

Ranking of ISCM Benchmarking Factors Using VIKOR Methodology

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ABSTRACT

In a competitive environment, balancing of demand and supply is a typical challenge for an entrepreneur. The continuous internal supply chain benchmarking practice would be helpful in establishing a balance between demand and supply. In this research paper, authors have come across variable factors of internal supply chain management benchmarking through literature review. The identified factors are: Human Resources Orientation, Inbound logistics, Operational logistics, Outbound logistics, Economies of scale, Flexibility, Logistics strategies, New Product development system, Material follow up and Procurement, Production Operation Process, Production Programming, Quality System, Products delivery, Foreign trade and service management and Transport-Reception-Custom decision. The opinions of industrial experts are collected through 15 questionnaire surveys with rating point scales from 1 to 5. VIKOR methodology is used to distinguish factors' performance gap and stimulate the scope of improvement. The main objective of authors is to establish factors' ranking using VIKOR methodology, including the calculated weight of factors through the analytical hierarchy process technique.

Keywords: Internal Supply Chain Management (ISCM), VIKOR Methodology, Factors Ranking, Analytical Hierarchy Process (AHP) Technique

INTRODUCTION

Internal supply chain management (ISCM) is a group of management that involves all departments and also does the planning of all types of materials/funds/information flow (Sahay et al., 2003). The main function of the internal supply chain is to transfer materials from one stage to the second stage, then the second stage to the third and up to final stage. The procurement task has gained importance in ISCM due to globalisation and accelerated technological change (De Boer et al., 2001). The procurement of goods and services at the lowest possible price is the most important point while considering the needs of the purchaser in terms of quality, quantity, time and location (Guo and Zhang, 2008). Therefore, perfect internal supply chain flow is necessary for improving the effectiveness of any business organisation. Benchmarking is a useful performance comparative tool for finding out the internal supply chain performance gap between competitors (Kailash et al., 2017b). Today, comparative benchmarking environment enforces the manufacturer

towards effective internal supply chain. Due to competitive environments and governments policies, manufacturers need to enhance ISCM benchmarking practice, which is influenced by practices of internal supply chain design and coordination of different sections within the industry. ISCM benchmarking has become a proactive approach to enhance internal supply chain performance (Kailash et al., 2017d).

In this study, we have identified the factors of ISCM benchmarking through literature review, because core factors may affect the performance of the internal supply chain of a manufacturing organization. The main aim of this study is to examine the variable factors of ISCM benchmarking. In a competitive environment, for a decision-maker it is very difficult to decide which factor is more critical out of all factors. In such type of critical situations, VIKOR methodology may provide some fruitful results. It is a multicriteria decision-making (MCDM) technique, which is generally used to determine the rank of factors. Further, on the basis of factor's rank,

best and worst factors may be decided easily without any delay. Then, decision-maker may identify the gap between factors and reduce them by some corrective and preventive measures.

LITERATURE REVIEW

Supply chain management (SCM) is defined as a type of management who manage the supply chain between suppliers and customers (Gunasekaran et al., 2001). Dubey and Gunasekaran (2016) proposed a sustained supply chain design that includes alignment, agility and alignment. The SCM aims to manage and coordinate the supply and demand activities from raw material purchase section up to distribution section through manufacturing, assembly, warehousing, inventory tracking and order entry management (Kailash et al., 2015).

Classification of the SCM

Dubey et al. (2018a) proposed different empirical studies in Indian manufacturing sector related to supply chain agility and adaptability. The SCM is a managerial activity whose function is to add some value to the final customer from product starting from activity plan, design, etc., to the last activity delivery. According to Simchi-Levi et al. (2008), it is an effective approach which integrates the elements of supply chain like suppliers, manufacturers, warehouses and stores, in such a way that manufacturer can easily produce and distribute the right quantity of product, to the correct location, at the right time and in minimum cost. There are lot of articles; literature review papers are available on the SCM, which include different techniques and technologies for the development and design of the SCM. It is a broad area. The SCM can be classified into two categories, that is, ESCM (external supply chain management) and ISCM (Kailash et al.,

2018). Both types of the supply chain are briefly explained in the next sections.

ESCM

The SCM is a managerial activity whose function is to manage the flow between supplier and customer. It is a complex activity which consists of different elements such as suppliers, manufacturers, warehouses, retailers and finally, end customers (Hicks, 1997). The management of external supply chain can effectively control the external supply chain activity, which exists outside the regions of a manufacturing organisation. The ESCM plays an important role in improving the performance of the SCM, because external factors such as suppliers, transporters, ways of transportation, government policies, taxes and customs, information technology, etc., are also responsible for the ineffective supply chain. The main function of the ESCM is to control all the process of supply chain outside the manufacturing industry.

ISCM

The first function of the ISCM is to control all the process of the supply chain within the manufacturing industry (Kailash et al., 2017a). The second function of the ISCM is to control the flow and create integration between the various departments. For improving the performance of manufacturing industries, it is necessary that the partners of internal supply chains to make collective efforts (Tracey and Leng Tan, 2001). The selection of best possible qualitative and quantitative factors of the ISCM is must for the improvement of internal supply chain performance of any business (Shahadat, 2003). During the literature survey, authors have come across some direct and indirect factors of the ISCM, which assist in improving ISCM performance (Kailash et al., 2017c). Out of all, some factors are listed in Table 1.

Table 1: ISCM Benchmarking Factors

S. No.	Factors	References
1	Human Resources Orientation	Mulang (2015). Delarue et al. (2008). Abdullah (2009). Schlosser et al. (2006). Vinesh (2014). Chen (2010)
2	Inbound Logistics	Dornhofer et al. (2016). Liu and Sun (2011)
3	Operational Logistics	Cowling et al. (2002). Ertogral and Wu (2000). Gram (2013)
4	Outbound Logistics	Alad and Deshpande (2014). Cetinkaya et al. (2009). De Koster et al. (2007). Kwateng et al. (2014). Hanson et al. (2015)
5	Economies of Scale	Sheu (2007). Celli (2013). Anwar and Ali (2015). Kristensen et al. (2008)
6	Flexibility	Jayant and Ghagra (2013). Beach et al. (2000). Charnsirisakskul et al. (2004). Chod et al. (2012). Charnsirisakskul et al. (2006). Hallgren and Olhager (2009). Kesavan et al. (2014). Grigore (2007). Wang (2008). He and Down (2009)
7	Logistics Strategies	Sodhi (2003). McKay and Wiers (2003). Ramaa (2012)

