



**Journal of Production and Operations Management**

**University of Isfahan E-ISSN: 2423-6950**

**Vol. 12, Issue 4, No. 27, Winter 2022, p 41-62**

**Submit Date: 1401-01-23 / Accept Date: 1401-05-15**



<http://dx.doi.org/10.22108/jpom.2022.133112.1436>

**(Research Paper)**

## **Analyzing the barriers and coordination enablers of logistics operations in the humanitarian supply chain**

**Reza Jalali \***

Department of Industrial Management,, Faculty of Business & Economic, Persian Gulf University, Bushehr, Iran, jalali.reza@pgu.ac.ir

**Hadi Balouei Jamkhaneh**

Department of Industrial Management,, Faculty of Business & Economic, Persian Gulf University, Bushehr, Iran, hadibalouei@pgu.ac.ir

**Reza Shahin**

COSYS-ESTAS, University of Gustave Eiffel, France, rezaa.shahin.1992@gmail.com

### **Abstract**

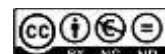
**Purpose:** This study aims to identify the factors affecting the coordination in the humanitarian supply chain and to provide appropriate solutions.

**Design/Methodology/Approach:** The techniques of Fuzzy Cognitive Mapping, Structural Equation Modeling, and Importance-Performance Analysis were used. A review of the literature and interviews with experts has led to the identification of 18 factors affecting coordination in the humanitarian supply chain, which were divided into five categories of strategic, infrastructure, cultural, process, and financial and non-financial resources.

**Findings:** Factor analysis using Fuzzy Cognitive Mapping (FCM) showed that cultural cohesion and cooperation between partners was identified as the most important element. Also, the interpretive structural model of the main factors showed that the strategic, infrastructural, and cultural factors were at the basic level. In addition, the importance-performance analysis was used in this study, which showed that to achieve better

---

\* Corresponding author



coordination in relief operations, long-term planning, providing efficient, effective, and planned training, as well as mutual learning, should be considered.

**Practical implication:** A potential practical implication is that actors involved in relief use the provided mechanisms such as operational and strategic planning.

Social implications - By building trust and taking cultural considerations into account, it is possible to help better coordinate actors in crisis relief.

**Originality/value:** One of the important things to improve the efficiency of humanitarian aid logistics operations is to establish coordination between the various partners and stakeholders. For the first time, the factors affecting the coordination in the humanitarian supply chain have been identified and appropriate solutions have been provided in this paper.

**Keywords:** Humanitarian Supply Chain, Coordination, Fuzzy Cognitive Mapping, Interpretive Structural Model, Importance-Performance Analysis

## 1. Introduction

In recent years, natural disasters such as earthquakes, floods, storms, etc., along with man-made disasters have caused a great increase in financial and human losses ([Van Wassenhove, 2006](#)). Disaster causes physical disturbances that can affect the priorities and goals of the system. Disaster can threaten human life and health by causing serious disturbances in the functioning of society, and accompanied by fear ([Kovács & Spens, 2009](#)). Disaster is examined from two dimensions: cause and effect. In terms of the cause of the occurrence, catastrophe is divided into two categories: natural and man-made, and in terms of speed of occurrence, they are divided into two categories: sudden and slow-onset ([Van Wassenhove, 2006](#)). Thus, in crisis management, we face four types of disasters as follows:

- Calamities: These kinds of disasters have natural causes and happen suddenly. Among the most important disasters, we can mention earthquakes, storms, floods, etc.
- Destructive actions: These types of disasters have human causes and their occurrence is sudden. Among the destructive actions, we can mention terrorist attacks, accidents at work, etc.
- Plague: These types of disasters have natural causes, and they occur slowly. Famine, drought, poverty, etc. are some of these catastrophes.
- Crise: These kinds of catastrophes have human causes and happen slowly. Among the crises, we can mention financial crises, political crises, etc.

Due to the accidental and unpredictable nature of catastrophes, especially sudden catastrophes, and due to the possibility of destruction or damage to buildings and infrastructure, survivors face major problems, in which case the most important task of managers is to reduce the pain and suffering of the survivors and providing assistance to the injured. Proper management in the event of a disaster is necessary to reduce these damages and provide better relief. The main role of disaster management is coordination between

departments and individuals involved in relief work through planning, organizing, directing, and controlling activities ([Zhang et al., 2012](#)). Coordination between the various departments, supply operations, and distribution of relief goods in the humanitarian supply chain is essential and, if they are properly coordinated, the crisis response phase will improve. Establishing coordination in the relief chain requires the removal of barriers and variables that make coordination difficult. At the same time, the variables or empowerments that strengthen coordination in the relief chain need to be improved.

Iran is one of the ten countries in the world in terms of natural disasters. In recent years we have witnessed many natural disasters, including earthquakes. Iran is among the top 10 countries in the world in terms of natural disasters, and in terms of the variety of disasters, it is also among the top 5 countries in the world. Out of the total of 41 disasters known in the world, 31 to 33 types of them have occurred in Iran, the most common of which are earthquakes and floods in the group of natural disasters and fires and accidents in the group of man-made disasters. As an example, 1000 earthquakes occur in the country every year, 240 of which are earthquakes with a magnitude greater than 4 degrees on the Richter scale. According to the available statistics, on average, one big earthquake occurs in Iran every year and every 10 years an earthquake with a magnitude of 6 degrees or more on the Richter scale occurs. The report on the effects of disasters, published by the International Federation of Red Cross Populations, also shows that Iran ranks fourth in terms of disasters in Asia after China, India, and Bangladesh. On the other hand, Iran's population has always been about 1% of the world's population over the past hundred years, but unfortunately, the casualties caused by earthquakes and natural disasters have been about 6% of the world's casualties.

During these crises, we see many irregularities that result from a lack of coordination between the various partners, and this has reduced the efficiency of relief work and the dissatisfaction of the victims.

Given that the country has been involved in numerous natural disasters and crises in recent years, and on the other hand is facing limited resources, it is necessary to increase the efficiency of humanitarian logistics operations, to provide maximum satisfaction to the injured and the best relief by spending the least resources. This requires increased efficiency and effectiveness. Increasing the efficiency of humanitarian operations is the rapid delivery of goods and services and relief items and delivering the injured to relief centers in the shortest possible time. Operational effectiveness also means the ability to minimize waste and avoid duplication of work and parallel activities ([Cozzolino, 2012](#)). Shafiq & Soratana ([2019](#)) believe that since many partners are involved in humanitarian operations, inconsistency leads to reduced efficiency and effectiveness through parallel work, re-work, and so on. Therefore,

to increase the efficiency of humanitarian operations, coordination between partners and activities must be seriously increased.

Mutebi et al. (2020) intra-organizational coordination is a necessary but insufficient condition for success in humanitarian operations and to increase productivity in humanitarian operations, it is necessary to coordinate between all internal and external actors and create a network of actors. Inconsistency between actors through increasing operation time, parallel work, increasing costs, and not determining priorities can reduce the efficiency of humanitarian operations (Suarez et al., 2019). John et al. (2020) and Wankmüller & Reiner (2020) consider coordination between actors to be the main driver and the only solution to increase the efficiency of humanitarian operations and emphasize the role of options contracts.

