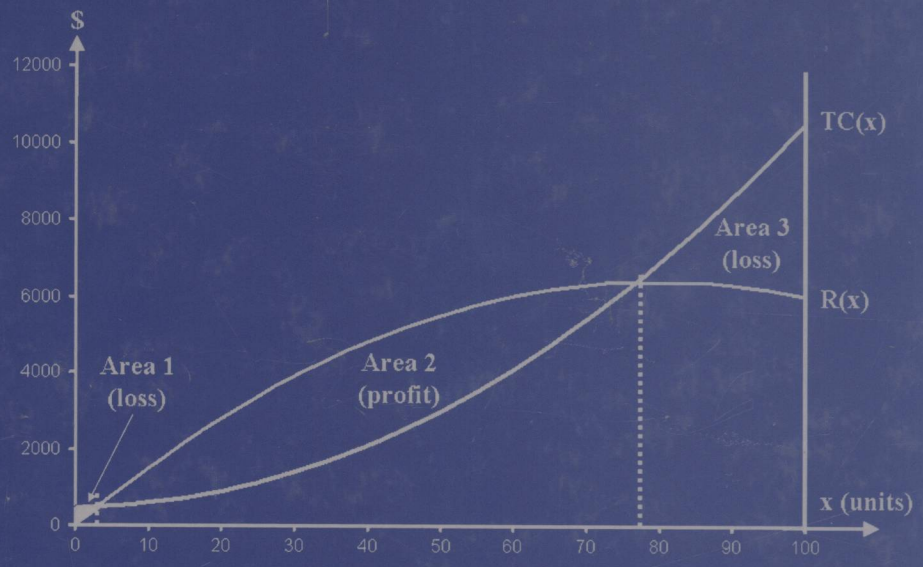
ADEDEJI B. BADIRU
OLUFEMI A. OMITAOMU

Computational Economic Analysis for Engineering and Industry



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Book series on industrial innovation

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Dedication

This book is dedicated to our families, from whom we directed our attention occasionally while we labored on this manuscript.

Preface

The bottom line, expressed in terms of cost and profits, is a major concern of many organizations. Even public institutions that have traditionally been nonchalant about costs and profits are now beginning to worry about economic justification. Formal economic analysis is the only reliable mechanism through which all the cost ramifications of a project, public or private, can be evaluated. Good economic analysis forms the basis for good decision making. Modern decisions should have sound economic basis. Decisions that don't have good economic foundations will eventually come back to haunt the decision maker. This is true for all types of decisions including technology decisions, engineering decisions, manufacturing decisions, and even social and political decisions.

Decision making is the principal function of an engineer or manager. Over two-thirds of engineers will spend over two-thirds of their careers as managers and decision makers. Ordinary decision making involves choosing between alternatives. Economic decision making involves choosing between alternatives on the basis of monetary criteria. Economic analysis is a fundamental tool of the decision-making process. Traditionally, the application of economic analysis techniques to engineering problems has been referred to as engineering economy or engineering economic analysis. However, the increasing interest in economic analysis in all disciplines has necessitated a greater use of the more general term, economic analysis. Over the past few decades, the interest in engineering economy has increased dramatically. This is mainly due to a greater awareness and consciousness of the cost aspects of projects and systems. In the management of technology, it is common for top management people to consist largely of former engineers. It has, consequently, become important to train engineers in the cost aspects of managing engineering and manufacturing systems. Colleges and universities have been responding to this challenge by incorporating engineering economy into their curricula. All engineering and technology disciplines now embrace the study of engineering economy. This has, consequently, created a big and delineated market with a growing demand for engineering economy books. The rapid development of new engineering technologies and the pressure to optimize systems output while minimizing cost has continued to fuel the market momentum. Unfortunately, the pace of generating text materials for engineering economy has not kept up with the

demand. This is even more so in the very complex industrial environment, where integrated computational analyses are required.

This book on **Computational Economic Analysis for Engineering and Industry** provides direct computational tools, techniques, models, and approaches for economic analysis with a specific focus on industrial and engineering processes. The book integrates mathematical models, optimization, computer analysis, and the managerial decision process. Industry is a very dynamic and expansive part of the national economy that is subject to high levels of investment, risks, and potential economic rewards. To justify the investments, special computational techniques must be used to address the various factors involved in an industrial process.

A focused compilation of formulations, derivations, and analyses that have been found useful in various economic analysis applications will be of great help to industry professionals. This book responds to the changing economic environment of industry. Recent global economic anxiety indicates that more focus needs to be directed at economic issues related to industry. The book provides a high-level technical presentation of economic analysis of the unique aspects of industrial processes. Existing conventional techniques, while well proven, do not adequately embrace the integrated global factors affecting unique industries. Conceptual and philosophical publications are available on the worldwide developments in industry. But industry-focused computational tools are not readily available. This book fills that void. The contents of the book include new topics such as:

New economic analysis models and techniques
Tent-shaped cash flows
Industrial economic analysis
Project-based economic measures
Profit ratio analysis
Equity break-even point
Utility based analysis
Project-balance analysis
Customized *ENGINEA* software tool

The book will provide students, researchers, and practitioners with a comprehensive treatment of economic analysis, considering the specific needs of industry. Topics such as investment justification, break-even analysis, and replacement analysis are covered in an updated manner. The book provides a pragmatic alternative to conventional economic analysis books. Readers will find useful general information in the Appendixes, which contain engineering conversion factors and formulae.

