The Optimal Design and Operation of Supply Chain Management By Hybrid Simulation Approach.

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1. Introduction

Supply Chain Management (SCM) has become one of the most important sources of competitive advantage in modern manufacuring. SCM is the management of material and information flows both in and between facilities, such as manufacturing, assembly plants and distribution centers.

The structure of SCM is composed of deterministic and stochastic elements. Therefore, the planning for the design and operation of SCM have many difficults. The planning which only considering deterministic elements defies realism of manufacturing environments. But, the planning based on stochastic elements is hard to find optimal results.

Our research proposes Hybrid-simulation approach which can reflect both deterministic and stochastic elements to solve SCM problems.

2.The Configuration and Analysis of Supply Chain Management.

2.1 The definition of Supply Chain Management.

The concept of SCM is very general and broad. It is very hard to define SCM as simple sentence. The definitions of SCM are little differentiated by view points from many respects. Thus, it is a good method that the only common parts of each definition are accepted for the definition of SCM. The common parts of each definition about SCM are as follows:

First, SCM is integrated process of manufacturing enterprises. Manufacturing system is composed of several elements such as supplier, facilities, distribute center etc. SCM considers manufacturing system as whole which is integrated the elements of manufacturing system into one system.

Second, SCM control the flow of material, information and cash at the same time. SCM is related with information, material and cash flow. Therefore, SCM should efficiently plan the production scheduling for obtaining and using the production information with minimum cash.

Third, SCM is an active organic management method. A active organic management is method which have a countermeasure obtained by the elements of manufacturing system itself after event was occurred.

Summarizing mentioned above, SCM is an active integrated management of material, information and cash flow both in and between facilities, vendors, manufacturing plants and distribution centers for making profit. So, the key issue for successful SCM is full-scale coordination between the elements and external partners of manufacturing system.

2.2 Supply chain model configuration

The model of SCM is configured by various view point. The view point on the flow of product and purchase is used in our research.

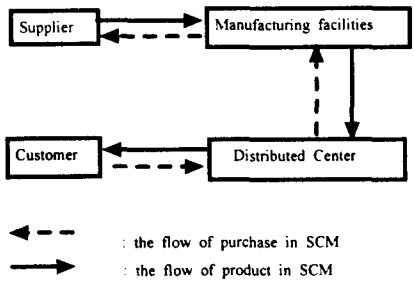


Figure1. supply chain model configuration

a.Supplier
:provide raw materials needed to produce goods.
b.Manufacturing facilities(Plant)
:produce the require products. Raw materials is converted goods at here.
c.Distributed Center(Warehouses)
:contain products to correspond to the fluctuation of demand.
d.Customers
:purchase products or require service.

2.3 Design factors in Supply Chain

In supply chain designing, many various factors exist. Factors used in supply chain designing is determined by the system structure and the view point of system analyst. But, Some factors selected in supply chain designing is independent of system structure and the view point of system analyst. Such factors are as follows:

a.Supply capacity which suppliers can provide.

b.Product capacity which manufacturing facilities can produce.
c.Inventory capacity which Distributed Center has storage.
d.Demand fluctuation which is came from custom -ers

2.4 Operation factors in Supply Chain

Designing Supply Chain, Supply Chain Administra -tor determine the value of operation factors. Many operation factors are existed as design factors in supply chain. General factors among many operation factors are as follows:

a.Selection of Distributed Center corresponding to customer demands.
b.Selection of Manufacturing facilities correspond -ing to stock outs and the decision of product -ion quantities of each Manufacturing facilities.
c.Selection of suppliers corresponding to produc- tion quantities of factories and the decision of supply quantities of each supplier.

2.5 stochastic factors in Supply Chain.

In Supply Chain, Both deterministic and stochastic factors exist. So, the optimization of design and operation is very hard in supply chain. The difference of deterministic and stochastic elements is based on time. If the status of factors are changed in given time period, factors are stochastic. If not, factors are deterministic. The supply capacity of supplier and product capacity of manufacturing facilities are representative stochastic factors in supply chain. In other words, the supply capacity and the product capacity are changed by any causes in given time period. Any causes mean production machine break down, error production rate, raw material delivery fails are etc.

