Multi-criteria Evaluation of Global Transportation Corridors Effectiveness. Case Study Analysis

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Abstract Transportation corridors are basic elements of whole transportation system. The selection of particular solution (transportation corridor) directly determines the effectiveness of whole transport. Thus, such selection should be based on detailed and thorough analysis, and evaluation factors should include all aspects contributing to transport effectiveness, i.e., time of transport, costs of transport, timeliness of transport or finally, transport reliability or flexibility. The overall research goal of this paper is to evaluate the global transportation corridors, considering effectiveness factor as the most significant. The authors claim that this aspect has a multiple-criteria character, and thus, they develop the proposed approach based on the principles of multiple-criteria decision making/aiding. The challenge and the novelty of this work are to distinguish all factors contributing to transport effectiveness and apply them to the proposed methodology, in particular, to the indicated family of evaluation criteria of the alternative options—global transportation corridors. To the best of the authors' knowledge, such a contribution has not been reported in the literature, so far.

Keywords Global supply chains · Freight transportation systems/corridors · Efficiency of transport · Multiple-criteria decision making/aiding

1 Introduction

Freight transportation, as a necessary element of each supply chain, is the set of activities connected with relocation of shipments in time and space with proper

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means [1, 2]. It is covering a distance or a change of place of goods using the transport facilities [3]. The general definition of the transportation defines it as a process which is the finite sequence of activities necessary to relocate shipments [4]. The set of transportation processes creates the transportation system. It is defined as a set of components such as transportation infrastructure, fleet of vehicles, human resources and governing rules that ensure a coordinated and efficient transfer of goods from their origins to destinations in a certain area [5]. One of the types of transportation system is the global transportation system which covers the whole world, continent, a specific group of countries or an economic group [6]. It has a huge influence on functioning of the international trade exchange where costs and time of transportation are very important [7].

What is more, effectiveness mainly determines transportation process as it involves transportation of the goods to the indicated destination and its efficiency, meaning the ability to optimize all resources in order to conduct the whole process effectively. There are, however, several methods which may increase the transport efficiency. One of such measures is decision making, based on the careful analysis which takes into account all gauges for transport evaluation. They are time of transport, costs of transport, reliability of transport, its timeliness and flexibility.

Next important part of the global transportation system is the global transportation corridor/solution. It ensures the transfer of significant passenger and freight traffic flows between separate geographic regions. It also contains infrastructural objects (mobile means of transportation and stationary equipment) of all transport modes occurring in a given corridor, as well as all technological, organizational and legal conditions for carrying out these transports [8]. This is a concept of moving goods between supply chain links on a described scale with the application of a single-mode, multimodal, intercontinental and worldwide transportation. The transportation corridors must fit the local or global configuration of manufacturing and distribution systems and strategies to provide the desired customer service at the lowest possible cost and to maximize the supply chain profit [9].

Effectiveness factors mainly determine the whole transportation process, which should be taken into account while creation of freight corridors. Also, selection of necessary corridors should be based on the complex analysis, including all factors which may have an impact on transport effectiveness.

The overall research goal of this paper is to evaluate the global transportation corridors, taking into account their effectiveness. The authors claim that this aspect has a multiple-criteria character, and thus, they develop the proposed approach based on the principles of multiple-criteria decision making/aiding (MCDM/A). The challenge and the novelty of this work are to present a coherent set of evaluation criteria for the transportation corridors, including all gauges considered in evaluation of transportation effectiveness.

The hypothesis of this work indicates the way of evaluating and selecting the most efficient global transportation solution, generating various possibilities based on the multiple-criteria analysis.

In the practical part of this paper, the authors describe alternative global transportation corridors between China and Central Europe (Poland) based on a multimodal transportation process used by the enterprise operating in energy and automation industry. Next, the authors evaluate them with a consistent family of criteria, model the decision maker's (DM's) preferences and carry out a series of computational experiments with the application of selected MCDM/A ranking methods. As a result, the final rankings of transportation options are generated that give the DM the most efficient transportation solution.

2 Methodological Background of the Research

2.1 Factors Contributing to Transport Effectiveness

The term "effectiveness" plays a crucial role in modern logistics although it leads to many problems on operational, tactical or strategy level. Thus, the evaluation of transportation corridors effectiveness should be subject to separate research which would involve all factors determining the corridors effectiveness, e.g., transportation process. Various researchers indicate logistics gauges as relevant to transport evaluation, which are all presented in Table 1.

