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SUPPLY CHAIN AGILITY IN HUMANITARIAN LOGISTICS

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Abstract: The supply chain agility plays a crucial role in logistics processes. The agility is of particular importance in humanitarian logistics, where the main aim is to save life and reduce suffers; food, pharmacy and accommodation must be transported to the location of natural or man-made disasters. The supply chain agility is influenced by different factors of logistics processes: alertness, accessibility, decisiveness, swiftness and flexibility. There are in the literature different approaches describing supply chain of humanitarian logistics processes. Within the frame of this paper, the author describes a new model of the supply chain of humanitarian logistics. After a careful literature review, this paper introduces an approach, which integrates not only the technical and technological aspects of the operation but also the design and optimisation of processes. This work considers the unique requirements of disasters and focuses on the agility of supply chain process. The present paper contributes to the system theory of humanitarian logistics and offers new insights in methodological theory, paving the way for further research works on this topic.
Keywords: *agility, humanitarian logistics, information technology, optimisation, supply chain*

1. Introduction

The humanitarian aid can be traced to the ancient world, but the organised, worldwide aid appeared in the 19th century. The first natural disaster, which became an international event and when coordinated humanitarian movement happened was the Northern Chinese Famine between 1876 and 1879. A continuous drought in 1875 led to the crop failures in the following years [1]. The crop failures led to mass starving and interfamilial cannibalism. More than 10 million people died in the four years long famine. To combat the famine, an international movement was set up to collect and transport donations to the provinces Shaanxi, Hebei and Henan [2]. The donations came the Roman Catholics, the Protestants and from the foreign businesses in China [3].

The next big natural and man-made disaster were the 1883–1985 famine in Ethiopia, which caused more than 1 million deaths [4]. Climatic problems and abused human rights led to this horrible disaster. An international movement organised the transportation of food and medicine to the starving country [5, 6].

The Fukushima nuclear disaster was a natural disaster caused by the tsunami and flooding following the Tohoku earthquake on 11 March 2011 [7]. The later investigations showed that the catastrophe and their causes had been foreseeable. The Fukushima nuclear disaster has been the biggest energy accident since the Chernobyl nuclear disaster [8]. This disaster became an international event, as all of the nuclear accident and an international cooperation formed to help. Because of the nuclear radiation, food, medicine and accommodation were transported only by unmanned vehicles and drones [9].

As the above-mentioned examples showed, disasters led to international cooperation and these international aid movements has required sophisticated logistics and supply chain. Within the frame of this paper, the author focuses on the agility of humanitarian

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logistics related supply chain. A careful literature review summarises the theoretical aspects of system theory, design and operation of supply chains of humanitarian logistics processes. The author describes a new approach to the supply chain, which takes into consideration the technical, technological, IT, communication and operational aspects (mathematical tools, algorithms to solve probability problems).

2. Literature overview

Humanitarian aid has been present throughout the history, but the modern concept of humanitarian aid as an international event has emerged since the 19th century [10].

The literature of humanitarian logistics includes a huge number or research. Humanitarian logistics is a quite complex problem, because of inadequate infrastructure, uncertainties, urgency, bureaucracy, untrained people, the secondary importance of logistics, lack of information and transportation management [11, 12].

Within the frame of this literature review the author focuses on the following topics related to humanitarian logistics:

- technology used in disaster sites to transport, distribute and evacuate;
- commodities used by people living in disaster sites,
- modelling methods and algorithms to design systems and processes.

The response and the recovery phases of natural and man-made disasters require special technology for transportation, distribution, evacuation, infrastructure restoration [13, 14].

Uncertainties make the design and operation of logistics processes of humanitarian logistics stochastic. There are different models and methods to handle the mentioned uncertainties, and these models and methods can support the decision making in real situations [15].

