The Inventory Cost of An Engineering Project Supply Chain Based on System Dynamics

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Abstract—In order to grasp the main factors of the inventory cost of an engineering project supply chain ,the causal relationship diagrams and system dynamics model of the inventory management of an engineering project supply chain are built according to the actual construction .Then using system dynamics simulation software ,which is vensim , this paper establishes a system dynamics equations and simulates to some factors which affects to the inventory management of an engineering project supply chain , in order to find the factor which effects the system more . Finding this factor can help to the future research to optimize and improve the inventory cost of an engineering project supply chain , which purpose is to reduce inventory levels and total costs of the engineering project supply chain.

Keywords-engineering project supply chain; the inventory management; system dynamics; simulation

I. INTRODUCTION

In 2013, national construction output is 15.9313 trillion yuan , an increase of 16.1% to 2012. Construction output margin is 3.5%, drop about 0.06 percentage point to 2012.[1] With the rapid development of the domestic construction industry, the competition among domestic construction companies becomes increasingly fierce. The profit margins are getting smaller and smaller. Thereby reducing the cost of the project will help the enterprises to have an invincible position in the fierce competition in the market .Engineering project engineering material costs account for around 60% -70% of the project cost, and therefore control engineering material cost is a key to the cost control of a project .Material inventory management play an important role in controlling engineering material costs.

Currently, the studies of project inventory management have a large number at home and abroad . Heng Wang[2] precludes the approach of ABC management and CAV-based management to classify the main materials needed for construction projects. Then he carries out specific quantitative analysis, and optimize inventory from the perspective of construction projects and their own construction projects. Zhongfu Li [3] uses dynamic programming model for solving the material supply problems, providing a new approach and ideas for building enterprise inventory management . XueHui Duan[4] uses genetic algorithm and JMI optimization model designs JMI optimization algorithm of the materials inventory management to optimize the analysis of inventory management .In short, the traditional inventory management projects often just study a single enterprise inventory management, lack the contact of other enterprises .Modern projects usually use the thought of supply chain to research inventory management. You[5] applies Multi-Agent method to simulate the global manufacturing supply chain cooperation and consultation issues and developed a multi-contract negotiation based on Multi-Agent collaboration system to support decision-making of enterprise. The construction project is a complex system. Using the ideas of supply chain to research to the related business, you can study the individual factors on the entire supply chain better and be closer to reality.

II. THE BASIC CONCEPTS OF SYSTEM DYNAMICS

System dynamics, referred to as SD, is initiated by Forrester in 1956. Professor Forrester , a professor at MIT, combine the decision-making theory, information theory and cybernetics to form an interdisciplinary. It can be used to solve system problems. System Dynamics uses qualitative and quantitative methods to research and it well suited to deal with complex issues with time change. [6]

III. BUILD SIMULATION MODELS

A. Model Assumptions

In this paper, the higher the value, the larger amount of important materials as the main object of study, the traditional inventory management method, quantitative method for ordering inventory management methods to create a system dynamics model and dynamic analysis.

The key to Quantitative ordering method is to determine the order quantity and reorder point. General economic order quantity order quantity (EOQ) prevail, which is calculated as:

$$EOQ = \sqrt{\frac{2RS}{hC}}$$

Among them: R- for average demand; S- for ordering costs; C- for material price; h- as a percentage of the product price storage costs.

Order Point = average demand × lead time + safety stock.[7]

In order to facilitate analysis and data to build the model, this paper presents several of the following assumptions:

i)Every order quantity is a fixed value.

ii)delays in procurement lead time = time + shipping time. Procurement delays including issuing orders to the front from the supplier delivery time delays. Procurement delays and transit time are fixed values.

iii) suppliers and inventory capabilities construction side is infinite, transport capacity has no limit.

iv) out of stock does not exist.

v）does not consider the impact of force majeure and other factors on the system.

B. Project Supply Chain Inventory Management System Dynamics Flow Chart

system dynamics flow chart of the project supply chain inventory management is plotted, shown in Figure 1.

As seen from Figure 1, the system dynamics flow chart contains material suppliers inventory, the construction inventory and costs three parts.

In the model , equations of the part of material suppliers inventory is as follows:

(1) Productivity = DELAY FIXED (Every single order quantity *Order Quantity, procurement delays, 0);

(2) Material Supplier Inventory = INTEG (Productivity - Delivery rates, 100);

(3) Delivery rates = Get rates;

(4) Expects shipments = Every single order quantity *Order Quantity;

(5) Order Quantity = IF THEN ELSE (order quantity> 0, 1, 0);

(6) Every single order quantity = Order Quantity.

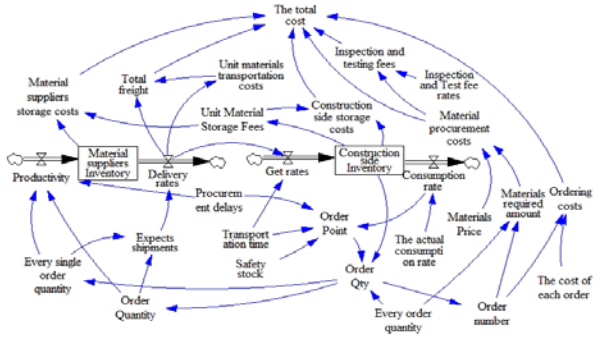

Figure 1. Project supply chain inventory management system dynamics flow chart

In the model , equations of the part of construction inventory is as follows:

(1) Get rates= DELAY FIXED (Delivery rates, transportation time, 0);

(2) Construction side stock = INTEG (Get rates - Consumption rate, 200);

(3) Consumption rate =The actual consumption rate;

(4) Order point =Safety stock + Consumption rate * (Transport time + Procurement delays);

(5) Order Quantity = IF THEN ELSE (The construction side stock <=Order point, every order quantity, 0).

