Study on Task Decomposition in Emergency Logistics based on System Dynamics

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Abstract: It analyzed several key factors by system dynamics that the task decomposition in emergency logistics impact on dynamic alliance of logistics. These factors included inter-constraints, quality of cooperation, collaboration time, ability to adapt with each other, core capabilities of logistics. To establish diagram and system dynamics model, it can forecast and analysis disadvantages of task decomposition in emergency logistics. It can for the government emergency management to provide strategic adjustment decision support. On this basis, it simulated the task decomposition of system dynamics model on dynamic alliance of logistics by EXCEL, tested and verified this way was a feasible approach.

1 INTRODUCTION

When unexpected events occurred, government organized the dynamic alliance of logistics quickly for transporting emergency supplies. Their primary job is to break down the missions into several sub-tasks, and then look for federates of dynamic alliance of logistics for each sub-tasks. In the process, the government should consider which way is the best of task decomposition.

The extent of task decomposition determines the number of federates in logistics dynamic alliance adapt to the emergency incident, the different running status of logistics dynamic alliance, and the success or failure to the emergency task ultimately. But the extent of task decomposition influence by many indicators, such as the mandate of the total stipulated completion time, each sub-task stipulated completion time, the working ability in core part of task, and ability to adapt to each other. It should be used to the co-ordinate system for ensuring access to the optimal task decomposition scheme.

When unexpected event occurred, the management system of emergency logistics is a non-stable, non-equilibrium dynamics of the process system. It should not be used the way as solve stable systems to resolving such issues. The system dynamics is to study the behavior of complex feedback systems in the computer simulation method, it can start from the system as a whole, find and study of related factors within the system. It also can focus on the dynamics of process and causality in logistics system, and to solve complex problems in a non-complete non-state analysis of information (Hu et al., 2006).

Currently, it has a lot of studies in task decomposition, particularly in large enterprises and multi-enterprise collaboration between departments in manufacturing. Pi (2006) studied and explored the significance and role in task decomposition of aerospace; Chen (1998) focused on analysis of task decomposition in the Boeing Commercial Aircraft Manufacturing Engineering System; Hu et al. (2005a) proposed the optimization of the virtual enterprise partner selection model based on the task decomposition, and the same year, she proposed process of building a virtual enterprise framework based on task decomposition (Hu et al., 2005b); Zhang et al. (2007) addressed a multi-level projects across the enterprise network planning method based on task decomposition, to solve multi-level program consistency problem in cross-enterprise projects.

This article built a dynamic alliance of logistics simulation model of task decomposition, with the impact of the relationship between the relevant indicators based on system dynamics theory .Finally, it discussed the model simulation results and applications.

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2 THE ANALYSIS OF THE CAUSAL RELATIONSHIP IN TASK DECOMPOSITION OF EMERGENCY LOGISTICS

Use of system dynamics to build the flow of causal relationship diagram, It can effectively express the relationship of system feedback, and identify the location of the proper task decomposition. In the process of task decomposition of logistics dynamic alliance, the quality of cooperation, collaboration time and so on, can be affected by many factors, such as logistics facilities and equipment damage, road conditions after expected events, government policies, as well as the impact from different quality of the federate and so on. According to the causal relationship between the determinants, and being combined with other variables in the decomposition of the project, it used VENSIM to build system flow diagram, shown in Figure1.

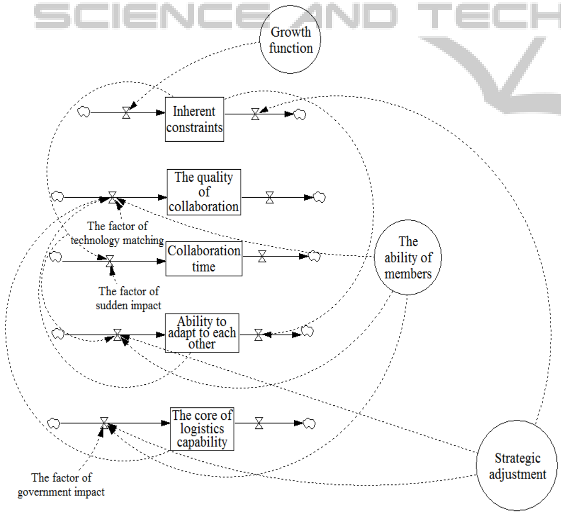

Figure 1: The flow chart of causal elements in emergency logistics task decomposition.