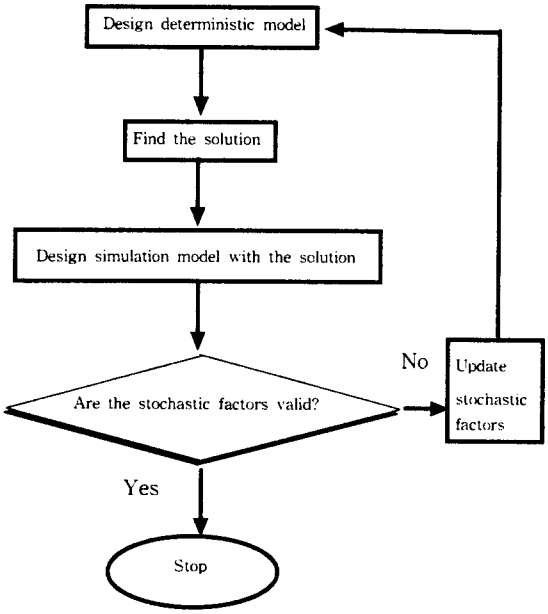
3.Hybrid-Simulation approach

3.1 The definition of Hybrid-Simulation approach

Analytic and simulation models can be regarded as two end points of a spectrum of possible mathematical models that can be used in modeling.Thus, it would be desirable to combine analytic and simulation models (or modeling) and use them if they are cost efficient. If such a combination is achieved through the models and their solution procedures, we call this combined model a hybrid simulation model. If the solution procedure of independently developed analytic and simulation models of the total system are used together in problem solving, we call this hybrid simulation model. Therefore, A hybrid simulation model is a mathematical model which combines identifiable simulation and analytic models. Deterministic model is represented as analytic model, simulation model is used as solution of stochastic problem. 3.2 Hybrid-Simulation algorithm

Our research used followed model to apply hybrid -simulation approach. This model in which simulation model is used as an overall model of the system and it requires values from the solution procedure of

deterministic model representing the system is.



Deterministic model gives simulation model the value of stochastic factors and solution. Simulation model check whether the value of stochastic factors is valid in almost real manufacturing environment with the solution of deterministic model. If there factors are not valid, the value of stochastic factors are updated through update procedure. And then, deterministic model resolve the model with the updated value of stochastic factors. Above the process above is repeated until the solution have reasonable values.

Updated procedure is as follows:

Step.1 Calculate capacity difference between goal capacity and current capacity. In here,

$$goal\ capacity = \frac{match\ capacity}{operation\ rate}$$

and

$$capacity\ difference = goal\ capacity - current\ capacity$$

If $capacity\ difference \geq 0$
then Step 2.1
else $capacity\ difference < 0$
then Step 2.2

Step.2 Update stochastic capacity

Step 2.1

$$current\ capacity = current\ capacity + capacity\ difference$$

Figure2 Hybrid-simulation algorithm

Step 2.2

$$current\ capacity = current\ capacity - capacity\ difference$$

Step 3 deterministic model updated stochastic factors.(*updated current capacity*)

In step1, match capacity is value which simulat -ion model propose to cover demand through many runs. Operation rate is given by supply chain admi

-nistrator considering surplus capacity to cover un -certainty demand fluctuation. Goal capacity means the maximum capacity of stochastic factors.

In step 2, now capacity is updated to catch goal capacity.

In step 3, updated stochastic factors is given to deterministic model to resolve.

4.Case study

Company 'WATER' sells two kinds of mineral water(Type A, Type B). These mineral water have same materials. Two products are different in the size of quantity. They are made by same proess which sources is put in the bottle and stored at the same size of inventory. Each type of sources is provided bt each different supplier. Company 'WATER' want to solve issues as follows:

a. the selection of inventory corresponding to customer demands and the decision on storage capacities of two types in the selected invent -ory.

b. the selection of factories corresponding to stor -age capacities and the decision on production capacities of two types in selected the factory.

c. the selection of suppliers corresponding to pro -ductin capacities of factories and the decision on supply capacities for production of two types in the selected suppliers.

d. the decision of manufacturing capacities of two types corresponding to the forecasted and uncertaint demand considering stochastic model.

Suppose that the cost is dependent on only distances and demand of customers can be forecasted. The structure of company "WATER" is as follows:

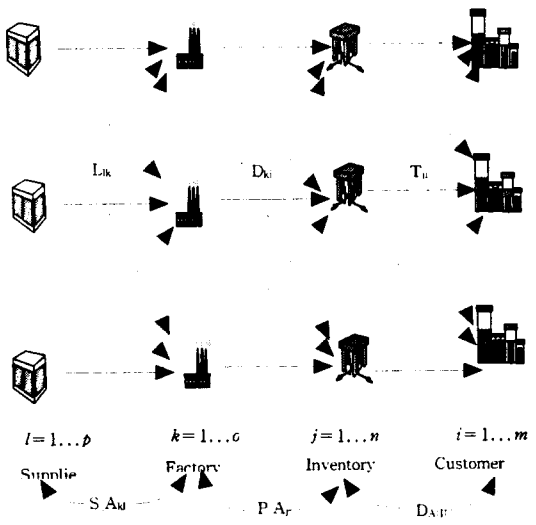


figure3. the structure of company

The symbols which is used in structure and mathematical model are as follows:

T_{ji} : Distance matrix from customer i to invent -ory j.

D_{kj} : Distancee matrix from Inventory j to fact -ory k.

L_{lk} : Distance matrix from factory k to suppl -ier l.

