

---

# Data Envelopment Analysis: Theory, Methodology, and Application

# Data Envelopment Analysis: Theory, Methodology, and Application

**Abraham Charnes**  
University of Texas at Austin

**William W. Cooper**  
University of Texas at Austin

**Arie Y. Lewin**  
Duke University

**Lawrence M. Seiford**  
University of Massachusetts

**Library of Congress Cataloging-in-Publication Data**

Data envelopment analysis: theory, methodology and application / by Abraham Charnes . . . [et al].

p. cm.

Includes bibliographical references and index.

ISBN 978-0-7923-9480-8 ISBN 978-94-011-0637-5 (eBook)

DOI 10.1007/978-94-011-0637-5

1. Social sciences—Statistical methods. 2. Data envelopment analysis. I. Charnes, A. (Abraham), 1917–1993.

HA31.38.D38 1993

94-22053

300'.1'5195—dc20

CIP

---

Copyright © 1994 by Springer Science+Business Media New York

Originally published by Kluwer Academic Publishers in 1994

Softcover reprint of the hardcover 1st edition 1994

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system or transmitted in any form or by any means, mechanical, photo-copying, recording, or otherwise, without the prior written permission of the publisher.

Springer Science+Business Media, LLC.

*Printed on acid-free paper.*

This book is dedicated to George Kozmetsky for his early championing of DEA and for his lifelong commitment to nurturing creativity.

# Contents

Preface	xi
I	
Concepts, Models, and Computation	1
1	
Introduction	3
2	
Basic DEA Models	23
3	
Extensions to DEA Models	49
4	
Computational Aspects of DEA	63
<i>Agha Iqbal Ali</i>	
5	
DEA Software Packages	89
II	
Novel Applications	95
6	
Evaluating the Impacts of Operating Strategies on Efficiency in the U.S. Airline Industry	97
<i>Rajiv D. Banker and Holly H. Johnston</i>	
7	
Analyzing Technical and Allocative Efficiency of Hospitals	129
<i>Patricia Byrnes and Vivian Valdmanis</i>	
8	
A Multiperiod Analysis of Market Segments and Brand Efficiency in the Competitive Carbonated Beverage Industry	145
<i>Abraham Chames, William W. Cooper, Boaz Golany, D. B. Learner, Fred. Y. Phillips, and John J. Rousseau</i>	
	vii

9	<b>Exploring Why Some Physicians' Hospital Practices Are More Efficient: Taking DEA Inside the Hospital</b>	167
	<i>Jon A. Chilingirian</i>	
10	<b>On the Measurement and Monitoring of Relative Efficiency of Highway Maintenance Patrols</b>	195
	<i>Wade D. Cook, Alex Kazakov, and Yaakov Roll</i>	
11	<b>Strategic Leaders in the U.S. Brewing Industry: A Longitudinal Analysis of Outliers</b>	211
	<i>Diana Day, Arie Y. Lewin, Hongyu Li and Ronald Salazar</i>	
12	<b>A Spatial Efficiency Framework for the Support of Locational Decision</b>	235
	<i>Anand Desai, Kingsley Haynes, and James Storbeck</i>	
13	<b>Productivity Developments in Swedish Hospitals: A Malmquist Output Index Approach</b>	253
	<i>Rolf Färe, Shawna Grosskopf, Björn Lindgren, and Pontus Roos</i>	
14	<b>Ownership Type, Property Rights, and Relative Efficiency</b>	273
	<i>Gary D. Ferrier</i>	
15	<b>A Comparative Analysis of Ferry Transport in Norway</b>	285
	<i>Finn R. Førsund and Erik Hemaes</i>	
16	<b>Incorporating Standards Via DEA</b>	313
	<i>Boaz Golany and Yaakov Roll</i>	
17	<b>Stratified Models of Education Production Using Modified DEA and Regression Analysis</b>	329
	<i>C. A. Knox Lovell, Lawrence C. Walters, and Lisa L. Wood</i>	
18	<b>The Problem of New and Disappearing Commodities in the Construction of Price Indexes</b>	353
	<i>C. A. Knox Lovell and Kimberly D. Zieschang</i>	
19	<b>Evaluating the Relative Efficiency of Baseball Players</b>	369
	<i>Mark J. Mazur</i>	
20	<b>Sensitivity Analysis of Efficiency Measures with Applications to Kansas Farming and Illinois Coal Mining</b>	393
	<i>Russell Thompson, P. S. Dharmapala, and Robert M. Thrall</i>	

CONTENTS	ix
III	
Epilogue: Process and Bibliography	423
21	
The DEA Process, Usages, and Interpretations	425
22	
A DEA Bibliography (1978–1992)	437
<i>Lawrence M. Seiford</i>	
Notes about Authors	471
List of Conference Participants	481
References	489
Index	509

## Preface

This book represents a milestone in the progression of Data Envelopment Analysis (DEA). It is the first reference text which includes a comprehensive review and comparative discussion of the basic DEA models. The development is anchored in a unified mathematical and graphical treatment and includes the most important modeling extensions. In addition, this is the first book that addresses the actual process of conducting DEA analyses including combining DEA and parametric techniques.<sup>1</sup>

The book has three other distinctive features. It traces the applications-driven evolution and diffusion of DEA models and extensions across disciplinary boundaries. It includes a comprehensive bibliography to serve as a source of references as well as a platform for further developments. And, finally, the power of DEA analysis is demonstrated through fifteen novel applications which should serve as an inspiration for future applications and extensions of the methodology.

The origin of this book was a Conference on New Uses of DEA in Management and Public Policy which was held at the IC<sup>2</sup> Institute of the University of Texas at Austin on September 27–29, 1989. The conference was made possible through NSF Grant #SES-8722504 (A. Charnes and W. W. Cooper, co-PIs) and the support of the IC<sup>2</sup> Institute. The purpose of the conference was to: (a) provide opportunities for further contacts between persons already working in DEA; (b) provide a common background, including knowledge of computer codes, for conference participants; and, (c) disseminate knowledge about DEA and its uses. In

---

<sup>1</sup>To accelerate diffusion of DEA instruction in undergraduate and graduate courses, authors of textbooks may obtain permission to incorporate any of these chapters by writing to Kluwer Academic Publishers.



pursuit of the latter goal, selections from this conference are contained in the novel applications chapters.

Unfortunately the production of this book was delayed by several unforeseen circumstances, perhaps the most important of which was the illness of Professor A. Charnes. Although he never saw the final product (Professor Charnes died on December 19, 1992) he remained enthusiastic about this project to the end.

Finally, the editors wish to note the unfailing support of George Kozmetsky, to whom this book is dedicated, and the IC<sup>2</sup> Institute which made possible the publication of the soft cover edition.

Our intention is that this book serve as an introduction to DEA for new users as well as a reference for persons already knowledgeable in DEA. In this way we hope that the book also provides a basis for participating in future endeavors and extensions of activities which have emerged from these uses.

**W. W. Cooper**

*University of Texas, Austin TX*

**Arie Y. Lewin**

*Duke University, Durham, NC*

**Lawrence M. Seiford**

*University of Massachusetts, Amherst, MA*

---

# Data Envelopment Analysis: Theory, Methodology, and Application