HANDBOOK ON DATA ENVELOPMENT ANALYSIS

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Preface

Data Envelopment Analysis (DEA) is a relatively new “data-oriented” approach for evaluating the performances of a set of entities called Decision-Making Units (DMUs) which convert multiple inputs into multiple outputs. 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 these activities, which are often reported in non-commeasurable units. 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 a 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 the areas of banking, education, sports, retail, health care, and a review of current DEA software technology.

This handbook’s chapters are organized into three categories: (i) basic DEA models, concepts, and their extensions; (ii) DEA applications; and (iii)

DEA software packages. The first category consists of eleven chapters. Chapter 1, by Cooper, Seiford and Zhu, covers the various models and methods for treating "technical" and "allocative" efficiency. It includes a new "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, Cooper, Seiford and Zhu, 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 new 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 "stability" and "sensitivity" 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 Chapter 4, Thanassoulis, Portela and Allen treat ways for analysts or decision-makers to incorporate value judgments into DEA analyses, including *a priori* information in both the "dual" (or "multiplier") and "direct" (or "envelopment") models. The authors then describe the effects of incorporating such information on other parts of a DEA such as possible effects on RTS characterizations. Chapter 5, by Färe, Grosskopf and Whittaker, applies distance functions to DEA. The treatment in this chapter covers distance functions and their duality relations, as defined in the relations between distance and cost functions established by R.W. Shephard — which are here extended to "directed distance" functions and the profit function duals that can be obtained from them. 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 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, provides a comprehensive study of Malmquist productivity-index-number calculations for use in identifying and evaluating technology and efficiency changes that may occur between different periods. This chapter also includes a new "slacks-based" index formulation that reflects *all* inefficiencies that the model can identify. This approach removes an inadequacy that may be

present in the usual calculations, which do not reflect inefficiencies associated with non-zero slack.

The final three chapters in this category are directed to probabilistic and statistical characterizations of the efficiency evaluation models discussed in Chapter 1. Chapter 9, by Cooper, Huang and Li, turns to probabilistic formulations as in "chance-constrained programming." "Joint" chance constraints, as well as the more customary types, are covered. All of this is accompanied by discussions of uses of both types of constraints in some of the applications of these chance-constrained-programming formulations of DEA. Chapter 10 by Simar and Wilson utilizes the relatively recently developed methods associated with "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 second category of the topics covered in this handbook involves six DEA applications chapters. Chapter 12, by Ruggiero, deals with DEA applications in education, along with a discussion of the treatment of non-discretionary variables. Chapter 13, by Paradi, Vela and Yang, 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. Chapter 15, by Anderson, provides an application to the sport of baseball and uses the concept of "super-efficiency" in DEA to supply insights into the debate on who had the most dominant baseball batting season: Babe Ruth or Barry Bonds? Chapter 16, by Athanassopoulos, deals with DEA applications in the retail trades with reports on case studies based on research undertaken by Athanassopoulos in commercial banking, restaurants, brewing markets and betting shops in the U.K. Chapter 17, by Chilingerian and Sherman, offers a succinct history of health care applications of DEA 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 health care applications with an emphasis on the need for including "quality" measures of the services provided.

The final category consists of Chapter 18, by Barr, which provides a detailed and comprehensive review of currently available commercial and non-commercial DEA software packages and related technologies.

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

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