Usage of logistics gauges may provide information about transportation process, detect all deviations from the transportation plan and also improve whole transport and its particular elements (including transportation corridors) making it more competitive. Based on the analyzed literature, evaluation of the global transportation corridors effectiveness (referred to as variants in the next section of this paper) included various logistics gauges (variants evaluation criteria), as described in Table 2.

Table 2 forms a relevant family of evaluation criteria which is one of the most important elements of applied methodology of multiple-criteria decision making—-further presented in the next section of this paper.

2.2 Principles of MCDM/A and Description of the Applied Methods

Multiple-criteria decision making (MCDM) also known as a multi-criteria decision aid or multi-criteria decision support derives from operational research [17, 18]. Such method supports DM (person who defines decision problem) with rules, tools and methods in solving complex decision problems, considering several—often contradictory—points of view [19, 20]. Evaluation process involves different aspects of the considerate variants of multi-dimensional nature (which are also hardly comparable) in order to select the best alternative [21, 22].

The main components of multiple-criteria decision problems are:

- a set of solutions (variants) A which are analyzed and evaluated in decision process (global transportation corridors in this case study);

Table 1 Logistics gauges in transport evaluation

Gauges	Twaróg [10]	Nowicka-Skowron [11]	Pfohl [3]	Kisperska-Moroń [12]	Litman [13]	Los [14]	Rodrigue [15]	Waściński and Zieliński [16]
Quantitative indicators								
Costs of transport: – For km – For carriage	X	X	X			X	X	X
Completed tonne-kilometers	X		X					
Number of kilometers driven		X						X
Time for one transport order completion	X				X	X	X	
Number of vehicles used for transport		X						
Number of employees in transport sector		X		X				
Number of completed consign-ments (number of transported shipment)	X		X				X	
Number of operational disturbances (including number of accidents)	X	X						X
Actual length of means of transport performance	X		X		X			
Means of transport utilization rate	X		X		X	X	X	X

(continued)

Table 1 (continued)

Gauges	Twaróg [10]	Nowicka-Skowron [11]	Pfohl [3]	Kisperska-Moroń [12]	Litman [13]	Los [14]	Rodrigue [15]	Waściński and Zieliński [16]
Working time utilization rate	X							X
Fuel consumption				X				
Value of the means of transport owned		X						
Means of transport maintenance costs		X						
Qualitative indicators (productivity)								
Timeliness of transport—within agreed time	X		X	X	X	X	X	X
Reliability of transport	X		X			X	X	X
Flexibility of transport (transport readiness)	X		X				X	X
Security of transport (number of goods damaged during transport)	X		X	X				X
Transport documentation accuracy				X				
Accessibility of transport					X	X		
Comfort for customer (quality of customer service)	X			X		X	X	

Table 2 Global transportation corridors effectiveness evaluation criteria

No.	Logistics indicator (criterion)	Description
K1	Costs of cargo transportation	The criterion specifies an overall unit cost of load unit transport (40 ft. container) from China (supplier's warehouse) into company's warehouse (Poland, Łódź). The criterion was formulated on the basis of the data provided by the company and offers from the freight forwarders. It is a minimized criterion. Formula: $\frac{\text{costs of cargo transportation}}{\text{number of cargo transportation}}$ (PLN/cargo transportation)
K2	Time of a single cargo transportation	The criterion specifies an overall time for unit load transportation (40 ft. container) including the duration time of handing over of consignment by Chinese supplier until delivery to the company's warehouse. The criterion is minimized. Formula: transport time duration + customs clearance duration + cargo loads duration + unloading time (number of days)
K3	Means of transport utilization rate	The criterion defines transport adaptation to the specificity of the transported material and expresses the percentage of available capacity utilization of transport unit (40 ft. container). It is a maximized criterion. Formula: $\frac{\text{actual goods carriage load}\ (m^3)}{\text{possible goods carraige load}\ (m^3)} \times 100\%\ (\%)$
K4	Timeliness of transport	The criterion specifies the percentage of consignments delivered on time. The results are based on the statistical data from the company and carriers. It is a maximized criterion. Formula: $\frac{\text{timely delivery of orders}}{\text{total amount of deliveries}} \times 100\%\ (\%)$
K5	Reliability of transport	The criterion specifies the percentage of transport requirements realization in relation to all transportations carried in a month. It was assumed that reliability of the transport decreases with the growth of trans-shipments during transport (number of indirect operations). It is a maximized criterion. Formula: $\frac{\text{number of transport requirements realizations}}{\text{total amount of transport requirements}} \times 100\%\ (\%)$