I_A_{ij} :Storage capacity of Type A corresponding consumption capacity of demand i in inventory j.

I_B_{ij} : Storage capacity of Type B corresponding consumption capacity of demand i in inventory j.

$I\_A_{(j)}$: Total storage capacity of Type A corres -ponding consumption capacity of each demand in inventory j.

$I\_B_{(j)}$: Total storage capacity of Type B corres -ponding consumption capacity of each demand in inventory j.

P_A_{jk} : Production capacity of Type A correspo -nding storage capacity of inventory j in inventory k.

P_B_{jk} : Production capacity of Type B correspo -nding storage capacity of inventory j in inventory k.

$P\_A_{(K)}$: Total Production capacity of Type A corresponding storage capacity of each inventory in inventory K.

$P\_B_{(K)}$: Total Production capacity of Type B corresponding storage capacity of each inventory in inventory K.

S_A_{kl} : Supply capacity for producing Type A in factory k provided by supplier l.

S_B_{kl} : Supply capacity for producing Type B in factory k provided by supplier l.

a : Cost spend when one Type A is moved as unit distance.

b : Cost spend when one Type B is moved as unit distance.

c : Size needed when one Type A is stored in inventory.

d : Size needed when one Type B is stored in inventory.

e : Cost required when one unit raw material is moved as unit distance.

f : manufacturing constant required when one Type A is made of raw material in factory.

g : manufacturing constant required when one Type B is made of raw material in factory.

The deterministic model of company "WATER" is divided three parts.

First part is "Inventory-Customer". This part can solve issue a.

Second part is "Inventory-Factory". This part can solve issue b.

Third part is "Factory-Supplier". This part can solve issue c.

The deterministic model is as follow

1)Inventory-Customer

$$\min \sum_{i=1} \sum_{j=1} T \cdot (a \cdot I\_A_{ij} + b \cdot I\_B_{ij})$$

subjec

t 0 $\sum_{j=1}^{n}(c \cdot I\_A_{ij} + d \cdot I\_B_{ij}) \le Inventory\ Capacity(i) \quad \forall i$

$\sum_{j=1}^{n} I\_A_{ij} \ge D_a(i) \quad \forall i$

$\sum_{j=1}^{n} I\_B_{ij} \ge D_b(i) \quad \forall i$

2)Manufacturing-Inventory

$\min \sum_{j=1}^{n}\sum_{k=1}^{n} D \cdot (a \cdot P\_A_{jk} + a \cdot P\_B_{jk})$

subject to $\sum_{j=1}^{n} P\_A_{jk} \le Manufacturing\ Capacity\ of\ A(k) \quad \forall k$

$\sum_{j=1}^{n} P\_B_{jk} \le Manufacturing\ Capacity\ of\ B(k) \quad \forall k$

$\sum_{k=1}^{n} P\_A_{jk} \ge I\_A_{(j)} \quad \forall j$

$\sum_{k=1}^{n} P\_B_{jk} \ge I\_B_{(j)} \quad \forall j$

$\sum_{i=1}^{n} I\_A_{ij} = I\_A_{(j)} \quad \forall j$

$\sum_{i=1}^{n} I\_B_{ij} = I\_B_{(j)} \quad \forall j$

3)Supplier-Manufacturing

$\min \sum_{l=1}^{n}\sum_{i=1}^{n} L \cdot e \cdot (S\_A_{il} + S\_B_{il})$

subject to $\sum_{i=1}^{n} S\_A_{il} + S\_B_{il} \le Supply\ Capacity\ (l) \quad \forall l$

$\sum_{l=1}^{n} f \cdot S\_A_{il} \ge P\_A_{(i)} \quad \forall k$

$\sum_{l=1}^{n} g \cdot S\_B_{il} \ge P\_B_{(i)} \quad \forall k$

$\sum_{l=1}^{n} P\_A_{il} = P\_A_{(i)} \quad \forall k$

$\sum_{l=1}^{n} P\_B_{il} = P\_B_{(i)} \quad \forall k$

Simulation Model

The structure of simulation model is based on the result of deterministic model. Simulation model im

-prove stochastic factors (Inventory capacity of each inventory, Manufacturing capacity of each factory, Supply capacity of each supplier in the model) through the update procedure of hybrid

algorithm we propose before.. After simulation is end, updated facors is used in the deterministic model.

5.Conclusion

The planning for the design and operation of supply chain is very hard when we consider concurrently the stochastic and deterministic factors So, we propose hybrid-simulation approach as a method by which the design and operation of supply chain is more efficiently planed. Using hybrid-simulation approach, stochastic and determin

-istic factors can be considered at the same time in planning supply chain. Therefore, the design and operation of supply chain management which is planned by hybrid-simulation approach is more realistic than other approaches and can optimize the deterministic model of supply chain.

Based on our research, more research is needed to update procedure and developing hybrid-simula

-tion model which can represent more realistic environment of supply chain.

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