Journal of Applied Science and Engineering Innovation, Vol.2 No.9 2015, pp. 372-376
ISSN (Print): 2331-9062
ISSN (Online): 2331-9070

The Study of Logistics Solutions' Choice and Optimization in Emergency Conditions

Ma Xiangguo[1], Jiang Rongfeng[2], Wu Manying [3]

[1] *Beijing Wuzi University, Beijing, China*
[2] *Graduate Faculty, Beijing Wuzi University, Beijing, China*
[3] *Mechanical Engineering Faculty, Tianjin College, University of Science and Technology Beijing, Tianjin, China*

Abstract: This article draws on logistics management and operations research content, integrated use of theory to study the emergency logistics solutions under the conditions of choice, according to the concept of the proposed emergency logistics as well as in domestic and international logistics field application and development, combined with emergency logistics public emergency in the practical application of AHP and gray theory method of emergency conditions, the selection of logistics solutions.

Keywords: Emergency logistics, Analytic hierarchy process, The DEA theory analysis, Scheme selection.

INTRODUCTION

Emergency logistics means to provide the unexpected natural disasters, public health emergencies and other unexpected events for the purpose of emergency supplies needed to pursue maximum profit and losses of time minimizing the target of special logistics activities[Jiuh-Biing Sheu, 2005]. It has a sudden, uncertainty, unconventional, and the weak economy and other characteristics. In the unexpected event occurs, many plan to quickly select from one of the best programs in emergency logistics is an extremely important aspect[Seth D et al., 2007][Chang M S et al., 2007]. Therefore, this application of operations research by studying the level of analysis and gray theory method, an enterprise logistics solutions under emergency conditions to make the best choice to pursue to maximize the benefits of time and the goal of minimizing losses.

Analytical Hierarchy Process (AHP) is presented by the TLSaaty, in the 70s of last century. Because of its decision-making in dealing with complex issues of practicality and effectiveness, AHP is soon widely used in various fields. However, comparison matrix is established by using AHP, only a single target is compared without considering the linkages between indicators. Evaluation indexes of emergency logistics solutions, however, are not independent of each other, and their relations are unclear, but exist, In essence, it is a gray relationship. Therefore, the preplan evaluation system is considered as gray Grey System Theory is mainly for the system model uncertainty, incomplete information under the conduct of systematic association analysis, model construction, through system which not only considers the relative weights of various evaluations index but consider the relationship between the indexes.

DEA is by Chames and Cooper who started in 1978 to create. DEA is the use of mathematical programming model evaluation is more input and more output "departments" or "units" (called the decision unit, JianJi for DMU) between the relative effectiveness (called DEA effective).

Specifically, the DEA is the use of mathematical programming model of decision making units compared between relative efficiency, decision making units to make comments. DEA model is based on the theory of mathematical programming, such as linear programming and its dual theory. At the same time, the DEA and can be regarded as a treatment of multiple input multiple output of multi-objective decision-making method, therefore, it is especially applicable to have multiple input multiple output of complex system.

This article draws on logistics management and operations research content, integrated use of theory to study the emergency logistics solutions under the conditions of choice, according to the concept of the proposed emergency logistics as well as in domestic and international logistics field application and development, combined with emergency logistics public emergency in the practical application of AHP and gray theory method of emergency conditions, the selection of logistics solutions.

BASED ON AHP METHOD OF THE EMERGENCY MODEL OF LOGISTICS SOLUTIONS

AHP Method to Determine Weights of Indicators

Index System and the Establishment of Hierarchy

Currently, the majority of emergency logistics of the program to the main indicators of aging, however, should be considered in practical applications a comprehensive analysis of various targets in order to obtain optimal solution[Huiskonen J, 2001]. In a number of objectives, some are not sure of the value, it is necessary to quantify these qualitative indicators, to avoid errors of estimates based on experience[Drew Fudenberg et al.,2010]. Eventually more objective is needed to be coordinated by the correlation analysis in order to choose the best solution.

In order to make the analysis of emergency logistics system more comprehensive and scientific, this paper presents the following evaluation: ① logistics services , including punctuality, integrity and security; ② logistics costs, including material costs, transportation costs and social environmental costs.

According to the three evaluations above, emergency logistics program evaluation model.