Wankmüller & Reiner (2020) consider the most important issue in this regard: how to create coordination and they emphasize that the solutions should be appropriate to the cultural and social environment. Therefore, the review of the literature on the subject and the research conducted in the country clarified the research gap. Therefore, it can be said that very little research has been done under the country's conditions to identify the factors affecting the efficiency of humanitarian relief operations and coordination in relief logistics, and we need to identify and further analyze these factors. Also, the review of other research shows that in each of the researches, this issue has been considered from one aspect only and we do not have a comprehensive and holistic point of view of these factors. Also, previously limited research has only identified the factors and it can be said that we have a research gap in structuring effective factors of coordination and performance analysis to provide the necessary strategy.

Accordingly, from a practical point of view, this research helps crisis and relief managers, and on the other hand, it offers a suitable approach for structuring and analyzing the factors based on the research gap in the country. In general, the main issues that this research pursues are: what are the effective factors in establishing coordination in humanitarian operations to increase the efficiency of these operations? Also, how can these factors be structured? How can we help to increase the efficiency of humanitarian operations?

## **2. Literature review**

### **2.1 Humanitarian supply chain**

The supply chain is a network of different facilities that are responsible for supplying materials, producing products, and distributing these products to customers (Stadtler, 2005). The supply chain is a network including flows of goods, information, and financial resources

from supplier to customer. Thus, the humanitarian supply chain can be defined, quite similarly, as a network of flow management of goods, information, and finance from relief sources to people in crisis ([Thomas & Kopczak, 2008](#)).

The humanitarian supply chain is a strategic and structured process that generally has four main phases: prevention, preparation, response, and reconstruction ([Van Wassenhove, 2006](#)). These steps shape the life cycle of the disaster. Prevention refers to mechanisms that reduce vulnerability. This phase includes the responsibilities of governments, including the enactment of appropriate laws and mechanisms to reduce social vulnerability. The preparation phase refers to the operation that takes place before a disaster occurs and includes strategies that lead to coordination and cooperation between the partners and contribute to the successful implementation of the response phase. The response phase also refers to various operations that begin after the disaster and its main purpose is to provide assistance to the victims and reduce and mitigate the risks and consequences of the disaster ([Jafarnejad et al., 2014](#)). In the response phase, humanitarian operations are carried out to preserve the lives of the people and the suffering of the people of the communities. These operations are divided into four categories and 14 sub-categories based on the Sphere ([2004](#)). The four main categories of humanitarian operations include i) increasing water supply, improvement, and health; ii) food, and nutrition security assistance; iii) items related to shelter, and housing; iv) health services. Also, sub-areas of humanitarian operations under the Spinner project are water supply, health improvement, food aid, nutrition, and food security, shelter, health services, and medical care, humanitarian access, protection of individuals, Restore and reuniting, Evacuation, HIV treatment, psychological and behavioral game, basic facilities, primary support systems, training activities ([Jafarnejad et al., 2014](#)).

The extent of humanitarian operations and the wide variety of partners involved highlighting the need for coordination in this chain to increase its operational efficiency, which will be addressed in this article.

## **2.2 Coordination in the humanitarian supply chain**

In the present era, the occurrence of catastrophe is an integral part of human life, which has caused great financial and human losses. In the event of a disaster, various government and humanitarian organizations start working to provide relief, save the lives of the injured and reduce their suffering. In such a situation, providing assistance and meeting the needs of the victims cannot be done by only one organization and requires cooperation between many organizations. Due to a large number of public and private sector stakeholders, managing and coordinating relief activities is a very complex and difficult task ([Balcik et al., 2010](#);

[Dolinskaya et al., 2011](#)). In addition, due to the lack of sites and financial incentives related to coordination, the challenges and problems in the humanitarian supply chain increase ([McLachlin & Larson, 2011](#); [Van Wassenhove, 2006](#)). Balcik et al. (2010) attribute coordination in the humanitarian supply chain to factors such as the number of diverse partners, competition for financial resources, the structure of financial resources and the expectations of the resource holders, and uncertainty about the occurrence of disaster and scarcity or surplus of resources. One of the most important factors to increase coordination in the humanitarian supply chain is the use of information and communication technology. At present, the use of information technology in the humanitarian supply chain is much less than in the commercial supply chain, which is one of the main elements and emphasis improving technical capabilities to increase coordination in the humanitarian supply chain. Many researchers emphasize the importance of coordination between partners as a key driver to increasing the efficiency of humanitarian operations and argue that this sector needs more attention ([McClintock, 2005](#); [Sowinski, 2003](#)). Regarding the importance of coordination, Murray (2005) argues that achieving coordination requires identifying and addressing barriers to coordination in the humanitarian relief chain, thereby improving performance in humanitarian operations, preventing waste of resources (operational efficiency), and providing prompt services, which helps and increase victim satisfaction, which is a sign of the effectiveness of humanitarian operations.

As mentioned, the purpose of this study is to identify the factors affecting coordination in the humanitarian supply chain, which will help to increase the efficiency of humanitarian operations. Van Brabant (1999) states that effective use of resources, rational allocation of resources, application of quality standards, and working on agreed priorities increase coordination among actors. Byman et al. (2000) in a study state that the effectiveness of humanitarian operations requires a higher speed of action in carrying out these operations and coordination between partners. One of the factors that cause this is the use of information technology. Weaknesses in the ICT infrastructure in the humanitarian supply chain and lack of financial resources to invest in it, limit the use of IT in humanitarian logistics and make coordination between partners and speed of action. McEntire (2002) points out that strategic constraints between all actors involved in relief activities can have a positive effect on performance, knowledge sharing, and coordination. Maiers et al. (2005); DeJohn (2005) and Kala (2014) believe that due to the presence of multiple actors in relief, the use of information and communication technology systems can increase agility, flexibility, and coordination, while saving, retrieving and information sharing help a lot. The use of information technology can also help coordinate key mechanisms such as procurement,

warehousing, and transportation. A similar study by Charles & Lauras (2011) states that information technology contributes to three key factors in supply chain coordination: balance, synchronization, and training. Davidson (2006) believes that humanitarian operations should be carried out with maximum efficiency to help the injured. In a study, he considers the most important reason for inefficiency in humanitarian operations as inconsistency between partners and believes that cultural differences between partners are the most important challenge in creating inconsistency. Agostinho (2013) and Lester & Krejci (2007) argue that inefficiencies in humanitarian operations are due to a lack of an appropriate plan for dealing with crises. Lack of strategic vision and willingness to short-term planning in the humanitarian supply chain is one of the most important obstacles to coordination and low efficiency in humanitarian aid. In another study, Ponomarov & Holcomb (2009) and Agostinho (2013) cite the commitment of senior management and performance management systems as critical factors in overcoming a critical role when addressing the problems of inconsistency between partners in humanitarian operations. Moshtari & Gonçalves (2011) in a study consider cultural differences and lack of trust between partners as one of the important obstacles in humanitarian logistics coordination.