There are a huge number of commodities, which are required by people living in disasters sites. Cooking and cooling facilities are among these most needed things. Researchers try to find new solutions to fulfil the special requirement of these appliances. One of the most interesting solutions is an innovative solar cooker using the packaging waste of humanitarian supplies [16, 17]. In total, more than 23 billion USD was spent to finance humanitarian events. More than 60 percent of this money is caused by logistics operations, like transporting, warehousing, loading and unloading. The usage of standard global tools makes it possible to reduce these costs. The standardisation requires the coordination of new product and technology design [18]. Other valuable commodities are the kits, like medical supplies (diagnostic kits for malaria, HIV etc.), water and sanitation (hygiene kits) and education supplies (childhood development kits, recreation kits and classroom kits) [19, 20].

The design of humanitarian logistics systems begins with modelling. Modelling parameters for objective functions and constraints influence the result of design. The objective function of transportation and evacuation are the followings: travel costs, loading and unloading time, short path selection, travel time, evacuation time. The distribution of food, medicine and accommodation can be designed by the aid of the following objective functions: relief distribution cost, relief distribution time, respond, resource allocation, the total life saved, the number of wounded people waiting [21, 22, 23].

3. Components of supply chain agility in humanitarian logistics

The supply chain agility is influenced by five important factors: alertness, accessibility, decisiveness, swiftness and flexibility. These factors are defined by GLIGOR [24] for production companies. In the case of humanitarian logistics related supply chain, these five factors must be re-evaluated, because of the special conditions, stochastic and dangerous environment. The five factors by Gligor can be redefined as follows:

Alertness: the supply chain must be able to detect changes, dangers, opportunities, threats, and requirements in the environment of the disaster. Alertness and flexibility are not the same. Flexibility means the capability to modify things, while alertness focuses only on the detection of changes.

- *Accessibility:* the supply chain has the capability to access relevant data to build a homogeneous information structure to support decisions. Data mining is a state of the art IT solution in the case of disaster areas to collect relevant data.
- *Decisiveness:* the ability for resolved decision making. Decision making is easier in a deterministic environment than in the case of stochastic, probabilistic systems and processes. When a natural disaster or man-made disaster strikes, timing is crucial. There is no time to hesitate among different solutions; the right decision must be made as soon as possible to save as many lives as possible.
- *Swiftness:* the ability to implement decisions quickly. Swiftness, decisiveness and alertness are connected with each other. In traditional supply chains the decision-making process and the realisation are on the same time scale, but in the case of humanitarian logistics, there is no unnecessary time to waste for decision making. The operation has the priority.
- *Flexibility:* the ability to change the operations to fulfil the main dynamically changing strategy of humanitarian aid processes.

As *Table 1* shows, the agility factors of supply chain include different contents in the case of humanitarian logistics as in the case of production or service companies. The supply chain agility includes the whole logistics process: purchasing, production, distribution and recycling. Purchasing is a very complex problem, because of the unknown requirements of disaster areas. Food, medicine and accommodation requirements are hard to determine. Distribution processes have the same problem; the quantity, quality and location of the requirement is hard to define, and they are dynamically changing, and the locations are accessible with difficulties. Recycling is especially important, because, from the disaster area huge amount of polluted waste, scrap, garbage or ruin must be transported, recycled or treated.

The supply chain of humanitarian logistics requires new technologies to fulfil the global strategies. Materials handling, information technology, telecommunication and optimisation algorithms influences the success of aid operations. *Figure 1* shows the most important influencing factors of supply chain agility of humanitarian logistics.

However the major objective of humanitarian logistics is to save life, reduce suffers and delivery aid, but other goals have to be fulfilled (secondary importance): reduction of duration of transportation operations; lead-time reduction for decision making and operations; utilisation of capacities; increasing the thrift; increasing the flexibility; transparency; usage of environmentally friendly technologies; reduction of emission; increasing the international cooperation.

