

Digital Supply Chain Agility Analysis Using IFTOPSIS Method

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Abstract: - Technological developments have taken place in many areas since the occurrence of industrial revolution. The technological developments have entered the digitalization path with the industry 4.0 and have taken the potential of firms in terms of volume and diversity in response to unexpected and sudden changes in demand and markets as well as efficiency and increase the competitiveness and technological advancements in the process of supplying them and accelerated the digitalization process. With all this, it has highlighted the structure of the digital supply chain agility (ADSC), which is a means of competitiveness in today's dynamic and turbulent business environment within the supply chain. At this stage, logistics companies have sought to integrate digital technologies, smart systems, internet, robots and mobile applications into the supply chain, thus aiming to achieve higher agility. Firms aim to improve their processes and to keep customer satisfaction high, to maintain their profitability and to survive in the competitive market. The aim of this study is to increase the ability to respond to the changing and developing market and market conditions and to include the best logistics company which can fulfill the demands and requirements of a company that is trying to comply with Industry 4.0 requirements. Intuitionistic fuzzy TOPSIS method is employed to select the most appropriate logistic company.

Key-Words: Intuitionistic Fuzzy TOPSIS, Industry 4.0, digital agility, digital supply chain, multi-criteria decision-making

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1 Introduction

Nowadays, influence of digital technology is so boundless that adaption of people to this new environment becomes too fast. This, not only increases the awareness and knowledge of customers about how to best use of the latest digital technologies, but also changes the dynamics of the competition between companies in a way that requires making fast improvements to their processes with wide variety of innovative technologies for satisfying demands of their well-equipped customers [1]. Thus, in order to get a head in completion companies need to transform their classical supply chain operations into a digital and agile form.

Agility of digital supply chain (ADSC) represents the alertness to internal and environmental changes and the capability to gather resources which support and synchronize interaction between organizations in responding to these changes in a timely and flexible manner in order to provide customer-driven goods and services. However, since ADSC is multi-dimensional and business-wide concept, building such a capability requires a holistic perspective which depends on various inter-related factors [2,3].

Thus, identifying and evaluating these factors is necessary to better understand the development goals with different priorities for achieving higher levels of ADSC.

Digital changes in technology have increased the importance of logistics for companies. With the use of information technologies, logistics services became widespread through integration in the supply chain. The companies' traditional operational solutions have been transformed into digital based solutions. This transformation created a wave that triggered the digitalization of supply chain agility, and customers' expectations began to change. Firms have begun to produce solutions to ensure customer satisfaction that significantly affects their performance and thus to stay competitive, to increase profitability and to ensure sustainability. For this purpose, companies have preferred third party services that perform digitalization in their processes in order to follow the logistics and supply chain processes easily, not to get away from the main focus and to stay strong in the competitive environment.

In this study, we focused on the selection of a logistics company among the alternatives for the realization of the logistic activities of a company

that produces fast moving consumer products at the desired level. The selection criteria are obtained by the literature review and approved by the decision makers. The weighting process is conducted by the decision makers, intuitionistic fuzzy TOPSIS (IFTOPSIS) methodology is employed to identify the best alternative in uncertain, vague, and hesitant environment.

The rest of this work is organized as follows. Section 2 gives the application steps of IFTOPSIS. The subsequent section provides the case study conducted in a logistics company. The final section delineates the conclusions and future research directions.

2 Intuitionistic Fuzzy TOPSIS Method

Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), introduced by Hwang and Yoon [4], is a technique used for solving decision problems. TOPSIS method determines the alternative, which has the shortest distance to ideal solution, and the longest distance to anti-ideal solution. Intuitionistic fuzzy TOPSIS (IFTOPSIS) methodology enhances TOPSIS technique by including intuitionistic fuzzy numbers into evaluation in order to solve decision problems under an uncertain, vague, and hesitant environment [5].

The applications steps of IFTOPSIS methodology, which is illustrated in Figure 1, can be listed as follows:

Step 1: Construct a committee of experts, determine the alternatives ($A_i=1,2,\dots,m$), and the evaluation criteria C_j ($j=1,2,\dots,n$).