Joerin et al. (2012) state that coordination in relief is not possible except with the cooperation of the government and the people. Accordingly, it refers to participatory solutions with an emphasis on the role of society (people) to increase the resilience of societies in case of disaster. Agostinho (2013) states that governments can greatly help coordinate by holding legal meetings between partners, especially the public, and evaluating the effectiveness of humanitarian activities. Krejci (2015) used factor-based models to simulate the partners' efforts in humanitarian operations. The results of these simulations showed that interactions between different stakeholders, cooperation between NGOs, and government, and holding regular meetings are the most important factors in increasing the coordination and efficiency of humanitarian operations. Kabra et al. (2015) used a fuzzy hierarchical analysis approach to identify and prioritize the factors affecting coordination in the humanitarian supply chain. Accordingly, management commitment, appropriate structure for information sharing, proper planning, and cultural factors were recognized as the most important factors in improving the coordination of humanitarian operations. Gavidia (2017) in a study identified and examined the factors affecting the increase of coordination in the humanitarian supply chain. Accordingly, cooperation between government and NGOs introduces flexibility in inventory, flexibility in supply and flexible transportation, information exchange, and the use of information systems and ERP as effective factors in coordinating humanitarian operations. Dubey et al. (2018) in another study, while applying

big data-based approaches, trust between partners, having managerial, human relations, and technical skills, using information technology, and access to advanced technologies communication and transportation are mentioned as the most important factors in coordinating humanitarian operations. Nikkhoo et al. (2018) in a study of cooperation between non-profit organizations and the government, inventory management and proper planning are among the effective factors in coordinating humanitarian operations. Ahmed et al. (2019) state in another study that information sharing, trust between partners, and increased commitment between actors increase operational coordination, and this helps to better manage resources and increase operational efficiency.

Li et al. (2019) in a study using game theory showed that having the right strategy and planning is the most important factor in creating coordination. Another important result of this research has been that the lack of trust between actors and cultural conflicts can severely affect humanitarian operations and create a lot of inconsistency. Wankmüller & Reiner (2020) in a study while defining and distinguishing between coordination, cooperation, and joint efforts in the humanitarian supply chain from the use of information technology, stakeholder commitment, trust, and proper division of labor are mentioned as effective factors in increasing the efficiency of humanitarian operations.

### **2.3 Productivity of humanitarian operations**

Logistics of humanitarian aid is one of the most important elements of relief operations in crisis management. Logistics planning in a crisis includes operations to meet the needs of the victims. This operation should be done with the highest quality and efficiency. Aid should be provided with the maximum speed and the least cost and in an effective way that has the greatest coverage of aid.

Effective humanitarian operations refer to the provision of assistance to all people in emergencies and need of assistance and refer to the provision of relevant quality services. This operation should include durable and sustainable solutions. To achieve effective operations, in addition to proper planning, we need to have sufficient resources and coordination between actors. Applying standard guidelines, using information technology, and a suitable project management system can greatly help to reduce costs by increasing coordination. The lack of coordination between the actors causes an increase in relief costs, a decrease in the speed of operations and the dissatisfaction of the victims, and ultimately, a decrease in the productivity of humanitarian operations.



### 3. Research methodology

This research is typically descriptive in terms of analysis, which currently examines, describes, and interprets the situation. The purpose of this study is to identify and analyze the factors affecting coordination in the humanitarian supply chain using Fuzzy Cognitive Mapping (FCM). In this study, first, the factors affecting the coordination of operations in the humanitarian supply chain were identified by studying the literature, then through interviews with eight experts who have experience and knowledge and at least five years of experience in assisting in situations and crises in countries, other factors were identified. The identified factors of these two methods were further investigated and categorized. Then questionnaires were designed to draw fuzzy cognitive mapping as well as interpretive structural modeling and significance-performance analysis. After collecting information, a cognitive mapping and interpretive structural model were drawn, and finally, the significance-performance analysis was performed. The steps of this research are as follows:

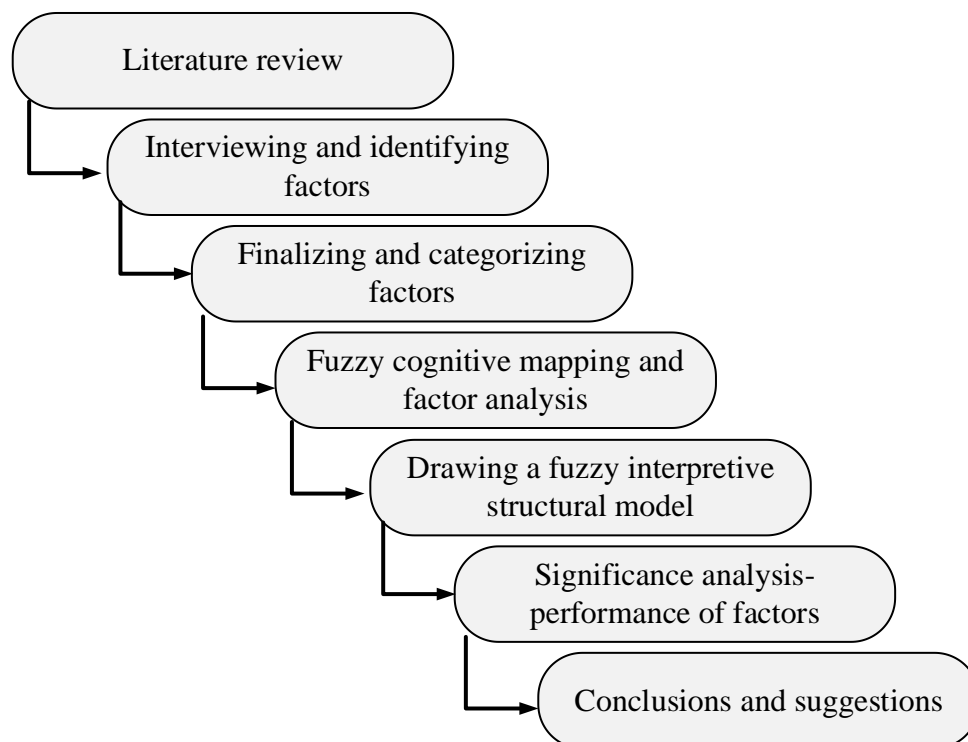


Fig. 1. Research steps

In the following, the methods of Fuzzy Cognitive Mapping (FCM), interpretive structural modeling, and significance-performance analysis are described.

### 3.1 Fuzzy Cognitive Mapping (FCM)

cognitive mapping is a cause-and-effect graphical model and was introduced by Robert Axelrod in 1976 in the Political Science field. FCM are hybrid methods that are in some ways between fuzzy systems and neural networks ([Özesmi & Özesmi, 2004](#)). Figure 2 shows an example of FCM.

