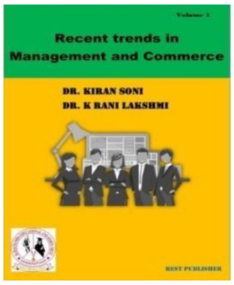
Recent Trends in Management and Commerce

Vol: 4(1), 2023

REST Publisher; ISBN: 978-81-936097-6-7

Website: http://restpublisher.com/book-series/rmc/

DOI: https://doi.org/10.46632/rmc/4/1/2



Design of Experiment with ARAS in Technology Selection for Effective Cognitive Supply Chain Management

*** [1]Nivetha Martin, [2]M. Renee Miriam**

[1] Arul Anandar College (Autonomous), Karumathur, Tamilnadu, India.

[2]Kamaraj University, Madurai, Tamilnadu, India.

*Corresponding author Email: nivetha.martin710@gmail.coms

Abstract: *The core principle of Industry 4.0 is the augmentation of artificial intelligence components with almost all the business activities. The manufacturers are preferring cognitive supply chain management (COGSCM) to conventional logistic practices for exercising effective planning and control. Automatic monitoring of production and inventory levels with less manual interference are the highlighting features of COGSCM. As the right choice of technology makes COGSCM more effective, this paper proposes a hybrid method of decision making to make optimal selection of the technology. The technique of Design of experiment (DOE) is combined with Additive Ratio Assessment (ARAS) to develop a new method. The competency and consistency of the model is tested with the secondary data sets and further analysed with other similar combined methods. It is observed that the proposed method is yielding better results in comparison to the existing methods of making decisions.*

Keywords: *Design of Experiment, Cognitive Supply chain management, ARAS, technology selection.*

1. INTRODUCTION

Artificial Intelligence is becoming one of the mainstreams of manufacturing processes in the context of industry 4.0. The production sectors are spinning their production activities with well advanced technology to develop smart products. Adding to smart production, a smart delivery system is also required and this is the evolving point of cognitive supply chain management. In this world of technology, supply chain management is expected to be intelligent with predictive analytics and machine learning interferences for demand forecasting [6]. How can a company transform the conventional SCM to COGCM? This is possible by adopting automation technologies such as IoT, location technologies, digital manufacturing, drones and robotics. These are primary technologies and many sub-technologies do exist [23-24]. The availability of several technologies constraint the production sectors in choosing the ideal technology and this is where the decision-making problem on technology selection is getting rooted up. To resolve such selection-based problems, the multi criteria decision making methods called as MCDM are applied in such circumstances. MCDM researchers have developed various methods of making decisions based on different theories. One of the simplest and most consistent MCDM methods is the method of ARAS introduced by Zavadakas [22]. This method is highly preferred by the decision makers to solve selection-based decision problems. This method is applied to compute ideal solutions to various problems and some of the recent applications are based on transportation analysis [14], green supplier selection [11], personnel selection [16,18], efficiency analysis [4,12,19], mobile game selection [15], indicators selection [1] and many other. This method is also used in combination with other methods such as VIKOR [8] with picture fuzzy sets, CRITIC [3], Entropy, TOPSIS [10], SWARA [21], MEREC [17]. The method of ARAS is also discussed with ordinary fuzzy sets [5], spherical fuzzy sets [9], rough sets [20], interval valued fuzzy sets [2] and many other forms of fuzzy representations. But to the best of our knowledge, this MCDM method of ARAS has not been integrated with the statistical technique of Design of Experiments. These two methods are alike in its objective of optimality and this shows the chances of combining these two methods. Dua [7] has laid the foundation of combining MCDM method with statistical technique for the first time. He has merged the MCDM method of Simple Additive Weighting with Design of Experiments and based on his approach, the method of ARAS is combined with DOE. The method of ARAS is better in terms of yielding consistent results in comparison to SAW and hence ARAS method is chosen in this research work. The remaining content of the paper is structured into the following sections. Section 2 presents the steps involved in the proposed hybrid method of DOEARAS. Section 3 applies the proposed method to the technology selection problem. Section 4 makes sensitivity analysis and the last section concludes the work with future scope and extensions.

2. METHODOLOGY

In this section the steps involved in the proposed method of DOEARAS are presented. The authors shall refer [7] for better understanding of the working principle of DOE.