S. No.	Factors	References
8	New Product Development System	Adis and Jublee (2010). Murthy (2007). Agrawal et al. (1996). Senk et al. (2010). Bhuiyan (2011)
9	Material Follow up and Procurement	Swain and Das, (2015). Subramani and Kumarapandiyan, (2012). Lenin, (2015). Bhargava and Chaitanya, (2015). Agboyi and Obiri-Yeboah (2015). Mehta and Sharma, (2013). Yadav et al. (2016)
10	Production Operation Process	Stawowy and Duda (2012). Wijaya (2013). Pekgun et al (2008). Kumar and Raj (2016). Tan et al. (2011)
11	Production Programming	Al-kuhali et al. (2012). Bettayeb et al. (2014). Jovanovic et al. (2014). Balogun et al. (2012). Leachman et al. (2002). Chen (2013)
12	Quality system	Deshmukh and Chaudhari (2011). Colledani and Tolio (2011). Jabnoun (2002). Batson and McGough (2007)
13	Products delivery	Chen and Wong (2012). Blanquart and Burmeister (2009). Ambe and Badenhorst-weiss (2011). Lonn and Stuart (2003)
14	Foreign trade and service management	Bil et al. (2015). Yu, et al. (2017). Forslund and Jonsson (2010). Min (2009). Krajewska and Kopfer (2009). Mukherjee and Goyal (2013)
15	Transport-reception-custom decision	Song and Carter (2009). Kim (2009). Montoya-Torres et al. (2015). Mogre et al. (2014). Maleki and Reimche (2011). Wang et al. (2016)

MCDM Techniques

There are many MCDM techniques to decide and evaluate the best factor out of all. During this research, authors have come across some multicriteria techniques which are discussed below:

- Deng et al. (2000) presented a modified TOPSIS method to evaluate and rank the relative performance of competing companies in China.
- Lin et al. (2005) presented a fuzzy agility index (FAI) based on agility providers using fuzzy logic.
- Yang et al. (2008) applied an integrated fuzzy MCDM technique for solving vendor selection problem.
- Shih et al. (2007) proposed the TOPSIS technique to a group decision environment.
- Banar et al. (2007) used ANP to choose the best alternative for land filling.
- Wu and Olson (2008) proposed three techniques to evaluate the risks in the supply chain such as chance-constrained programming (CCP), data envelopment analysis (DEA), and multi-objective programming.

It is always important to apply accurate evaluation technique to design future strategies of organisations. A lot of literature is available on MCDM methods but, in this study, authors used VIKOR methodology for deciding the rank of factors. Then select the best factors of ISCM benchmarking based on ranking.

RESEARCH METHODOLOGY

In this study, after factor's identification, VIKOR methodology is implemented for the evaluation of factors on the basis of ranking. The detail of each step is explained consecutively. The flow diagram of the proposed methodology is shown in Fig. 1.

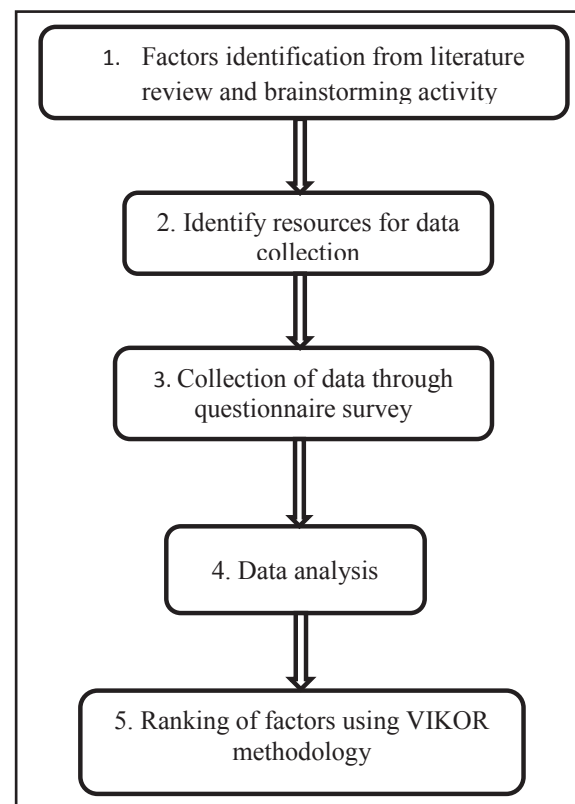


Fig. 1: Proposed Methodology

VIKOR METHODOLOGY

VIKOR method was developed by Opricovic and Tzeng (2004), Faculty of Civil Engineering, Belgrad University, SERBIA. VIKOR ranks the different attributes, and the attributes are evaluated according to all established criteria alternatives.

Analytical Hierarchy Process (AHP) Technique

Saaty (1986) proposed the foundation of AHP and after that applied AHP technique to select the best decisions out of complex decisions. Kailash et al. (2017e) developed a benchmarking model for the evaluation of internal supply chain performance of selected Indian manufacturing industries using fuzzy AHP technique. The objective of the AHP technique is to solve the problem into subgroups, analyse independently and then arrange all in a hierarchy

level (Kumar et al., 2009).

AHP techniques have the following steps:

- Solve the problems into subgroups and then determine the relative weights of each subgroup based on the comparison.
- Compare each alternative based on each attribute.
- The final evaluation of subgroups should be decided on behalf of aggregate weights.

Ranking of Factors Using VIKOR Methodology

VIKOR method is very fruitful for the illustration of ISCM benchmarking factors ranking. In this study, an industrial expert’s advice is collected in terms of factors’ score between rating point scale 1 and 5. The score of factors by experts has been collected through a questionnaire survey.

