Ranking of the Factors for Resilient Humanitarian Supply Chain: A TOPSIS Approach

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Abstract

With the increasing frequency of disaster and their impact, the global humanitarian agencies are facing challenges in responding to urgent requirements on timely basis. Therefore the aim of humanitarian organizations should be to increase the resiliency towards disaster among the societies. This would not only help to increase their effectiveness and efficiency but will also help in decreasing the impact of future disasters. Hence, this paper aims to identify and analyse the major driving factors for resilient humanitarian supply chain. Based on the literature review and experts opinion, eight factors were identified, which were then ranked using the TOPSIS methodology. Government support and policy formulation, strategy and capacity planning; and progress assessment of project was identified as the major driver factors. By managing these factors, humanitarian organizations can increase the resiliency and agility in the supply chain.

Keywords :
Humanitarian supply chain, TOPSIS, MCDM, Resilient

1.0 Introduction

Even after the massive development in the supply chain management, the humanitarian organizations are not able to utilize the knowledge. This has lead to indiscriminate proportion of development in the commercial and humanitarian supply chain. Though there may be various differences between the commercial and humanitarian supply chain, but the fundamental chain for both, remains the same. This similarity can be used for analyzing and bringing resiliency in the humanitarian supply chain.

According to UN reports, the number of disaster and their impact has raised manifolds as compared to 1970 (ESCAP 2015). This calls for the immediate need to stream line the humanitarian operations to make them more efficient, responsive and agile. Therefor the concept of resilient humanitarian supply chain seems to be the most feasible solution. Resiliency towards the disaster and crisis would help to achieve short term and long term objectives of the organizations. Therefore, this paper aims at identifying the major driving factors for the resilient humanitarian supply chain and then ranking them using Technique for order preferences by similarity to ideal solution (TOPSIS) methodology. Remaining part of this study is organised as follows: Section 2 deals with literature review, Section 3 deals with theresearch methodology used to analyse the factors for bringing resilience in the humanitarian supply chain, Section 4deals with the results and analysis and finally, Section 5 is the concluding remark.

2.0 Literature review

The success of any organization depends heavily on its critical success factor. These factors can be categorized as driving factors or dependent factors. Driving factors are process oriented whereas dependent factors are result oriented. Driving factors are the one which helps in achieving the organization goals i.e, the dependent factors. Therefore, managers should give a high priority to driving factor to achieve the desired goals. This section tries to identify the major driving factors for increasing the resiliency in the humanitarian supply chain. The major driving factors identified from literature review and expert opinion are discussed below in table 1.

Table 1 : Driving factors for resilient humanitarian supply chain

Factor Code	**Factor**	**Explanation**	**References**
F1	Government support and policy formulation	Support from the host government is the major factor in humanitarian operations. In fact, they are the activator of the supply chain. Without their authorisation, other players like NGO's, neighbour countries government etc. Can't operate in the disaster region(Singh et. al., 2018). Prior international agreement and good relations of the host government with the other countries helps at the time of disaster in the form of global humanitarian assistance.	Kabra and Ramesh,2015
F2	Strategy and capacity planning	Strategy and capacity planning has always been considered as an important factor to streamline and make the operations effective, agile and efficient. Strategy planning promotes speedy response, flexibility and safety against future disasters. Whereas prepositioning various relief aid at strategic locations helps in saving the life immediately after the disaster, hence increasing the responsiveness(Torabi et. al., 2018).	Torabi et. al., 2018; Singh et. al., 2018
F3	Progress assessment of project	With the increasing pressure on humanitarian organizations to increase their efficiency and to use resources strategically, it becomes of paramount importance to measure the projects performance(Bealt et. al., 2016). It helps to identify the areas of improvement(Singh et. al.,2018). Performence measuremnet of the the project should try to capture the short term and long term expectation of the project.	Singh et. al., 2017; Bealt et. al., 2016
F4	Collaboration between stakeholders	Humanitarian supply chain consists of very complex network of stakeholders, working under complex situations. This demands the need for collaboration and coordination among all the stakeholders. Possible lack of collaboration leads to redundancy of efforts, last mile confusions. Collaboration leads to knowledge creation and thus helps in increased efficiencies and learning(Singh et. al., 2018)	Naor et. al., 2017
F5	Skilled and competent manpower	Manpower in humanitarian operations consists of staff specifically trained for crisis or experts from different facets like telecommunications, logistics, medicine etc. The level of competence an aid agency, able to develop in its staff directly influences the level of effectiveness of the relief operation. Therefor knowledge management is considered very vital.	Blecken,2010
F6	Application of technology and information system	Application of IT enabled tools has been identified as one of the major factor, which can boost the amount collaboration and coordination among the players. Also it can help to find the accurate picture about the goods and equipments needed in the humanitarian scenerio. It thus helps in development of common operation picture (COP). Thus helping in prediction aof actual demand, with the status of actual transit (Singh et. al., 2018).	Kabra and Ramesh (2016)
F7	Problem assessment	Problem assessment refers to immediate and accurate determination of the required aid material. Once the needs of the affected community is determined, the requirements are assessed on the basis of the current available sources and the future demand patterns. Problem assessment should of project should be continued tiil the project is live.	Tatham et. al., 2017
F8	Integrated logistics management	Logistics have always been the major contributor of the cost, in case of humanitarian supply chain. Therefor it provides the biggest opportunity to stream line and make the operation efficient and effective. Integrated logistics management can be the one stop solution for the aid organizations. The IT enabled, integrated and iterative logistic process can help to make sure that the desired	Manopiniwes and Irohara (2017)