Table 1
Components of supply chain agility from the point of view production companies [24] and humanitarian logistics

Agility factor	Production company	Humanitarian logistics
Alertness	• detect changes • detect opportunities • detect threats	• detect changes • detect opportunities • detect threats and dangers • detect requirements
Accessibility	• ability to access relevant data from a previously built IT system	• ability to access relevant data from a stochastic disaster area • data mining and quick data processing has priority to support decisiveness
Decisiveness	• resolved decision making	• timing is crucial • probabilistic or chaotic environment
Swiftness	• quick decision making ability	• quick decision making ability depending on the decisiveness and alertness conditions • operation has the priority
Flexibility	• change the range of operation to fulfil global strategy	• change HW components and tools of operations (technical and technological flexibility) • change tactical decisions

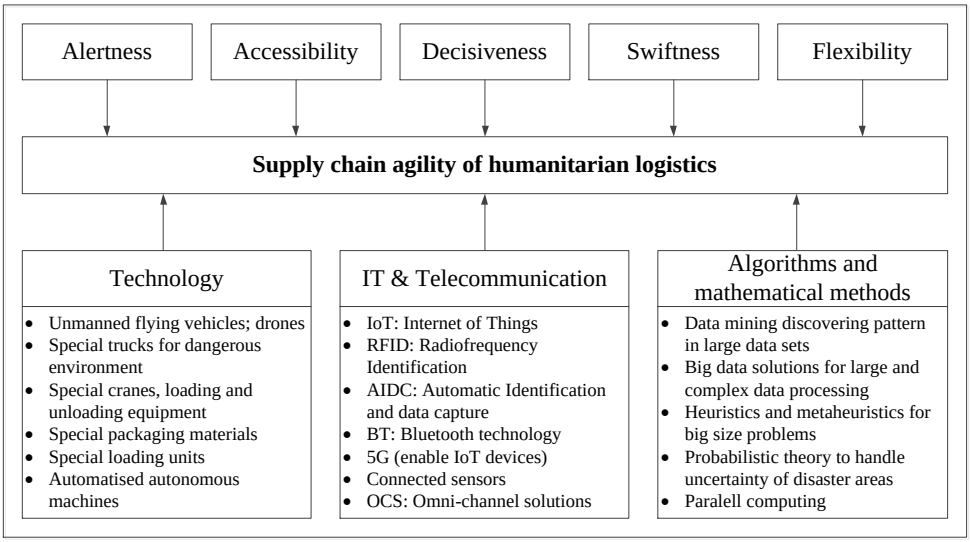

Figure 1. Agility factors of supply chain and supporting technologies from the point of view materials handling, IT, telecommunication and algorithms

Logistics represents in generally 20 per cent to 90 per cent of costs, depending on the business processes. Therefore, it is very important to take the logistics related operations and processes under control. In the case of humanitarian logistics these costs can be shared among different subsystems of logistics. As *Figure 2* demonstrates, the humanitarian logistics includes and integrates all logistic subsystems: transportation; commerce; logistic centres; warehousing, military; service and production logistics.

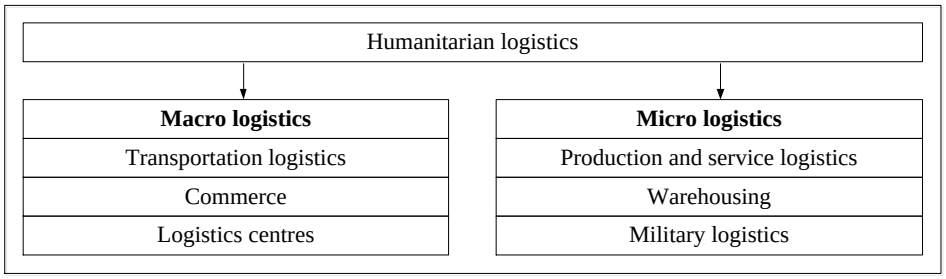

Figure 2. Logistics subsystems in humanitarian logistics

The World Humanitarian Summit held in 2016 in Istanbul discussed the internationalisation of disaster events. However more than 1000 humanitarian organisation responded to the earthquake in Haiti 2010, but in the future, not only the prevention but also the management of all crises will be organised as an international movement. Therefore the organisation of logistics processes will be more complex.

4. Summary

The agility of supply chain processes is very important for humanitarian logistics movements. Within the frame of this paper, the author described the major theoretical knowledge by the aid of a literature review. He introduces a new approach, which focuses on the supply chain agility. The five factors of supply chain agility worked out by GLIGOR [10] were redefined for humanitarian logistics processes. This work considered the unique requirements of disasters and contributed to the system theory of humanitarian logistics and offered new insights in methodological theory.

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