The Modeling Research on the Cost of 3PL Transportation Based on System Dynamics

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Abstract. In this paper, we analyse the structure of third-party logistics cost. We specially analyzes influence factor of transportation cost which account for 1/3 to 2/3 of the third-party logistics from the view of system dynamics. We establish the system dynamics model of transportation cost, and further more, we give the Vensim equations and explanation for it.

Introduction

Nowadays, with the increasing of social division of labor, logistics has become important industry in many countries. It has been key winning factor in military, economic, technology and sports competition. Nevertheless, in China, the logistics cost accouts for 40% in the whole process of production[1]. This paper takes aim at the transportation cost of third-party logistics(we call it 3PL for short), establishes the simulation model form the view of system dynamics.

Structure of 3PL Cost

In the process of logistics, it will take up activation labour force and materializing labour in order to provide relevant services. We call the monetary form of these labour logistics cost, or logistics expense[2]. The 3PL business includes transportation, storage, load and unload, packing, delivery, distribution processing and information service that have the close relationship. We can regard these 7 basic functions and personalized service as intangible products of 3PL. And the expense on these products is 3PL cost.

In the actual operation, the 3PL enterprise services mostly concentrate on traditional transportation and warehousing. Even if the 3PL provides complete logistics services, transportation usually represents the largest single cost which accouts for 1/3 to 2/3 in logistics total cost for most corporations. The cost of inventory function which has close relationship with transportation and plays an equally important role accounts for 30% of the total cost of the 3PL system[3]. Therefore, it can be said that transportation and inventory functions are the key factors in logistics system to reduce cost and increase economic benefits, they are also the bottleneck that can restrict 3PL development. Due to the different function of 3PL system has the different influence and the paper length is limited, we mainly aim at the transportion cost systems for modeling that accout for larger porportion in 3PL cost.

The Basic View and Method of System Dynamics

System dynamics is a interdiscipline subject which bases on system theory, drain feedback theory and Information theory, with computer simulation technology. It is also an edge discipline that solves system problems and communicates natural science and social science. It is a branch of system science. System dynamics can analyse problems with qualitative and quantitative methods and simulate and analyse system dynamic behavior with simulation technology. This simulation is fit to study complex system changes with time.

The Basic View of System Dynamics. System is composed of unit, unit movement and information. The basic unit of system is the feedback loop. Any complex system is composed of these interactional feedback loops that perform the whole system function. We can assort these feedback into positive feedback and negative feedback according to the characteristics of the feedback process. Positive feedback characteristic is able to produce self-reinforcing mechanism while negative feedback characteristic is able to produce self-inhibit mechanism. The crossed mechanism of positive and negative feedback loop determines the behavior of complex system.

First, we should make clear the key variable of the system and analyze the interactional relationship among them. According this, we can draw causality diagram. Secondly, with the help of the diagram, we can make the system modeling and formulation in order to analyze the structure of the system and the process of behavior changes.

The Steps of System Dynamics for Problem solving. There are mainly three steps. First, we should systematically analyze the object using system dynamics theory, principle and method, make modeling purpose clearly, divide the main problems of the system, delimit the boundaries of the system, confirm the main varibales. Secondly, establish mathematical and standard model and test the validity of it. Finally, simulate and make policy analyses by using computer.

The Introduction of System Dynamics Simulation Language Vensim. System dynamics has its simulation languages. Of all, Vensim is generally accepted as functions optimal, widely used software. It is based on Windows interface, provides powerful graphics editing environment, form out all causality among varibales with tree diagram. It can perform all of the feedback loops in the model, and show the figures of all the varibales in the whole simulation cycle with graphics form. Its main characteristics show as follows: Modeling under Windows interface. The output information is very rich. It provides various analysis methods. It can undertake authenticity test.

The Modeling Research on 3PL transportation cost Based on System Dynamics

As it mentioned above, the 3PL services includes transportation, storage, load and unload, packing, delivery, distribution processing and information service. But in actual operation process, transportation cost usually represents bigger cost. So we mainly aim at the transportion cost systems for modeling that accout for larger porportion in 3PL cost.

Modeling Purpose. The transportation cost accounts for 3PL cost almost more than half. The reduction of one logistics activity cost may cause increase of the other logistics activity cost because of the tradeoff. So the modeling purposes of this paper are as below.

Analyse the internal and external factors of 3PL transportation. Form the model structure and quantitative relationship of the varibales.

Establish the model which runs under Vensim system. Input data, simulate transportation system costs change, analyse the data and give policy advice.