		goods reach the victims at right place and at right time(Nagurney et. al., 2015).	

3.0 Research methodology

For efficient and resilient humanitarian supply chain, management should prioritize the critical factors based upon their relative importance. In this section, major factors are ranked by using MCDM tool to formulate effective strategy**.** Multi criteria decision making (MCDM) helps to deal with problems containing conflicting and multiple objectives. Many 'MCDM' techniques have been developed, but the TOPSIS approach is the most widely used technique. Hwang and Yoon (1981) first proposed Technique for order preferences by similarity to ideal solution (TOPSIS) method. It is considered to give very reliable solution because in TOPSIS poor performance in one criteria can be negated by good performance in other criteria. Therefore, many researchers have used TOPSIS methodology.Singh et. al. (2016) used TOPSIS for ranking barriers for effective maintenance. Jothimani and Sarmah, (2014) have used TOPSIS for measuring the supply chain performance (SCP) in the light of a real life case study. Strength of TOPSIS methodology over other MCDM techniques is that the both negative and positive criteria can be easily used in decision making. In addition to this, it is simpler and faster than other methods such as Analytic Hierarchy Process (AHP), Fuzzy Delphi Analytic Hierarchy process (FDAHP), Simple Additive Weighting (SAW) method. Two artificial alternatives are hypothesized in this method:

- Ideal alternative: the one having the best level for all attributes considered.
- Negative ideal alternative: the one having worst attribute values.

TOPSIS selects the alternative that is the closest to the ideal solution and farthest from negative ideal alternative. Thus providing a more realistic form of modelling as compared to non-compensatory methods.
Further analysis will be done on basis of different steps of TOPSIS approach given below.
Major steps in TOPSIS approach are as follows.
Step1: On the basis of 'm' and 'n', a matrix with elements x_{kj} is made, where each element denotes the rating of k^{th} decision making unit (DMU) with respect to j^{th} criteria.

This matrix is known as decision matrix denoted by 'M':

$$M = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix}$$

Step2:Now, the normalized matrix is calculatedwith elements

$$r_{kj}\left(x\right) = \frac{x_{kj}}{\sqrt{\sum_{k=1}^{n} x_{kj}^{2}}}, k = 1,\ldots,n; j = 1,\ldots,m.$$

It is denoted by R.

$$R = \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{21} & r_{22} & \cdots & r_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ r_{m1} & r_{m2} & \cdots & r_{mn} \end{bmatrix}$$

Step 3: Construct the weighted normalized matrix with elements $v_{kj} = w_j r_{kj}$, where w_j = weights of different decision makers. This matrix is denoted by V.

$$V = \begin{bmatrix} v_{11} & v_{12} & \cdots & v_{1n} \\ v_{21} & v_{22} & \cdots & v_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ v_{m1} & v_{m2} & \cdots & v_{mn} \end{bmatrix}$$

Step 4: Determining the positive ideal solution $v_j^+$and negative ideal solution v_j^-byfinding the maximum and minimum values of weighted normalized elements in eachcolumn in the case of benefit criteria and just reverse for cost criteria.

Step 5: Calculate the Euclidean distance for each alternative.

