Reliability research on dynamic logistics alliance based on GO methodology

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Received 1 October 2013, www.cmnt.lv

Abstract

In order to calculate the reliability accurately and dig out the dominant influencing factors of dynamic logistics alliance, GO methodology is applied in reliability research on dynamic logistics alliance. Through building the structure model of dynamic logistics alliance, failure factor of each subsystem is diagnosed. With the GO methodology, the dynamic logistics alliance is transformed into the GO chart, the system reliability is calculated in detail, its failure mode diagnosis and importance calculation are quantitatively studied and then a case of automobile dynamic logistics alliance is employed to verify GO methodology for effectiveness and validity.

Keywords: dynamic logistics alliance, system reliability, GO methodology, influencing factor, failure mode

1 Introduction

Currently, Dynamic Logistics Alliance (DLA for short) has always been one of the hot fields of logistics. As the most competitive logistics operation model in the 21st century, it is a complex organization, which is involving multiple logistics cooperation, dynamic, uncertainty. In this paper, the research is from perspective of logistics service integrator. Logistics service integrator can not only provide a comprehensive logistics operation solution for the customer, also have a strong ability to integrate logistics resources [1]. Due to complexity and uncertainty in the integration process of the DLA, it has exposed some problems, such as low alliance' stability, high integration cost, poor information and other issues. In order to improving the operational efficiency and digging out the dominant influencing factors of DLA, we need study the reliability of DLA. Reliability is used to measure the probability that the DLA integrate the logistics resources to complete the logistics tasks in accordance with customer needs within a specified period of time. Research scholars about the reliability of the logistics system has focused on logistics network systems and specific logistics (including military logistics and emergency logistics), these documents always is created complex mathematical models and solved very difficult. Chen A [2] studied the reliability of Military Logistics in the war, ÁrniHalldórsson [3], Wang N [4], Yu X C [5] studied the reliability of the logistics network, or system. Chen J [6] designed regional emergency logistics network based on reliability analysis. But reliability problem about DLA, which include reliability' calculation and factors, are studied very little, and it is very necessary to find a method to study the reliability problem about DLA.

GO methodology is a system probability analysis technique, which is success-oriented, its' main steps is to step up the GO chart, and calculate the system reliability. The two factors of GO chart are Operator and Signal flow. Shen Zupei [7] has described the 17 Operators and its Algorithms. Operator represents the logical relation between unit functions and input, output signals. Signals flow represent the association between system unit and its input, output signals, the attribution of Signals flow is state value and probability. Currently, the application of GO methodology is mainly focused on reliability analysis of complex repairable machine, equipment and other hardware systems [8-11].And the GO methodology is also used in reliability of supply chain systems, emergency management systems, etc [12-15]. DLA is a system, which is more complex, dynamic than general logistics system. Each subject and logistics resources in the process of operation are likely in a variety of state, so the reliability study of dynamic logistics alliance using the GO method is feasible.

In view of this, we will use the GO method to study the reliability of DLA. Through comprehensively analyzing the subsystem in the DLA, such as logistics services integrator, strategic logistics resource provider, common logistics resource provider and client, some important factors are analyzed which leads to their failure. The GO model, which is used to diagnosis the reliability of the DLA, is established with GO method, and it provides a new idea for the reliability analysis of DLA.

2 Application of GO method in the DLA reliability

2.1 STRUCTURE MODEL OF DLA

For researching simply, first of all, the structure model of DLA must be assumed. DLA, which take logistics services integrator as the core, include logistics services integrator, functional logistics resource providers, clients and other units. Logistics service integrator integrate logistics resources of various functional logistics resource provider and provide all kinds of high level, low cost, on time logistics service to customers. The structure model of DLA has been

constructed based on core competitiveness of the enterprise and resource advantage, which is shown in Figure 1.

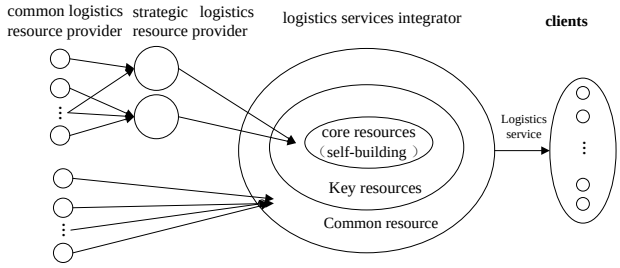


FIGURE 1 The structure model of DLA

In Figure 1, according to the own ability and the strategy need of logistics service integrators, we divide all kinds of logistics resources into core resources, key resources, and common resources. In order to maintain the core competitiveness of enterprises, logistics services integrator usually build the core resources by themselves. Because of the great influence of key resources, logistics services integrator is generally associated with some important partners (strategy resource providers) to get strategic cooperation mode. Common resources is the basic resources to achieve customer demand, and logistics service integrator is usually in the form of outsourcing to establish common trading partnership with other common resource provider. Strategic resource providers also have capability to integrate logistics resources.