(continued)

Table 2 (continued)

No.	Logistics indicator (criterion)	Description
K6	Flexibility of transport	The criterion measures the time of variant's response (including its contractors–carriers) toward unexpected road events. It is a percentage of immediate deliveries of orders in relation to all performed deliveries. It was assumed that flexibility of the transport increases with the growth of transport capacity during a month period. The criterion is maximized. Formula: $\frac{\text{immediate deliveries of orders}}{\text{total number of deliveries}} \times 100\%$ (%)
K7	Security of transport	The criterion specifies the percentage of damaged goods in transport unit load (40 ft. container), in a month period. It is a minimized criterion. Formula: $\frac{\text{number of damaged goods}}{\text{total number of goods}} \times 100\%$ (%)
K8	Customer's comfort	The criterion defines various communication aspects such as option to track the package during transportation. It is expressed in 1–3-point scale. It is a maximized criterion. Formula: 1 point for tracking option during transport, door-to-door transport, option for free storage of goods in the port (points)

- a consistent family of criteria F (global transportation corridors evaluation criteria in the case study).

Each criterion in the family of criteria F is used to evaluate the A set and represents the DM's preferences in relation to a proper aspect of a decision problem.

To solve multiple decision problems, various tools, procedures or methods can be used. They can be generally divided into two groups [20, 23, 24]:

- the methods of American inspiration based on the utility function, referred to as the unique criterion of synthesis methods, e.g., UTA, AHP;
- the methods of the European/French origin, based on the outranking relation, considering incomparability relation, e.g., Electre, Promethee and Oreste.

Electre III/IV and Promethee II, two ranking methods, have been applied in order to evaluate transportation corridors effectiveness in this paper. They are indicated by the researchers as the most popular methods implementing the outranking relations framework [25].

2.3 Description of Electre III/IV Method

Electre III/IV method belongs to a family of Electre methods, proposed by Roy [26]. It is a universal, multi-dimensional ranking method, based on the outranking relation [19, 20, 22, 26, 27]. In this method, the basic set of data is composed of the following elements: a finite set of variants, a family of criteria and the preferential information submitted by the DM. The preferential information is defined in the form of criteria weights and the indifference, preference and veto thresholds [5]. (The thresholds define the sensitivity of the DM to the changes of the criteria values and the weight expresses the importance of each criterion.) Computational algorithm of Electre III/IV comprises of three stages [28]:

I. matrix evaluation construction and definition of the DM's preference model;
II. outranking relation construction;
III. outranking relation implementation.

Electre III/IV algorithm generates the final ranking of variants and orders them from the best to the worst. The following relations may occur between variants: equivalence, outranking, reverse outranking and incomparability.

2.4 Description of Promethee II Method

Promethee method was introduced by Brans et al. [29, 30] to preference rank a set of decision alternatives, based on their values over a number of different criteria. Put simply, a ranking of alternatives is based on the accumulative preference comparisons of pairs of alternatives' values over the different criteria (using generalized preference functions) [31]. The Promethee method will provide the DM with a ranking of actions (choices or alternatives) based on preference degrees. The method falls into three main steps:

I. the computation of preference degrees for every ordered pair of actions on each criterion;
II. the computation of unicriterion flows;
III. the computation of global flows.

Based on the global flows, a ranking of the actions will be obtained as well as a graphical representation of the decision problem [32].

The difference between Electre III/IV and Promethee II methods is key parameters. Electre requires indifference, preference and veto thresholds, while Promethee requires only indifference and preference thresholds.

3 Description of Decision Situation

3.1 Verbal Description

This paper presents the issue of evaluation and selection of the most effective global transportation corridor (China–Poland) for the international daughter company operating in energy and automation industry. The company is located in Łódź, Central Poland. It manufactures distribution transformers and power transformers as well as insulation components used in power transformers. Most of the suppliers' warehouses are located in Europe; nonetheless, some of the components need to be delivered from the Far East, China.

The delivery process from China is affected by a number of various difficulties, mainly caused by huge delivery distance and length of transportation process. The company uses several transportation variants offered by a forwarding company, responsible for the whole transportation process under the general contractor agreement.