1. Formulation of the Decision-making matrix of order g × h based on the expert's opinion

$$D = \begin{bmatrix} x_{11} & \cdots & x_{1g} \\ \vdots & \ddots & \vdots \\ x_{g1} & \cdots & x_{gh} \end{bmatrix}$$

2. The optimal values x_{0j} are determined from the matrix D by choosing the maximum value for the benefit criteria and minimum value for the cost criteria.
3. The experimental matrix of different levels with the above determined minimum and maximum criterion values is formulated and the score values of the alternatives are determined using the steps 4-6

4. The values in the matrix are normalized either by using 2.1 or 2.2 based on respective beneficial or cost criteria.

   For benefit criteria $$\overline{x_{ij}} = \frac{x_{ij}}{\sum_{i=0}^{g} xij} \quad (2.1)$$

   For cost criteria $x_{ij} = \frac{1}{x_{ij}^*}$ $$\overline{x_{ij}} = \frac{x_{ij}}{\sum_{i=0}^{g} xij} \quad (2.2)$$

5. Find the weighted normalized matrix by multiplying the normalized matrix with criterion weights.
6. The utility degree of the alternatives is determined using $K_i = \frac{S_i}{S_0}$, where S_0 is the optimal score value.
7. An equation connecting the output and the criteria is constructed and by substituting the respective values of the alternatives, the final score values of the alternatives are determined.
8. The number of experiments runs varies with the number of criteria.

3. DOEARAS IN TECHNOLOGY SELECTION OF COGSCM

In this section, the decision-making problem on technology selection for effective cognitive supply chain management is described. The decision-making problem comprises five technologies and 4 criteria. The performance scores of the technology with respect to four significant criteria is presented in the following decision-making matrix. The criteria chosen for making optimal decisions are presented in Table 3.1

TABLE 1. Criteria Description

Criteria	**Description**
Comprehensiveness (CO)	Accommodative of wide range of features
Customizable (CU)	Flexible in modifying to the local requirements
Consistency (CS)	Efficiency in terms of energy, time and costs
Reliability (RE)	Durability must be long with minimum occurrences of failures

The following decision matrix comprises the performance score values of five different technologies pertaining to the criteria described in table 3.1 that shall be used in effective cognitive supply chain management. The data is of secondary type and it is obtained from the perspective of the experts in the field of supply chain management.

TABLE 2. decision matrix comprises

	CO	CU	CS	RE
T1	45	80	40	55
T2	65	70	60	35
T3	50	65	55	70
T4	75	50	60	55
T5	60	55	55	50

In this case all the criteria are considered to be benefit type. Table 3.2 comprises the maximum and minimum values of the criteria

TABLE 3. Max-Min Criterion Values

Criteria	CO	CU	CS	RE
Max	75	80	60	70
Min	45	50	40	35

The experimental matrix based on DOE with the computed score values using the steps in section 2 is as follows.

TABLE 4. Experimental Matrix

Experimental Runs	CO	CU	CS	RE	Score values
1	75	50	40	70	0.827789
2	45	80	40	70	0.820219
3	75	50	60	35	0.775461
4	75	80	60	70	1
5	45	80	60	35	0.76789
6	75	50	40	35	0.695429
7	45	50	60	70	0.808071
8	45	50	40	70	0.72804
9	45	50	60	35	0.675711
10	75	50	60	70	0.907821
11	75	80	60	35	0.86764
12	75	80	40	70	0.919968
13	45	50	40	35	0.59568
14	75	80	40	35	0.787608
15	45	80	40	35	0.687859
16	45	80	60	70	0.90025

The required equation connecting the final output i.e the score values and the criteria is 0.0083 + 0.0033249 CO + 0.0030726 CU + 0.004001575 CS + 0.0037817RE ------------- 3.1. The final score values of the alternatives using the equation 3.1 is presented in Table 3.3

TABLE 5. Score values & Ranking based on DOEARAS with Equal Weights

Alternatives	Score values	Rank
T1	0.771785	5
T2	0.811955	3
T3	0.85907	2
T4	0.859386	1
T5	0.785959	4

The above procedure is repeated with different criterion weights obtained using the methods of AHP, Entropy, CRITIC, MEREC. The criterion weights are presented in Table 3.4

TABLE 6. Criterion Weights using Different methods

Criterion Weights using different Methods	CO	CU	CS	RE
AHP	0.24657	0.234561	0.210564	0.308305
Entropy	0.256447	0.249681	0.22057	0.273302
CRITIC	0.245123	0.235416	0.245613	0.273848
MEREC	0.251432	0.231456	0.24156	0.275552

