Research on the Selection of Logistics Service Integrators in Emergency Supply Chain

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Abstract: In the traditional emergency supply chain, it cannot guarantee supplying and producing disaster relief orderly in emergency, which leads to many problems including financing of relief supplies, storage, and transportation. This article emphasis on the prominent theory that it should be insert some logistics integrators between the government and the logistics dynamic alliance to connect the government and the logistics alliance. At last, this paper explore how to use AHP analysis and VP-level multi-objective planning method, with integrating the needs of emergency government, suppliers and manufacturers in emergency supply chain, to select the appropriate emergency logistics service integrators.
Key words: Emergency supply chain; Logistics dynamic alliance; Logistics integrators; AHP analysis; Multi-objective planning

1 Introduction

When the unexpected events occur, the emergency relief supplies would be in huge demand[1]. And it can also break the balance of operation in the supply chain.

During the period of early development in emergency supply chain, a number of scholars made significant contributions to build a dynamic alliance of logistics involved multi-entities.

Dynamic Alliance is made up by logistics center, logistics companies and a number of 3PL companies. When the emergency occurs, these entities, according to the order of the government, are quickly organized for the support and protection of emergency supplies[2]. However, in actual operation, when the emergency comes, dynamic alliance of logistics cannot be organized timely and efficiently.

In the framework, we proposed that it should be selected a group of logistics service integrators who are under the supervision of the government directly in the dynamic alliance, when an unexpected event occurs, the relevant government departments should contact the appropriate logistics service integrators and integrate resources both of the government and the dynamic alliance of logistics to concert the operation of emergency supplies from the research and development, production to transportation and supply, within the shortest time. We mainly focus on how to choose these integrated logistics service integrators in emergency supply chain.

Many researches paved the way for many subsequent studies in logistics service integrators in emergency supply chain using quantitative methods. Works by Charles, reviewed integrators choice of 74 articles, and summarized a variety of basic method of integrators selection, it is the sense of a general methodology of the research[3];Brisen and Karpak discussed a multiple criteria such as the "visual interactive goal programming" (VIG) decision model to help the procurement team builders select integrators[4]; TianYu used AHP and LP methods, with examples of supply chain logistics services integrators, discussed multi-source supplier selection and optimal allocation of the purchase[5]; Liu Weihua studied how logistics service integrators allot orders for more functional logistics service integrators in the case of uncertain demand[6].

Subsequent to the case studies, We put the traditional selection of logistics integrators into the emergency supply chain, and comprehensively used AHP analysis and VP-level multi-objective planning[7]to discuss how to integrate the government, suppliers and manufacturers in the emergency supply chain to choose logistics integrators to maximize the functioning of the whole chain efficiency.

2 Selection Methodologies

2.1 Emergency logistics integrators selecting principles

(1) The ability for combining peacetime with wartime

Emergency management focuses on prevention, combining normal with emergency accident conditions, and make preparations to be unhurried in wartime condition. Emergency supply chain

logistics integrator, who is the organizer of handling emergencies, should also follow the principle of combining with peacetime and wartime.

(2) Agility

Emergency management highlights time efficiency. It requires the supply chain to be with flexible quick response ability. Logistics integrators in emergency supply chain are also required to quickly take the supply chain internal and external process of reconstruction and optimization according to environment and task to insure the emergency supplies could be supplied efficient and timely.

(3) Dynamic

In emergency circumstances, there exists uncertainty everywhere such as the change of emergency development, materials demand, and information and so on. Therefore, logistics integrators in emergency supply chain can take dynamic adjustment, according to various uncertainties, to reduce the threat from the uncertainty.

(4) Relational

The efficiency of supply chain not only depends on the efficiency of each node in supply chain, but also depends on the relationship between one-node to another node. The relationships of emergency logistics integrators are the guarantee of best performance, and it can guarantee the integrity advantage in supply chain.

2.2 Emergency logistics integrators selecting process

The process of emergency procurement of logistics integrators is shown as Figure 1.