Step 2: Obtain the data that represent the ratings of alternatives regarding criteria and the weights of criteria.

Step 3: Construct the fuzzy decision matrix (\tilde{D}) that denote the evaluation of alternatives with respect to criteria and the weight matrix of criteria (\tilde{W}) as

$$\tilde{D} = \begin{bmatrix} \tilde{x}_{11} & \tilde{x}_{12} & \dots & \tilde{x}_{1n} \\ \tilde{x}_{21} & \tilde{x}_{22} & \dots & \tilde{x}_{2n} \\ \vdots & \vdots & \dots & \vdots \\ \tilde{x}_{m1} & \tilde{x}_{m2} & \dots & \tilde{x}_{mn} \end{bmatrix} \quad i = 1,2, \dots, m; j = 1,2, \dots, n. \quad (1)$$

$$\tilde{W}_j = (\tilde{w}_1, \tilde{w}_2, \dots, \tilde{w}_n) \quad j = 1,2, \dots, n.$$

Step 4. Compute the weighted decision matrix $\tilde{V} = [\tilde{x}_{ij}]_{m \times n}$ using the following Equation

$$\tilde{V}_{ij} = w_j \tilde{x}_{ij} \quad (2)$$

where \tilde{w}_{ij}, w_j and \tilde{x}_{ij} represent the weighted rating of alternative i , the weight of criterion j , and the rating of alternative i with respect to criterion j , respectively.

Step 5. Define the ideal solution $A^* = (r_1^*, r_2^*, \dots, r_n^*)$ and the anti-ideal solution $A^- = (r_1^-, r_2^-, \dots, r_n^-)$, where $r_j^* = \langle 1,0 \rangle$ and $r_j^- = \langle 0,1 \rangle$ for $j = 1,2, \dots, n$.

Step 6. Compute the distances from ideal solution and anti-ideal solution (D_i^* and D_i^- , respectively) for each alternative employing the following Equation [6].

$$d(\tilde{A}, \tilde{B}) = \frac{\sqrt{\frac{1}{2} \sum_{i=1}^n [(i_{\tilde{A}}(x_i) - i_{\tilde{B}}(x_i))^2 + (i_{\tilde{A}}(x_i) - i_{\tilde{B}}(x_i))^2 + (g_{\tilde{A}}(x_i) - g_{\tilde{B}}(x_i))^2]}} \quad (3)$$

Step 7. Calculate the closeness coefficient CC_i^* of the alternatives using Equation (4).

