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A Review on Main Challenges of Disaster Relief Supply Chain to Reduce Casualties in Case of Natural Disasters

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ABSTRACT

Iran is among the ten disaster-prone countries and, in terms of earthquake, it has been ranked the sixth in the world. Although the damages caused by the disasters are not irreversible from different aspects, they could be reduced to minimum by choosing appropriate preventive actions as well as preparedness plans to counteract the impacts of these incidents. According to the increasing trend of disasters and crises which destroy businesses and communities, considering relief supply chain under crisis situations (HDRSC), in the wide field of supply chain management (SCM), is necessary and vital. Even though considerable volume of research have been done in the field of supply chain and with the focus on the disaster relief, few studies have addressed its complex features and properties. So, this paper concentrates on the activities such as demand determination and supply chain coordination. This research provides the supply chain managers who are faced with similar problems in other environments with valuable insights.

Introduction

Nowadays, despite of technological advances, one of the main barriers of the countries' sustainable development is suffering from natural disasters (earthquake, flood, storm, lightning, avalanche, tornado, fire, volcanic burst and etc.) as well as unnatural ones (war, terrorist attacks, road accidents, industrial accidents, political issues, immigration, homelessness and etc.) and unpreparedness and inappropriate confrontation against these disasters impose heavy damages and losses to nations and their properties which might sometimes be irrecoverable.

What happens in a part of world, influences on the other parts' activities. When disasters and crisis take place continuously in a part of today's world, their economic, social and emotional effects is not limited to the part facing them directly only, but their second and third order effects remain in the form of wave in supply chains all over the world. In 27th of August 1883, explosion and eruption in Krakatoa, Indonesia left 100000 dead behind and the explosion had been heard from 3000 miles away. Weeks later people in Australia, Netherland, Berlin and New York realized the real details of this disaster (BEAMON, 2004). On Friday 11th of March 2011, east coasts of Japan were destroyed by Tohoko earthquake and tsunami. Many people around the world watched this disaster live. Therefore, disasters and crisis generate influences needing immediate action aiming reduction of these effects (social, humanitarian and economic) and speeding up the recovery process. In the heart of these challenges lays HDRSC (Humanitarian disaster relief supply chain).

According to investigations, Iran is among the first ten disaster-prone and the sixth earthquake-prone countries of the world. Random and unpredictable nature of natural disasters (especially earthquake) requires designing thorough crisis management plans in order to reduce the risks and alleviate the sufferings caused by crisis. In fact, the main purpose of relief responses and reactions is better planning for encountering these types of phenomena and increasing public awareness to be able to decrease death and injuries as well as reducing property loss (Bozorgi-Amiri, Jabalameli, & Al-E-Hashem, 2013).

Among natural disasters, three specific ones- earthquake, flood and drought- cause the most damages in Iran. According to international institute of seismology and earthquake engineering, nearly 83% of population in Iran live in areas with relatively much danger of earthquake and 51% are subjected to flood. Deadly earthquakes in Iran are due to the fact that Iran is located on one of the two large seismic belts in the world known as Alpa as well as existing numerous

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faults in Iran plateau.

On the other hand, based on geological studies, it would not be beyond expectation for occurring at least one deadly earthquake in Tehran every 151 years. In accordance with the last earthquake in Tehran (with larger than 7 in Richter scale) which occurred 168 years ago as well as several crucial faults located around Tehran, one could expect the possibility of a deadly earthquake every moment in Tehran district. This problem together with Tehran condition from different aspects of unprincipled structures, population concentration, political-cultural concentration and probable damages in water, electricity and gas lines after earthquake would lead Tehran earthquake to being deadlier; the way that, based on existing reports, it will be considered as one of the largest disasters of the world from humanitarian and financial losses point of view.

Since wideness and intensity of natural disasters are increasing due to reasons, like population growth, climate changes and global integration, it is predicted that current aids would be insufficient. On the other hand, nature of natural disasters is the way that responding to them should be carried out in a short time. In such urgent and complicated situations, the decider should quickly and effectively respond to logistic problems and transfer suffered people from damaged areas to specified center; where this will not also be possible without precise planning and systematic relief network.

