The Reconfiguration Alternatives Model of the Supply Chain Network

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Abstract

Supply Chain Management (SCM) has been drawing much attention for most companies. Among others, the reconfiguration of the existing supply chain network is essential to retain their competitive edges. In the strategic level, however, even if we focus on the quantitative criterion such as cost, however, there are situations where it is not easy to aggregate various costs into the overall cost, because of their imprecision, indetermination and uncertainty. Furthermore, other qualitative criteria must be taken in to account for evaluating the performance of supply chain networks.

This paper presents a supply chain network model with case. It has been implemented in the evaluation of several reconfiguration alternatives of warehouses distributed all over the nation, especially focusing on the warehouse in the North East region in Japan, of a major household appliances company.

Keywords: supply chain network, reconfiguration SCM model

1. Introduction

In the 1980s companies discovered new manufacturing technologies and strategies that allowed them to reduce costs and better compete in different markets. Strategies such as just-in-time manufacturing, *kanban*, lean manufacturing, total quality management, and others became very popular, and vast quantities of resources were invested in implementing these strategies. In the last few years, however, it has become clear that many companies have reduced manufacturing costs as much as is practically possible. Many of these companies are discovering that effective supply chain management (SCM) is the next step they need to take in order to increase profit and market share (Simchi-Levi et al. [6],p.5).

Nowadays, the importance of SCM has been recognized worldwide, and many companies have been applying this concept. From the production to the delivery of the products to the consumers; retailers, wholesalers, manufacturers and material supplier are closely related and form a chain called the 'Supply Chain'. Initially the efficiency of a distribution system were dealt with only by an individual company. However, eventually, all the companies related to a specific product started adopting SCM to minimize the system wide costs while satisfying service level requirements.

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One of the most advanced cases in SCM is the “direct” model which gives Dell computer direct access to their final customers, by making use of information technology and unifying the production, distribution, and sales information. Further, the cross-docking system employed by Wal-Mart, the continuous replenishment program (CRP) developed by P&G, efficient consumer response (ECR) in the grocery industry and quick response (QR) in fiber-related industries have been successfully implemented.

There are various SCM issues. One is the network configuration decision regarding the number, location, and capacity of warehouses and manufacturing plants. So far, mixed integer programming models have been widely used to configure facility locations, and improve overall operations (See, for instance, Shapiro[5]).

The reconfiguration of the existing supply chain network is essential to retain their competitive edges. In the strategic level, however, even if we focus on the quantitative criterion such as cost, it is not unusual that various costs involved in supply chain networks cannot easily be aggregated into the overall cost, because of their imprecision, indetermination and uncertainty. Furthermore, there are other qualitative criteria to evaluate the performance of supply chain networks. In theses complex situations, as an overall evaluation, for instance, a simple weighted sum of criteria is not adequate.

We propose a supply chain network model as a case study of the evaluation of various reconfiguration alternatives of the warehouses distributed all over the nation, especially focusing on the warehouse in North East region in Japan, of a major household appliances company, say, Company A, hereafter.

2. A Case Study: Reconfiguration Problem of Company A

Company A has many warehouses and agents all over Japan. There is a long demand chain of A’s products consisting of construction dealers, agents, business offices, enterprises, and plants/ factories. The distribution process of company A is illustrated in Figure 1. As shown in Figure 1, the logistics network of A comprises a two-stage distribution system, where frontline warehouses order from backline warehouses, and the backline warehouses are supplied from the factory. In order to secure one-day delivery service, frontline warehouses are distributed in local regions. Since, more than 10,000 items are handled, it is a difficult and impractical process to store all items in the frontline warehouses. Therefore only high demand items are stocked and other items are delivered from backline warehouses in two days.

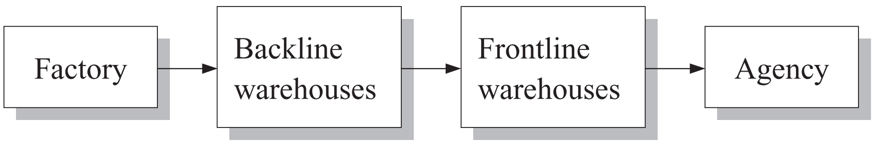

Figure 1. Company A’s distribution process

Problem Formulation

We are examining the effectiveness of merging some frontline warehouses distributed all over the nation. Some of the advantages of merging are as follows:

(a) to reduce the safety inventory.
(b) to reduce the operating cost.