$$CC_i^* = \frac{D_i^-}{(D_i^* + D_i^-)}, i = 1,2, \dots, m. \quad (4)$$

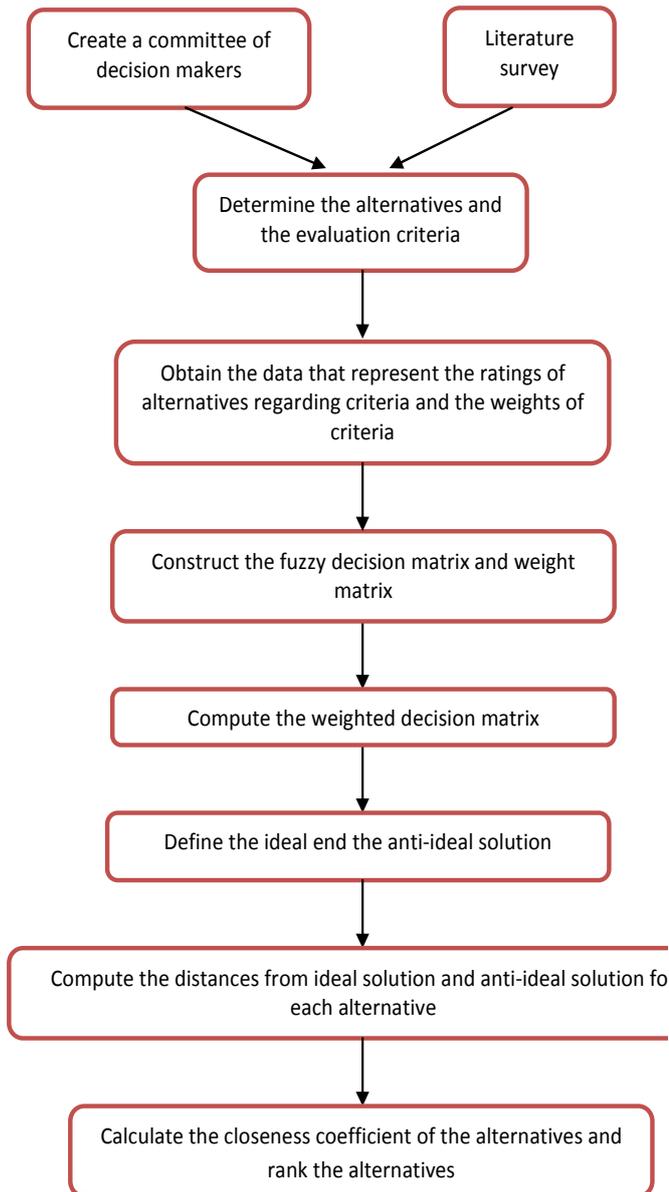


Figure 1. Stepwise illustration of the employed methodology

3 Case Study

In this section, important factors for logistics company selection are determined by collecting experts' opinions and reviewing the literature. Evaluation criteria are given in Table 1.

Table 1. Logistics company selection criteria

Label	Criterion
C_1	Cyber security
C_2	Smart warehousing
C_3	Real-time data
C_4	Artificial intelligence
C_5	Digital roadmap
C_6	Logistics visibility
C_7	Flexible business processes
C_8	Reduced customization
C_9	Robotics
C_{10}	Serialization
C_{11}	Predictive maintenance
C_{12}	IoT and integrated execution

Evaluation process is carried out by reaching consensus among the experts. The decision-makers prioritized the evaluation criteria and determined the ratings of the alternatives with regard to the criteria by using linguistic terms that are associated with intuitionistic fuzzy scale (IFS) given in Table 2.

Table 2. Linguistic scale

Linguistic variable	IFS
VH	$\langle 0.95, 0.05 \rangle$
H	$\langle 0.70, 0.25 \rangle$
M	$\langle 0.50, 0.40 \rangle$
L	$\langle 0.25, 0.70 \rangle$
VL	$\langle 0.05, 0.95 \rangle$

The evaluations of four alternatives regarding criteria as well as criteria weights provided by the decision-makers are shown in Table 3.

Table 3. Related data for logistics company selection

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}
A_1	M	M	H	L	L	H	VH	M	H	VL	VL	L
A_2	M	M	M	H	H	VH	H	H	L	L	L	VL
A_3	M	H	H	H	L	M	VH	L	L	L	M	VH
A_4	H	VH	VH	VH	L	H	M	H	H	L	M	VH
Weight	M	H	M	VH	M	H	L	M	VL	H	M	H

The closeness coefficient of the alternatives to the ideal solution is computed and the alternatives are ranked according to the closeness coefficients as in Table 4.

Table 4. Ranking results of the alternatives

Logistics company	D_i^*	D_i^-	P_i^*	Rank
A_1	2.684824	1.015274	0.274391	4
A_2	2.487896	1.330273	0.348406	3
A_3	2.397453	1.391144	0.367192	2
A_4	2.215546	1.690752	0.432827	1

4 Conclusion

Key logistic activities (such as warehouse and inventory management, transport and information technology management etc.) are realized outside the core business processes for many companies. For this reason, firms prefer to manage logistics activities by outsourcing in order not to fall behind the market and avoid competition. The objective of this study is to improve the ability to keep up with sudden changes in market conditions by working with the best logistics company which can meet the demands and requirements of the outsourcer company, which tries to adapt Industry 4.0 into the processes. For that reason, the selection procedure of the most appropriate logistics company becomes a crucial decision-making problem for the firms that outsource their logistics activities to a third-party service provider. For that reason, Intuitionistic fuzzy TOPSIS method is employed to select the most suitable logistic company due to uncertainty, vagueness, and hesitation in data.

Future research will probably focus on selecting the best performing third party logistics company by proposing group decision-making issues.

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