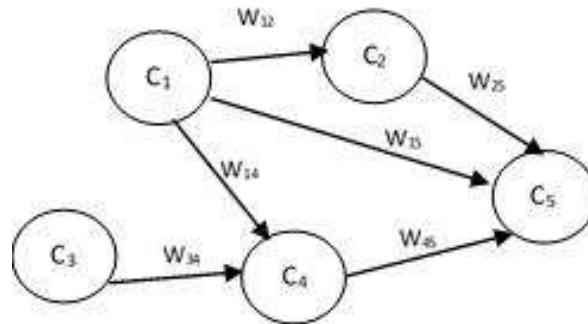


Fig. 2. FCM example

The relationships between conceptual variables  $C_i$  and  $C_j$  can be different, positive, negative, and different. the value of  $W_{ij}$  shows How much a conceptual variable  $C_i$  can impact  $C_j$  ([Bağdatlı et al., 2017](#)). Therefore, the Existence of a positive causal relationship between  $C_i$  and  $C_j$  shows that increase in the activity level of the concept of  $C_i$  can increase (decrease)  $C_j$ . Also, decreasing the concept of  $C_i$ , decreases (increases)  $C_j$  ([Tsadiras & Zitopoulos, 2017](#)). Regarding the graph theory, in cognitive mapping, values can be converted to adjacent matrices in  $W=[W_{ij}]$  form and the impact power and impact capacity and the degree of centrality of each indicator can be computed ([Özesmi & Özesmi, 2004](#)). The impact power is the sum of the absolute values of the row of a variable in the adjacency matrix ([Özesmi & Özesmi, 2004](#)).

### 3.2 Interpretive Structural Modeling (ISM)

Structural equation modeling involves "structural models" that are constructed using graphics and words to illustrate the structure of a complex problem ([Warfield, 1974](#)). While this is an interpretive method, group judgment decides whether the factors are related; A structure in which the general structure of a set of factors is extracted based on relationships, and modeling depicts specific relationships and the general structure as a directed graph model. The different stages of ISM are as follows ([Azar et al., 2016](#)):

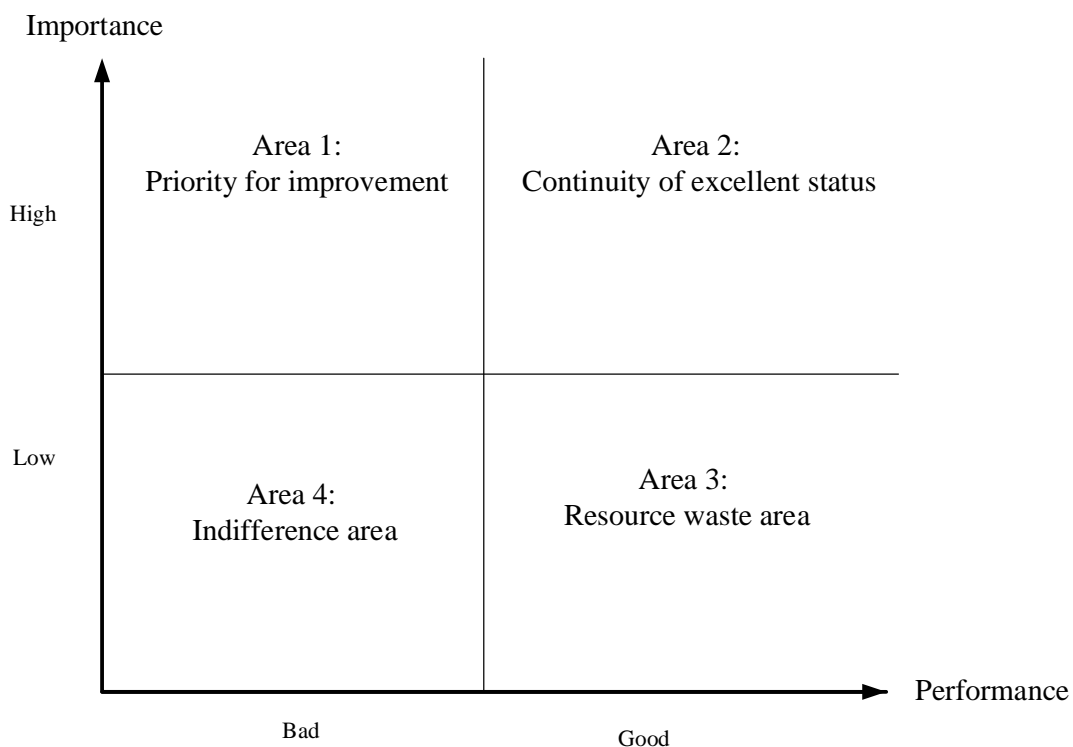
1. Structural Self-Interactive Matrix Formation (SSIM)
2. Formation of the initial availability matrix
3. Formation of the final achievement matrix
4. Determine the level and priority of variables
5. Model drawing

### 3.3 Importance-Performance Analysis (IPA)

IPA is used as a popular management tool to identify strengths and weaknesses and provide policy solutions in various industries. This model has two main components of importance and performance, which are the intersection of these two elements of the four quadrants according to Figure 3.

### 3.4 Significance-Performance Analysis (SPA)

SPA is used as a well-known management tool to identify strengths and weaknesses and provide policy solutions in various industries ([Chu & Choi, 2000](#)). This model has two main components of importance and function: from the intersection of these two elements, four houses are formed according to Figure 3.



**Fig. 3. Importance-Performance Analysis**

The concept of each of the four areas is as follows ([Chu & Choi, 2000](#)):

*Area 1. Priority for improvement:* The indicators of this area are very important, but they are at a low level in terms of performance, so improvement and development efforts should be focused on this area.

*Area 2. Continuity of excellent status:* The indicators of this area are very important and the performance of the organization is good in them, so we must act on these indicators as in the past.

*Area 3. Resource waste area:* Indicators in this area are of little importance but the performance of the organization in these indicators is relatively high. Organizations should limit their efforts to these factors.

*Area 4. Indifference area (low priority):* The indicators of this area are of low importance and the performance of the organization is also low in these indicators and limited resources should be allocated to this area.

#### 4. Findings

After reviewing the literature and interviewing experts and specialists, the factors affecting coordination in the humanitarian supply chain were identified. These factors were divided into five categories strategic, infrastructural, cultural, process, and financial factors. As shown in table 1, strategic factors include the strategic link between actors, the focus on long-term planning, and the determination of effective coordination policies. Infrastructure factors include the use of ICT infrastructure, web-based systems, and ease of use of ICT tools. Table 1 shows the dimensions and variables affecting coordination in the humanitarian supply chain and how to identify them.