It was the reason why the transportation director—DM in the decision situation—-did not undertake any analysis of different transportation variants (global transportation corridors) against the criteria of their effectiveness (including the following criteria: costs, time, degree of utilization of means of transport, timeliness, reliability, flexibility and safety or customer's comfort).

What is more, due to the last year increase in delivery costs of materials transported from China, DM finally decided to carry out a detailed analysis and evaluation of global transportation corridors. The aim was to improve their effectiveness, in particular, costs and time reduction and improvement of security and timeliness. Thus, DM would examine all possible transportation options.

3.2 Characteristics of Variants—Global Transportation Corridors

Selection of the most effective global transportation corridor is defined as a multiple-criteria problem of variants ranking. The considered variants correspond to the modes of transport (China/supplier's warehouse—Poland/Łódź) V1–V4 (Table 3). Analyzed transportation corridors include four transport modes: transport by sea, rail, air or road.

As DM has not yet undertake an evaluation of current transportation corridors, the selection of the most effective solution must be based on the comprehensive analysis. Thus, a number of criteria will be applied, determining the effectiveness of each transportation corridor.

Based on the variants evaluation criteria and the original raw data, the evaluation matrix has been constructed. The importance wages of the criteria were formulated on the basis of the interview with the DM, his preferences and aspirations (Table 4).

Table 3 Variants—global transportation corridors—in decision situation

Variant	Type and verbal description
V1	Road transport + sea transport + road transport; Stages: • road transport from supplier's warehouse to sea port in Shanghai • sea transport from Shanghai port to Gdynia port • road transport from Gdynia to Łódź warehouse
V2	Road transport + rail transport + road transport; Stages: • road transport from supplier's warehouse to railway station in Hefei • rail transport from Hefei to railway station in Małaszewicze • road transport from Małaszewicze to company's warehouse in Łódź
V3	Road transport + rail transport + rail transport; Stages: • road transport from supplier's warehouse to railway station in Hefei • rail transport from Hefei to railway station in Małaszewicze • rail transport from Małaszewicze to company's warehouse in Łódź (the company owns its siding)
V4	Road transport + air transport + road transport; Stages: • road transport from company's warehouse to Shanghai Airport • air transport from Shanghai Airport to Frankfurt Airport (Germany) • road transport from Frankfurt to company's warehouse in Łódź

Table 4 The evaluation matrix in described case study

Criterion	Weight of criterion—Electre method	Weight of criterion—Promethee method	Variants			
			V1	V2	V3	V4
K1 (PLN)	8	0.20	12,791	20,252	21,252	111,329
K2 (Days)	9	0.25	35	21	28	7
K3 (%)	5	0.08	0.90	0.80	0.80	0.95
K4 (%)	7	0.15	0.80	0.90	0.90	0.98
K5 (%)	7	0.15	0.90	0.95	0.95	1
K6 (%)	6	0.10	0.75	0.80	0.85	0.98
K7 (%)	4	0.05	0.10	0.05	0.05	0.02
K8 (Points)	3	0.02	2	2	3	2

Main global transportation corridors evaluation criteria in terms of their effectiveness are time of transport (K2), costs of transport (K1), timeliness of transport (K4) and transport reliability (K5). The results of computational experiments, based on Electre III/IV and Promethee II methods, are described in the next section of this paper.

4 Computational Experiments

Due to formal limitations of the study, the results of computational procedures were reduced to presentation of the final rankings, identifying the position of the variants in relation to global transportation corridors.

In accordance with the Electre III/IV method algorithm, the evaluation matrix has been constructed and the DM's preference model has been defined. In the second stage of the algorithm, the outranking relation has been constructed. In the third stage of the algorithm, the outranking relation has been applied and on the basis on the indexes of the variants (global transportation corridors V1–V4), the ascending and descending distillations have been performed, formulating the structure of complete preorders. Then, they have been averaged into the median ranking, and the intersection of preorders resulted in the final ranking. The results of these transportation corridors selection calculations are presented in Fig. 1a.

In accordance with the Promethee II method algorithm, the evaluation matrix has been constructed and the DM's preference model has been defined in the process of naming the wages of criteria and thresholds: indifference and preference. Due to experimental procedures, the final ranking has been obtained, as shown in Fig. 1b.