Adedeji B. Badiru
Olufemi A. Omitaomu
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The Authors

Adedeji "Deji" B. Badiru is the department head of systems and engineering management at the U.S. Air Force Institute of Technology (AFIT), Wright Patterson Air Force Base, Ohio. Previously head of industrial and information engineering at the University of Tennessee in Knoxville, he served as professor of industrial engineering and dean of University College at the University of Oklahoma. He is a registered professional engineer, a fellow of the Institute of Industrial Engineers, and a fellow of the Nigerian Academy of Engineering. He holds a B.S. degree in industrial engineering, an M.S. in mathematics, an M.S. in industrial engineering from Tennessee Technological University, and a Ph.D. in industrial engineering from the University of Central Florida.

His areas of expertise and courses taught cover mathematical modeling, project management, systems analysis, and economic analysis. He is the author of several technical papers and books, and is the editor of the *Handbook of Industrial and Systems Engineering*. He is a member of several professional associations, including the Institute of Industrial Engineers (IIE), Society of Manufacturing Engineers (SME), Institute for Operations Research and Management Science (INFORMS), American Society for Engineering Education (ASEE), American Society for Engineering Management (ASEM), and the Project Management Institute (PMI).

He has served as a consultant to several organizations around the world, including Russia, Mexico, Taiwan, Venezuela, South Africa, Nigeria, Ghana and South Korea. He has conducted customized training workshops for numerous organizations including Sony, AT&T, Seagate Technology, the U.S. Air Force, Oklahoma Gas and Electric, Oklahoma Asphalt Pavement Association, Hitachi, Nigeria National Petroleum Corporation, and ExxonMobil. He is the recipient of several honors including the IIE Outstanding Publication Award, University of Oklahoma Regents' Award for Superior Teaching, School of Industrial Engineering Outstanding Professor of the Year, Eugene L. Grant Award for Best Paper in Volume 38 of *The Engineering Economist* journal, University of Oklahoma College of Engineering Outstanding Professor of the Year, Ralph R. Teetor Educational Award from the Society of Automotive Engineers, Award of Excellence as chapter president from the Institute of Industrial Engineers, UPS Professional Excellence Award, Distinguished Alumni Award from Saint Finbarr's College, Lagos, Nigeria, and Distinguished

Alumni Award from the Department of Industrial and Systems Engineering, Tennessee Tech University. He holds a leadership certificate from the University of Tennessee Leadership Institute.

Dr. Badiru has served as a technical project reviewer for the Third-World Network of Scientific Organizations, Italy. He has also served as a proposal review panelist for the National Science Foundation and National Research Council, and a curriculum reviewer for the American Council on Education. He is on the editorial and review boards of several technical journals and book publishers, and was an industrial development consultant to the United Nations Development Program.

Olufemi Abayomi Omitaomu received a B.S. degree in mechanical engineering from Lagos State University, Nigeria in 1995, an M.S. degree in mechanical engineering from the University of Lagos, Nigeria in 1999, and a Ph.D. in industrial engineering from University of Tennessee, Knoxville, in 2006. He won several academic prizes during his undergraduate and graduate programs. After his B.S., he worked as a project engineer for Mobil Producing Nigeria between 1995 and 2001. During his Ph.D. program, he taught engineering economic analysis course for several semesters. Olufemi has published several journal and conference articles in international journals including *The Engineering Economist*. He has also published book chapters on economic analysis and data mining techniques. He jointly published two computer software programs including the ENGINEA, which is included in this book. Olufemi is a member of several professional bodies including the Institute of Industrial Engineers (IIE), Institute of Electrical and Electronic Engineers (IEEE), Institute for Operations Research and the Management Sciences (INFORMS), and the American Society of Mechanical Engineers (ASME). He was a board member of the Engineering Economy Division, Institute of Industrial Engineers (IIE) for 4 years. He is listed in the 2006 edition of *Who's Who in America* and 2007 edition of *Who's Who in Science and Engineering*. He is currently a research associate in the Computational Sciences and Engineering Division at Oak Ridge National Laboratory, Tennessee. His research interests include computational economic analysis and online knowledge discovery and data mining. He is married to Remilekun Enitan, and they have two children, Oluwadamilola and Oluwatimilehin.

December 2006

Table of Contents

chapter one

Applied economic analysis

Industrial enterprises have fundamentally unique characteristics and require unique techniques of economic analysis. Thus, although the methodologies themselves may be standard, the specific factors or considerations may be industrially focused. Fortunately, most of the definitions used in general economic analyses are applicable to industrial economic analysis. This chapter presents computational definitions, techniques, and procedures for applied industrial economic analysis. As in the chapters that follow, a project basis is used for most of the presentations in this chapter.

1.1 Cost- and value-related definitions

We need to define and clarify some basic terms often encountered in economic analysis. Some terms appear to be the same but are operationally different. For example, the term *economics* must be distinguished from the term *economic analysis*, and even more specifically from the term *engineering economic analysis*. *Economics* is the study of the allocation of the scarce assets of production for the purpose of satisfying some of the needs of a society. *Economic analysis*, in contrast, is an integrated analysis of the qualitative and quantitative factors that influence decisions related to economics. Finally, an *engineering economic analysis* is an analysis that focuses on the engineering aspects. Examples of the engineering aspects typically considered in an economic design process include the following:

- Product conceptualization
- Research and development
- Design and implementation
- Prototyping and testing
- Production
- Transportation and delivery

Industrial economics is the study of the relationships between industries and markets with respect to prevailing market conditions, firm behavior,