**Table 1. Factors affecting coordination in the humanitarian supply chain**

Dimensions	Variable	Reference	interview
Strategic	The strategic bond between partners	Lester & Krejci (2007);Agostinho (2013);McEntire (2002)	
	Focus on long-term planning	Lester & Krejci (2007);Agostinho (2013);Li et al. (2019)	
	Determine effective coordination policies	Lester & Krejci (2007);Agostinho (2013);McEntire (2002)	
Infrastructural	Use of information and communication technology	Wankmüller & Reiner (2020); Dubey et al. (2018); DeJohn (2005);Maiers et al. (2005);Kala (2014); Byman et al.(2000)	
	Web-based systems		✓
	Ease of use of information exchange and communication tools		✓
Cultural	The commitment of partners involved in humanitarian activities	Wankmüller & Reiner (2020);Ahmed et al. (2019)	
	Creating a reliable environment between chain members		✓
	Mutual learning of commercial and humanitarian organizations		✓
	Cultural cohesion and cooperation between partners	Li et al. (2019)	
Process	Regular meetings between actors	Gavidia (2017)	
	Efficient, effective, and planned staff training		✓
	Determining a transparent work cycle and open-door policy		✓
	Performance evaluation system		✓
Financial	Feedback mechanism		✓
	Access to financial resources		✓
	financial resources allocation method		✓
	Electronic financial infrastructure		✓

Cultural factors also include the commitment of partners involved in humanitarian activities, the creation of a trusting environment between chain members, the mutual learning of commercial and humanitarian organizations, and cultural cohesion and cooperation between partners. One of the most important factors in coordinating humanitarian operations; modify and improving related processes. These processes include holding regular meetings between partners, efficient, effective, and planning staff training, determining a transparent work cycle or open-door policy, evaluating the effectiveness and efficiency of the performance appraisal system, and feedback mechanisms to facilitate learning from experiences. Finally, coordination is not possible without access to financial resources and the use of appropriate allocation methods. As mentioned, after identifying the variables affecting humanitarian supply chain coordination, we seek to draw an FCM. To do this, the necessary information was collected through a questionnaire. Then, the data were analyzed using graph theory and FCMapper software, which are summarized in Table 1. This table shows the effectiveness and centrality of the indicators. The centrality index includes the sum of impact power and impact capacity. In fact, the more the factor (index) has the total impact power and the capacity to influence, the more we call it the index of superiority or centrality.

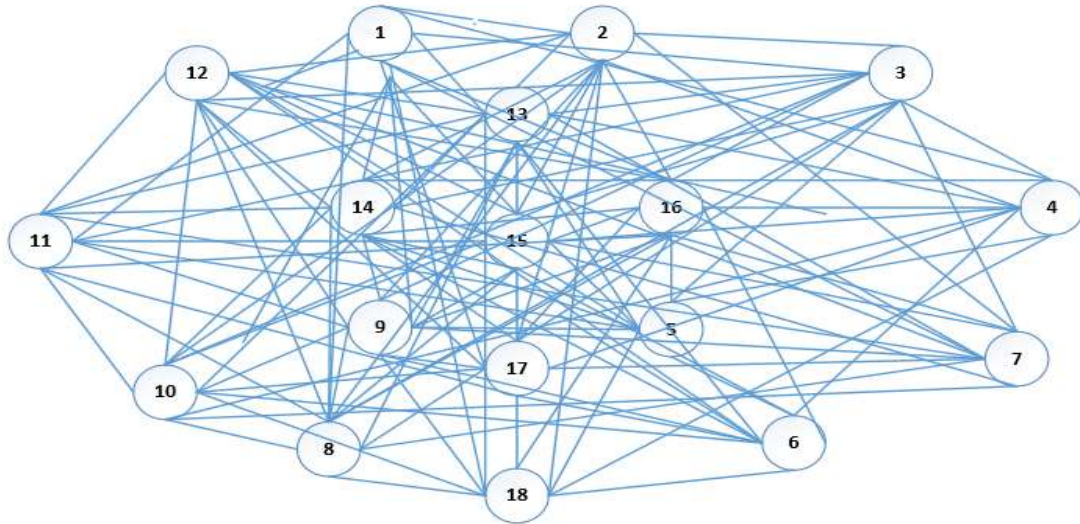
The value of this index for each factor indicates the degree of interaction of this factor or specific indicators with other factors (indicators) of the cognitive mapping. This table also shows the performance of aid organizations in crises in each of the indicators that are used in the importance-performance analysis.

**Table 2. Impact power, impact capacity and Recognize centrality related to research variables**

Dimension	Variables	Code	Impact Power	Impact Capacity	Recognize Centrality	Rank	Performance
Strategic	The strategic bond between partners	S <sub>1</sub>	4.70	6.70	11.40	4	1.89
	Focus on long-term planning	S <sub>2</sub>	5.98	4.74	10.72	6	1.24
	Determine effective coordination policies	S <sub>3</sub>	4.32	5.56	9.88	8	2.16
Infrastructural	Use of information and communication technology	S <sub>4</sub>	4.67	2.65	7.32	15	2.24
	Web-based systems	S <sub>5</sub>	2.31	1.59	3.90	18	1.03
	Ease of use of information exchange and communication tools	S <sub>6</sub>	2.19	1.78	3.97	17	2.96
Cultural	The commitment of partners involved in humanitarian activities	S <sub>7</sub>	5.86	5.52	11.38	5	2.41
	Creating a reliable environment between chain members	S <sub>8</sub>	6.50	6.99	13.49	2	2.59
	Mutual learning of	S <sub>9</sub>	2.38	8.22	10.60	7	1.62

Dimension	Variables	Code	Impact Power	Impact Capacity	Recognize Centrality	Rank	Performance
Process	commercial and humanitarian organizations Cultural cohesion and cooperation between partners	S <sub>10</sub>	6.92	7.11	14.03	1	1.98
	Regular meetings between actors	S <sub>11</sub>	2.80	4.80	7.60	14	1.93
	Efficient, effective, and planned staff training	S <sub>12</sub>	5.87	5.77	11.64	3	1.59
	Determining a transparent work cycle and open-door policy	S <sub>13</sub>	5.07	3.93	9.00	10	2.03
Financial	Performance evaluation system	S <sub>14</sub>	4.02	4.66	8.68	12	1.24
	Feedback mechanism	S <sub>15</sub>	4.23	4.73	8.96	11	1.14
	Access to financial resources	S <sub>16</sub>	5.80	1.91	7.71	13	2.14
	financial resources allocation method	S <sub>17</sub>	4.57	4.57	9.14	9	1.75
	Electronic financial infrastructure	S <sub>18</sub>	4.53	1.49	6.02	16	1.98

The related FCM shown in Figure 5 was then drawn. Based on this, it can be said that among the factors affecting coordination in the humanitarian supply chain, cultural cohesion, and cooperation between partners were identified as the most central element. Then, the criterion of creating a reliable environment among the members of the chain is in second place. Both of these factors fall into the category of cultural factors. The table above also shows that cultural cohesion and cooperation between partners have the greatest impact on other variables and the variable of creating a reliable environment between members of the chain has the greatest impact on other variables. Among the strategic factors, having a strategic connection with the partners; among the infrastructure factors, the use of information and communication technology; among process factors, efficient, effective, and planned education and among financial factors, the variable of financial resources, and allocation method is more central than other variables. Figure 4 shows the FCM that shows the effect and effectiveness of each of the variables affecting coordination.