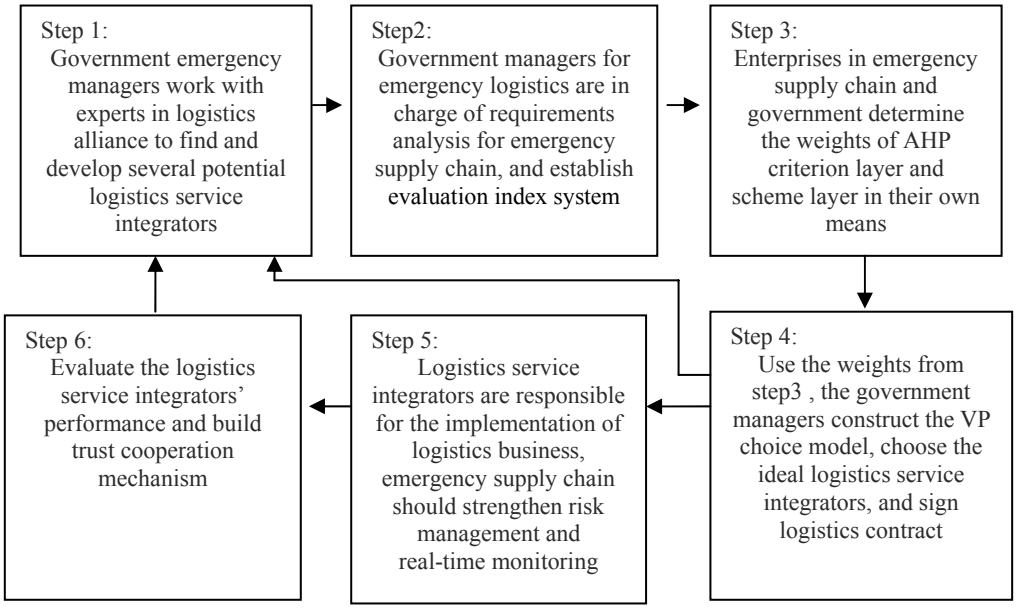

Figure 1 The Evaluation Selection Process of Emergency Logistics Integrators

Furthermore, we also should continue to cycle the process of emergency procurement of logistics integrators, fully satisfy the new need of the supply chain logistics services and make the need of logistics more realistic so that select a more appropriate logistics services integrator. The detailed process is shown in Figure 1. In the following sections, we will focus on building the method of group decision aiming at the problem of the selection of logistics service integrators in emergency supply chain.

2.3 AHP model

AHP model, which was first presented by operation scholar T.L.Satty in the United States in the 20th century, is a multi-objective decision method with both qualitative analysis and quantitative analysis[8]. The key point is that putting a complex problem down into component elements, and forming a hierarchy of dominance according to relations, and then using the one-one comparison method to determine the importance of decision-making program. AHP model's algorithm:

$$AW = \lambda \max W \tag{1}$$

AHP can be used to evaluate logistics integrators by us. It combined with the need of government supplier and manufacturer, and assesses the logistics service integrators considering five factors

including integrated ability, information ability, speed of response, logistics capabilities and industry correlation.

According to these basic elements, we can list AHP hierarchy structure assessment of logistics services integrators, to simplify the analysis, we only list the criteria level and project level without subdividing into sub-criteria level further, which is specifically shown in Figure2.

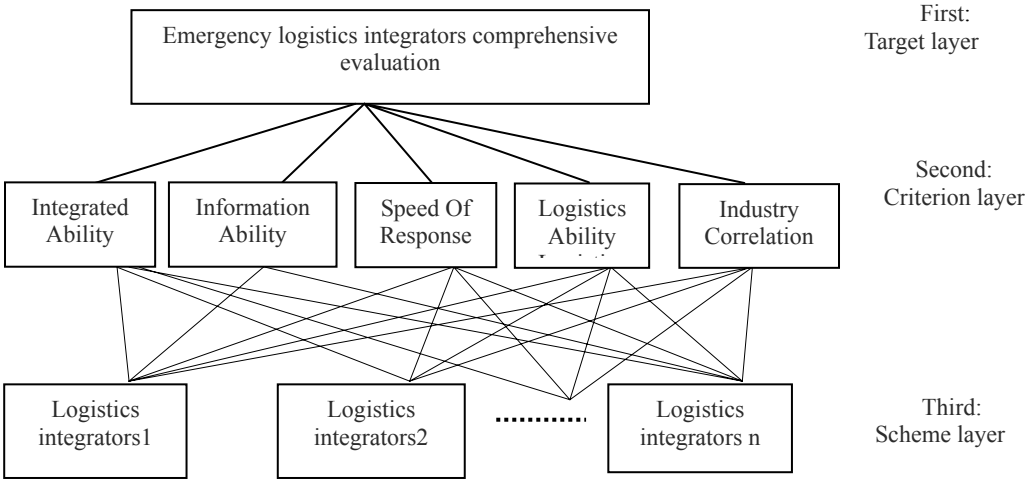

Figure 2 The AHP Level Structure from Emergency Logistics Integrators' Assessment