Structure Matrix

AHP proposed by Saaty scale from 1 to 9 of the comparison between the various factors are quantified comparison matrix, the matrix element values are compared the relative importance of the correspondence between the following: ratio of equal importance: a_{ij} =1, a_{ji} =1; A_i is a little more important than A_j; a_{ij}=3, $a_{ji} = 1/3$; A_i is obvious more important than A_j; a_{ij} = 5, $a_{ji} = 1/5$; A_i is much more important than A_j; a_{ij} =7, $a_{ji} = 1/7$; A_i is extremely important than A_j; a_{ij} = 9, $a_{ji} = 1/9$;

The weight Vector Calculation and Consistency Test

By using comparison matrix analysis, the weight values of each index are determined and the characteristic equation $AX = \lambda X$ of matrix A is judged, which λ is the Eigen value of A and X is the feature vector of A.

After normalization, the eigenvectors corresponding to the maximum Eigen value $\lambda_{\max}$ are the sorting weights which the same levels corresponding to a certain level factors have relative importance factor, denoted by the weight vector w . The w_i weight is the relative import degree of various factors. Commonly, the feature vector approximations are calculated by using the summation method.

a) Summation Method

For a consistent judgment matrix, its each column normalized is the corresponding weight vector. When A is inconsistent, each column normalized approximates weight vector. Summation method uses the n column vectors as the arithmetic average of the weight vector.

So, $$w_i = \frac{1}{n}\sum_{j=1}^{n}\frac{a_{ij}}{\sum_{j=1}^{n}a_{kj}} \quad (i=1\ 2\ 3\ \ldots..n),$$

The calculation steps of Summation Method are as follows: ① matrix elements of A normalized by the column; ② the normalized sum of each column; ③ will add up to get the vector divided by n weight vector.

b) Consistency check

To ensure the comparison result that we make non-contradictory and the result of AHP method meaningful, the need for consistency test.

First of all, calculating the consistency index CI,

$$CI = \frac{\lambda_{\max} - n}{n - 1}$$

And, $$\lambda_{\max} = \frac{1}{n}\sum_i \frac{(AW)_i}{W_i}$$

Then, calculated random coincidence rate CR,

$$CR = \frac{CI}{RI}$$

In the above formula, RI as the average random consistency index was the calculated average based on sufficient number of random samples of matrix consistency index. Values of RI are shown in Table 1.

Table 1. Mean Random Consistency Index

Order of Matrix	1	2	3	4	5	6	7	8	9
RI	0	0	0.52	0.89	1.12	1.26	136	1.41	1.46

The method of DEA

DEA is by Chames and Cooper who started in 1978 to create. DEA is the use of mathematical programming model evaluation is more input and more output "departments" or "units" (called the decision unit, Jian Ji for DMU) between the relative effectiveness (called DEA effective).

Its basic method is that treats every valued unit as a DMU, and the valued groups are made up of large numbers of DMU。Supposing that we have to value n DMU, and every DMU has m imports and s exports. Including:

$$X_j = X_{1j}X_{2j}\ldots\ldots\ldots\ldots X_{mj}$$
$$Y_j = Y_{1j}Y_{2j}\ldots\ldots\ldots\ldots\ldots Y_{mj}$$

for every DMU j , j $\in$ { 1, 2, ···, n} .

The C2R model which values the relative availability is as follows:

$$D\varepsilon\left[\begin{array}{l}\min\left[\theta-\varepsilon\left(e^{T}s^{-}+e^{T}s^{+}\right)\right]=V_{D\varepsilon}\\ S.t\sum_{j=1}^{n}X_{j}+S^{-}=\theta X_{0}\\ \sum_{j=1}^{n}Y_{j}\lambda_{j}-S^{+}=Y_{0}\\ \lambda_{j}\geq 0,\ j=1,2,,,,n\\ S^{-}\geq 0,S^{+}\geq 0\end{array}\right]$$

For eT = (1, 1, ···, 1) $\in E_m$, eT = (1, 1, ···, 1) $\in E_s$

If the DEA (C2 R) model did not limit j, then this model belongs to CRS, and can be used to determine whether the system activities are effective from the aspect of technology and scale. If we introduced the constraint condition j=1 ,we would draw another BBC model of DEA, that is the VRS model, which can further judge the returns to scale state of systems activities. If J=1,then the DMU returns to scale is constant, if j<1, means that the DMU returns to scale is increasing; j> 1, the DMU returns to scale is diminishing. When the calculation result of the model shows θ = 1, and S -> 0, S +> 0, the DMU is valid for DEA; θ of ≠ 1, the DMU is invalid for the DEA.

