MULTI-TIER SUSTAINABLE GLOBAL SUPPLIER SELECTION USING A FUZZY AHP-VIKOR BASED APPROACH: A DISCUSSION

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Abstract: Awasthi et al. (International Journal of Production Economics, 195 (2018): 106-117) used an integrated fuzzy AHP-VIKOR approach-based framework for sustainable global supplier selection. In this approach the fuzzy analytic hierarchy process (FAHP) is used to generate criteria weights for sustainable global supplier selection. To do the same Awasthi et al. have transformed the fuzzy pairwise comparison matrix into a crisp pairwise comparison matrix and then the crisp AHP is applied on the transformed crisp pairwise comparison matrix. After a deep, study it is observed that Awasthi et al. have transforming the fuzzy pairwise comparison matrix into the crisp matrix, but the transformed crisp matrix will not be a crisp pairwise comparison matrix and hence the crisp AHP approach cannot be used. Therefore, the approach, proposed by Awasthi et al., is not valid in its present form. Keeping the same in mind, the required modification is suggested for its validity.

Keywords: Analytic Hierarchy Process, FAHP, Pairwise Comparison Matrices.

Introduction: Awasthi et al. (2017) addressed the problem of global sustainable supplier selection by considering the risks that arises from a focal company's sub-suppliers. Awasthi et al. (2017) pointed out that most of the existing studies consider sustainability based on three pillars (economy, environment, and social) in general. However, including global risks in sustainable supplier selection activities will make the selection process more efficient.

Keeping the same in mind, Awasthi et al. (2017) used an integrated fuzzy AHP-VIKOR approach-based framework for sustainable global supplier selection by considering the global risk as a major criterion. In this approach, FAHP is used to evaluate the criteria weights and fuzzy VIKOR is used to rate supplier performances against the evaluation criteria.

After a deep study, it is observed that in FAHP approach, used by Awasthi et al. (2017), some mathematical incorrect assumptions have been considered and hence, the approach, proposed by Awasthi et al. (2017), is not valid in its present form. Keeping the same in mind, the required modifications in the approach, proposed by Awasthi et al. (2017), is suggested for its validity.

FAHP Approach: The steps of the FAHP approach, used by Awasthi et al. (2017) in their integrated approach to generate criteria weights for the fuzzy pairwise comparison matrix

$$\tilde{A}=\begin{bmatrix}1 & \tilde{a}_{12} & \dots & \tilde{a}_{1n}\\ \tilde{a}_{21} & \ddots & \vdots & \vdots\\ \vdots & \dots & \ddots & \vdots\\ \tilde{a}_{n1} & \tilde{a}_{n2} & \dots & 1\end{bmatrix}_{n\times n}$$

where $\tilde{a}_{ii}=1, i=j$ and $\tilde{a}_{ij}=\frac{1}{\tilde{a}_{ji}}, i\neq j$, are as follows:

Step 1: Considering the fuzzy number $\tilde{a}_{ij}$ as a triangular fuzzy number $(a_{ij},\ b_{ij},\ c_{ij})$, the fuzzy pairwise comparison matrix $\tilde{A}$ can be re-written as

$$\tilde{A}=\begin{bmatrix}1 & (a_{12},b_{12},c_{12}) & \dots & (a_{1n},b_{1n},c_{1n})\\ \frac{1}{(a_{12},\ b_{12},\ c_{12})} & \ddots & \vdots & \vdots\\ \vdots & \dots & \ddots & \vdots\\ \frac{1}{(a_{1n},\ b_{1n},\ c_{1n})} & \frac{1}{(a_{2n},\ b_{2n},\ c_{2n})} & \dots & 1\end{bmatrix}_{n\times n}$$