Although damages caused by these accidents will not be recoverable, especially financially and mentally, but with predictive actions and appropriate plans for being well prepared to encounter these disasters, the damages could be reduced to minimum. Since intensity and wideness of these accidents are large, the produced volume of request for aid and rescue operation would also be large after occurrence and aid centers, which are able to supply the city needs in normal situations, are often insufficient for quick respond to the produced requests in these situations.

Furthermore, it would be worth noticing that dealing with victims, transporting necessary items, offering medical first aids and transferring the injured to relief centers in suitable time, specifically the first 72 hours after the disaster (the golden relief time) have important role in reduction of loss and disabilities caused by these accidents (Jang, Lien & Tsal, 2009).

Therefore, the main necessity is in the difference between crisis and normal conditions. One of the important actions necessary to be conducted in case of crisis is to optimize the distribution and assignment of resources among people. Time has crucial influence on increasing number of rescued people by relief activities. Since precisely determining the demand for critical items in case of disasters, among which medicine is the most important one, is indeed difficult and impossible in many situations, this adds up the difficulty of the problem. In fact, the main difference between the problem in crisis and in normal situation is the severe uncertainty and time limitation in helping the victims.

This paper introduces the opportunities and importance of crisis supply chain. It has been attempted to detect what distinguishes the crisis supply chain. In case of crisis, many things are in danger the most critical of which is the staff lives. Designing, implementing and managing the crisis supply chain, and especially its logistic, one could not only reduce the costs, but also it could save more lives.

An Introduction on Supply Chain Management (SCM)

A supply chain includes all stages that, directly or indirectly, play roles in meeting a customer's demand. In an ordinary supply chain, raw materials are sent by providers to factories and, then, the products produced in the factories are delivered to central warehouses and distributor ones and, from there, they are transferred to retailers and, eventually, are delivered to the final customer which is the consumer. Thereby, an article passes through different stages of the chain to reach to consumer. In some stages, the article is stored and in others it is shipped. The Supply chain members are generally as following:

Providers, Stocks of raw materials, Distribution centers, Distributors, Retailers and Final customer.

Figure (1) shows the schematic of a supply chain:

Figure (1): General structure of a supply chain

Activities of the supply chain start with the customer order and end when the customer pays the expenses of received article and service and the final product is delivered to him. The difference between the money spent by customer with total costs spent by the whole chain to produce and distribute the article shows the chain profitability. Accordingly, success of a chain is defined by its profitability and the supply chain management requires managing the flows between the

stages and inside each of the stages of the chain in order to maximize the total profit. Thereby, supply chain management would be definable as below:

A set of guidelines for integration of the chain members (providers, producers, distributors, retailers and final customer) whose purpose is to reduce the system costs and to increase the level of service to customers (Yi & Özdamar, 2007). From this definition two following points would be comprehended:
First, the supply chain management pays attention to any approach that leads to reduction of costs and plays a role in meeting the customer's need, from provider and production facilities to raw material stocks of distribution centers as well as retailers and products stock. In fact, in some supply chain analysis, it would be essential to focus on providers and customers, because they have critical role in formation of the supply chain.
Second, the supply chain management means increasing effectivity as well as reducing costs within the whole system. Employing the well-known approaches in supply chain management, total cost of the system, including transportation costs, stock, material handling and etc., would be decreased. However, this does not emphasize that transportation, stocks and other costs will be reduced only, but, using a systematic approach, the supply chain management attempts to improve the whole system efficiency and level up serving the customer as well.
Since supply chain management emphasizes on integration between providers, distributors and final customer, it covers most of the company activities in different levels, from strategic levels to tactical and operational ones.
Main barriers for integrating the supply chain are as following:
1- It is possible that different members of supply chain have different and incompatible goals. For instance, the providers would usually want the producers to buy a large amount of article with constant volume and flexible delivery date form them. However, the producers are supposed to be flexible with respect to the customer need as well as changes in the demand, because the production decisions are often made without exact information about the demand.
2- Capability of producers in adopting supply with demand is highly dependent on their ability to change the size of order lot and, for this reason, they are willing to buy in smaller lot-sizes and with variable volume. Similarly, the purpose of producers in productions with high volumes is usually in contrast with the target of distributors and shopping centers, because they always want to reduce their stock and increase their order frequency which could lead to an incline in transportation costs. At the end of the chain, i.e. from the customer side, when a change is induced in the demand, all members of the chain should change themselves with respect to it, but a lot of time is required to have this change applied in all levels of the chain, because this change accompanies a time delay. The main problem is this fluctuation in demand gets more intense when approaching the beginning of the chain. This phenomenon is called Bullwhip effect in the supply chain (Yi & Özdamar, 2007).