The Euclidean distance from positive ideal solution is represented by D_k^*

$$D_k^* = \sqrt{\sum_{j=1}^{m}\left[v_{kj}(x) - v_j^+(x)\right]^2}$$

Where k= 1, 2, …., m; j= 1, 2, …., n

The Euclidean distance from negative ideal solution is represented by D_k^-.

$$D_k^- = \sqrt{\sum_{j=1}^{m}\left[v_{kj}(x) - v_j^-(x)\right]^2}$$

Where k= 1, 2, …., m; j= 1, 2, …., n

Step 6: Calculate the relative closeness to the ideal solution C_k^*. If it is closest to 1,then it depicts the best solution.

$$C_k^* = D_k^- / \left(D_k^* + D_k^-\right)$$

where $0 < C_k^* < 1$

Where D_k^*represents distance from positive ideal solution and,D_k^-representsdistance from negative ideal solution.

Step 7: Rank the alternatives according to the preference orderof closeness ratioC_k^*. The one that have the shortest distance to the ideal solution is the best alternative Shortest distance to the ideal solution depicts longest distancefrom negative ideal solution.

4.0 Analysis based on TOPSIS approach

A successful humanitarian relief operation is very critical, because there is life dependency on the effectiveness of the programme. To effectively carry out the relief operation, the supply chain managers should be aware about the relative importance of the main factors of humanitarian supply chain, and should try to give relatively more emphasis on the higher ranked factors. Decision makers based on their consensus selected eight important factors and gave the score to the factors in scale of 1-10 (1-Very low, 10-Very high). These factors have been found to play the major driving role in an humanitarian supply chain(Singh et. al., 2018). On basis of the experience of humanitarian supply chain experts, DM1 (Decision maker 1) is given a weightage of '0.3', DM2 (Decision maker 2) a weightage of '0.3', DM3 (Decision maker 3) a weightage of '0.2', DM4 (Decision maker 4) a weightage of '0.1' and DM5 (Decision maker 5) a weightage of '0.1'. Experts were informed about the objectives of study and questionnaire was shared with them in advance to give weight to different factors. By using step 2 and 3, weighted normalized decision matrix is made as given in Table 2. By using step 4, positive and negative ideal solutions are determined as given in table 3.By using step 5, separation of each CSF from the positive and negative ideal solution is determined and shown in Table 4 and 5. Now, by using step 6, the relative closeness of each barrier to the ideal solution (closeness ratio) is found and based on closeness ratio i.e step 7, relative ranking of these barriers is given in table 6and in the form of a bar graph in figure 1.

Table 2: weighted normalized matrix

Factors code	Decision makers ⟶	D.M 1 (0.3)	D.M 2 (0.3)	D.M 3 (0.2)	D.M 4 (0.1)	D.M 5 (0.1)
	Factors					
F2	Strategy and capacity planning	0.125	0.110	0.065	0.039	0.042
F6	Application of technology and information system	0.097	0.110	0.065	0.039	0.037
F4	Collaboration between stakeholders	0.111	0.110	0.084	0.029	0.042
F5	Skilled and competent manpower	0.111	0.096	0.056	0.039	0.028
F7	Problem assessment	0.083	0.082	0.065	0.024	0.028
F8	Integrated logistics management	0.069	0.082	0.074	0.024	0.018

F1	Government support and policy formulation	0.125	0.123	0.074	0.044	0.042
F3	Progress assessment of project	0.111	0.123	0.074	0.034	0.037

Table 3: Summary of +ve ideal solution and –ve ideal solution

Decision makers	D M 1	D M 2	D M 3	D M 4	D M 5
Negative ideal solution	0.069	0.082	0.056	0.024	0.018
Positive ideal solution	0.125	0.123	0.084	0.044	0.042

Table 4: Distance from positive ideal solution (D_k^*)

Decision makers	D.M 1	D.M 2	D.M 3	D.M 4	D.M 5	Average
Factors code						
F2	0	0.013	0.018	0.004	0	0.007
F6	0.027	0.013	0.018	0.004	0.004	0.013
F4	0.013	0.013	0	0.014	0	0.008
F5	0.013	0.027	0.028	0.004	0.014	0.017
F7	0.041	0.041	0.018	0.019	0.014	0.027
F8	0.055	0.041	0.009	0.019	0.023	0.029
F1	0	0	0.009	0	0	0.001
F3	0.013	0	0.009	0.009	0.004	0.007