Step 2: Transform the fuzzy pairwise comparison matrix $\tilde{A}$, obtained in Step 1, into the crisp matrix

$$A=\begin{bmatrix}1 & R((a_{12},\ b_{12},\ c_{12})) & \dots & R((a_{1n},\ b_{1n},\ c_{1n}))\\ R\left(\frac{1}{(a_{12},\ b_{12},\ c_{12})}\right) & \ddots & \vdots & \vdots\\ \vdots & \dots & \ddots & \vdots\\ R\left(\frac{1}{(a_{1n},b_{1n},c_{1n})}\right) & R\left(\frac{1}{(a_{2n},b_{2n},c_{2n})}\right) & \dots & 1\end{bmatrix}_{n\times n}$$

where, $R\left((a_{ij},\ b_{ij},\ c_{ij})\right)=\frac{a_{ij}+4\otimes b_{ij}+c_{ij}}{6}$.

Step 3: Transform the crisp matrix A, obtained in Step 2, into the crisp matrix

$$A=\begin{bmatrix}1 & R((a_{12},\ b_{12},\ c_{12})) & \dots & R((a_{1n},\ b_{1n},\ c_{1n}))\\ \frac{1}{R((a_{12},b_{12},c_{12}))} & \ddots & \vdots & \vdots\\ \vdots & \dots & \ddots & \vdots\\ \frac{1}{R((a_{1n},b_{1n},c_{1n}))} & \frac{1}{R((a_{2n},b_{2n},c_{2n}))} & \dots & 1\end{bmatrix}_{n\times n}$$

Step 4: Check that the crisp pairwise comparison matrix A, obtained in Step 3, is consistent or not. If it is consistent then applying the crisp AHP approach (Saaty, 1980) to generate the criteria weights.

Mathematical Incorrect Assumptions: It is obvious from the existing FAHP approach, discussed in Section 2, that to transform the crisp matrix

$$A=\begin{bmatrix}1 & R((a_{12},\ b_{12},\ c_{12})) & \dots & R((a_{1n},\ b_{1n},\ c_{1n}))\\ R\left(\frac{1}{(a_{12},b_{12},c_{12})}\right) & \ddots & \vdots & \vdots\\ \vdots & \dots & \ddots & \vdots\\ R\left(\frac{1}{(a_{1n},b_{1n},c_{1n})}\right) & R\left(\frac{1}{(a_{2n},b_{2n},c_{2n})}\right) & \dots & 1\end{bmatrix}_{n\times n},$$

obtained in Step 2, into the crisp matrix

$$A=\begin{bmatrix} 1 & R\big((a_{12},\ b_{12},\ c_{12})\big) & \dots & R\big((a_{1n},\ b_{1n},\ c_{1n})\big) \\ \frac{1}{R((a_{12},b_{12},c_{12}))} & \ddots & \vdots & \vdots \\ \vdots & \dots & \ddots & \vdots \\ \frac{1}{R(a_{1n},b_{1n},c_{1n})} & \frac{1}{R((a_{2n},b_{2n},c_{2n}))} & \dots & 1 \end{bmatrix}_{n\times n},$$

obtained in Step 3, Awasthi et al. (2017), have assumed that $R\left(\frac{1}{(a_{ij},b_{ij},c_{ij})}\right)=\frac{1}{R\left((a_{ij},b_{ij},c_{ij})\right)}$. While, the following example clearly indicates that $R\left(\frac{1}{(a_{ij},b_{ij},c_{ij})}\right)\neq\frac{1}{R\left((a_{ij},b_{ij},c_{ij})\right)}$. Therefore, the existing FAHP approach, discussed in Section 2 and used by Awasthi et al. (2017) in their proposed approach, is not valid in its present form.