The steps to determine the weight

Using the AHP method to determine weights

After we established the hierarchical structure, every indicator makes pair-wise comparison and builds judge according to the selected scale. By the given matrix we carry on the single-sort level and consistency checking. The single-sort level is necessary to calculate the relative importance of sorted weights of all the factors in the same level for the highest level, i.e. the level of total sort, this process are realized layer by layer from the highest to the lowest level. Finally we get the weights α_i (i = 1, 2 ……..n).

The DEA to determine the weight

Establishing DEA model, we need to translate this model into the linear programming model which we can resort to the dual theory to solve this problem, and get the optimal efficiency evaluation index, finally we could get weights β_i (i = 1, 2 …… n).

Determining the weight by Combination method

Use the formula $\phi_i = \lambda\alpha_i + (1-\lambda)\beta_i$, we can get the total combination weight.

PRACTICAL APPLICATIONS

A company needs to transport washing machines to its distributors peremptorily and formulate three emergency logistics plan. Experts gave the score of the three method based on the above six indicators.

AHP Method to Determine Weights of Indicators

With 1 to 9 scale method to construct the Matrix and the consistency test as follows:

Table 2. Judgment Matrix and Calculation Results of Overall Goal

A	B1	B2	Wi
B1	1	3	0.75
B2	1/3	1	0.25

Note: $\lambda_{\max} = 2$, CI = 0, RI = 0, CR= 0 <0.1

Table 3. Judgments matrix and calculation results of B1, C1, C2, and C3 for logistics services

B1	C1	C2	C3	Wi
C1	1	1	5	0.4545
C2	1	1	5	0.4545
C3	1/5	1/5	1	0.0910

Note: $\lambda_{\max} = 3.0423$, CI = 0.0236, RI = 0.52, CR=0.0454 <0.1

Table 4. Judgment matrix and calculation results of B2, C4 and C5 for logistics costs

B2	C4	C5	Wi
C4	1	5	0.8333
C5	1/5	1	0.1667

Note: $\lambda_{\max} = 2$, CI = 0, RI = 0, CR= 0 <0.1

Table 5. Judgments matrix and calculation results of C1, D1, D2, and D3 for logistics program

C1	D1	D2	D3	Wi
D1	1	3	5	0.6370
D2	1/3	1	3	0.2583
D3	1/5	1/3	1	0.1047

Note: $\lambda_{\max} = 3.0523$, CI = 0.0324, RI = 0.52, CR= 0.0623 <0.1

In the same logic, we can get Judgments matrix and calculation results of C, D1, D2, and D3 for logistics program at table 6.

Table 6. Judgments matrix and calculation results of C, D1, D2, and D3 for logistics program

		C1	C2	C3	C4	C5
Program	**D1**	0.633	0.088	0.429	0.656	0.143
	D2	0.261	0.243	0.429	0.187	0.143
	D3	0.106	0.669	0.143	0.158	0.714

Note: All the judgments matrix and calculation results are effective

So we can draw the conclusion at table 7.

Table 7. Conclusion

Criteria layer 1		B1			B2		Total weight of program
Criteria layer 2		0.75			0.25		
		C1	C2	C3	C4	C5	
		0.455	0.455	0.091	0.833	0.167	
Program level	D1	0.633	0.088	0.429	0.656	0.143	0.418
	D2	0.261	0.243	0.429	0.187	0.143	0.247
	D3	0.106	0.669	0.143	0.158	0.714	0.337

From the table 7 we know that D1 is the best of three programs, so we choose the program D1.

Table 8. The impact factor value of the program

	time（day）	security	Damage rage（%）	Economical costs	Social environment costs
Program 1	1	1	5	6	2
Program 2	2	1	7	6.5	1
Program 3	1.5	1	7	7	3

DEA Method to Determine Weights of Indicators

The establishment of the DEA model

The three programs point to the decision unit DMU 1, DMU 2, and DMU 3.