Some of the disadvantages are:
(a) to increase in the cost of delivery due to the distance of some frontline warehouse to the customers.
(b) to decrease the level of delivery service.

Taking into account the advantages, disadvantages and the existence of competitors, we consider the following strategies:

Strategy 1: The frontline warehouse in the North East region is merged into 'Kanto' warehouse.
Strategy 2: The status quo (non-merging).
Strategy 3: The frontline warehouse in the North East region is used as a depot.

Three strategies have different inventory and distribution systems. Therefore, they can be subdivided into 6 alternatives.

Alternative 1 (merging and non-operating) (see Figure 2):

The frontline warehouse in the North-East region (this region is surrounded by the circle in the figure) is merged into the 'Kanto' warehouse (its location is depicted by a star in the figure).

Figure 2. Alternative 1

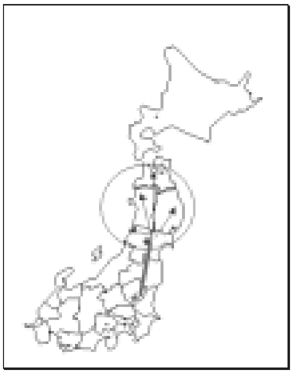

Figure 3. Alternatives 2, 3 and 4.

- Customers in North-East region will receive the products in one day (the following day) from the 'Kanto' warehouse.

Alternative 2 (the status quo) (see Figure 3):

- the frontline warehouse in the North-East region (it is depicted by a star within the circle) is not merged and only 25% of all items will be stocked/stored for one day delivery.
- the rest will be delivered from the 'Kanto' warehouse in 2 days

Alternative 3 (a variant of the status quo) (see Figure 3):

- the frontline warehouse in the North-East region is not merged and 50% of all items will be

stocked/stored for one day delivery.
- the rest will be delivered from the ‘Kanto’ warehouse in 2 days

Alternative 4 (a variant of the status quo) (see Figure 3):

- the frontline warehouse in the North-East region is not merged and 80% of all items will be stocked/stored for one day delivery.
- the rest will be delivered from the ‘Kanto’ warehouse in 2 days

Alternative 5 (operating as a depot and one day delivery) (see Figure 4)

- the frontline warehouse in the North-East region is merged into the ‘Kanto’ warehouse and operates as a depot (no storage).
- the one day delivery from the ‘Kanto’ warehouse via the depot to all over North East region except for customers in some part of the North-East region that are directly delivered from the ‘Kanto’ warehouse in one day.

Figure 4. Alternative 5

Figure 5. Alternative 6

Alternative 6 (operates as a depot and two day delivery in some part) (see Figure 5)

- The warehouse in the North-East region is merged into the ‘Kanto’ warehouse and operates as a depot.
- All customers in North-East region will receive products via the depot from the ‘Kanto’ warehouse. Therefore, some customers receive 2 day delivery service.

Criteria for Consideration:

The following are the criteria for considerations.

- Cost
  - Distribution cost
  - Handling cost
  - Storage cost
- Total inventory
- Customer satisfaction
  - Number of items delivered in one day (the following day)

- · Number of regions delivered in one day (the following day)
- Competitive advantage

Cost

It is difficult to aggregate distribution, handling and storage costs, into an overall cost, because it is difficult to estimate precisely cost values due to time and cost constraints. Therefore, we have decided to look at all these costs separately. We use the following scores:

Significant reduction compared to the status quo	7
Some reduction compared to the status quo	6
A little reduction or almost the same	5
Same as the status quo	4
Almost equal to the status quo or higher	3
Higher than the status quo	2
Significantly high compared to the status quo	1

Total inventory

Estimate the backline + frontline warehouses stock/inventory.
Since the lesser the inventory stock the better, this is a minimization Criterion. In order to convert this into a maximization criterion, define the following:

Inventory score = large value – estimated value

Customer satisfaction

We look at the number of items delivered in a day and use it as the score. If all regions are delivered in one day, then score is 2 and if some regions are delivered in 2 days, we take 1 as a score

Competitive advantage

a If the North East region is the stock/storing base: 3 point
b If the North East region is operating as a depot: 2 point
c If the North East region is not operating: 1 point

3. Model Formulation

Notation

K_i	capacity of factory i,	x_{ij}	transport quantity from i to j
C_j	capacity of backline j,	y_{jm}	transport quantity from backline j frontline m
E_m	capacity of frontline i,	α_{ij}	unit cost from factory i to backline j
D_n	demand of agency n ,	β_{jm}	unit cost from backline j to frontline m
Q_j	warehouse expense of backline j,	J_0	a number of backline
R_m	warehouse expense of frontline m,	M_0	a number of frontline
L	vehicle's upper bound of frontline m,	P_m	agent's upper bound of frontline m

Objective Function

$$Min\left\{\sum_{i=1}^{I}\sum_{j=1}^{J}\alpha_{ij}x_{ij}+\sum_{j=1}^{J}\sum_{m=1}^{M}\beta_{jm}y_{jm}+\sum_{j=1}^{J}Q_jU_j+\sum_{m=1}^{M}\sum_{l=1}^{L}S_l^m+\sum_{m=1}^{M}R_mV_m\right\}$$

Constraints

$$\sum_{j=1}^{J}x_{ij}\leq K_i,\qquad i=1,2,\cdots,I$$

$$\sum_{i=1}^{I}x_{ij}\leq C_jU_j,\qquad j=1,2,\cdots,J$$

$$\sum_{m=1}^{M}y_{jm}\leq\sum_{i=1}^{I}x_{ij},\qquad j=1,2,\cdots,J$$

$$\sum_{j=1}^{J}y_{jm}\geq\sum_{n=1}^{N}D_nZ_{mn},\qquad m=1,2,\cdots,M$$

$$\sum_{n=1}^{N}D_nZ_{mn}\leq E_mV_m,\qquad m=1,2,\cdots,M$$

$$\sum_{n=1}^{N}Z_{mn}\leq P_m,\qquad m=1,2,\cdots,M$$

$$\sum_{j=1}^{J}U_j\leq L\quad \text{L:Backline warehouses}$$

$$\sum_{m=1}^{M}V_m\leq K\quad K\text{:Frontline warehouses}$$

$$\sum_{m=1}^{M}z_{mn}=1,\quad n=1,2,\cdots,N$$

$$U_j=\{0,1\},\ j=1,2,\cdots,J$$

$$V_m=\{0,1\},\ m=1,2,\cdots,M$$

$$z_{mn}=\{0,1\},m=1,2,\cdots,M;\ n=1,2,\cdots,N$$

$$x_{ij}\geq 0,i=1,2,\cdots,I;j=1,2,\cdots,J$$

$$y_{jm}\geq 0,j=1,2,\cdots,J;m=1,2,\cdots,M$$

$$D^m=\sum_{l=1}^{L}D_l^m\ from\ m=1,\cdots,M,\qquad l=1,\cdots L$$

$$S_l^m=\{0,1\}\quad from\ m=1,\cdots,M,\qquad l=1,\cdots L$$

$$S_l^m\leq S_{l-1}^m\quad from\ m=1,\cdots,M,\qquad l=2,\cdots L$$

$$800S_l^m(l-1)\leq D_l^m+800S_l^m(l-1)\leq 800S_l^m l\qquad from\ m=1,\cdots,M,\qquad l=1,\cdots L$$

4. Concluding remarks

Even if the scores of alternatives do not seem to provide enough insight on ranking alternatives, by carrying out various solutions like ElECTREIII, meta heuristic method, we expect to derive the overall ranking by making the best use of them. In general, the relative importance of criteria is ambiguous and the scores are imprecise. It suggests that, in such cases, we expect meta-heuristic methods as like genetic algorithm, Tabu Search and else are useful.

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