Table 2: ISCM Benchmarking Factors Score by Experts

S. No.	Factors	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Average
1	Human Resources Orientation	1.71	2.43	2.14	2.00	2.14	2.14	1.86	2.29	1.57	2.14	2.286	2.143	2.1429	2	2.429	2.10
2	Inbound Logistics	2.50	2.00	1.92	1.92	1.92	2.00	1.92	1.83	2.08	1.75	1.75	1.917	1.8333	2.083	1.833	1.95
3	Operational Logistics	2.33	2.17	1.67	2.00	1.83	1.50	2.50	1.50	2.00	1.83	2	1.833	2.1667	2	2.167	1.97
4	Outbound Logistics	1.38	1.63	1.13	1.50	1.25	1.75	1.00	1.88	1.13	1.50	1.125	1.625	1.375	1.375	1.375	1.40
5	Economies of Scale	2.00	2.00	2.00	2.25	1.75	2.50	1.75	2.00	2.75	2.50	1.75	2.5	2	2.25	2.25	2.15
6	Flexibility	2.75	1.50	2.50	1.50	2.25	2.00	2.25	2.25	2.25	2.50	2	2	2.25	1.75	2.25	2.13
7	Logistics Strategies	2.00	2.40	2.20	2.20	2.00	2.40	2.20	2.20	2.60	2.20	2.8	2.6	2.2	2.4	2	2.29
8	New Product Development System	1.00	1.57	1.00	1.14	1.43	1.29	1.14	1.00	1.14	1.14	1.143	1.143	1.2857	1	1.286	1.18
9	Material Follow up and Procurement	1.71	1.50	1.43	1.43	1.50	1.50	1.79	1.57	1.57	1.50	1.357	1.357	1.7857	1.643	1.643	1.55
10	Production Operation Process	1.44	1.67	1.56	1.56	1.44	1.56	1.89	1.33	1.56	1.44	1.333	1.556	1.5556	1.444	1.556	1.53
11	Production Programming	1.56	1.67	1.56	1.22	1.56	1.22	1.67	1.56	1.67	1.44	1.444	1.333	1.3333	1.556	1.333	1.47
12	Quality System	2.60	2.20	2.40	2.30	2.30	2.40	2.50	2.40	2.50	2.40	2.8	2.4	2.4	2.3	2.1	2.40
13	Products Delivery	2.78	2.22	2.44	1.89	2.22	2.00	2.89	2.11	2.67	2.44	2.333	2.333	2.5556	1.667	2.444	2.33
14	Foreign Trade and Service Management	1.91	1.64	2.00	1.82	1.73	2.09	1.91	1.82	1.73	1.91	1.818	1.636	1.5455	1.909	1.727	1.81
15	Transport-Reception-Custom Decision	2.64	1.73	1.91	1.55	1.82	1.64	1.82	1.82	1.73	1.64	2	1.818	1.6364	2	1.545	1.82
	SUM	30.31	28.31	27.84	26.27	27.14	27.98	29.07	27.55	28.94	28.35	27.94	28.19	28.066	27.38	27.94	
	Maximum	2.78	2.43	2.5	2.3	2.3	2.5	2.89	2.4	2.75	2.5	2.8	2.6	2.56	2.4	2.6	
	Minimum	1	1.5	1	1.14	1.25	1.22	1	1	1.13	1.14	1.13	1.14	1.29	1	1.29	
	Difference	1.78	0.93	1.5	1.16	1.05	1.28	1.89	1.4	1.62	1.36	1.67	1.46	1.27	1.4	1.31	

Table 3: Influence Matrix

Alternatives → ↑ Attributes	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Geometric mean	Weight
	1	1	0.145238	0.128571	0.695238	0.054762	0.038095	0.198095	0.914286	0.542857	0.569312	0.621164021	0.304762	0.238095	0.283117	0.277056	0.280937739
2	6.885246	1	0.016667	0.55	0.2	0.183333	0.343333	0.769048	0.397619	0.424074	0.475925926	0.45	0.383333	0.137879	0.131818	0.351386801	0.018802714
3	7.777778	60	1	0.566667	0.183333	0.166667	0.326667	0.785714	0.414286	0.440741	0.492592593	0.433333	0.366667	0.154545	0.148485	0.614949995	0.032905986
4	1.438356	1.818182	1.764706	1	0.75	0.733333	0.893333	0.219048	0.152381	0.125926	0.074074074	1	0.933333	0.412121	0.418182	0.545777114	0.029204543
5	18.26087	5	5.454545	1.333333	1	0.016667	0.143333	0.969048	0.597619	0.624074	0.675925926	0.25	0.183333	0.337879	0.331818	0.660605427	0.035349009
6	26.25	5.454545	6	1.363636	60	1	0.16	0.952381	0.580952	0.607407	0.659259259	0.266667	0.2	0.321212	0.315152	1.189196903	0.063633948
7	5.048077	2.912621	3.061224	1.119403	6.976744	6.25	1	1.112381	0.740952	0.767407	0.819259259	0.106667	0.04	0.481212	0.475152	1.007020246	0.053885672
8	1.09375	1.30031	1.272727	4.565217	1.031941	1.05	0.898973	1	0.371429	0.344974	0.293121693	1.219048	1.152381	0.631169	0.637729	0.888862595	0.047563054
9	1.842105	2.51497	2.413793	6.5625	1.673307	1.721311	1.349614	2.692308	1	0.026455	0.078306878	0.847619	0.780952	0.25974	0.265801	0.839668135	0.044930657
10	1.756506	2.358079	2.268908	7.941176	1.602374	1.646341	1.303089	2.898773	37.8	1	0.051851852	0.874074	0.807407	0.286195	0.292256	1.345799254	0.072013743
11	1.609881	2.101167	2.030075	13.5	1.479452	1.516854	1.220615	3.411552	12.77027	19.28571	1	0.925926	0.859259	0.338047	0.344108	1.933595252	0.103466718
12	3.28125	2.222222	2.307692	1	4	3.75	9.375	0.820313	1.179775	1.144068	1.08	1	0.066667	0.587879	0.581818	1.320222146	0.070645112
13	4.2	2.608696	2.727273	1.071429	5.454545	5	25	0.867769	1.280488	1.238532	1.163793103	15	1	0.521212	0.515152	2.204156446	0.117944452
14	3.53211	7.252747	6.470588	2.426471	2.959641	3.113208	2.078086	1.584362	3.85	3.494118	2.958167331	1.701031	1.918605	1	0.006061	1.842879862	0.098612536
15	3.609375	7.586207	6.734694	2.391304	3.013699	3.173077	2.104592	1.569293	3.762215	3.421659	2.906066536	1.71875	1.941176	165	1	3.663031295	0.196008872
SUM																18.68808921	1

Due to competitive environment, it is very typical to decide the importance of factors. It means which factor is more important and which factor is less important (Kannan and Choon, 2003). That’s why authors used VIKOR methodology for making decision regarding ranking of factors. There are 15 factors and 15 experts for deciding rank of factors. (Ai represent i^{th} alternatives, $i = 1, 2, \dots, 15$, C_j represents the j^{th} attributes, $j = 1, 2, \dots, 15$). Let there be following attributes: factors F1, F2, F3, F4, F5, F6, F7, F8, F9, F10, F11, F12, F13, F14 and F15, and the following alternative criteria: experts opinion E1, E2, E3, E4, E5, E6, E7, E8, E9, E10, E10, E11, E12, E13, E14 and E15. One can get the average mark of i^{th} factors and thus the decision matrix formulated by the expert

team. Table 2 consists of identified factors with scores of experts. VIKOR methodology consists of the following steps:

1. To determine the objective like best value of attributes $(mij)_{max}$ and the worst value of attributes $(mij)_{min}$. The weights of factors should be decided by a pairwise comparison influence matrix as shown in Table 3. It is prepared from the mean of various scores given by 15 respondents to each factor.
2. Calculate the values of E_i and F_i : The values of E_i and F_i are calculated by using equations 1 and 2. Table 4 consists of all calculated values of E_i and summation of E_i for all 15 corresponding factors.