It is usually that the more federates the more bindings. To be targeted strategic adjustments timely, such as replace members of union, can improve the collaboration efficiency and adapt of ability, and prevent the growth trend of inherent constraints in logistics dynamic alliance. But at the same time, the completion time of task will be extended, and emergency supplies cannot be delivered on time. It can bring many dangers to the people in disaster areas and the losses of economic.

3 CONSTRUCTION OF SYSTEM DYNAMICS MODEL

Logistics dynamic alliance is an organization which be needed to maintain close between logistics enterprises. It requires federates matched hardware and software resources. With the increasing number of federates, the demanding of breakpoints have become increasingly in the supply chain. It expressed as the increasing of intrinsic constraints.

Based on this consideration, this paper modified the Pearl curve model, the formula is expressed as:

$$y = \frac{K}{1+ae^{-b(n-1)}} \tag{1}$$

In here, “n” is expressed that the required total number of enterprises in a particular task of emergency logistics alliance, and it takes a positive real number. The “k” is the limit of the “y”, and it takes “50”. “a” and “b” are the model parameters, and it takes that “a” is “1”and “b” is “1”.

In addition, it should be noted that the followings, such as: if it has only one company in alliance (n = 1), at this time, that means “y” is “25”, this is the minimum constrains; but with the increasing number of federates, the increasing “y” was, and the “50” is assumed maximum constrains of “y”.

It uses DYNAMO language to the identity (Zhao, 2010). “K” is the current moment and “J” is the last moment. “DT” said that the steps between “K” and “J”. It makes “DT” is “1” initially, and you can adjust it in the actual simulation process.

Conveniently, it will use the letters to replace each variable, as shown in Table 1:

Table 1: The alphabet of variable corresponding.

Letters	Variable
A	Inherent constraints
B	The quality of collaboration
C	Collaboration time
D	Ability to adapt to each other
E	The core of logistics capability
M	Strategic adjustment
N	The ability of members
SF	The factor of sudden impact
GF	The factor of government impact
TF	The factor of technology matching

With the causal relationship in Figure 1, the alliance model is expressed as:

$$pearl(n) = \frac{K}{1 + ae^{-b(n-1)}} \tag{2}$$

With the increasing number of federates, the inherent constraints is growth. To reduce the inherent constraints, government can make strategic adjustments to the members of logistics dynamic alliance. Shown as:

$$A.K=A.J+PEARL\ (n)\ -M \tag{3}$$

The growth of the quality of collaboration will be affected by ability to adapt to each other, the core of logistics capability, and the factor of technology matching. Shown as:

$$B.K=B.J+DT^{*}\ (D.J+E.J+N+TF) \tag{4}$$

With the increasing of inherent constraints, the collaboration time is increased. In addition, some unexpected event will lead to collaboration time changes. Shown as:

$$C.K=C.J+DT^{*}\ (A.J+SF) \tag{5}$$

Ability to adapt to each other is mainly affected by the ability of members and the factor of technology matching. In addition, it also can be influenced by the government and inherent constraints. Shown as:

$$D.K=D.J+DT^{*}\ (N+TF+M-A.J) \tag{6}$$

The core logistics capabilities can be influenced by the decision of government. in addition, it can be also affected by the strategic adjustment, and the ability of members. Shown as:

$$E.K=E.J+DT^{*}\ (M+N+GF) \tag{7}$$

4 SIMULATIONS

4.1 Realization of the Simulation

It used EXCEL to achieve the model simulation.