Let $\tilde{a}_{ij}=\left(a_{ij},\ b_{ij},\ c_{ij}\right)=(1,2,3)$. Then, using the existing expression

$R\left(\left(a_{ij},\ b_{ij},\ c_{ij}\right)\right)=\frac{a_{ij}+4b_{ij}+c_{ij}}{6}$ i.e., $\frac{1}{R\left((a_{ij},b_{ij},c_{ij})\right)}=\frac{6}{a_{ij}+4b_{ij}+c_{ij}}$,

$$\frac{1}{R((1,2,3))}=\frac{6}{1+4\times2+3}=\frac{1}{2} \qquad (1)$$

Furthermore, using the expression $R\left(\frac{1}{(a_{ij},b_{ij},c_{ij})}\right)=R\left(\frac{1}{c_{ij}},\frac{1}{b_{ij}},\frac{1}{a_{ij}}\right)=\frac{\frac{1}{c_{ij}}+4\times\frac{1}{b_{ij}}+\frac{1}{a_{ij}}}{6}$, $R\left(\frac{1}{(1,2,3)}\right)=$

$$R\left(\frac{1}{3},\frac{1}{2},\frac{1}{1}\right)=\frac{\frac{1}{3}+4\times\frac{1}{2}+\frac{1}{1}}{6}=\frac{5}{9} \qquad (2)$$

It is obvious from (1) and (2) that $R\left(\frac{1}{(1,2,3)}\right)\neq\frac{1}{R((1,2,3))}$. i.e., $R\left(\frac{1}{(a_{ij},b_{ij},c_{ij})}\right)\neq\frac{1}{R\left((a_{ij},b_{ij},c_{ij})\right)}$.

Suggested Modification: In the existing FAHP approach, discussed in Section 2, the element $\tilde{a}_{ij}=\left(a_{ij},\ b_{ij},\ c_{ij}\right)$ of the fuzzy pairwise comparison matrix is transformed into the real number $R\left(\tilde{a}_{ij}\right)=\frac{a_{ij}+4\otimes b_{ij}+c_{ij}}{6}$. This real number actually represents the weighted arithmetic mean, $\omega_1\times a_{ij}+\omega_2\times b_{ij}+\omega_3\times c_{ij}$ of $a_{ij},\ b_{ij}$ and c_{ij} where, $\omega_1=\frac{1}{6}$, $\omega_2=\frac{4}{6}$ and $\omega_3=\frac{1}{6}$.

If instead of this weighted arithmetic mean, the weighted geometric mean, $R\left(\tilde{a}_{ij}\right)=\left(a_{ij}\right)^{\omega_1}\times\left(b_{ij}\right)^{\omega_2}\times\left(c_{ij}\right)^{\omega_3}=\left(a_{ij}\right)^{\frac{1}{6}}\times\left(b_{ij}\right)^{\frac{4}{6}}\times\left(c_{ij}\right)^{\frac{1}{6}}$ is used to transform the element $\tilde{a}_{ij}=\left(a_{ij},\ b_{ij},\ c_{ij}\right)$ into a real number i.e., if the fuzzy pairwise comparison matrix $\tilde{A}=\left[\left(a_{ij},\ b_{ij},\ c_{ij}\right)\right]_{n\times n}$ is transformed into the crisp matrix $A=\left[\left(a_{ij}\right)^{\frac{1}{6}}\times\left(b_{ij}\right)^{\frac{4}{6}}\times\left(c_{ij}\right)^{\frac{1}{6}}\right]_{n\times n}$ instead of the crisp matrix $A=\left[\frac{a_{ij}+4\otimes b_{ij}+c_{ij}}{6}\right]_{n\times n}$ then the transformed crisp matrix $A=\left[\left(a_{ij}\right)^{\frac{1}{6}}\times\left(b_{ij}\right)^{\frac{4}{6}}\times\left(c_{ij}\right)^{\frac{1}{6}}\right]_{n\times n}$ will be a crisp pairwise comparison matrix. Hence, the crisp AHP approach (Saaty, 1980) can be used to generate the criteria weights i.e., the existing approach (Awasthi et al., 2017) will be valid.

Conclusion: On the basis of the present study, it can be concluded that the existing approach (Awasthi et al., 2017) is not valid in it is present form. Furthermore, the required modification, in the existing approach (Awasthi et al., 2017), is suggested for its validity.

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