Table 4: Calculation of E_i

E_i	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Sum
E1	0.399	1.000	0.760	0.741	0.848	0.719	0.455	0.921	0.272	0.735	0.695	0.685	0.669	0.714	0.870	10.483
E2	0.843	0.538	0.613	0.672	0.638	0.609	0.487	0.593	0.586	0.449	0.371	0.534	0.425	0.771	0.412	8.542
E3	0.747	0.720	0.447	0.741	0.552	0.219	0.794	0.357	0.537	0.507	0.521	0.473	0.693	0.714	0.672	8.694
E4	0.213	0.140	0.087	0.310	0.000	0.414	0.000	0.629	0.000	0.265	0.000	0.336	0.071	0.271	0.069	2.804
E5	0.562	0.538	0.667	0.957	0.476	1.000	0.397	0.714	1.000	1.000	0.371	0.932	0.559	0.893	0.733	10.798
E6	0.983	0.000	1.000	0.310	0.952	0.610	0.661	0.893	0.691	1.000	0.521	0.589	0.756	0.536	0.733	10.236
E7	0.562	0.968	0.800	0.914	0.714	0.922	0.635	0.857	0.907	0.779	1.000	1.000	0.717	1.000	1.000	12.775
E8	0.000	0.075	0.000	0.000	0.171	0.055	0.074	0.000	0.006	0.000	0.006	0.000	0.000	0.000	0.000	0.388
E9	0.399	0.000	0.287	0.250	0.238	0.219	0.418	0.407	0.272	0.265	0.138	0.151	0.394	0.457	0.267	4.160
E10	0.247	0.183	0.373	0.362	0.181	0.266	0.471	0.236	0.265	0.221	0.120	0.288	0.213	0.314	0.206	3.945
E11	0.315	0.180	0.373	0.069	0.295	0.000	0.354	0.400	0.333	0.220	0.186	0.130	0.031	0.400	0.031	3.318
E12	0.899	0.753	0.933	1.000	1.000	0.920	0.794	1.000	0.846	0.926	1.000	0.863	0.874	0.929	0.618	13.355
E13	1.000	0.774	0.960	0.647	0.924	0.610	1.000	0.793	0.951	0.956	0.719	0.815	1.000	0.479	0.878	12.504
E14	0.511	0.151	0.667	0.586	0.457	0.680	0.481	0.586	0.370	0.566	0.413	0.342	0.205	0.650	0.336	7.001
E15	0.921	0.247	0.607	0.353	0.543	0.328	0.434	0.590	0.370	0.368	0.521	0.466	0.276	0.714	0.198	6.936

$$E_i = w_j [(mij) - (mij)_{min}] / [(mij)_{max} - (mij)_{min}] \quad J = 1 \tag{1}$$

$$F_i = \text{Maximum of } \{w_j [(mij) - (mij)_{min}] / [(mij)_{max} - (mij)_{min}]\} \quad J = 1, 2, 3, \dots, M \tag{2}$$

$$E_{i_{max}} = 12.775, \quad E_{i_{min}} = 0.388$$

$$F(1) = 1, F(2) = 1, F(3) = 1, F(4) = 1, F(5) = 1, F(6) = 1, F(7) = 1, F(8) = 1, F(9) = 1, F(10) = 1, F(11) = 1, F(12) = 1, F(13) = 1, F(14) = 1, F(15) = 1$$

$$F_{i_{max}} = 1, \quad F_{i_{min}} = 1$$

3. Calculate the values of P_i : The value of P_i for all factors is calculated by using equation 3.

$$P_i = v ((E_i - E_{i_{min}}) / (E_{i_{max}} - E_{i_{min}})) + (1 - v) ((F_i - F_{i_{min}}) / (F_{i_{max}} - F_{i_{min}})) \tag{3}$$

$$P(1) = 0.5 [(10.48333 - 0.38762) / (12.77491 - 0.38762)] + (1 - 0.5) [(1 - 1) / (1 - 1)] = 0.407502606$$

The calculated value of $P(1)$ is 0.407502606. Similarly, other values from $P(2)$ to $P(15)$ are determined using equation 3 as shown in Table 5. $E_{i_{max}}$ is the maximum value of E_i and $E_{i_{min}}$ is the minimum value of E_i , $F_{i_{max}}$ is the maximum value of F_i and $F_{i_{min}}$ is the minimum value of F_i . v is introduced as the weight of strategy of the majority of attributes. Usually, the value of v is taken as 0.5. However, v can take any value from 0 to 1.

Table 5: Calculation of Pi

Ei	Sum	P(i)
E1	10.48333	0.407502606
E2	8.54247	0.329161965
E3	8.694497	0.335298371
E4	2.804233	0.097544042
E5	10.7978	0.420195889
E6	10.23556	0.397501795
E7	12.77491	0.5
E8	0.38762	0
E9	4.16026	0.152278656
E10	3.945023	0.143590845
E11	3.317771	0.11827245
E12	13.35462	0.523399311
E13	12.50398	0.489064008
E14	7.001462	0.266960773
E15	6.936328	0.264331707

4. Arrange all attributes in the ascending order, according to the values of Pi. Similarly, arrange the attributes according to the values of Ei and Fi, separately. Thus, the ranking list can be obtained. The compromise ranking list for a given v is obtained by ranking with Pi measures. The best attributes ranked by Pi are the one with the minimum value of Pi. The ranking of factor is decided based on P(i) scores the value of factors. For example, factor 8 (new product development system) P(i) score value is 0, which is the minimum score so that the rank of this factor is 1. The P(i) value of factor 12 (quality system) is 0.52, which is maximum, which is why the rank of this factor is 15. Similarly, the rank of other factors may be decided as shown in Table 6.