Method

The method employed in the present study is theoretical where library method has been used to collect information. Here the crisis and its management have been initially studied in a supply chain and the main focus has been on the management approach. On the other hand, principal issues of natural disasters management have been discussed.

Findings

Before investigating the crisis management approach in case of natural disasters, first crisis and crisis logistics have been studied and the main focus has been on its characteristics.
Besides, the principles of logistic management of natural disasters have been studied and, due to the nature of disasters and the approach to managing them in timely manner, the main cycle of this type of management and its applicable methodology have been scrutinized as well.

Definition of Crisis

a) Crisis is a sudden or accident together with wide financial losses or casualties and inducing trouble and suffering to a group or a human society whose way of overcoming would be urgent, immediate and extraordinary actions.
b) Crisis is the force or a set of opposing and unpredictable forces taking place and destructively affecting the foundation and focus of a targeted move and, in case of not passing through it, would cause unrecoverable damages (Yi & Özdamar, 2007).

Crisis Management

a) The systematic, genuine and comprehensive process of detection, prioritization, prediction and prevention from a crisis, intervention in the crisis and purification after the crisis for the purpose of overcoming it or limiting the consequences caused by it.
b) The process of planning, organizing, guiding, leading and controlling the required activities for preventing any intervention in the crisis in order to prevent the crisis from happening, overcoming it and purifying after it is being taken place (Yi & Özdamar, 2007).

Crisis management is categorized into four phases of prevention, preparation, respond and reconstruction (Bozorgi-Amiri, Jabalameli, & Al-E-Hashem, 2013).

1- Prevention: Set of actions executed before crisis with the purpose of preventing the sufferings or reducing the damaging effects of it.

2- Preparation: Set of actions (including gathering information, teaching, researching, planning, providing managerial structures and supplying resources) conducted in order to increase the capability of society, government and people in acting in different steps of crisis management.

3- Respond: Includes offering urgent services carried out after the crisis has taken place with the purpose of preserving different sources of the organization to prevent widening the damages.

4- Reconstruction: Includes activities in order to return the conditions of a suffered organization to normal conditions considering the features of a successful organization as well as all safety regulations.

Definition of the Crisis Logistic

It has been predicted that until 2125, above 5 billion people will live in urban areas around the world from which 81% will reside in less developed cities and this could induce challenges for urban planners and managers (Chang, Tseng, & Chen, 2007). Undoubtedly, the major influence of accelerated growth of urbanization and uncontrolled growth of urban spaces would be impairing of the service distribution system and malfunctioning of the service system. Therefore, the optimal pattern of living in urban communities would require suitable planning in the cities. One of the important goals of urban designers is creating an urban space where all citizens could easily have access to city services, because accessibility represents the quality of an urban space (Chang, Tseng, & Chen, 2007). The crisis logistic includes all process of providing, supplying, transporting, storing and distributing articles, equipment, services and all necessities of sufferers and relief groups which should be achieved in minimum time and in suitable places and in essential amount.

