficiencies in already functioning systems.

In contrast, the service sector holds substantial challenges for productivity analysis because most service delivery is often heterogeneous, simultaneous, intangible, and perishable. Chapter 15, by Avkiran, provides a selection of DEA applications in the service sector with a focus on building a conceptual framework, research design, and interpreting results. Chapter 16, by Chilingerian and Sherman, offers a succinct history of DEA to the provision of health care by, e.g., hospitals, and discusses the models and the motivations behind the applications with an eight-step application procedure and some "do's and don'ts" in DEA healthcare applications with an emphasis on the need for including "quality" measures of the services provided.

We hope this DEA handbook will serve as a comprehensive reference for researchers and practitioners and as a guide for further developments and uses of DEA. We welcome comments, criticisms, and suggestions.

Austin, TX — William W. Cooper
Ann Arbor, MI — Lawrence M. Seiford
Worcester, MA — Joe Zhu

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