Table 6: Ranking of Factors (Attributes)

S. No.	Factors	P(i)	Ranking of Factors
1	New Product Development System	0	11
2	Outbound Logistics	0.097544042	8
3	Production Programming	0.11827245	9
4	Production Operation Process	0.143590845	2
6	Material Follow up and Procurement	0.152278656	12
7	Transport-Reception-Custom Decision	0.264331707	10
8	Foreign Trade and Service Management	0.266960773	14
9	Inbound Logistics	0.329161965	1
10	Operational Logistics	0.335298371	5
11	Flexibility	0.397501795	4
12	Human Resources Orientation	0.407502606	3
13	Economies of Scale	0.420195889	15
14	Products Delivery	0.489064008	13
15	Logistics Strategies	0.5	7
12	Quality System	0.523399311	6

5. For given attribute weights, propose a compromise solution, alternative A_K , which is the best ranked by the measure P, if the following two conditions are satisfied.

Condition 1: ‘Acceptable advantage’ $P(A_K) - P(A_1) \leq (1/(N-1))$. A_1 is the second best alternative in the ranking by P.

Condition 2: ‘Acceptable stability in decision-making’ alternative A_K must also be the best ranked by E and/or F. This compromise solution is stable within a decision-

making processes which could be; ‘voting by majority rule’ (when $v > 0.5$ is needed), ‘by consensus’ (when $v \approx 0.5$) or ‘with veto’ (when $v > 0.5$). If one of the conditions is not satisfied, a set of compromise solution is proposed, which consists of:

Alternatives A_K and A_1 if only condition 2 is not satisfied.

Alternatives A_K, A_1, \dots, A_p if condition 1 is not satisfied; A_p is determined by the relation $P(A_p) - P(A_1) \approx (1/(N-1))$.

RESULT

VIKOR methodology is a very appropriate method for factors ranking. By this method, the manufacturer

identified the best factor and created ISCM benchmarking based on best-ranking factors. Fig. 2 consists of different factors with its evaluated rank.

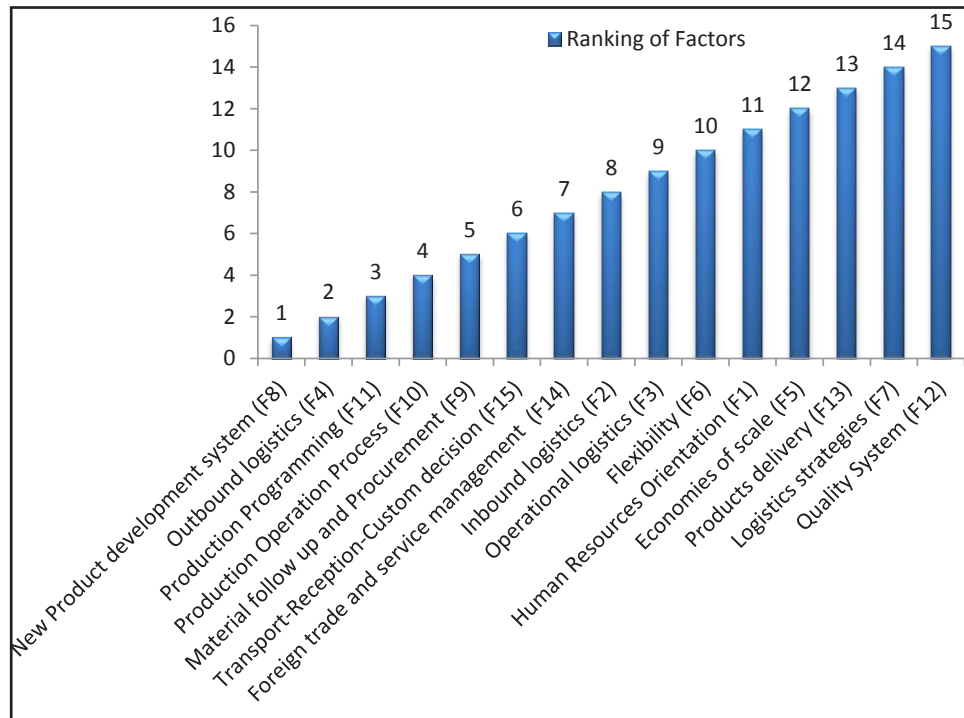


Fig. 2: Ranking of Factors Using VIKOR Methodology

CONCLUSION

ISCM benchmarking is a most effective technique to identify the performance gap between factors and then reduce them by taking some corrective and preventive measure action. There are various types of MCDM techniques. In this study, VIKOR methodology has been effectively used to do the ranking of ISCM benchmarking factors. In a competitive environment when situation is typical for researchers/decision-makers, it is not easy to select best decision in case of multiple alternatives. Then, MCDM-VIKOR methodology is very helpful for considering the best alternatives out of all available multiple factors. In this research work, authors have implement VIKOR methodology in deciding the ranking of factors. The attributes $P(i)$ values are in such order according to scores: as shown in Table 5. The rank of factors is decided on the basis $P(i)$ score value. The ranking of factors starts with lowest value of $P(i)$; it means, first rank is assigned to those attributes whose score is less. For example, F8 factor's $P(i)$ value is zero. So, first rank is assigned to factor F8. In Table 6, factor

F8 is ranked first and factors F4, F11, F10, F9, F15, F14, F2, F3, F6, F1, F5, F13, F7 and F12 are having ranks 2nd, 3rd, 4th, 5th, 6th, 7th, 8th, 9th, 10th, 11th, 12th, 13th, 14th and 15th, respectively. Thus, it is clear that attribute 'factor F8' is the best factor and attribute 'factor F12' is the worst factor. The selection of best factors of ISCM benchmarking is a challenging work in competitive environment. Researchers and industrialist can easily use this MCDM-VIKOR methodology to distinguish the best and the worst alternative variable factors. Therefore, manufacturer/entrepreneur will focus only on worst factors and then improved them without wastage of time for improving the performance of ISCM.