3PL Transportation Cost System Model and Vensim Equation Explanation. Transportation cost is composed of two parts. The first is the product of freight volume and transportation rate. Freight volume is influenced by transportation demand growth rate per month. Transportation rate is influenced by actual stowed rate, transportation distance, freight volume and inventory in transit. The second is freight damage cost which is dertermined by freight damage of each transportation as shown in figure 1.
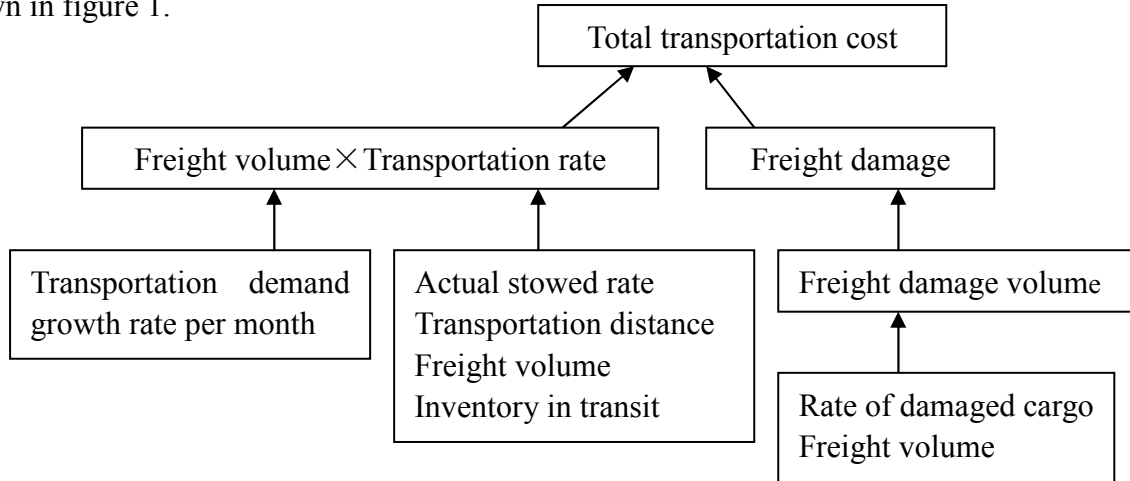

Fig. 1 The relationship of the key variables in transport system

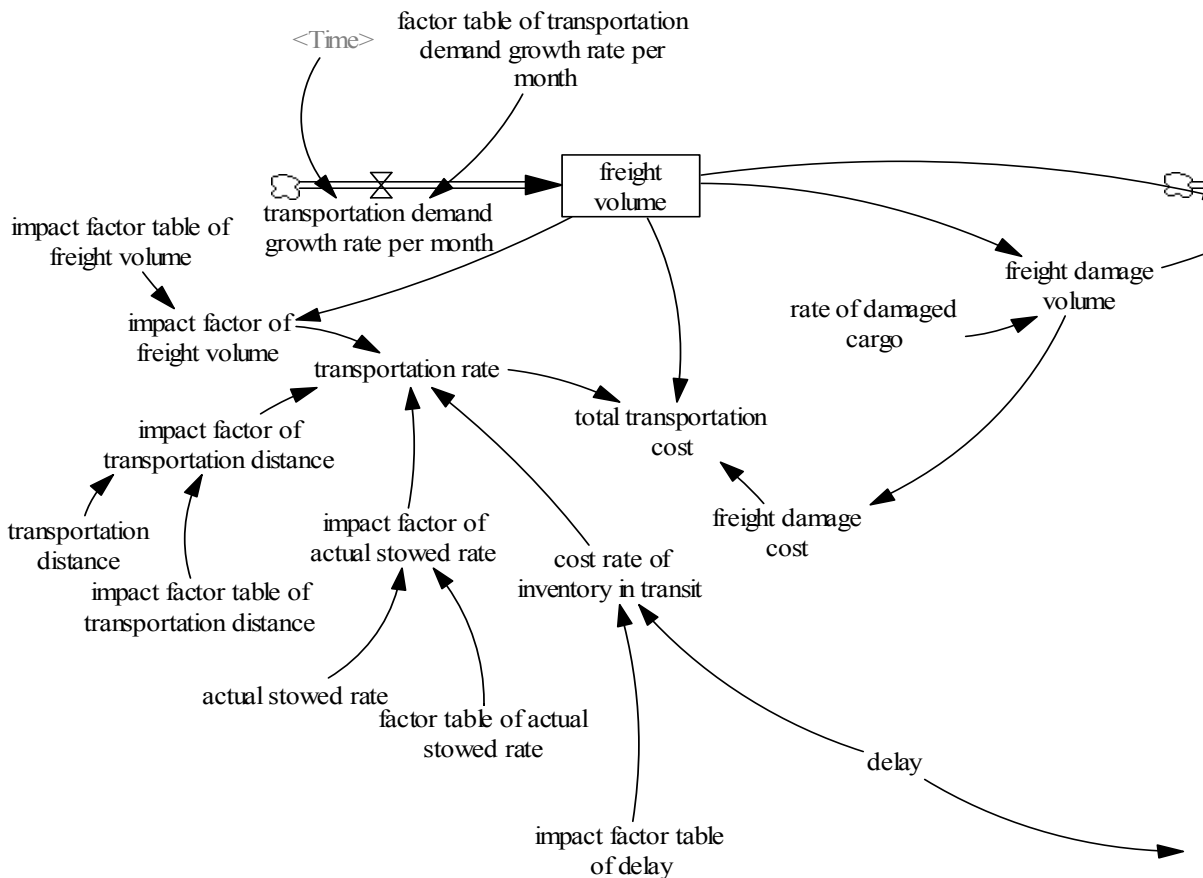The model of 3PL transportation cost system is shown as figure 2.