**Fig. 4. Fuzzy cognitive mapping of factors affecting coordination in the humanitarian supply chain**

Then, using the interpretive structural modeling approach, the factors affecting coordination in the humanitarian supply chain were structured. Based on this, the opinions of experts were collected first. Then, the self-interactive matrix related to the factors was formed. The initial and modified accessibility matrices related to the factors were obtained. In the next step, the related factors were graded according to Table 3 according to the inputs and outputs of each factor.

**Table 3. Determines the relationships and levels of factors associated with coordination in the humanitarian supply chain**

Dimension	Code	Input Set	Output Set	Joint Collection	Level
Strategic	1	1,2,3	1,2,3,4,5	1,2,3	2
Infrastructural	2	1,2,3	1,2,3,4,5	1,2,3	2
Cultural	3	1,2,3	1,2,3,4,5	1,2,3	2
Process	4	1,2,3,4,5	4,5	4,5	1
Financial	5	1,2,3,4,5	4,5	4,5	1

After extracting the agent levels, the interpretive structural modeling of the factors affecting the coordination in the humanitarian supply chain was drawn in Figure 5.

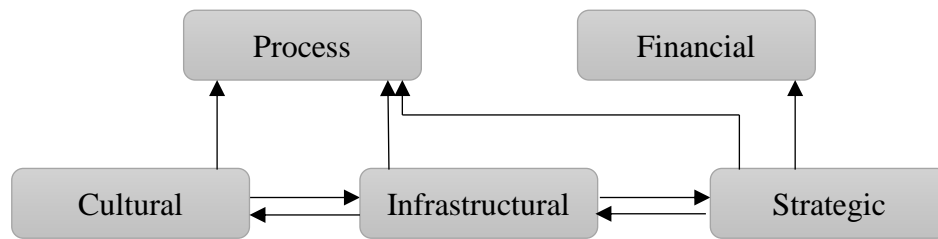


Fig. 5. Interpretive structural model of factors affecting coordination in the humanitarian supply chain

As the figure above shows, strategic, infrastructural, and cultural factors are at the grassroots level, and as a result, these factors affect the process dimensions and financial factors. In other words, it can be said that the coordination process strongly depends on having a plan and especially a strategic plan, having the right infrastructure as well as the right culture. Then, for further analysis, the significance-performance matrix was drawn according to Figure 5. This matrix can help to provide the necessary solutions and policies to achieve greater coordination in humanitarian operations. Thus, the importance of each indicator was considered as the same degree of centrality obtained in the FCM approach and experts' opinions were used to obtain a performance score. This score, which is shown in Table 3, reflects the opinions of experts about the performance of the responsible organizations in each of the indicators.

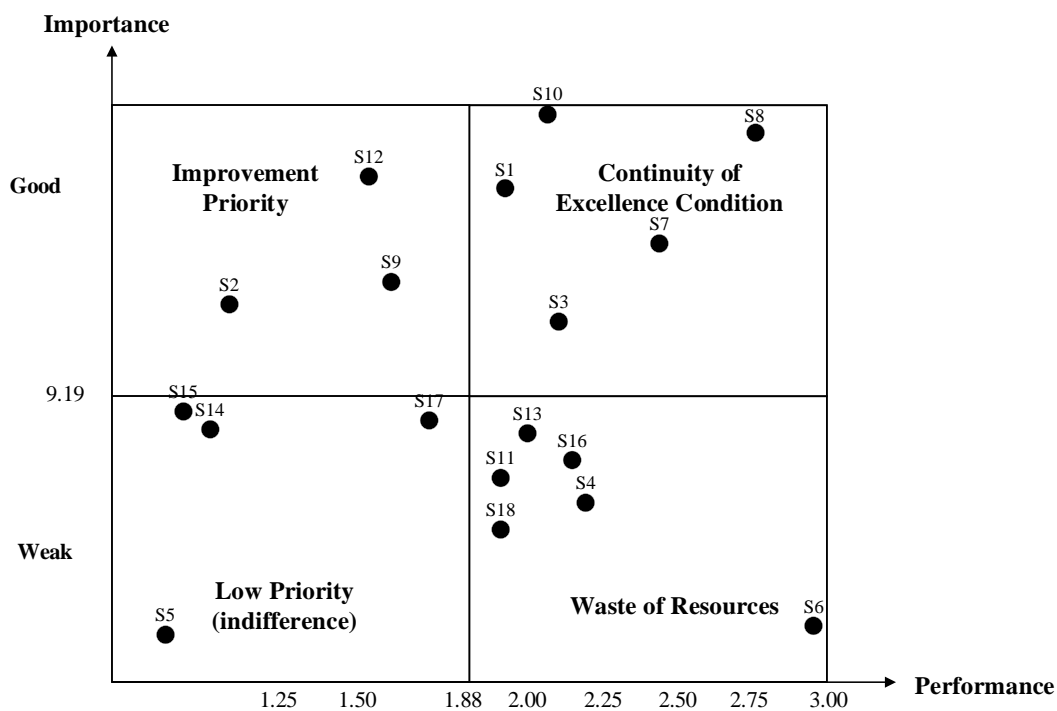


Fig. 6. Importance-performance matrix of factors affecting coordination in the humanitarian supply chain



Based on the results, the indicators of strategic bonding between actors, determining effective coordination policies, the commitment of partners involved in humanitarian activities, creating a trustworthy environment between members of the chain, and cultural cohesion and cooperation between partners in the area of excellent status (second area) were located. In fact, in these indicators, which are very important, there is a relatively good performance. Indicators of focus on long-term planning, mutual learning of commercial and humanitarian organizations, and efficient, effective, and planned training are among the important factors in which the performance of relief organizations is poor and should be moved towards improvement with planning (Area1. Priority for improvement). In addition, indicators such as the use of information technology, regular meetings between partners, determining the transparent work cycle and open door policy, access to financial resources, and electronic financial infrastructure are among the indicators of which the performance of responsible organizations. They are good, but they are not as important as other indicators, and you can focus less on them, and reduce the cost, energy, and time spent on these variables (third area - waste of resources).

Indicators such as web-based systems, performance appraisal systems, feedback mechanisms, and methods of allocating financial resources are indicators that are of little importance and the performance of organizations has been poor (fourth area, indifference).

## **5. Discussion**

The occurrence of various natural disasters and their financial and human losses has made it necessary to plan for better relief for the victims. Due to the wide range of effects of disasters, relief and humanitarian action require cooperation between government agencies and many people, which often disrupts the coordination and speed of relief. This research has been conducted in the same direction to identify and analyze the factors that affect the coordination in the supply chain. Accordingly, the results of the factors affecting coordination in the supply chain are divided into five categories strategic, infrastructural, cultural, process, and financial factors.