REFERENCES

- Abdullah, H. (2009). Major challenges to the effective management of human resource training and development activities. *Journal of International Social Research*, 2(8), 11–25.
- Adis, A. A. A., & Jublee, E. (2010). Market orientation and new product performance: The mediating role

- of product advantage. *African Journal of Marketing Management*, 2(5), 91–100.
- Agboyi, M. R., & Obiri-Yeboah, D. A. (2015). The impact of sourcing on the delivery of raw material. *International Journal of Advanced Research in Computer Science and Software Engineering*, 5(8), 108–122.
- Agrawal, J., Richardson, P. S., & Grimm, P. E. (1996). The relationship between warranty and product reliability. *Journal of Consumer Affairs*, 30(2), 421–443.
- Alad, A. H., & Deshpande, V. A. (2014). A review of various tools and techniques for lead time reduction. *International Journal of Engineering Development and Research*, 2(1), 1159–1164.
- Al-Kuhali, K., Zain, Z. M., & Hussein, M. I. (2012). Production planning of LCDS: Optimal linear programming and sensitivity analysis. *Industrial Engineering Letters*, 2(9) 1–10.
- Ambe, I. M., & Badenhorst-Weiss, J. A. (2011). An automotive supply chain model for a demand-driven environment. *Journal of Transport and Supply Chain Management*, 5(1), 1–22.
- Anwar, R. S., & Ali, S. (2015). Economies of scale. *International Interdisciplinary Journal of Scholarly Research*, 1(1), 51–57.
- Balogun, O. S., Jolayemi, E. T., Akingbade, T. J., & Muazu, H. G. (2012). Use of linear programming for optimal production in a production line in coca-cola bottling company, Ilorin. *International Journal of Engineering Research and Applications*, 2(5), 2004–2007.
- Banar, M., Kose, B. M., Ozkan, A., & Acar, I. P. (2007). Choosing a municipal landfill site by analytic network process. *Environmental Geology*, 52(4), 747–751.
- Batson, R. G., & McGough, K. D. (2007). A new direction in quality engineering: Supply chain quality modelling. *International Journal of Production Research*, 45(23), 5455–5464.
- Beach, R., Muhlemann, A. P., Price, D. H., Paterson, A., & Sharp, J. A. (2000). A review of manufacturing flexibility. *European Journal of Operational Research*, 122(1), 41–57.
- Bettayeb, B., Bassetto, S. J., & Sahnoun, M. (2014). Quality control planning to prevent excessive scrap production. *Journal of Manufacturing Systems*, 33(3), 400–411.
- Bhargava, M. G., & Chaitanya Kumar, J. D. (2015). State of art of usage of alternative materials in concrete. *International Journal of Engineering Sciences & Management Research*, 2(12), 32–37.
- Bhuiyan, N. (2011). A framework for successful new product development. *Journal of Industrial Engineering and Management*, 4(4), 746–770.
- Bil, M., Vodak, R., Kubecek, J., Bilova, M., & Sedonik, J. (2015). Evaluating road network damage caused by natural disasters in the Czech Republic between 1997 and 2010. *Transportation Research Part A: Policy and Practice*, 80, 90–103.
- Blanquart, C., & Burmeister, A. (2009). Evaluating the performance of freight transport: A service approach. *European Transport Research Review*, 1(3), 135–145.
- Celli, M. (2013). Determinants of economies of scale in large businesses - A survey on UE listed firms. *American Journal of Industrial and Business Management*, 3(3), 255–261.
- Cetinkaya, S., Uster, H., Easwaran, G., & Keskin, B. B. (2009). An integrated outbound logistics model for Frito-Lay: Coordinating aggregate-level production and distribution decisions. *Interfaces*, 39(5), 460–475.
- Charnsirisakskul, K., Griffin, P. M., & Keskinocak, P. (2004). Order selection and scheduling with lead time flexibility. *IIE Transactions*, 36(7), 697–707.
- Charnsirisakskul, K., Griffin, P. M., & Keskinocak, P. (2006). Pricing and scheduling decisions with lead time flexibility. *European Journal of Operational Research*, 171(1), 153–169.
- Chen, C. W., & Wong, V. (2012). Design and delivery of new product preannouncement messages. *Journal of Marketing Theory & Practice*, 20(2), 203–222.
- Chen, T. (2013). A systematic cycle time reduction procedure for enhancing the competitiveness and sustainability of a semiconductor manufacturer. *Sustainability*, 5(11), 4637–4652.
- Chod, J., Rudi, N., & Van Mieghem, J. A. (2012). Mix, time and volume flexibility: Valuation and corporate diversification. *Review of Business and Economic Literature*, 57(3), 262–282.
- Colledani, M., & Tolio, T. (2011). Integrated analysis of quality and production logistics performance in manufacturing lines. *International Journal of Production Research*, 49(2), 485–518.
- Chen, X. (2010). Suggestions on effective corporate new employee orientation program for human resource specialists. *Online Journal of Workforce Education and Development*, 4(3), 1–11.
- Cowling, P., & Johansson, M. (2002). Using real-time information for effective dynamic scheduling. *European Journal of Operational Research*, 139(2), 230–244.