2.2 FACTORS ANALYSIS OF FAILURE DIAGNOSIS ABOUT DLA

From the perspective of system operation, DLA includes subsystem, such as logistics services integrator, client (Group), strategic resource provider, general resource provider. To ensure the successful operation of dynamic logistics alliance, each subsystem must keep normal state. The dominant factors of supply chain cooperation from two aspects of hardware and software is given in the literature [16]. From two aspects of soft and hard environment, important factors affecting the successful operation of DLA is summed up, which is in the Table 1.

2.3 THE GO CHART ESTABLISHMENT OF DLA

Based on the structure model of DLA and the factor of each subsystems, we have established a GO chart about DLA, as shown in Figure 2.There are two operator symbols: the fifth (signal generator) and the tenth (And gate), which make the realization of computer programming and automation calculation conveniently.

The illustration of operator symbols:

$Y_{ij}(i=1,2\cdots m,\ j=1,2,\cdots 8)$: the influencing factor j of common resource supplier i of strategic resource provider;

$X_{pq}(p=1,2\cdots e,q=1,2,\cdots 8)$: the influencing factor q of common resource supplier of logistics services integrator;

$Z_{bt}(b=1,2\cdots n,t=1,2,\cdots 8)$: the influencing factor t of strategic resource provider b ;

$J_k(k=1,2,\cdots 8)$: the influencing factor k of logistics resource integrator;

$C_{ar}(a=1,2\cdots d,r=1,2)$: the influencing factor r of customer a .

In the signal flow, Y_{ij}, X_{pg}, Z_{bc}, J_k, C_a respectively represent their signal flow number. The signal issued by input operator is according to the respective operation symbol stream, and other signal flows are in numerical order from small to large order.

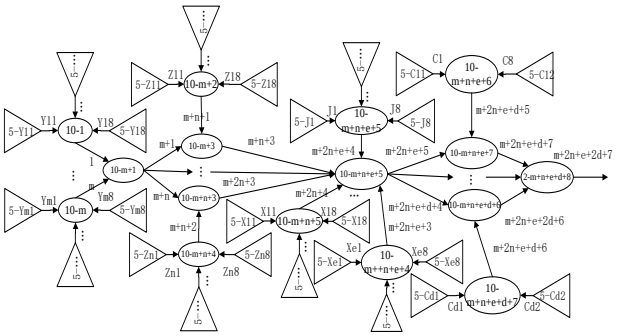
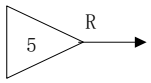


FIGURE 2 The GO chart of DLA

2.4 GO METHODOLOGY CALCULATION OF DLA RELIABILITY

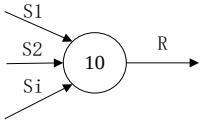
DLA is a two-state system, there are only two states in the input operator: success and failure. Meanwhile the operator symbol has two types: type 5 and type 10.The intermediate operator symbols of GO chart about DLA (Figure 2) are all logical operator symbols, so the quantitative calculation are more convenient. Suppose that the successful state of input operator is 1, the failure state is 0, so the signal flow only has successful state 1 and failure state 0. Suppose the probability of success for the operator symbol as $P(S=1)$, the probability of failure for the operator symbol as $P(S=0)$, the probability of the output signals as $P(R)(R=1 \text{ or } 0)$. The algorithm of 2 types of operator symbols in the GO chart about DLA is shown as follows:

1) Single signal generator (type 5)



State probability of output signal in single signal generator is the operator of state probability.

2) And gate (type 10)



When there is one failure of N independent input signals, the output signal is failure, the algorithm is as follows: the success probability of the output signal is

$$P(R=1)=P(S1=1)P(S2=)...P(Si=1)$$

Failure probability:

$$P(R=0)=1-P(S1=1)P(S2=)...P(Si=1)$$

According to the above algorithm, starting from the input signal of the input operator in the GO chart about DLA, the calculation is operated according to the operation rules of an operator, and get the state probability of the output signal. In accordance with the signal flow sequence in the GO chart, the state probability of each output signal are gradually calculated, we can conveniently calculate the state probability of the final output signal, namely the reliability of DLA.

2.5 DETERMINATION AND IMPORTANCE DEG-REE CALCULATION OF DLA FAILURE MODE

The determination of dynamic logistics alliance failure mode is mainly to determine the minimum cut sets of DLA. For DLA, the two states of the system, can be directly applied to the quantitative calculation method for qualitative analysis to get the minimal cut sets. The methods are as follows: for the 1 order cut set, as long as suppose that one operator in M operators is in a failure state and the probability of success is 0, the other operator symbol keep the same, and the system success probability is directly calculated. If the probability of success is 0, the fault state of the operator symbol is a one-order cut set of a system. M operators are calculated successively and one-order cut sets can obtained. Then we take 2 operator symbols out of M operators except the one- order cut set, and use the same method to get all of the two-order minimum cut sets. And so on, each order cut set can be got. For higher order cut sets, if high order combination already contains low order cut set, it will not need to calculate system success probability, then cut set is the minimal cut sets [8]. This method is easy to programming and it can also realize the automatic calculation of complex system.