Among the strategic factors, the link between partners is the focus on long-term planning and effective coordination policies. The strategic link between partners refers to strategic relationships or joint work between two or more organizations that can improve humanitarian activities not only in the event of a disaster but also before it happens. Long-term planning is essential to determine the responsibilities of the partners so that they can make extensive progress in the lives of those affected by the disaster. Policies also point to guidelines that increase coordination between partners. These results are consistent with the research of

Lester and Krejci (2007), Agostinho (2013), and McEntire (2002). Infrastructure factors include three indicators: the use of information technology, web-based systems, and the ease of use of information and communication tools.

As Byman et al. (2000), Wankmüller and Reiner (2020), Dubey et al. (2018), Maiers et al. (2005), DeJohn (2005), Kala (2014) state using IT systems to store, retrieve and share information during relief work. Web-based systems are automated systems that help share information and increase mutual trust between partners, reducing the need for manpower. Communication tools help to communicate the message between the partners in the event of a disaster, which makes it easier to use and better share information. Cultural factors include the four indicators of partners' commitment involved in humanitarian activities, creating a trusting environment between chain members, mutual learning of commercial and humanitarian organizations, and cultural cohesion and cooperation between partners.

As Wankmüller and Reiner (2020), Ahmed et al. (2019) and Li et al. (2019) state the partners' commitment involved in humanitarian activities leads to the support of the processes at every stage. Creating a trustworthy environment supports sharing information and encourages collaborators (different partners) to achieve a greater level of coordination. Mutual learning between business and humanitarian organizations refers to the exchange of information between organizations to develop coordination and improve decision-making. Process factors include five indicators: i) holding regular meetings between partners; ii) efficient, effective and planned staff training; iii) determining a clear work cycle or open-door policy; iv) evaluating the effectiveness and efficiency of the performance appraisal system, and v) feedback mechanisms to facilitate experiential learning. Partners should hold regular meetings in the event of a disaster to analyze the strengths and weaknesses of relief operations and improve the performance of partners. These results are consistent with the research of Agostinho (2013) and Gavidia (2017).

Also, disaster management training for employees in critical and emergency case needs assessment makes trained people respond more effectively to accidents. In addition, a transparent workflow helps share information between partners and ensures agility, alignment, and consistency in the humanitarian supply chain. Performance appraisal systems improve operations through decision evaluation and ultimately increase operational efficiency. In this operation, providing feedback can lead to learning and prevent the repetition of mistakes. Financial factors include access to financial resources, the way financial resources are allocated, and electronic financial infrastructure. Humanitarian operations require financial resources. In the absence of financial resources, coordination between operations becomes very difficult. Another financial factor that contributes to

coordination is having a proper allocation plan. Due to limited resources available, without proper planning and allocation, there will be a lot of dissatisfaction and inconsistency. It is also possible to access and exploit financial resources using the financial infrastructure.

## **6. Conclusions and implications**

After designing the model using fuzzy cognitive mapping, a cognitive model was drawn which showed that among the factors affecting coordination in the humanitarian supply chain, cultural cohesion and cooperation between partners were identified as the most central element. Then, the criterion of creating a reliable environment among the members of the chain is in second place. Therefore, to create more coordination for relief, the officials should take action to strengthen the culture. Also, using interpretive structural modeling, the main factors of coordination were modeled. The results showed that strategic, infrastructural, and cultural factors were at the basic level and these factors play a major role in creating coordination. Finally, using the importance-performance analysis matrix, the status of the indicators was examined. Based on the results, it can be said that to increase coordination in relief operations, long-term planning should be focused on. Involved organizations also need to learn from each other and provide efficient, effective, and planned training.

When a crisis occurs, many institutions, organizations, and people work together for relief, and coordination between them can lead to the efficiency and effectiveness of relief operations. This research identified the effective factors in establishing coordination between the actors, whose results confirm one of the most important social considerations when a crisis occurs. Based on this, the most important factor in creating cooperation between actors is cultural cohesion, trust, and cooperation between actors. This is only possible through the provision of public education and social and cultural programs that strengthen public trust. In addition, it is suggested that the crisis management of the country should form a committee to develop long-term and strategic plans appropriate to each crisis. This committee can determine effective policies to increase coordination by simulating crises and predicting different scenarios. Also, municipalities can help better coordinate institutions by creating infrastructures of information and communication technology when a crisis occurs.

From a social point of view, the results of this research can greatly contribute to policy-making in humanitarian logistics aid and by implementing the proposed measures, volunteer to coordinate between NGOs, government organizations, and individuals. At the same time, these organizations should act on public education and increase social commitment among the general public.

When crises occur, we are usually at the scene of the accident with a lot of citizens, NGOs, and volunteers. This can disrupt all the previous plans; therefore, the results of this research can be associated with challenges. In addition, the possibility of secondary incidents (secondary crises) can make coordination very difficult. Therefore, one of the limitations of this research is the lack of attention to secondary crises and the large influx of citizens to provide relief and being influenced by the mechanisms introduced in this research.

Considering the mentioned limitations, it is suggested for future research that researchers focus on establishing coordination between actors when secondary crises occur and massive influx of citizens to provide relief. In addition, by using approaches such as dynamic systems, analyze the dynamics of this phenomenon.

## References

- Agostinho, C. F. (2013). Humanitarian logistics: how to help even more? *IFAC Proceedings Volumes*, 46(24), 206-210.
- Ahmed, W., Najmi, A., Khan, F., & Aziz, H. (2019). Developing and analyzing framework to manage resources in humanitarian logistics. *Journal of Humanitarian Logistics and Supply Chain Management*, 9 (2), 270-291.
- Azar, A., Khosravani, F., & Jalali, R. (2016). *Soft Operations Research (Problem Structuring Approaches)*. Industrial Management Organization Publications.
- Bağdatlı, M. E. C., Akbiyıklı, R., & Papageorgiou, E. I. (2017). A fuzzy cognitive map approach is applied in cost-benefit analysis for highway projects. *International Journal of Fuzzy Systems*, 19(5), 1512-1527.
- Balcik, B., Beamon, B. M., Krejci, C. C., Muramatsu, K. M., & Ramirez, M. (2010). Coordination in humanitarian relief chains: Practices, challenges, and opportunities. *International Journal of production economics*, 126(1), 22-34.
- Byman, D., Lesser, I. O., Pirnie, B. R., Benard, C., & Waxman, M. (2000). *Strengthening the partnership*. [http://www.rand.org/pubs/monograph\\_reports/MR1185.html](http://www.rand.org/pubs/monograph_reports/MR1185.html)
- Charles, A., & Lauras, M. (2011). An enterprise modeling approach for better optimization modeling: application to the humanitarian relief chain coordination problem. *OR Spectrum*, 33(3), 815-841.
- Chu, R. K., & Choi, T. (2000). An importance-performance analysis of hotel selection factors in the Hong Kong hotel industry: a comparison of business and leisure travelers. *Tourism Management*, 21(4), 363-377.
- Cozzolino, A. (2012). Humanitarian logistics and supply chain management. In *Humanitarian logistics* (pp. 5-16). Springer.
- Davidson, A. L. (2006). *Key performance indicators in humanitarian logistics*. Massachusetts Institute of Technology.
- DeJohn, P. (2005). Heroic efforts keep supplies coming in wake of Katrina. *Hospital Material [dollar Sign] Management*, 30(10), 1, 8-9.
- Dolinskaya, I. S., Shi, Z. E., Smilowitz, K. R., & Ross, M. (2011). *Decentralized approaches to logistics coordination in humanitarian relief*. IIE Annual Conference. Proceedings, May 21 to May 25, 2011, Reno, NV, United States.
- Dubey, R., Luo, Z., Gunasekaran, A., Akter, S., Hazen, B. T., & Douglas, M. A. (2018). Big data and predictive analytics in humanitarian supply chains: Enabling visibility and coordination in the presence of swift trust. *The International Journal of Logistics Management*, 29 (2), 485-512.