- De Boer, L., Labro, E., & Morlacchi, P. (2001). A review of methods supporting supplier selection. *European Journal of Purchasing and Supply Management*, 7(2), 75–89.
- Delarue, A., Van Hootegeem, G., Procter, S., & BurrIDGE, M. (2008). Teamworking and organizational performance: A review of survey-based research. *International Journal of Management Reviews*, 10(2), 127–148.
- Deng, H., Yeh, C. H., & Willis, R. J. (2000). Inter-company comparison using modified TOPSIS with objective weights. *Computers & Operations Research*, 27(10), 963–973.
- Deshmukh, A. J., & Chaudhari, A. A. (2011). A review for supplier selection criteria and methods. In *Technology Systems and Management* (pp. 283–291). Springer, Berlin, Heidelberg.
- Dornhofer, M., Schroder, F., & Gunthner, W. A. (2016). Logistics performance measurement system for the automotive industry. *Logistics Research*, 9(1), 11–26.
- De Koster, R., Le-Duc, T., & Roodbergen, K. J. (2007). Design and control of warehouse order picking: A literature review. *European Journal of Operational Research*, 182(2), 481–501.
- Dubey, R., & Gunasekaran, A. (2016). The sustainable humanitarian supply chain design: Agility, adaptability and alignment. *International Journal of Logistics Research and Applications*, 19(1), 62–82.
- Dubey, R., Altay, N., Gunasekaran, A., Blome, C., Papadopoulos, T., & Childe, S. J. (2018a). Supply chain agility, adaptability and alignment: Empirical evidence from the Indian auto components industry. *International Journal of Operations & Production Management*, 38(1), 129–148.
- Ertogral, K., & Wu, S. D. (2000). Auction-theoretic coordination of production planning in the supply chain. *IIE Transactions*, 32(10), 931–940.
- Forslund, H., & Jonsson, P. (2010). Integrating the performance management process of on-time delivery with suppliers. *International Journal of Logistics Research and Applications*, 13(3), 225–241.
- Gram, M. (2013). A systematic methodology to reduce losses in production with the balanced scorecard approach. *Manufacturing Science and Technology*, 1(1), 12–22.
- Grigore, S. D. (2007). Supply chain flexibility. *Romanian Economic and Business Review*, 2(1), 66–70.
- Gunasekaran, A., Patel, C., & Tirtiroglu, E. (2001). Performance measures and metrics in a supply chain environment. *International Journal of Operations & Production Management*, 21(1/2), 71–87.
- Guo, J., & Zhang, W. (2008, December). *Selection of suppliers based on rough set theory and VIKOR algorithm*. In International Symposium on Intelligent Information Technology Application Workshops (pp. 49–52). IEEE.
- Hallgren, M., & Olhager, J. (2009). Flexibility configurations: Empirical analysis of volume and product mix flexibility. *Omega-International Journal of Management Science*, 37(4), 746–756.
- Hanson, O., Ackah, D., & Agboyi, M. (2015). Assessing the impact of efficient inventory management in on organization. *International Journal of Advanced Research in Computer Science and Software Engineering*, 5(8), 86–103.
- He, Y. T., & Down, D. G. (2009). On accommodating customer flexibility in service systems. *INFOR Information Systems and Operational Research*, 47(4), 289–295.
- Hicks, D. A. (1997). Manager's guide to supply chain and logistics problem-solving tools and techniques Part III: End user experiences. *IIE Solutions*, 29(11), 340–38.
- Jabnoun, N. (2002). Control processes for total quality management and quality assurance. *Work Study*, 51(4), 182–190.
- Jayant, A., & Ghagra, H. S. (2013). Supply chain flexibility configurations: Perspectives, empirical studies and research directions. *International Journal of Supply Chain Management*, 2(1), 21–29.
- Jovanovic, J. R., Milanovic, D. D., & Djukic, R. D. (2014). Manufacturing cycle time analysis and scheduling to optimise its duration. *Strojnicki Vestnik/Journal of Mechanical Engineering*, 60(7–8), 512–524.
- Kailash, Saha, R. K., & Goyal, S. (2015). Integrity of supplier and distributor with manufacturing company in supply chain management. *Invertis Journal of Science & Technology*, 8(2), 95–100. ISSN: 0973–8940.
- Kailash, Saha, R. K., & Goyal, S. (2017a). Systematic literature review of classification and categorisation of benchmarking in supply chain management. *International Journal of Process Management and Benchmarking*, 7(2), 183–205.
- Kailash, Saha, R. K., & Goyal, S. (2017b). Benchmarking practice for identification of internal supply chain management performance factors gap. *Journal of Supply Chain Management System*, 6(4), 33–38.
- Kailash, Saha, R. K., & Goyal, S. (2017c). Performance indicators for benchmarking of internal supply chain management, World Academy of Science, Engineering and Technology, International Science Index 127. *International Journal of Social, Behavioral,*

- Educational, Economic, Business and Industrial Engineering*, 11(7), 1940–1944.
- Kailash, Saha, R. K., & Goyal, S. (2017d). Scope of internal supply chain management benchmarking in Indian manufacturing industries, *World Academy of Science, Engineering and Technology, International Science Index* 126. *International Journal of Social, Behavioral, Educational, Economic, Business and Industrial Engineering*, 11(6), 1638–1641.
- Kailash, Saha, R. K., & Goyal, S. (2017e). Benchmarking model to analyse ISCM performance of selected Indian manufacturing industries using Fuzzy AHP Technique. *International Journal of Industrial & System Engineering*, (in press).
- Kailash, Saha, R. K., & Goyal, S. (2018). Benchmarking framework for internal supply chain management: A case study for comparative analysis. *International Journal of Manufacturing Technology and Management*, 32(4–5), 412–429.
- Kannan, V. R., & Choon Tan, K. (2003). Attitudes of US and European managers to supplier selection and assessment and implications for business performance. *Benchmarking: An International Journal*, 10(5), 472–489.
- Kesavan, S., Staats, B. R., & Gilland, W. (2014). Volume flexibility in services: The costs and benefits of flexible labor resources. *Management Science*, 60(8), 1884–1906.
- Kim, S. (2009). The toll plaza optimization problem: Design, operations, and strategies. *Transportation Research Part E: Logistics and Transportation Review*, 45(1), 125–137.
- Krajewska, M. A., & Kopfer, H. (2009). Transportation planning in freight forwarding companies: Tabu search algorithm for the integrated operational transportation planning problem. *European Journal of Operational Research*, 197(2), 741–751.
- Kristensen, T., Olsen, K. R., Kilsmark, J., & Pedersen, K. M. (2008). *Economies of scale and optimal size of hospitals: Empirical results for Danish public hospitals*. Syddansk Universitet.
- Kumar, S., & Raj, T. (2016). Selection of material handling equipment for flexible manufacturing system using FAHP. *International Journal of Recent Advances in Mechanical Engineering*, 5(1), 25–45.
- Kumar, S., Parashar, N., & Haleem, A. (2009). Analytical hierarchy process applied to vendor selection problem: Small scale, medium scale and large scale industries. *Business Intelligence Journal*, 2(2), 355–362.
- Kwateng, K. O., Manso, J. F., & Osei-Mensah, R. (2014). Outbound logistics management in manufacturing companies in Ghana. *Review of Business & Finance Studies*, 5(1), 83.
- Leachman, R. C., Kang, J., & Lin, V. (2002). SLIM: Short cycle time and low inventory in manufacturing at Samsung Electronics. *Interfaces*, 32(1), 61–77.
- Lenin, K. (2015). A study on the air cargo logistics operations in Dubai. *Management*, 4(5), 313–315.
- Lin, J. H., Tzeng, G. H., & Jen, W. (2005). Utilizing VIKOR to make ERP system supplier selection decision. *Agriculture and Economics*, 34(11), 69–90.
- Liu, X., & Sun, Y. (2011). Information flow management of vendor managed inventory system in automobile parts inbound logistics based on internet of things. *Journal of Software*, 6(7), 1374–1380.
- Lonn, S., & Stuart, J. A. (2003). Increasing service through aggressive dealer inventory return policies. *International Journal of Physical Distribution & Logistics Management*, 33(6), 519–530.
- Maleki, R. A., & Reimche, J. (2011). Managing returnable containers logistics - A case study part I - Physical and information flow analysis. *International Journal of Engineering Business Management*, 3(2), 1–8.
- McKay, K. N., & Wiers, V. C. (2003). Integrated decision support for planning, scheduling, and dispatching tasks in a focus factory. *Computers in Industry*, 50(1), 5–14.
- Mehta, N., & Sharma, L. (2013). A modification over ratio estimator using empirical data. *Statistics*, 2(1), 65–67.
- Min, H. (2009). The best practice supplier diversity program at Caterpillar. *Supply Chain Management: An International Journal*, 14(3), 167–170.
- Mogre, R., Wong, C. Y., & Lalwani, C. S. (2014). Mitigating supply and production uncertainties with dynamic scheduling using real-time transport information. *International Journal of Production Research*, 52(17), 5223–5235.
- Montoya-Torres, J. R., Franco, J. L., Isaza, S. N., Jiménez, H. F., & Herazo-Padilla, N. (2015). A literature review on the vehicle routing problem with multiple depots. *Computers & Industrial Engineering*, 79, 115–129.
- Mukherjee, A., & Goyal, T. M. (2013). FDI in services sector in India. *Foreign Trade Review*, 48(3), 413–430.
- Mulang, A. (2015). The importance of training for human resource development in organization. *Journal of Public Administration and Governance*, 5(1), 190–197.
- Murthy, D. N. P. (2007). Product reliability and warranty: An overview and future research. *Production*, 17(3), 426–434.
- Opricovic, S., & Tzeng, G. H. (2004). Compromise solution by MCDM methods: A comparative analysis of