According to the final ranking, based on Electre III/IV method, the most effective global transportation corridor is variant V4, implementing air transport for the

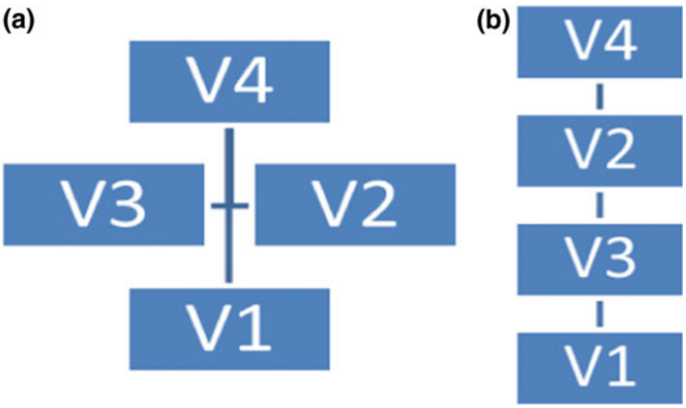

Fig. 1 The final ranking in the case study. **a** Electre III/IV method, **b** Promethee II method

longest transport route. It clearly outranks the other variants, against six out of eight evaluation criteria. Its strongest values are very short period of transport (K2), high degree of means of transport utilization (K3), excellent timeliness (K4), reliability (K5) and flexibility (K6) of transport and finally, very low rate of goods' damages during transportation process (K7). The interesting fact is that variant V4 represents the most expensive solution what is compensated by other values of the variant. The least effective global transportation corridor is variant V1, using transport by sea. Although it offers the cheapest price (K1), the other criteria are ranked very poorly.

The results generated with the application of Promethee II method are fast identical to those produced by the application of Electre III/IV method. Promethee II method indicated a slight difference between transportation corridors V2 and V3, whereas in the ranking of Electre III/IV method, they were ranked on the equivalent position. The authors of this paper recommend selection of global transportation corridor V4 as it is the most effective solution according to the conducted computational procedures. If DM would define cost criterion as the most important in the final selection, then variant V2 is the best solution, ranking on the second position in both cases.

5 Final Conclusions

The paper presents evaluation and ranking of global transportation corridors used by company operating in energy and automation industry, based on the multiple-criteria decision making/aiding (MCDM/A). The decision problem was formed as a multiple-criteria problem of ranking variants. Two methods were applied in order to generate the final ranking of global transportation corridors, namely Electre III/IV and Promethee II. The novelty of this paper was output of logistics gauges implementation into the final evaluation of global transportation corridors.

The paper contains not only methodological values but also utility functions. The methodological approach is based on the identification of the criteria which may determine the effectiveness of global transportation corridors. In practical terms, the authors demonstrate that the most effective solution is variant V4 which, although not the cheapest, is characterized by many other advantages. Thus, the authors of this paper recommend the selection of global transportation corridor V4 as it is the most effective and desired. At the same time, for the customer of lower sensitivity on the price, variant V2 is considerable.

References

1. Cavinato, J.L.: Transportation-Logistics Dictionary. Springer Verlag (1989)
2. Galińska, B.: Koncepcja Global Sourcing. Teoria i Praktyka. Difin S.A., Warszawa (2015)
3. Pfohl, H.C.: Logistiksysteme. Betriebswirtschaftliche Grundlagen. Springer Verlag (2010)
4. Borkowski, P., Koźlak, A.: Global competitiveness of Baltic Sea region in view of transport infrastructure development challenges. In: Globalizácia a jejsociálno-ekonomickédôsledky'09:

elektronickýzborníkpríspevkov z medzinárodnej vedeckej konferencie, pp. 54–65. Žilinská Univerzita, Rajecké Teplice, Žiline (2009)
5. Żak, J.: Design and evaluation of transportation systems. In: Sierpiński, G. (ed.) Advances in Intelligent Systems and Computing, vol. 631: Advanced Solutions of Transport Systems for Growing Mobility, pp. 3–29. Springer Verlag (2018)
6. Galińska, B., Grądzki, R.: Factors which determine the achievement of benefits deriving from the concept of global sourcing. In: Conference Proceedings of CLC 2013, Tanger, Ostrava (2014)
7. Gołembska, E.: Conditions of global logistics development. In: Żołądkiewicz, K., Michałowski, T. (eds.) Meeting Global Challenges. Working Papers Institute of International Business, University of Gdańsk, Gdańsk (2008)
8. Mindur, L. (ed.): Technologie transportowe. PIB, Radom (2014)
9. Yücenur, G.N., Vayvay, Ö., Demirel, N.Ç.: Supplier selection problem in global supply chains by AHP and ANP approaches under fuzzy environment. Int. J. Adv. Manuf. Technol. **56**, 823–833 (2011)
10. Twaróg, J.: Mierniki i wskaźniki logistyczne. Biblioteka Logistyka, Poznań (2003)
11. Nowicka-Skowron, M.: Efektywność systemów logistycznych. Polskie Wydawnictwo Ekonomiczne, Warszawa (2000)
12. Kisperska-Moroń, D.: Pomiar funkcjonowania łańcuchów dostaw. Wydawnictwo Akademii Ekonomicznej im. Karola Adamieckiego, Katowice (2006)
13. Litman, T.: Sustainable Transportation Indicators. Victoria Transport Policy Institute, Canada (2003)
14. Los, P.: Mobility indicators and accessibility of transport. Slovak J. Civ. Eng. **1**, 24–32 (2007)
15. Rodrigue, J.P.: The Geography of Transport Systems. Routledge, New York (2017)
16. Waściński, T., Zieliński, P.: Efektywność procesu transportowego. Systemy Logistyczne Wojsk **42**, 221–236 (2015)
17. Hillier, F., Lieberman, G.: Introduction to Operations Research. McGraw-Hill, New York (1990)
18. Żak, J.: Application of operations research techniques to the redesign of the distribution systems. In: Dangelmaier, W., Blecken, A., Delius, R., Klöpfer, S. (eds.) Advanced Manufacturing and Sustainable Logistics. Conference Proceedings of 8th International Heinz Nixdorf Symposium, IHNS 2010, Paderborn, Germany (2010)
19. Figueira, J., Greco, S., Ehrgott, M.: Multiple Criteria Decision Analysis. State of the Art Surveys. Springer, New York (2005)
20. Vincke, P.: Multicriteria Decision-Aid. Wiley, Chichester (1992)
21. Roy, B.: Decision-aid and decision making. Eur. J. Oper. Res. **45** (1990)
22. Roy, B.: Wielokryterialne wspomaganie decyzji. Wydawnictwo Naukowo Techniczne, Warszawa (1990)
23. Żak, J.: The methodology of multiple criteria decision making/aiding in public transportation. J. Adv. Transp. **45** (2011)
24. Żak, J., Galińska, B.: Multiple criteria evaluation of suppliers in different industries—comparative analysis of three case studies. In: Żak, J., Hadas, Y., Rossi, R. (eds.) Advances in Intelligent Systems and Computing, vol. 572: Advanced Concepts, Methodologies and Technologies for Transportation and Logistics, pp. 121–155. Springer Verlag (2017)
25. Doumpos, M., Evangelos, G.: Multicriteria Decision Aid and Artificial Intelligence: Links, Theory and Applications. Wiley (2013)
26. Roy, B.: The outranking approach and the foundations of ELECTRE methods. In: Bana e Costa, C. (ed.) Readings in Multiple Criteria Decision Aid. Springer Verlag (1990)
27. Żak, J.: Wielokryterialne wspomaganie decyzji w transporcie drogowym. Wydawnictwo Politechniki Poznańskiej, Poznań (2005)
28. Galińska, B.: Multiple criteria evaluation of global transportation systems—analysis of case study. In: Sierpiński, G. (ed.) Advances in Intelligent Systems and Computing, vol. 631: Advanced Solutions of Transport Systems for Growing Mobility, pp. 155–171. Springer Verlag (2018)

29. Brans, J., Mareschal, B., Vincke, P.: PROMETHEE. A new family of outranking methods in MCDM. In: International Federation of Operational Research Studies (IFORS 84), pp. 470–490. North Holland (1984)
30. Brans, J., Vincke, P., Mareschal, B.: How to select and how to rankprojects: the PROMETHEE method. Eur. J. Oper. Res. **24**, 228–238 (1986)
31. Kun-Huang, H. (ed.): Quantitative Modelling in Marketing and Management. World Scientific Publishing Co Pte Ltd., Moutinho (2014)
32. Ishizaka, A., Nemery, P.: Multi-Criteria Decision Analysis. Methods and Software. Wiley, Chichester (2013)