- Gavidia, J. V. (2017). A model for enterprise resource planning in emergency humanitarian logistics. *Journal of Humanitarian Logistics and Supply Chain Management*, 7(3), 246-265.
- Jafarnejad, A., Hashemi Petroodi, H., & Talaei, H. R. (2014). *New Approaches to Supply Chain Management: Resilience, Humanitarian, Services, Sustainability*. Negah Danesh Publications.
- Joerin, J., Shaw, R., Takeuchi, Y., & Krishnamurthy, R. (2012). Assessing community resilience to climate-related disasters in Chennai, India. *International Journal of Disaster Risk Reduction*, 1, 44-54.
- John, L., Gurumurthy, A., Mateen, A., & Narayanamurthy, G. (2020). Improving the coordination in the humanitarian supply chain: Exploring the role of the options contract. *Annals of Operations Research*, 1-26. <https://doi.org/10.1007/s10479-020-03778-3>.
- Kabra, G., Ramesh, A., & Arshinder, K. (2015). Identification and prioritization of coordination barriers in humanitarian supply chain management. *International Journal of Disaster Risk Reduction*, 13, 128-138.
- Kala, C. P. (2014). Deluge, disaster and development in Uttarakhand Himalayan region of India: Challenges and lessons for disaster management. *International Journal of Disaster Risk Reduction*, 8, 143-152.
- Kovács, G., & Spens, K. (2009). Identifying challenges in humanitarian logistics. *International Journal of Physical Distribution & Logistics Management*, 39(6), 506-528.
- Krejci, C. C. (2015). Hybrid simulation modeling for humanitarian relief chain coordination. *Journal of Humanitarian Logistics and Supply Chain Management*, 5(3), 325-347.
- Lester, W., & Krejci, D. (2007). Business “not” as usual: The national incident management system, federalism, and leadership. *Public Administration Review*, 67, 84-93.
- Li, C., Zhang, F., Cao, C., Liu, Y., & Qu, T. (2019). Organizational coordination in the sustainable humanitarian supply chain: An evolutionary game approach. *Journal of cleaner production*, 219, 291-303.
- Maiers, C., Reynolds, M., & Haselkorn, M. (2005). *Challenges to effective information and communication systems in humanitarian relief organizations*. IPCC 2005. Proceedings. International Professional Communication Conference.
- McClintock, A. (2005). Tsunami logistics. *Logistics and Transport Focus*, 7(10), 39.
- McEntire, D. A. (2002). Coordinating multi-organizational responses to disaster: lessons from the March 28, 2000, Fort Worth tornado. *Disaster Prevention and Management: An International Journal*, 11(5), 369-379.
- McLachlin, R., & Larson, P. D. (2011). Building humanitarian supply chain relationships: lessons from leading practitioners. *Journal of Humanitarian Logistics and Supply Chain Management*, 1(1), 32-49.
- Moshtari, M., & Gonçalves, P. (2011). *Understanding the drivers and barriers of coordination among humanitarian organizations*. POMS 23rd annual conference, April 20 to April 23, 2011, Chicago, Illinois, United States.
- Murray, S. (2005). How to deliver on the promises: supply chain logistics: humanitarian agencies are learning lessons from business in bringing essential supplies to regions hit by the tsunami. *Financial Times*, 7(5), 9.
- Mutebi, H., Ntayi, J. M., Muhwezi, M., & Munene, J. C. K. (2020). Self-organization, adaptability, organizational networks and inter-organizational coordination: empirical evidence from humanitarian organizations in Uganda. *Journal of Humanitarian Logistics and Supply Chain Management*, 10(4), 447-483.
- Nikkhoo, F., Bozorgi-Amiri, A., & Heydari, J. (2018). Coordination of relief items procurement in humanitarian logistics based on quantity flexibility contract. *International Journal of Disaster Risk Reduction*, 31, 331-340.
- Özesmi, U., & Özesmi, S. L. (2004). Ecological models based on people’s knowledge: a multi-step fuzzy cognitive mapping approach. *Ecological modeling*, 176(1-2), 43-64.

- Ponomarov, S. Y., & Holcomb, M. C. (2009). Understanding the concept of supply chain resilience. *The international journal of logistics management*, 20(1), 124-143.
- Shafiq, M., & Soratana, K. (2019). Humanitarian logistics and supply chain management—a qualitative study. *LogForum*, 15(1), 19-38.
- Sowinski, L. L. (2003). The lean, mean supply chain: and its human counterpart. *World Trade*, 16(6), 18-29.
- Sphere, P. (2004). Humanitarian charter and minimum standards in disaster response. *The Sphere Project, Geneva, Switzerland*.
- Stadtler, H. (2005). Supply chain management and advanced planning—basics, overview, and challenges. *European journal of operational research*, 163(3), 575-588.
- Suarez, J. D., Rincón, M. P., & Ramirez, C. O. (2019). Characterizing Coordination in Humanitarian Supply Chains: A Case Study in Colombia. In *Handbook of Research on Urban and Humanitarian Logistics* (pp. 263-276). IGI Global.
- Thomas, A., & Kopczak, L. (2008). From logistics to supply chain management: The path forward in the humanitarian sector. Fritz Institute.
- Tsadiras, A., & Zitopoulos, G. (2017). Fuzzy cognitive maps as a decision support tool for container transport logistics. *Evolving Systems*, 8(1), 19-33.
- Van Brabant, K. (1999). *Opening the black box: An outline of a framework to understand, promote and evaluate humanitarian collaboration*. Wageningen: The Netherlands: Crisis Studies Programme of the Centre for Rural Development Sociology.
- Van Wassenhove, L. N. (2006). Humanitarian aid logistics: supply chain management in high gear. *Journal of the Operational research Society*, 57(5), 475-489.
- Wankmüller, C., & Reiner, G. (2020). Coordination, cooperation, and collaboration in relief supply chain management. *Journal of Business Economics*, 90(2), 239-276.
- Warfield, J. N. (1974). Developing interconnection matrices in structural modeling. *IEEE Transactions on Systems, Man, and Cybernetics*,(1), 81-87.
- Zhang, J.-H., Li, J., & Liu, Z.-P. (2012). Multiple-resource and multiple-depot emergency response problems considering secondary disasters. *Expert Systems with Applications*, 39(12), 11066-11071.