(6) Order number = INTEG (IF THEN ELSE Order quantity> 0,1, 0), IF THEN ELSE (Order quantity> 0, 1, 0));

(7) Material demand = Every order quantity * Order number.

Part of the cost of the model equations:

(1) Unit Material Storage Fees = WITH LOOKUP (The construction side Inventory / 1, ([(100,50) - (500, 100)], (100,100), (150,90), (200, 80), (250,70), (300,60), (350,50), (400,60), (450,70), (500,80)));

(2) Material suppliers storage costs = INTEG (Unit material storage fee * Material suppliers inventory, 0);

(3) The construction side storage costs = INTEG (Unit construction side material inventory storage fee , 0);

(4) Units of material transportation costs = WITH LOOKUP (Delivery rates / 1, ([(20,0) - (240,40)], (40, 40), (80, 35), (120,32), (160, 30), (200,27), (240,25)));

(5) Total freight = INTEG (Unit material transport costs * Delivery rates, 0);

(6) material procurement costs = Material Price * Materials required amount;

(7) Inspection and Testing Fees = Material procurement costs * Inspection and testing fee rates;

(8) ordering cost = The cost of every order * Order number;

(9) Total cost = Construction side storage costs + Total freight + Material suppliers storage costs + Material procurement costs + Ordering costs +Inspection and test fees.

IV. Simulation and Analysis Model

Research the amount of cement of a project, some constant value is as follows: (1) the actual consumption rate = 80t / week; (2) Every order quantity = 200t / times; (3) procurement delays = 0.5week; (4) transport time = 0.3week; (5) safety stock = 30t; (6) = 1000 yuan per order cost / time; (7) material Price = 350 yuan / t; (8) inspection and testing fee rate = 0.003。

Using the system dynamics simulation software Vensim , the model simulation time is set to 52 weeks, in steps of 0.5 weeks. The simulation model is made as follows:

Option One: only the safety stock is changed in the construction side inventory, other values unchanged. the simulation shows in Figure 4 . Original safety stock is 30t, shown in line 1 of Figure 4, but now it is 0t, shown in line 2 of Figure 4 . As seen from Figure 4, the amount of safety stock inventory has a big effect on the construction side stock. Increasing of the safety stock will lead to the delays of material suppliers deliver and the increase of the construction side stock. The total cost will also decrease because of the decrease of safety stock .

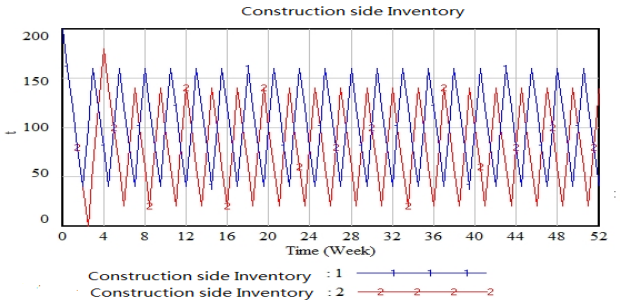

Figure 2. The diagram of the impact with the change of safety stock to the system

TABLE 1: THE TOTAL COST WITH THE CHANGE OF SAFETY STOCK

safety stock t	The total cost Ten thousand yuan
30	237.35
0	228.78

Option Two: Changing the order quantity of every time, other values do not change, which will affect the number of orders. The simulation results is shown as Figure 5 . Original order quantity is 200t every time, shown as line 5 in Figure 5. Now it is 150t, shown as line 2 in Figure 5. As is shown in Figure 5 , we can know that the reduce of the order amount of every time will lead to the reduce of the construction side inventory and an increase of the materials suppliers inventories. The total cost is reduced.

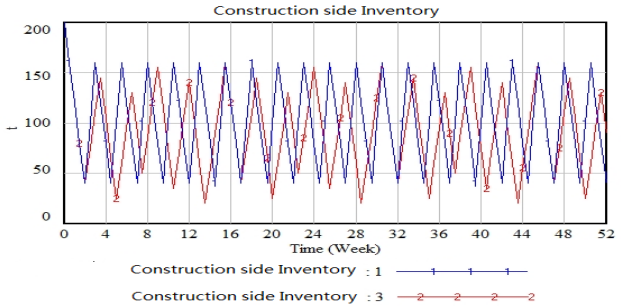

Figure 3: The diagram of the impact with the change of Every order quantity

TABLE 2: THE TOTAL COST WITH THE CHANGE OF EVERY ORDER QUANTITY

Every order quantity t/ Every time	The total cost Ten thousand yuan
200	237.35
150	233.59

V. IN CONCLUSION

In this paper, system dynamics method is used to research the inventory management of project supply chain. Selecting safety stock and the amount of each ordering possible simulate to the project supply chain inventory .You can see greater impact on the change of the advance time of ordering.

System dynamics model of inventory management is used to research project supply chain. through the factors that affect the cost of inventory and inventory system dynamics simulation, you can find out the impact on inventory levels and inventory total cost of the more obvious factors. It can help to improve the actual production of the system, reduce the overall system cost and improve the efficiency of the whole system.

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