Fig.2 The flow graph of 3PL transportation cost system

The explanations of Vensim equations are as follows.

The box in the model represents that freight volume is a state variable. The equation is as follows.

$$\text{freight volume} = \text{INTEG(transportation demand growth rate per month}, a) . \tag{1}$$

Dimension unit: piece. It represents that freight volume is integration of transportation demand growth rate per month.

Transportation demand growth rate per month is the rate variable of freight volume. The model defines transportation demand growth rate per month as table function which changes over time. It is shown through factor table of transportation demand growth rate per month.

The Vensim equation of total transpotation cost in the model is as follows.

$$\text{total transportation cost} = \text{freight volume} \times \text{transportation rate} + \text{freight damage cost} . \tag{2}$$

Dimension unit: yuan.

Freight volume and transportation distance are inportant factors of transportation cost. Considering actual stowed rate and inventory in transit cost in combination with other influencing factors, the Vensim equation of transportation rate is as follows.

$$\text{transportation rate} = \text{impact factor of freight volume} \times \text{impact factor of actual stowed rate} \times \\ \text{impact factor of transportation distance} \times \text{cost rate of inventory in transit} . \tag{3}$$

Dimension unit: yuan per piece.

The model defines transportation distance variable as random uniform function.

$$\text{transportation distance} = \text{RANDOM UNIFORM}(a, b, 0) . \tag{4}$$

Dimension unit: kilometer.

Actual stowed rate is another important factor of transportation rate. The model defines it as random normal function from a to b, with average and standard deviationed.

$$\text{actual stowed rate} = \text{Random Normal}(a, b, c, d, 0) \tag{5}$$

The delay variable is also defined as random normal function from a to b, with average c and standard deviation d.

$$\text{delay} = \text{Random Normal}(a, b, c, d, 0) \tag{6}$$

Dimension unit: day.

Freight damage cost is another part of total transportation cost which is determined by freight damage volume. The model defines that if one commodity damage in transit, then a yuan lost. Its Vensim equation is as follows.

$$\text{freight damage cost} = \text{freight damage volume} \times a \tag{7}$$

Dimension unit: yuan.

$$\text{freight damage volume} = \text{freight volume} \times \text{rate of damage cargo} . \tag{8}$$

Dimension unit: piece.
The model defines the rate of damage cargo as random uniform function from a to b.

$$\text{rate of damage cargo} = \text{RANDOM UNIFORM}(a, b, 0) . \tag{9}$$

Conclusion

Logistics cost accounting is always a difficult problem of 3PL operation. Existing 3PL cost accounting methods tend to focus on single logistics activity costs, while ignore the tradeoff. This paper introduced system dynamics viewpoint to 3PL cost, established model with system standpoint, considered logistics operation cost in the whole. It established 3PL transportation simulation model with Vensim and gave Vensim equations and explanation.

Due to the limit of the paper length, this paper didn't input data to the model and gave the availability test. These are what the authors want to do the next step. Meanwhile, 3PL is the complex system that contains several subsystems. The author will further research on these subsystems, establishing relationships among these systems, regarding 3PL cost system as a whole, realizing 3PL operation cost optimization.

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