Characteristics of the Crisis Logistic System

In recent decades, the logistic system for organizations has been inevitable and has found a role in the organizations costs basket; so that activities of logistic system could significantly influence on effectiveness and efficiency of the organization.

Expectations and demands of sufferers and relief and rescue groups as consumers and final user of articles, equipment and support serveices could be included in various subject. Providing equipment and essential quality and quantity supports in required time and place are among the most important expectations from the logistic system.

Preparing and planning appropriately, the logistic system provides a suitable bed for association and application of maximum power and potential of providers, the way that it could not only attract their confidence, but also provides the sufferers and relief groups with equipment and articles with appropriate speed and quality and in demanded time and place.

This goal would not be realized unless by formation of a logistic system with features compatible with crisis conditions and integrated management using modern and efficient information technologies. Effectiveness of the logistic system could be determined via its preparation, speed and reactivity.

Similarities and Differences between Commercial and Relief Supply Chains

Conceptually, there are some similarities between the commercial and humanitarian relief supply chain; the way that, similar to the logistic concept in commercial supply chain, the crisis logistic includes activities, such as planning, prediction, supplying, transportation, storage, delivery and also supplementary actions like offering help request and displacement.

The humanitarian relief chain connects all beneficiaries in the relief process. These beneficiaries include donors, relief organizations, army, governments and sufferers.

Similarities between commercial and relief supply chains in crisis conditions provides possibility of using some tools and methods of commercial supply chain in the relief ones; however, there are fundamental differences between them causing even more complexities and unique challenges in managing relief chains. One of the main differences between commercial and humanitarian relief supply chains is in their goals.

In the commercial supply chain, making profit is considered as one of the main targets; whereas, in humanitarian relief chains, this goal replaces with on time and suitable relief actions (on time delivery of relief articles in suitable place) to sufferers.

According to conditions and different aspects of natural disasters, most important features of relief chain that distinct it with commercial supply chains and make solution of relief logistic problem much more complicated, are as following (Beamon, 2004):

- Lack of information most of which are due to uncertainties and malfunction of connection lines.
- Sudden nature of incidents and time limits in responding the needs
- Limitations in resources with respect to the accident dimensions, such as limitations of articles, human resources, technologies, fuel, transportation

fleet and budget available that could cancel rescue and help all sufferers.

- Complexity of coordination due to presence of different relief groups, people and government.
- Existence of conflicting target functions
- Unpredictability and uncertainty of demand from time and incident place point of view as well as its type and wideness
- Uncertainties and various dynamic factors in environmental conditions after the accident

Above points have turned the logistic of relief chain into a very challenging topic; such that increasing efficiency and improving the performance of relief actions would require special attention and precise logistic plans and management and complete coordination between related relief staff would seem necessary more than ever before.

It is obvious that paying attention to time in responding to the generated demand and delivering help and services required to suffered points in minimum time is of great importance in relief logistic.

Crisis Management Cycle

The crisis management cycle has four steps including the following (Van Hentenryck, Bent, & Coffrin, 2010):

The Step of Expectation and Prediction

In this Step, conducting the following items is necessary:

- Exact identification of probable mass disasters and develop a geographical map of areas at risk according to type of disaster, severity and probability of occurrence.
- Developing preventive guidelines about structures (private and public), urban facilities, infrastructures and national treasures.
- Supervising the execution of guidelines
- Identification of technical predictive ways, tools and required instruments for predicting the mass disasters
- Public training in order to enhance the public awareness for the probable mass disasters and suitable individual behaviors in case of incident
- Training the special national and local staff related to type of probable disaster according to local facilities and needs
- Providing necessary equipment for help and rescue and founding permanent relief and rescue basements within national borders
- Developing permanent plans of precautionary and predictive action in national level
- Developing mandatory evacuation plans when necessary and predicting location, facilities and tools and necessary instruments after evacuation of population
- Regular study on possibility of evacuation of endangered areas and changing the use of the land with respect to type of the probable mass disaster
- Regular study of crisis management and deciding in crisis situations and practicing the crisis management guidelines