The respective equation obtained with different sets of criterion weights are presented in Table 7

TABLE 7. Equations using different weights

DOEARAS combined with	Equations
AHP	0.00166533+0.003262198 CO + 0.002867796 CU + 0.003352711 CS + 0.004639269 RE
Entropy	-0.0011+0.003402CO + 0.003061CU + 0.003522CS + 0.004124 RE
CRITIC	0.00194 +0.003254 CO + 0.002888 CU + 0.003924 CS + 0.004135 RE
MEREC	0.00222 +0.003337 CO + 0.002839 CU + 0.003858 CS + 0.004159 RE

The respective score values obtained using the above equations listed in Table 8

TABLE 8. Score values using DOEARAS with different methods

Score values of the Alternatives	AHP	Entropy	CRITIC	MEREC
T1	0.767156	0.76457	0.763795	0.76257
T2	0.777991	0.78996	0.795775	0.7949
T3	0.86033	0.850355	0.85763	0.856925
T4	0.846042	0.84524	0.853255	0.85467
T5	0.771489	0.771285	0.77859	0.778725

The ranking of the alternatives based on the above score values is presented in Table 9

TABLE 9. Ranking of the Alternatives

Alternatives	AHP	Entropy	CRITIC	MEREC
T1	5	5	5	5
T2	3	3	3	3
T3	1	1	1	1
T4	2	2	2	2
T5	4	4	4	4

4. SENSITIVITY ANALYSIS

In addition to the above ranking computations in section 3, the alternatives are ranked in this section without using DOE to make comparison with the newly proposed method. The ranking results are presented in Table 10

TABLE 10. Ranking results without DOE

Alternatives	ARAS with Equal Weights		ARAS with AHP		ARAS with Entropy		ARAS with CRITIC		ARAS with MEREC	
	Score values	Rank	Score values	Rank	Score values	Rank	Score values	Rank	Score values	Rank
T1	0.765005	5	0.766741	5	0.766995	5	0.76329	5	0.761694	5
T2	0.802761	3	0.775855	4	0.790454	3	0.792995	3	0.79185	3
T3	0.848491	2	0.856479	1	0.849182	1	0.853451	1	0.85244	1
T4	0.849049	1	0.842701	2	0.844506	2	0.849393	2	0.850583	2
T5	0.775805	4	0.768271	3	0.770702	4	0.774872	4	0.774748	4

It is observed that the ranking results obtained using DOEARAS with equal weights and distinct weights are same. On repeating the ARAS procedure with equal and distinct weights the ranking results differs to some extent. This shows that the ranking results obtained using DOE in combination with ARAS are more consistent. The proposed hybrid method yields the results as T3 > T4 >T2 >T5 > T1.

5. CONCLUSION

The proposed method of decision making will surely assist the decision makers in making ideal decisions on the technology used in COGSCM. The hybrid method developed using DOE and ARAS is more optimal and robust in making ideal solutions. The decision-making problem on selecting technology shall be easily resolved using this novel method. The method of DOE shall be integrated with other ranking methods and this shall be considered as a part of future research work.

