# Studies in Systems, Decision and Control

Volume 88

**Series editor**

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Krishnendu Mukherjee

# Supplier Selection

## An MCDA-Based Approach

Springer

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ISSN 2198-4182 ISSN 2198-4190 (electronic)
Studies in Systems, Decision and Control
ISBN 978-81-322-3698-6 ISBN 978-81-322-3700-6 (eBook)
DOI 10.1007/978-81-322-3700-6

Library of Congress Control Number: 2016963662



Printed on acid-free paper

This Springer imprint is published by Springer Nature
The registered company is Springer (India) Pvt. Ltd.
The registered company address is: 7th Floor, Vijaya Building, 17 Barakhamba Road, New Delhi 110 001, India

*I would like to thank my mentors—Prabir Kumar Bose, Ardhendu Bhattacharayya, and Bijon Sarkar—who have taught me the value of decision making and its effect on human life. I am also grateful to my parents for their love and encouragement. Specifically, I am indebted to my mother for her continuous support to complete this work.*

*Finally, this entire work is dedicated to Lord Krishna and to my mother. Without their blessing it would be difficult for me to give my best during my odd days.*

# Preface

Supplier selection is not a mere clerical process. It is a product-specific multi-criteria-based optimization problem. Judicious selection of suppliers could minimize procurement cost, enhance quality and reliability of supply, and thereby enhance profit margin of the company by minimizing upstream supply chain risk. Today, supply chain surplus of a company depends considerably on proper selection of its suppliers. Success of Apple Industry is a good indication of that. A decision maker has to trade off tangible and intangible criteria to select the best supplier or suppliers for the focal company. Several methods are available for selecting the best ones. Among these methods, the analytic hierarchy process (AHP) and the analytic network process (ANP) are the most used for their computational simplicity and consistency. This book encompasses several criteria and methods for supplier selection in a systematic way based on extensive literature review from 1998 to 2012 and includes illustrative case studies and examples for interested researchers.

The purpose of this book is to present a comprehensive review of the latest research and development trends at the international level for modeling and optimization of the supplier selection process for different industrial sectors. It is targeted to serve two audiences: the MBA and Ph.D. student interested in procurement and the practitioner who wishes to gain a deeper understanding of procurement analysis with multi-criteria-based decision tools to avoid upstream risks to get better supply chain visibility. This book is expected to serve as a ready reference for supplier selection criteria and various supplier evaluation methods for forward, reverse, and mass-customized supply chain. This book also encompasses strategic sourcing in detail for forward, reverse, and sustainable mass-customized supply chain.

Chapter 1 introduces the basic concept of multi-criteria decision-making process. It also introduces fundamental idea and steps of decision-making process. In brief, Chap. 1 gives fundamental idea of AHP, type of scale, prioritization methods, problem of rank reversal, validation of AHP, fuzzy hierarchical TOPSIS, VIKOR, uncertainty analysis with multi-criteria decision analysis tools, cascaded fuzzy inference system, and intuitionistic fuzzy set. Chapter 2 reviews supplier selection

methods for traditional, reverse, and mass-customized supply chain. Chapter 3 mentions steps to develop mathematical model for supplier selection, evaluation, and order allocation problem. Chapter 4 discusses in detail about strategic sourcing. It includes several mathematical models with illustrative case studies. Chapter 5 discusses mainly on the limitations of fuzzy analytic hierarchy process and consistency of decision to aware researchers about certain limitations of fuzzy analytic hierarchy process. All mathematical models are solved with either MATLAB or R or LINGO. In the appendix, some computer code written in MATLAB, R, and VB.NET is also included for the interested reader.

I would like to give sincere thanks to Prof. T.L. Saaty, the originator of AHP and ANP method, and distinguished University Professor of Business Analytics and Operations Department of Joseph M. Katz Graduate School of Business, University of Pittsburgh, USA, for sharing his notes, published and unpublished research work on AHP and ANP. Without his continuous support and inspiration, it was difficult for me to know AHP and ANP in detail. My special thanks are due to Prof. Rozann Whitaker Saaty of the Creative Decisions Foundation of Pittsburgh, USA, for sharing her research work on AHP and ANP. I wish to thank Professor Timothy J. Ross of Civil Engineering Department of University of New Mexico; Professor Ahti A. Salo of Mathematics and Systems Analysis Department of Aalto University School of Science, Finland; and Dr. Matteo Brunelli, postdoctoral researcher of Systems Analysis Laboratory of Aalto University, Finland, for their wholehearted support and great encouragement in producing this book. I wish to thank various researchers and my students for their support to complete my work. I am also indebted to editorial team at Springer, for their support, assistance, and guidance on this book.