The Step of Warning against Crisis

In this step all the following should be conducted:

- Determining ways of warning in case of danger of any mass disaster
- Providing warning tools
- Public training of the signals of mass disaster
- Guidelines of rescue and safety from mass disasters in case of incidence

The Step of Rescue

This step includes the following:

- Identification of the location, severity and domain of the disaster
- Declaration of public mobilization according to severity and domain of the mass disaster
- Dispatch of special relief staff and necessary tools and working instruments
- Immediate protection of damaged areas from hygienic point of view and social and legal controls of quick transferring of sufferers to prepared centers
- Search and rescue operations
- Evacuation of bodies and burying them and doing necessary hygienic actions
- Evacuation of remainders to points pre-designed in step of expectation and prediction
- Formation of temporary and permanent camps
- Providing the camp residents with daily needs and essential facilities
- Evacuating properties and dividing them
- Quick reopening of roads and constructing temporary landing runaways for helicopters and airplanes
- Founding field hospitals
- Wide social, mental and behavioral relief actions
- Executing evaluations of rescue and identification of defects and limitations

The Step of Normalization and Release

In this step the following actions would be performed:

- Short term relief actions
- Mental and behavioral actions
- Mid-term relief actions
- Calculation of damages and financial and humanitarian losses
- Inspection of all structures and urban and infrastructural facilities and national treasures from point of the amount of imposed damages and

probability of intensification of losses in the future and ways to repairing and reconstructing them

- Researches of evaluating the damages and ways of normalization

Planning in Crisis Logistic

In order to plan and manage the crisis logistic, the following conditions should be met:

1- For this procedure all information are supposed to be available on time and accurately and completely.

2- Planning should be capable and idea full and sufficient knowledge should be in service of the system. While planning, experienced people should be employed, because factor of experience is determining in making final decisions.

3- The crisis logistic management system should always be equipped with the best methods and prediction techniques and required information in order for the prediction of future necessities to be performed easily.

4- A powerful crisis logistic is highly in need of strong and uniform information systems.

Investigating the Studies about Relief Actions in Respond Phase

Looking thoroughly to the researches in the field of supply chain and crisis logistic, one could categorize the problems presented in the crisis logistic literature into the following groups (Beamon, 2004):

- Locating the relief facilities
- Stock management
- Flow in the network
- Navigating the transportation tools

Generally, the relief logistic models could be divided into three overall categories with respect to type of their goal:

1- Minimizing the costs

Minimizing the costs include the ones after the incident and the costs before it. The costs like establishing storage spaces, storage of relief items, transportation costs, operational costs and etc. whose presence in function of most multi-goal models of relief logistic is considerable.

2- Maximizing the sufferers' satisfaction through maximizing the justice in distributing help

In literature of relief logistic, minimizing the unanswered demand and expectation time for receiving help are two parameters in increasing satisfaction of sufferers. On the other hand, maximizing the satisfaction of sufferers all through the relief network would lead to maximizing justice in distributing help and, therefore, in relief logistic literature, both these expressions are used (Beamon, 2004).

(Huang, Smilowitz & Balcik, 2012) used minimization of average or total time of goods delivery and/or, on average, the latest time of goods delivery to the demanded points to investigate justice in relief distribution; where these types of goals would eventually lead to faster distribution of help with higher transportation costs. (Chang, Tseng & Chen, 2007) have considered weighing the travel time by means of the delivered good and (Doran et al. 2011) considered minimizing the total cost of delivering operation of the goods together with minimizing total time required for good delivery. On the other hand, (Tzeng, Cheng, & Huang, 2007) and (Lin, Batta, Rogerson, & Blatt, 2011) attempted to minimize the maximum unanswered demand together with minimizing total time required for delivery of the goods.