In the five factors, integrated ability refers to the ability of logistics integrators in supply chain to integrate each node, including customers evaluation index and complaint rate; Information ability refers to the informatization level of logistics integrators, including the mature of information platform, the ability of application in logistics technology, the ability of innovation in logistics technology; The speed of response means, in face of unexpected events, each node of the supply chain can be organized by logistics integrators quickly, including the rate of customer orders content in history, the ability of value-added service, the accuracy of order predict; Logistics ability refers to logistics service integrators' logistics facilities and equipment, including the types and type of transport, layout and capacity of warehouse; Industry correlation refers to the relationship between logistics service integrators and various sectors of network ties, including logistics business coverage and historical transaction's records, the ability and channels for logistics knowledge collection.

The supplying and manufacturing enterprises and government in emergency supply chain, according to their actual needs of preference in the emergency supply, should fully express their views on the assessment of integrators, and quantities these qualitative assessment index of logistics service integrators, and then get some weights of the criteria layer to target layer and scheme layer to criteria layer according to the solution of AHP model algorithm.

2.4 VP model

Multi-objective programming (VP) model is a branch of mathematical programming researching on the optimization of multiple objective functions with some given constraints [9].

We first use AHP model to evaluate the options of logistics integrators for each, and get assessment of the layers of weights, and then, follow a multi-objective programming (VP) to select the final logistics integrator [10].

The way of combing the two models, considering both the Government's request and the request of suppliers and manufacturers in emergency supply chain, integrates each enterprise and government's preferences effectively to select more satisfying logistics service integrators by all of entities of the entire supply chain.

Using linear weighting method, and transforming the VP model into the weighted special model, after that, the selection model of logistics integrators can be described as follows:

$$MinV = \sum_{k=1}^{p} \sum_{j=1}^{m} W_{kj} d^{-}_{kj} \tag{2}$$

Subject to:

$$\sum_{i=1}^{n} A_{i1}X_i + d^-_{k1} = A1^* \quad (3)$$

$$\sum_{i=1}^{n} A_{i2}X_i + d^-_{k2} = A2^* \quad (4)$$

$$\sum_{i=1}^{n} A_{i3}X_i + d^-_{k3} = A3^* \quad (5)$$

$$\Sigma_{i=1}^{I} X_i \le 1 \quad (6)$$

Objective function *(2)* minimize the sum of decision-makers' weighted deviations variables. Generally, as it is less than the maximum assessment weight of all enterprises, so here we only consider the negative deviation variable d^-_{kj}. W^-_{kj} is from the weights of criterion layer to the target layer in the AHP model. Constraints *(3)(4)(5)* is the formation of the criterion and Scheme, so these index of integrated ability, information ability , the speed of response, logistics ability and industry relation are near to the largest assessment of the weight of all the enterprises and the government. Constraints *(6)* are the selective constraint, for avoiding choosing more than one logistics integrator.

Table 1 The Meaning of the Letters in the Formula

Variable	Meanings
p	The total number of evaluation index
m	Total enterprises participate in the decision of the supply chain
k	The first "K" in the evaluation index, k=1,2,3,4,5
W^-_S	With deviation variables related weights
d^-_S	The largest evaluation weights' negative deviation variables
n	The total number of optional logistics service integrators
Xi	The first "i" in integrators; Values "0"is that "i" did not be chosen; Value "1" is that "i "did be selected
Aij	The first "j" in integrators to the first "i" in integrators of assessment weights when they are under some special index
*Aj**	The biggest evaluation weights of the first "j" in integrators to all of integrators when they are under the special index

3 One Example

We assumed that there is only one supplier and one manufacturer in this emergency supply chain, government procurement group has established evaluation index system about logistics integrators, and has chosen three of the logistics integrators as the potential qualified logistics integrators: logistics integrator 1 *(X1)*, logistics integrator 2 *(X2*), logistics integrator 3 *(X3)*.

In the following passage, we would explain how to use AHP model and the VP model to make the final determination of the logistics integrator. The raw data is from the literature [11, 12].

The steps of selection of logistics integrators are as follows:

(1) With the actual demand preferences for emergency supply chain from suppliers, manufacturers and government, and with each of the entities' experts scoring for the three of the logistics integrators, according to the established evaluation indicators, we can structure judgment matrix. Take the government for example, and its evaluation index comparison matrix is shown in Table 2.