Table 5: Distance from negative ideal solution (D_k^-)

Decision makers	D M 1	D M 2	D M 3	D M 4	D M 5	Average
Factors code						
F2	0.055	0.027	0.009	0.014	0.023	0.026
F6	0.027	0.027	0.009	0.014	0.018	0.019
F4	0.041	0.027	0.028	0.004	0.023	0.025
F5	0.041	0.013	0	0.014	0.009	0.015
F7	0.013	0	0.009	0	0.009	0.006
F7	0	0	0.018	0	0	0.003
F8	0.055	0.041	0.018	0.019	0.023	0.031
F1	0.041	0.041	0.018	0.009	0.018	0.026
F3	0.055	0.027	0.009	0.014	0.023	0.026

Table 6: Closeness ratio (C_k^*) and Ranking of factors for resilient humanitarian supply chain

Factors code	Factors	Closeness ratio	Ranking
F2	Strategy and capacity planning	0.777	2
F6	Application of technology and information system	0.584	5
F4	Collaboration between stakeholders	0.747	4
F5	Skilled and competent manpower	0.473	6
F7	Problem assessment	0.193	7
F8	Integrated logistics management	0.111	8
F1	Government support and policy formulation	0.944	1
F3	Progress assessment of project	0.774	3

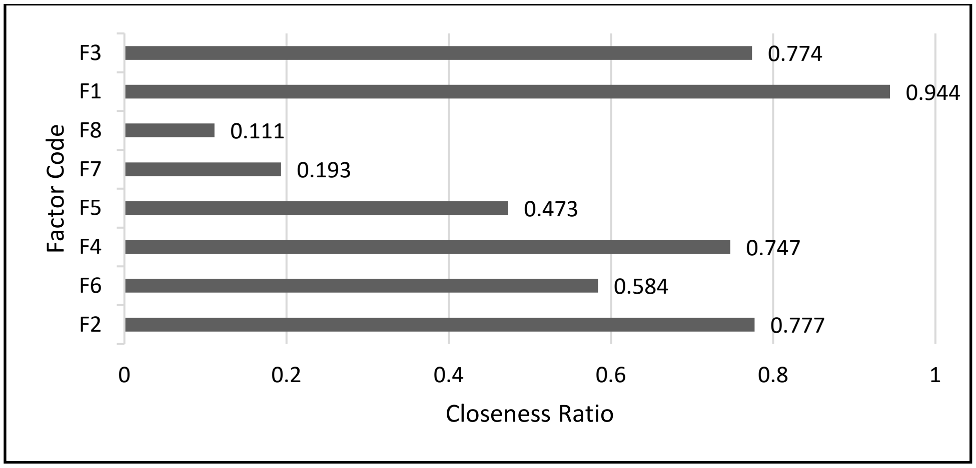

Figure 1: closeness ratio vs factor

It is observed that government support and Policy formulation is the most important factor. Strategy and capacity planning is ranked second in this study. It helps to set the targets and lay the road map to achieve the targets (Fulzele et al., 2016). Progress assessment of project is ranked third, it helps to identify the areas of improvement to achieve the desired targets. Collaboration and coordination among the stake holders is ranked fourth for achieving resilience in humanitarian supply chain. Application of technology and information system has been ranked fifth, whereas skilled and competent manpower has been ranked sixth. Problem assessment is ranked seventh, as it is very important to know the actual needs of the victims (Yadav and Barve,2015). Integrated logistics management is ranked eighth, because logistics constitutes 80% of the cost of disaster relief operation, thus logistics is very important from the humanitarian supply chain point of view (John et. al., 2016).

5.0 Conclusion

Disaster and crisis situations are known to give deep scars. Weather physical or psycological to the victims. Though the natural disaster can not be avoided but their impact can surely be decreased by the state of the art humanitarian supply chain. Resilient humanitarian supply chain has been identified as the appropriate goal to reduce the impact of the disasters. Total of eight driving factors have been identified and ranked for the resilient humanitarian supply chain. Government support and policy formulation; strategy and capacity planning has been identified as the major driving factors for resilient humanitarian supply chain. Findings imply that government should develop effective strtaegies and resources to enhance capacity of organisations engaged in humanitarian works to meet uncertain circumstances. Despite significant contribution, this study has some limitations. TOPSIS methodology applied has considered five decision makers. Therefore chances of biaed decisions are there. Empirical study may be considered to validate the results for generalisation of findings..

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