However, in all the above multi-target models, the costs minimization function has also been considered as a target function. On the other hand, (Clark & Culkin, 2013) and (De Angelis, Mecoli, Nikoi, & Storchi, 2007) mentioned the unanswered demand and (Yi & Özdamar 2007) mentioned the concept of distribution in delivery and minimization function of total unanswered demand in their models and considered the novel idea of displacing equipment between medical centers in order to better serve the sufferers.

3- Maximizing the capability of the travel assurance:

(Van Hentenryck, Bent, & Coffrin, 2010) used the possibility of reaching the vehicles to pre-defined destinations for them to maximize their reliability. In addition, they used the minimizing costs and minimizing unanswered demands functions in their multi-target model as well.

Methodology

As mentioned above, time is a critical factor in the crisis supply chain; therefore, in this survey a proposed research plan has been developed using the expert-led approach has been used in two steps for detecting the main challenges of the crisis supply chain in order to reduce the service time. The first step is to identify and prioritize the challenges ahead of the relief supply chain. The second step has been employed for validation, clarification and specification of the important challenges.

The Main Identified Domains

Four important domains of challenges where the researchers could help the crisis supply chain have been obtained from the two-step methodology. These four domains are as following: (1) Visibility of

demand and determining the needs, (2) information management and coordination between relief activities (in a variant environment), (3) planning the crisis relief and (4) communications management and developing trust in the supply chain. Although some other domains are of importance in this area, but these four domains are the most significant and applicable ones in reducing the relief time. In the following, these four domains have been discussed.

Visibility of Demand and Determining the Needs

Identification of the customer's demand in crisis conditions, is one of the most difficult jobs in the set of actions of crisis relief; therefore, obtaining reliable information about the demand in crisis conditions is one of the main concerns of crisis management; because determining the demand in the initial hours of the crisis is very difficult and, in many cases, needs days and months of investigations. Since crisis management is trying to specify the exact amount of demand and necessity, lot of time would be lost and, therefore, the crisis losses would increase.

Information Management and Coordination between Relief Activities in Variant Environment

Challenge of information flow management and coordination between activities among relief staff is considered as one of the important concerns in the relief phase. The modified coordination includes money flow and resources flow, such as relief services and critical goods stock, is a crucial need in the crisis supply chain management. Improving coordination between goods flows and resources is tightly related to enhancement in sharing information and communications in the supply chain.

Planning the Crisis Relief

Planning for crisis has been demonstrated as an essential issue. Though the lifetimes of crisis plans are short, but necessity of validation of important parts for preparation and prevention from getting surprised has been considered important to encounter crises. All communicative hardwares and softwares should be prepared enough for any crisis at any time. In other words, each of the chain members should be in thorough coordination with each other. This is important from this aspect that in case of crisis, no time should be lost for coordination of the chain members and relief activities should start right after crisis (respond phase).

Communications Management and Developing Trust

Trust and good communications are positive factors in performance of supply chain in the crisis scenario. Trust is one of the important components in good performance of the crisis relief operations. A key and crucial question here is how these communications should be formed. Training association and cooperation in using pre-defined patterns is one of the most suitable ways for improving communications and developing trust among the crisis chain members.

Results and Discussions

A huge necessity is felt for new researches and studies in the supply chain in the four challenge domains (Visibility of demand and determining the needs, information management and coordination between relief activities (in a variant environment), planning the crisis relief and communications management and developing trust in the supply chain). These research domains are not only connected to the branch of philanthropy supply chain and HDRSC, but also to the studies in the area of SCM.

At the beginning, convergence influences on information management and coordination of relief activities, such as communications management and trust development. Secondly, uncertainty affects the problems, including visibility of demand and determining the needs and planning the crisis relief. Finally, the emergency organizations create challenges for information management and coordination among relief activities, crisis relief planning and communications and trust development management.

Although some initial jobs in these problems have emerged from the crisis supply chain domain, but none of these four challenging domains have not naturally been part of previous studies, but they have been a part of a bigger branch of SCM. However, until now, SCM has not investigated these issues sufficiently in the form of crisis relief. These observations could explain why the crisis supply chain needs a development beyond traditional logistic borders.

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