Table 2 The Judgment Matrix of Government to Evaluation Index

Index	Integrated Ability	Information Ability	Speed Of Response	Logistics Ability	Industry Correlation	weights
Integrated Ability	1	1/3	1/3	1	2	0.121
Information Ability	3	1	2	3	3	0.363
Speed of Response	3	1/2	1	5	5	0.338
Logistics Ability	1	1/3	1/5	1	1	0.095
Industry Correlation	1/2	1/3	1/5	1	1	0.083

(2) We can get the weights of criterion layer to target layer for every entity like that, the results are shown in Table 3. The weights will be ordered in the VP model objective function *(2)* to constitute the coefficients of negative deviation variables.

Table 3 The Criterion Layer to Target Layer Weights of Each Enterprises in Emergency Supply Chain

Index	Suppler	Manufacturer	Government
Integrated Ability	0.263	0.476	0.121
Information Ability	0.475	0.264	0.363
Speed Of Response	0.055	0.054	0.338
Logistics Ability	0.099	0.098	0.095
Industry Correlation	0.110	0.109	0.083

(3) We can get the weights of scheme layer to criterion layer for every entity like that too, the results are shown in Table4. The weights will be ordered in the VP condition *(3)(4)(5)* to constitute the coefficients of the decision variables *Xi.*

Table 4 The Scheme Layer to Criterion Layer Weights of Each Enterprises in Emergency Supply Chain

Index	Suppler			Manufacturer			Government		
	X1	X2	X3	X1	X2	X3	X1	X2	X3
Integrated Ability	0.595	0.277	0.128	0.655	0.250	0.095	0.637	0.105	0.258
Information Ability	0.082	0.236	0.682	0.683	0.200	0.117	0.163	0.540	0.297
Speed Of Response	0.429	0.429	0.142	0.739	0.167	0.094	0.163	0.540	0.297
Logistics Ability	0.633	0.193	0.174	0.648	0.230	0.122	0.105	0.637	0.258
Industry Correlation	0.166	0.166	0.668	0.558	0.320	0.122	0.185	0.156	0.659

(4) Finally, we can use VP model to select the final logistics integrator when the supplier, the manufacturer and the government come to an agreement. At this point, the relevant government experts, using the calculated results in Table 4, construct the VP weighted model, as follows:

$$\text{MinV} = 0.263\bar{d}_{11} + 0.476\bar{d}_{12} + 0.121\bar{d}_{13} + \cdots + 0.110\bar{d}_{51} + 0.109\bar{d}_{52} + 0.083\bar{d}_{53}$$

$$
\begin{cases}
0.595X1+0.277X2+0.128X3+d_{11}^{-}=0.595 \\
0.082X1+0.236X2+0.682X3+d_{21}^{-}=0.682 \\
\ldots\ldots \\
0.166X1+0.166X2+0.668X3+d_{51}^{-}=0.668 \\
0.655X1+0.250X2+0.095X3+d_{12}^{-}=0.655 \\
0.683X1+0.200X2+0.117X3+d_{22}^{-}=0.683 \\
\ldots\ldots \\
0.558X1+0.320X2+0.122X3+d_{52}^{-}=0.558 \\
0.637X1+0.105X2+0.258X3+d_{13}^{-}=0.637 \\
0.163X1+0.540X2+0.297X3+d_{23}^{-}=0.540 \\
\ldots\ldots \\
0.185X1+0.156X2+0.659X3+d_{53}^{-}=0.659 \\
X1+X2+X3\leq 1 \\
Xi=0 \text{ or } 1,\ i=1,2,3
\end{cases}
$$

(5) In EXCEL, we can use the VP weighted model to get the effective solution: $X1 = 1$, $X2 = 0$, $X3 = 0$. So we will choose *X1* as the logistics service integrator in the emergency supply chain.

4 Conclusion

This article attempts to solve the problem of emergency supply chain. We proposed adding logistics services integrators in emergency supply chain, and described the processes of selection of logistics service integrators in emergency supply chain. Finally, we also provided a selection method based on the model of AHP and VP groups-assessment model.

Contrary to conventional researches, our method makes the emergency chain more complete, more systematical and more coordinate. It can also mobilize the logistics integrators to integrate the supply chain fully. It not only considered the government's emergency requirements but also took into account of requirements of suppliers and manufacturers to emergency logistics integrators. In addition, with combination of traditional selected method about integrating logistics integrators, it also proposed to introduce the AHP model and the VP model to apply to the emergency supply chain, and used one special case to make reader clear.

To further, this research offered a feasible way for selection of logistics integrators in emergency supply chain, to provide reference for government departments. How to adjust the selection method of the emergency logistics integrators to specifically evaluation index is the emphasis for future research.

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