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Multi-Criteria Decision Making in Maritime Studies and Logistics

Applications and Cases

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This book is dedicated to the family members of the Editors, who have supported their academic life.

Paul Tae-Woo Lee and Zaili Yang

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About the Editors

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Chapter 1
Introduction

Paul Tae-Woo Lee and Zaili Yang

After a careful literature survey of the publications on Multi-Criteria Decision Making (MCDM) (e.g., Chen and Hwang 1992; Figueira et al. 2005; Hwang and Masud 1979: Hwang and Yoon 1981; Lai and Hwang 1994; Tanino et al. 2003; Zopounidis and Pardalos 2010), we found that few books have been published to address the theoretical demands on the use of advanced survey techniques and MCDM methods in a complementary way. Furthermore, there are increasing practical concerns on the scanty real cases of using MCDM methods in shipping, port, and logistics, available from the International Series in Operations Research and Business Management by Springer, and/or other sources/publishers such as Ishizaka and Nemery (2013), Triantaphyllou (2000) and Tzeng and Huang (2011). To fulfill this gap, we have edited this book entitled Multi-Criteria Decision Making in Maritime Studies and Logistics, which has peculiar advantages and characteristics, demonstrated by a few highlights and research challenges as follows.

- This book applies MCDM to real case studies in a wide range of areas relating to the maritime subject including shipping, port, maritime logistics, cruise ports, waterfront developments, and shipping finance, etc. In such areas, researchers, students and industrialists, in general, felt struggling to apply MCDM to find the solutions to their real problems in practice.
- More than four thousand papers involving MCDM methods have been published in international journals since 2000, according to Web of Science. However to present the most important and concise information in these journal papers, their

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authors do not often describe the calculation processes of using the MCDM methods, leading to limited access to the relevant detailed information by students and early stage researchers. This book having a focus on the in-depth step-by-step applications of the most popular MDCM methodologies will be able to address this challenge.
- Our teaching experience confirms that students can easily learn the principles and theoretical backgrounds of MCDM but feel struggling to apply them to real cases, because the applications of MCDM require well designed questionnaires to collect data from respondents. However there are few publications, showing real samples of the questionnaires applied in solving MCDM problems. This book discloses some samples of the questionnaires with reference to the applications of MCDM to real cases.
- The real cases described in this book also address the emerging issues in the maritime context such as green shipping, port, and logistics as well as security and safety issues, revealing new hybrid MDCM solutions in complex dynamic decision making environments.

This book brings together an eclectic collection of twelve chapters which seek to respond to the above challenges. The first contribution by Zhuohua Qu, Chengpeng Wan, Zaili Yang, and Paul Tae-Woo Lee (Chap. 2) is an overview of major MCDM techniques. This chapter describes the detailed mathematical steps of well-established MCDM methodologies such as Analytic Hierarchy Process (AHP), TOPSIS, VIKOR, ELECTRE, and PROMETHEE in order to provide a holistic knowledge. It also analyses the advantages and disadvantages of the methods so as to serve as a foundation to their applications in the ensuing chapters.

Recognizing that AHP is very functional and popular in both academia and professional life, Emrah Bulut and Okan Duru (Chap. 3) claim that there is various biases and misuse of the method due to lack of the full understanding of its comprehensive theoretical basis. Their work discusses, first, the theory of AHP in detail with references to the strong assumptions inherently adjunct to the method and their practical impacts on the AHP analysis. Secondly, it investigates a fuzzy AHP (FAHP) approach and its capability and rationale in dealing with decision problems of ambiguous information. Last, empirical applications including dry port location and shipping asset selection have been conducted to demonstrate their feasibility and to provide effective solutions to maritime and logistics problems.

Green shipping has become a focal issue aiming to mitigate the negative environmental impacts caused by maritime transportation in conjunction with the effort from the International Maritime Organization (IMO). Chapter 4 by Jingzheng Ren, Marie Lützen, and Hanna Barbara Rasmussen proposes a generic methodology to identify the key factors influencing green shipping and to establish an evaluation system for the assessment of shipping greenness. The authors employ Analytic Network Process (ANP) to determine the relative importance of the identified factors in green shipping with the consideration of their interdependences and interactions for realizing precise evaluation of shipping greenness. In addition, Chap. 4 adopts Interpretative Structuring Modeling (ISM) to analyze the cause-

effect relationships among the measures of and solutions to the greenness of shipping. Consequently, it contributes to analyzing the influential factors of green shipping and studying the strategic measures for enhancing the greenness of shipping in a hybrid approach.

Chapter 5 by Zaili Yang, Lefteris Mastralis, Stephen Bonsall, and Jin Wang proposes a new function of fuzzy Evidential Reasoning (ER) to improve the vessel selection process in which multiple criteria with insufficient and ambiguous information are evaluated and synthesised. By doing so, a numerical case study of selecting an oil tanker based on a voyage charter party is presented to demonstrate the proposed method. Chapter 5 contributes to overcoming the difficulty and complexity in selecting vessels that the stakeholders of conflicting interests encounter, to helping analysts or decision makers derive rational decisions from uncertain and incomplete data contained in different quantitative and qualitative forms. In the decision making process, the Window-based software tool called Intelligent Decision System (IDS) via ER (Yang and Xu 2000) is used to build up the model, define alternatives and criteria, and perform different assessments according to the decision makers' requirements.

Feng Ma and Yu-wang Chen propose, in Chap. 6, a novel methodology by using an Artificial Potential Field (APF) model and the ER approach to estimate the collision probabilities of monitoring targets for coastal radar surveillance. Initially, the probability of a monitoring target being a real moving vessel is estimated using the records of manual operations and the ER rule. Subsequently, the bridges, piers and other encountering vessels in a waterway are characterized as collision potential fields using an APF model. As a result, the positional collision potential of any monitoring vessel can be obtained through overlapping all the collision potential fields together. The probabilities of authenticity and the collision potential are further formulated as two pieces of evidence on which the Dempster's rule of combination is used to reason the collision probability of a monitoring target. The vessels associated with high collision probabilities can be highlighted for supervisors' decision on risk avoidance, as they potentially pose high risks to safety.

Based on the literature review of port performance evaluation and brainstorms with domain experts, Chap. 7 by Chengpeng Wan, Di Zhang, and Hang Fang attempts to develop the inland port performance assessment model (IPPAM) using AHP and ER and a utility function. IPPAM is a dynamic complex system involving many indicators from four main perspectives, namely, infrastructure, operations and management, financial status, and development potential with a case study by evaluating the performance of the Port of Wuhan in China from 2007 to 2013. This chapter contributes to developing a hierarchical model for the evaluation of inland port performance by using AHP and ER in a complementary way in which AHP is employed to calculate the relative importance of the relevant qualitative and quantitative criteria, while ER is hired to deal with synthesis in order to achieve the estimation of inland port performance. The novel model and flexible method presented in this chapter could be applied for evaluating performance of