The initial value of variable represents the initial state of the system. According to the actual input, these variables will be simulated by iterative changes to future operating conditions of dynamic alliance of logistics. The flow diagram of system dynamics, which used in the characteristic parameters of the reaction system, should be depended on specific characteristics of dynamic alliance of logistics in the simulation.

After the simulation running, firstly, it was input the initial value of variables. Then, it can be set parameters to simulate the actual situation according to the special. By view of output value and table, future running of the dynamic alliance of logistics can be mastered. After the model data generated, the data generated will be out of the curve form of visual representation.

4.2 Example

It selected the representative data form one particular Union in the task decomposition stage, shown in Table 2, and selected the other parameters for model to do the initial value of iteration. Here, "n" is "10".

Table 2: The table of initial value of each variable in Table.

Variable	A	B	C	D	E
initial value	0	20	50	10	20

The data listed in Table 2 is designed to verify the validity of the model of artificial data. In practice, the representative from government and dynamic alliance of logistics enterprises provided the data and input to the program according to the actual. By the simulation of the data in Table 2, the output of the model can express the relative value of each factor trends. It verified that system dynamics model created whether show the effectiveness of impact of relationships between the task decomposition and the evaluation factors or not. And it also verified whether can achieve the best solution by application of this model. Put the data in Table 2 into EXCEL and get changes in each index. Shown as Figure 2.

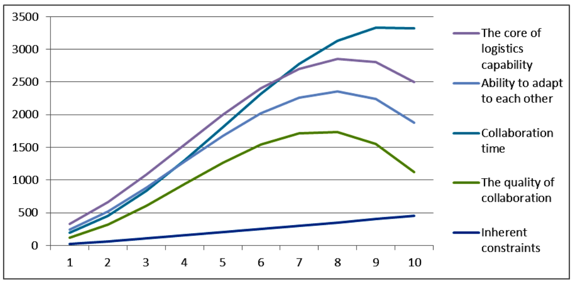

Figure 2: The changes map in each index to model.

The simulation results of the analysis of the figure:

(1) Adding a degree of inherent constraints will bring the improving of the quality of collaboration. However, when the alliance members to a certain amount of time, the quality of collaboration will deteriorate. The ability to adapt to each other also will be bad.

(2) Internal constraints may not necessarily bring about the extension of time collaboration. As

members of the co-ordinated, but to a certain extent, increasing of the number of members will cut down the collaboration time.

By validated, it can illustrate the feasibility of this model. This model can provide some reference value of information to the government in the extent of the emergency task decomposition.

4.3 Significance

Mainly reflected in two aspects:

(1) Some person from emergency management department of government and dynamic alliance of logistics are in charge of discussing to achieve the initial values of variable. Next to simulation, it can be given the optimal extent of decomposition. Then informed of the operational status of the future trend of alliance, it can help the government have more in-depth grasp of the dynamic alliance of logistics.

(2) When the emergency of task decomposition cannot be changed, it can design a set of strategies of different intensity adjustment programs and put it simulate together with the current of initial value from logistics alliance. This has been a different result set. From these results, select a few good according to the logistics alliance needs and the strategic adjustment of the corresponding intensity is the best solution. It can provide a basis for strategic adjustment in emergency management for government.

5 CONCLUSIONS

This text used the method of system dynamics to construct modeling and simulation studies in task decomposition of dynamic alliance of logistics in the supply chain of emergency. Based on analysis of the key elements of the task decomposition of causality in dynamic alliance of logistics, it established a causal flow diagram and system dynamics model. And furthermore, it used random data to achieve the simulation in EXCEL. As can be conclude from the simulation results, the design of the model can express the causal relationship between the key factors of the task decomposition in emergency logistics effectively. The conclusion is in line with the operation of conventional dynamic alliance of logistics.

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