Combination of operator symbol failure states in the minimal cut set represents the combination of the system functional subsystem failure event, the product of failure probability of these subsystems represents a minimum cut sets of probability. The probability of the minimum cut set can be used to evaluate the important degree of minimal cut sets, so as to system optimization.

In the DLA, including logistics services integrator, customers, strategic resource provider, common resource providers and other subsystems, so the DLA failure mode has 1 order, d order, n order, m+e order minimum cut sets. One-order cut set is mainly determined by the influencing factors of logistics resources integrator. D-order cut set is the main collection, which is composed by one factor of each client's customers in d customers, n order cut set is mainly consisted of one factors of each strategic logistics resources provider in providers, m+e order cut set is mainly consisted of one factors of each common resource provider in m+e providers.

3 Application case

3.1 THE BASIC SITUATION

There is a automobile dynamic logistics alliance, whose core is a third party logistics company, which consists of 4 common resource providers (Y_1, Y_2, X_1, X_2), 2 strategic resource providers (Z_1, Z_2), 1 logistics resource service integrator (J), 3 customers (C_1, C_2, C_3). Through the cooperation with the quality department of the company, we statistics particular data of operation situation of the system in July 2012 to October 2013 during the implementation of logistics task 120 times, and use the fish bone diagram method to analyze the abnormal problem, and various reasons are classified and analyzed to obtain quantitative failure probability as shown in Table 1, Table 2, Table 3.

TABLE 1 Failure probability of logistics services integrator

Influencing factors	*J*
The poor ability of anti-risk inside and outside	0
adjustment difficulty about enterprise management mode, organization structure, business process	0
The high cost of logistics alliance cooperation	0.07
The unreasonable operation plan of DLA	0
Low coordination ability to enterprise resource provider	0
Unsmooth information communication	0.04
weak control of the operation process of DLA	0
Imperfect Logistics network/equipment	0

TABLE 2 Failure probability of strategic resource provider

Influence factors	Z_1	Z_2
The poor ability of anti-risk inside and outside	0	0
adjustment difficulty about enterprise management mode, organization structure, business process	0	0
The unreasonable operation plan of logistics alliance	0	0
The low alliance income about participation in logistics cooperation	0.03	0.07
poor convergence of information	0.09	0.04
Poor execution force of logistics personnel	0	0
Low level of Logistics service technology	0.06	0
Imperfect Logistics network / equipment	0	0

TABLE 3 Failure probability of common resource providers and Clients

	Influence factors	Y_1	Y_2	X_1
Common resource provider	The poor ability of anti-risk inside and outside	0.06	0	0
	adjustment difficulty about enterprise management mode, organization structure, business process	0	0	0
	Low profits of participation in the integration of logistics resources	0.07	0.06	0.08
	Unreasonable logistics task operation plan	0	0	0
	Unsmooth information communication	0.05	0.07	0
	Pool executive force of logistics management and operating personnel	0	0	0
	Low level of Logistics service technology	0	0.08	0.04
	Imperfect Logistics network / equipment	0	0	0
	Influence factors	C_1	C_2	
Clients	The change degree of Customer demand plan	0.04	0	
	The smooth degree of Customer information communication	0	0.06	

3.2 RELIABILITY ANALYSIS OF DLA BASED ON GO METHODOLOGY

3.2.1 The establishment of GO chart

Combining each subsystem structure of the dynamic logistics alliance and each subsystem failure situation, DLA GO chart is established (Figure 3). The factor whose probability

of failure is 0 has no influence on the system reliability calculation, so it will not be put in the GO chart.

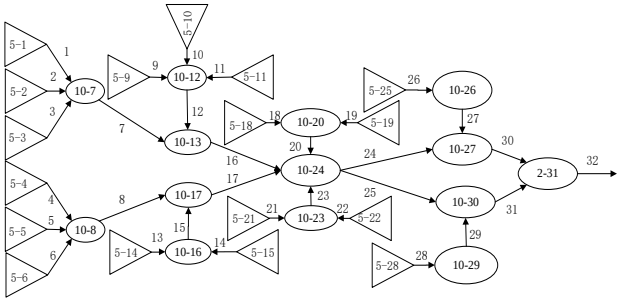


FIGURE 3 Automobile logistics alliance GO diagram

3.2.2 Probability Calculation of each signal flow

In Figure 3, according to the operation rules of GO chart and signal flow order in the GO chart, the reliability degree of output signal in dynamic logistics alliance are calculated, the ultimate output signal 32 represents the reliability of dynamic logistics alliance. The calculated results are shown in Table 3, in which the calculation of signal flow 32 involves a total signal flow, which is shown in reference [8].