For the decision unit DMUj (j = 1, 2, 3), punctuality are regarded as output indicator 1, the safety index as output indicator 2, the damage rate as output indicator 3, the economic costs as output indicator 4, social environment costs as output indicators 5. We treat input indicators for the program, all the production unit input indicators are 1. So this problem can be translated into C2R model.

Table 9. The Input and output value of decision units

	Output 1	Output 2	Output 3	Output 4	Output5	input
DMU1	1	1	5	6	2	1
DUM2	2	1	7	6.5	1	1
DUM3	1.5	1	7	7	3	1

$$\max \theta_1 = \frac{u_1 + u_2 + 5u_3 + 6u_4 + 2u_5}{v}$$

$$s\,t\ \frac{u_1 + u_2 + 5u_3 + 6u_4 + 2u_5}{v} \le 1$$

$$\frac{2u_1 + u_2 + 7u_3 + 6.5u_4 + u_5}{v} \le 1$$

$$\frac{1.5u_1 + u_2 + 7u_3 + 7u_4 + 3u_5}{v} \le 1$$

We can solve the linear programming model by Lingo software, and find the optimal efficiency evaluation index $\theta_1 = 0.978$, Similarly we can obtain DMU2, $\theta_2 = 1.00$, DMU3 : $\theta_3 = 0.197$.

The Second step, to seek a combination of weight

Use the formula $\phi_i = \lambda \alpha_i + (1-\lambda)\beta_i$, in this paper, the method of DEA and AHP reflects that the objective and subjective preference of decision-makers is relatively modest, so they chose λ = 0.5, λ can be given based on personal preferences. The combined weights of three options are calculated as follows:

$$\varphi_1 = \frac{0.418 + 0.979}{2} = 0.6985$$

$$\varphi_2 = \frac{0.247 + 1.00}{2} = 0.6235$$

$$\varphi_3 = \frac{0.337 + 0.197}{2} = 0.267$$

This shows that the value of program1 is the maximum, so the program is more reasonable.

CONCLUSION

This paper studies Emergency Logistics mechanism and emergency logistics system, treats qualitative and quantitative analysis as the guiding ideology, applies creatively DEA and AHP to the emergency logistics solutions selection. By Introducing gray correlation analysis, we can overcome defects which various indicators are independent when we use the Analytic Hierarchy Process between, the combination of AHP and DEA method not only takes the subjective indicators weight into account, also applies the weight of objective indicators, makes the evaluation process free of subjective factors to some extent, and the workloade is reduced.

By studying emergency logistics examples, we can prove that the combination of AHP and DEA method is valuable in solving the practical emergency logistics solutions problems.

In this paper, we can not only enhance the accuracy of the program, and also provide a new method for the choice of logistics solutions under emergency conditions.

ACKNOWLEDGEMENT

This work was supported by Beijing 2015 annual Social Science Fund Project for Research on the Reserve Problem of Emergency Resource in the Context of Beijing-Tianjin-Hebei

Integration (NO: 15JGB071). As the same time, this work was supported by Beijing Wuzi University 2014 annual Youth Fund Project for Performance Analysis and Simulation Optimization of AS/RS (NO: 054140301003) and was also supported by the Funding Project for Youth Talent Cultivation Plan of Beijing City University under the Grant

Number (CIT&TCD201504051) and the Training Project of Beijing Key Laboratory (NO: BZ0211).

REFERENCES

Chang M S, Tseng Y L, Chen J W. A scenario planning approach for the flood emergency logistics preparation problem under uncertainty[J]. Transportation Research Part E: Logistics and Transportation Review, 2007, 43(6): 737-754.

Drew Fudenberg, Jean Tirole Game theory [M]. China Renmin University Press,2010,10.

Huiskonen J. Maintenance spare parts logistics: Special characteristics and strategic choices[J]. International journal of production economics, 2001, 71(1): 125-133.

Jiuh-Biing Sheu. Special Issue on Emergency LogisticsManagement Transportation Research Part E: Logistics and Transportation Review [J] 2005, 41:459-460.

Seth D. guikema,Ningxiong Xu,Rachel A. Davidson, etc .Optimizing scheduling of post earthquake electric power restoration task[J]. Earthquake Engineering and Structural Dynamics .2007(36).