While every attempt has been made to ensure that no errors (printing or otherwise) may be present, the possibility of their existence is expected. As the saying goes, to err is human. I would be grateful to the readers if these errors are pointed out to me. Suggestions for further improvement of the book would be thankfully acknowledged. If any fact, data, figure, concept, etc, resemble with any published and/or unpublished work, then it is unintentional and I would remain grateful to readers if they kindly acknowledge it.

Jaipur Krishnendu Mukherjee

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# About the Author

**Krishnendu Mukherjee** is an operations research scientist with the Operations Research Machine Learning & Analytics Experts (ORMAE), where he has been dealing with several projects for multi-national companies in India and abroad. He did his Bachelor of Engineering in mechanical from Jadavpur University and Master of Engineering from BITS Pilani. He also worked as invited reviewer of IJPE, EJOR, JORS, IJAHP, etc. In 2004, he got opportunity to design and develop innovative carpet backing machine at IICT, Bhadohi, as one of the core team member. In 2014, he received US copyright for developing computer code to facilitate selection and evaluation of n-number of suppliers in fuzzy environment. In 2015, he introduced new concept of postponement strategy to prevent upstream supply chain risk. He has published 15 papers in international journals/conferences. His areas of research include multi-criteria decision analysis, fuzzy set theory, mixed-integer programming, linear programming, constrained programming, non-linear programming, optimization, supply chain management, sustainability, procurement analysis, vehicle routing, airlines scheduling, and tankers scheduling. He has also completed his Ph.D. work including the preparation of final draft of Ph.D. thesis at Jadavpur University. This book encompasses extended work of his Ph.D. thesis. He previously worked with National Institute of Technology Silchar (former REC); Ministry of Manpower, Oman; Indian Institute of Carpet Technology, Ministry of Textile, Govt. of India; Heritage Institute of Technology, Kolkata; MAHE, Dubai, etc.

# Notations

| | |
|---|---|
| AHP | Analytic hierarchy process |
| ANP | Analytic network process |
| ATO | Assembly to order |
| CA | Cluster analysis |
| CBR | Case-based reasoning |
| CI | Consistency index |
| CODP | Customer order decoupling point |
| DEA | Data envelopment analysis |
| EM | Eigenvalue method |
| EPAs | Environmental Protection Agencies |
| ETO | Engineer to order |
| FAHP | Fuzzy analytic hierarchy process |
| FANP | Fuzzy analytic network process |
| FNIS | Fuzzy negative ideal solution |
| FPIS | Fuzzy positive ideal solution |
| GA | Genetic algorithm |
| GDM | Group decision-making method |
| GHGs | Greenhouse gases |
| GP | Goal programming |
| GPD | Green product design |
| IFS | Intuitionistic fuzzy set |
| LLSM | Logarithmic least square method |
| MADM | Multi-attribute decision making |
| MAUT | Multi-attribute utility theory |
| MCDA | Multi-criteria decision analysis |
| MCDM | Multi-criteria decision making |
| MEFAHP | Modified extent fuzzy AHP |
| MEFAHP-GA | Modified extent fuzzy AHP and GA |
| MIP | Mixed-integer programming |
| MODM | Multi-objective decision making |

| | |
|---|---|
| MOGA | Multi-objective genetic algorithm |
| MTO | Make to order |
| MTS | Make to stock |
| NIS | Negative ideal solution |
| PFA | Product family architecture |
| PIS | Positive ideal solution |
| SCV | Supply chain visibility |
| TFN | Triangular fuzzy number |
| TOPSIS | Technique for order preference by similarity to ideal solution |
| TVP | Total value of purchase |
| TVRP | Total value of reliable purchase |
| VIKOR | VlseKriterijumska Optimizacija I Kompromisno Resenje in Serbian |

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