In Table 4, we can find the reliability of dynamic logistics alliance is not high, only 0.4823, which is obviously related to multi-system structure of the dynamic logistics alliance and the complex operation process, so it is necessary to find out the key factors restricting the dynamic logistics alliance reliability, so as to improve and have better control it.

TABLE 4 The calculation results of DLA reliability

Signal flow	P	Signal flow	P	Signal flow	P
1	0.9400	12	0.8297	23	0.8832
2	0.9300	13	0.9300	24	0.3923
3	0.9500	14	0.9600	25	0.3923
4	0.9400	15	0.8928	26	0.9600
5	0.9300	16	0.6928	27	0.9600
6	0.9200	17	0.7181	28	0.9400
7	0.8305	18	0.9300	29	0.9400
8	0.8043	19	0.9600	30	0.3766
9	0.9700	20	0.8928	31	0.3688
10	0.9100	21	0.9200	32	0.4823
11	0.9400	22	0.9600		

3.2.3 Determination of the minimal cut set and important degree calculation

The composition of the DLA of minimal cut sets is shown in Table 5, probability of cut set is obtained by the product of the failure event probability, the important degree represents the percentage of the cut set failure probability for total system failure probability. The larger importance degree means the larger impact on the system for the factor, and then it should be the focus of attention.

Table 5 shows that the importance degree in the first place is cut set composed of No. 18 operator, namely logistics alliance cooperation cost of logistics service integrator is high, up to 51.19%, which is the most important factors of logistics alliance operation, it is in accordance with the current logistics services integrator's concern (logistics cost) and cost of resources integration. The important degree in second place is cut set composed of No.19 operator, namely the bad information communication of logistics service integrator, reached to 29.25%. The important degree in third place, fourth place are composed of No. 10, No. 14 operators cut sets and No. 11, No. 14 operators cut sets, namely strategic resource provider's 'poor information convergence', 'low income from participation in the logistics alliance cooperation', 'low level of logistics services technology', in turn, we can determine the factors which we should pay more attention on the operation process of DLA. And it provides ideas and basis for the improvement and optimization of DLA.

TABLE 5 The minimum cut sets and the important degree

Order number	Operator number in Cut set	Cut set probability (10^{-2})	Important degree
1	18	7	51.19%
1	19	4	29.25%
2	9,14	0.21	1.54%
2	9,15	0.12	0.88%
2	10,14	0.63	4.61%
2	10,15	0.36	2.63%
2	11,14	0.42	3.07%
2	11,15	0.24	1.76%
2	27,28	0.24	1.76%
3	1,4,21	0.0288	0.21%
3	1,4,22	0.0144	0.11%
3	1,5,21	0.0336	0.25%
3	1,5,22	0.0168	0.12%
3	1,6,21	0.0384	0.28%
3	1,6,22	0.0192	0.14%
3	2,4,21	0.0336	0.25%
3	2,4,22	0.0168	0.12%
3	2,5,21	0.0392	0.29%
3	2,5.22	0.0196	0.14%
3	2,6,21	0.0448	0.33%
3	2,6,22	0.0224	0.16%
3	3,4,21	0.024	0.18%
3	3,4,22	0.012	0.09%
3	3,5,21	0.028	0.20%
3	3,5,22	0.014	0.10%
3	3,6,21	0.032	0.23%
3	3,6,22	0.016	0.12%
Total			100%

5 Conclusions

Due to the characteristics and advantages of GO method, more and more attention and application in the enterprise and scholars are gradually done in recent years. In this paper, through the establishment of DLA structure model, and the diagnostic analysis of failure factors, we established the GO chart model of DLA reliability using the GO method. This model not only can accurately calculated the reliability of system, but also can diagnose and calculate the important degree of failure mode of DLA, at the same time the calculation of the method is simple, easy to programming.

The reliability analysis of DLA through GO method, can not only calculate the reliability of DLA and the reliability of each subsystem, but also can find the factors that restricts the successful operation of the DLA, which provides important basis for the improvement of the reliability of dynamic logistics.

Acknowledgments

This paper is supported by the Science and Technology Research Project of Chongqing Municipal Education Commission (Grant No. KJ1400415). The youth scientific research project of Chongqing University of Posts and Telecommunications (Grant No. A2013-34), the doctoral start-up fund of Chongqing University of Posts and Telecommunications (Grant No. A2013-20), Chongqing science and technology project (Grant No. cstc2012gg-yyjs80024) and the open Fund of Chongqing E-commerce and Modern Logistics Key Laboratory (NO. ECML201404).

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