REFERENCES

[1]. Akbari, M., Azizi, M., Jahanirad, H. A., & Pashapour, H. A. (2022). Application of Aras technique in the analysis of housing development indicators in the cities of Kohgiluyeh and Boyer-Ahmad.
[2]. Aydoğdu, A., & Gül, S. (2022). New entropy propositions for interval-valued spherical fuzzy sets and their usage in an extension of ARAS (ARAS-IVSFS). Expert Systems, 39(4), e12898.
[3]. Aytekin, A., Okoth, B. O., Korucuk, S., Mishra, A. R., Memiş, S., Karamaşa, Ç., & Tirkolaee, E. B. (2023). Critical success factors of lean six sigma to select the most ideal critical business process using q-ROF CRITIC-ARAS technique: Case study of food business. Expert Systems with Applications, 224, 120057.
[4]. Azzahra, J., Maulita, Y., & Syari, M. A. (2022). Motorcycle Credit Purchase Decision Support System With Additive Ratio Assesstment (ARAS) Method. International Journal of Health Engineering and Technology, 1(2).
[5]. Čabrić, N., Branković, N., & Kalem, A. (2023). The Selection of a Possible Organizational Structure of Railway Companies by Application Fuzzy-ARAS Method. Science, Engineering and Technology, 3(1), 22-32.
[6]. Daghar, A., Alinaghian, L., & Turner, N. (2023). The role of cognitive capital in supply chain resilience: an investigation during the COVID-19 pandemic. Supply Chain Management: An International Journal, 28(3), 576-597.
[7]. Dua, T. V. (2023). Combination of design of experiments and simple additive weighting methods: a new method for rapid multi-criteria decision making. EUREKA: Physics and Engineering (2023),(1), 120-133.
[8]. Fan, J., Han, D., & Wu, M. (2023). Picture fuzzy Additive Ratio Assessment Method (ARAS) and VIseKriterijumska Optimizacija I Kompromisno Resenje (VIKOR) method for multi-attribute decision problem and their application. Complex & Intelligent Systems, 1-13.
[9]. Gocer, F., & Sener, N. (2022). Spherical fuzzy extension of AHP-ARAS methods integrated with modified k-means clustering for logistics hub location problem. Expert Systems, 39(2), e12886.
[10]. Gök-Kısa, A. C., Çelik, P., & Peker, İ. (2022). Performance evaluation of privatized ports by entropy based TOPSIS and ARAS approach. Benchmarking: An International Journal, 29(1), 118-135.
[11]. Hashim, A., Faisal, S. M., & Khan, A. K. (2023). Analysis of Green Supplier Using ARAS Model Integration in the Decision-Making Process. Journal of Environmental Impact and Management Policy (JEIMP) ISSN: 2799-113X, 3(03), 1-14.
[12]. Karadağ Ak, Ö., Hazar, A., & Babuşcu, Ş. (2022). Evaluation of the financial performance of development and investment banks with entropy-based ARAS method. Macroeconomics and Finance in Emerging Market Economies, 1-21.
[13]. Lukić, R., & Zekić, B. H. (2022). Efficiency analysis of trade companies in Serbia using the ARAS method. Business Logistics in Modern Management, 105.
[14]. Manoj, A. D. Transportation system Analysis of MCDM ARAS method.
[15]. Meidelfi, D., Idmayanti, R., Maulidani, F., Ilham, M., & Muhlis, F. A. (2022). Additive Ratio Assessment (ARAS) Method in The Selection of Popular Mobile Games. International Journal of Advanced Science Computing and Engineering, 4(1), 56-66.
[16]. Pangestu, B., & Kosasih, A. (2022). Application of Additive Ratio Assessment (ARAS) Method for the Selection of Youth Red Cross Chairperson at SMA Negeri 1 Lebakwangi Kuningan. Journal of General Education and Humanities, 1(2), 83-94.
[17]. Rani, P., Mishra, A. R., Saha, A., Hezam, I. M., & Pamucar, D. (2022). Fermatean fuzzy Heronian mean operators and MEREC-based additive ratio assessment method: An application to food waste treatment technology selection. International Journal of Intelligent Systems, 37(3), 2612-2647.
[18]. Supriatin, S., Saputra, A. R., & Satria, B. (2022). Implementation of Aras Algorithm on Decision Support System to Determine the Best Lecturer. JITK (Jurnal Ilmu Pengetahuan dan Teknologi Komputer), 8(1), 25-32.
[19]. Susliansyah, S., Sumarno, H., Priyon, H., Maulida, L., & Indriyani, F. (2022). Application of A Decision Support System on Additive Ratio Assessment (ARAS) Method in Determining Best-Selling Korean Snacks. IJISTECH (International Journal of Information System and Technology), 6(4), 469-476.
[20]. Tanackov, I., Badi, I., Stević, Ž., Pamučar, D., Zavadskas, E. K., & Bausys, R. (2022). A Novel Hybrid Interval Rough SWARA–Interval Rough ARAS Model for Evaluation Strategies of Cleaner Production. Sustainability, 14(7), 4343.
[21]. Toygar, A., Yildirim, U., & İnegöl, G. M. (2022). Investigation of empty container shortage based on SWARA-ARAS methods in the COVID-19 era. European Transport Research Review, 14(1), 8.
[22]. Zavadskas, E.K.; Turskis, Z. 2010. A new additive ratioassessment (ARAS) method in multi-criteria decision-making, Technological and Economic Development of Economy16(2): 159–172
[23]. https://www2.deloitte.com/us/en/pages/operations/articles/cognitive-supply-chain.html
[24]. https://www.ibm.com/downloads/cas/DGP9YPZV