- VIKOR and TOPSIS. *European Journal of Operational Research*, 156(2), 445–455.
- Pekgun, P., Griffin, P. M., & Keskinocak, P. (2008). Coordination of marketing and production for price and lead time decisions. *IIE Transactions*, 40(1), 12–30.
- Ramaa, A., Subramanya, K. N., & Rangaswamy, T. M. (2012). Impact of warehouse management system in a supply chain. *International Journal of Computer Applications*, 54(1), 14–20.
- Saaty, T. L. (1986). Axiomatic foundation of the analytic hierarchy process. *Management Science*, 32(7), 841–855.
- Sahay, B. S., Cavale, V., & Mohan, R. (2003). The “Indian” supply chain architecture. *Supply Chain Management: An International Journal*, 8(2), 93–106.
- Schlosser, F. K., Templer, A., & Ghanam, D. (2006). An integrated agenda for understanding the impact of HR outsourcing on organisational learning orientation. *Journal of Labor Research, Special Issue on Outsourcing Management*, 27(3), 291–303.
- Senk, M., Metlikovic, P., Maletic, M., & Gomiseck, B. (2010). Development of new product/process development procedure for SMEs. *Organizacija*, 43(2), 76–86.
- Shahadat, K. (2003). Supplier choice criteria of executing agencies in developing countries. *International Journal of Operations and Production Management*, 16(4), 261–285.
- Sheu, J. B. (2007). Challenges of emergency logistics management. *Transportation Research Part E: Logistics and Transportation Review*, 43(6), 655–659.
- Shih, H. S., Shyur, H. J., & Lee, E. S. (2007). An extension of TOPSIS for group decision making. *Mathematical and Computer Modelling*, 45(7–8), 801–813.
- Sodhi, M. S. (2003). *How to do strategic supply-chain planning*. Fall Magazine.
- Song, D. P., & Carter, J. (2009). Empty container repositioning in liner shipping. *Maritime Policy & Management*, 36(4), 291–307.
- Stawowy, A., & Duda, J. (2012). Models and algorithms for production planning and scheduling in foundries -Current state and development perspectives. *Archives of Foundry Engineering*, 12(2), 69–74.
- Subramani, J., & Kumarap, G. (2012). Modified ratio estimators for population mean using function of quartiles of auxiliary variable. *Bonfring International Journal of Industrial Engineering and Management Science*, 2(2), 19–23.
- Swain, A. K. P. C., & Das, M. (2015). Some classes of modified ratio type estimators in sample surveys. *Statistics in Transition New Series*, 16(1), 37–52.
- Simchi-Levi, D., Kaminsky, P., Simchi-Levi, E., & Shankar, R. (2008). *Designing and managing the supply chain: Concepts, strategies and case studies*. Tata McGraw-Hill Education.
- Tan, X. C., Wang, Y. Y., Gu, B. H., Mu, Z. K., & Yang, C. (2011). Improved methods for production manufacturing processes in environmentally benign manufacturing. *Energies*, 4(9), 1391–1409.
- Tracey, M., & Leng Tan, C. (2001). Empirical analysis of supplier selection and involvement, customer satisfaction, and firm performance. *Supply Chain Management: An International Journal*, 6(4), 174–188.
- Vinesh, A. (2014). Role of training & development in an organizational development. *International Journal of Management and International Business Studies*, 4(2), 213–220.
- Wang, Y. C. (2008). Evaluating flexibility on order quantity and delivery lead time for a supply chain system. *International Journal of Systems Science*, 39(12), 1193–1202.
- Wang, Y., Zhang, D., Liu, Q., Shen, F., & Lee, L. H. (2016). Towards enhancing the last-mile delivery: An effective crowd-tasking model with scalable solutions. *Transportation Research Part E: Logistics and Transportation Review*, 93, 279–293.
- Wijaya, J. (2013). The relationship between price, lead time, and delay toward the order quantity in steel manufacturer. *Universal Journal of Industrial and Business Management*, 1(1), 1–7.
- Wu, D., & Olson, D. L. (2008). Supply chain risk, simulation, and vendor selection. *International Journal of Production Economics*, 114(2), 646–655.
- Yadav, S. K., Gupta, S., Mishra, S. S., & Shukla, A. K. (2016). Modified ratio and product estimators for estimating population mean in two-phase sampling. *American Journal of Operational Research*, 6(3), 61–68.
- Yang, J. L., Chiu, H. N., Tzeng, G. H., & Yeh, R. H. (2008). Vendor selection by integrated fuzzy MCDM techniques with independent and interdependent relationships. *Information Sciences*, 178(21), 4166–4183.
- Yu, B., Wang, K., Wang, C., & Yao, B. (2017). Ship scheduling problems in tramp shipping considering static and spot cargoes. *International Journal of Shipping and Transport Logistics*, 9(4), 391–416.