A STUDY ON TRANSFER PRICING CONSIDERING FAIRNESS AND PROFITABILITY

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ABSTRACT

Transfer pricing is the setting of the price for goods or services sold among related members within an organization, which is an important financial and business issue that has been ignored in many supply chain network designs studies. Some studies have considering transfer pricing into production and supply chain planning; however, total profit optimization is a single-objective and does not consider the satisfaction of individual member from a fair perspective. Since the sustainable development is also very important for long-term strategy in an organization, this study focused on balancing the trade-off of fairness and total profit on supply chain network design problem using transfer pricing. Meantime, a multi-supplier, multi-parts factory, multi-assy factory, multi-sales distributor, multi-item problem is solved by the integrated method of Mixed Integer Linear Programming and Fuzzy-Programming proposed by this study. From the experimental results, we verify that the transfer pricing can maximize the total profit of supply chain network. In addition, the proposed multi-objective optimization model that takes fairness into consideration can benefit each member with minimal satisfaction while nice total profit.

Keywords: Supply Chain Network Design, Transfer Pricing, Fairness, Mixed Integer Linear Programming, Fuzzy-Programming.

1. INTRODUCTION

Transfer pricing is the setting of the price for goods or services sold among related members within an organization. In recent years, the transaction range of transfer prices is from related departments in a company, extended to related companies in different group companies on the supply chain. Global manufacturing companies with multi-site all over the world have a flow of money along with the flow of parts and finished products among sites. Depending on how the transfer price is determined, the received and costed money of each site are quite different. Moreover, due to the difference in corporate tax between the exporting country and the importing country, the transfer pricing will have a significant impact on customs duties and profit after tax. To prevent illegal dumping, the possible range of transfer pricing is provided by OECD (Organization for Economic Co-operation and Development). Value-added standards are often used compared to item standards. Although the transfer price cannot be greatly adjusted using of the value-added standards with transportation rules of FOB/CIF, it is possible to adjust in a range. Therefore, how to set a reasonable transfer price for a global company to save money is quite a hot issue. In other words, it is possible to maximize the total profit after tax for company by setting the transfer price.

There are many studies that focus on maximizing total profit by setting transfer pricing, however, other tough problem occurs as conflicts of profit among members since without considering the interests of each member. As a result, members do not want to cooperate with each anther, some of them get worse performance, lower profit. Which form a bad circulation in the whole organization lead to weak competence in supply chain. Moreover, it is prohibited to distribute the profit by mother company because of rules of transfer pricing taxation system. Therefore, despite of the efficient objective in total profit, it is necessary to consider the sustainable objective in fairness, which can be expressed as the satisfaction of each member at the same time.

This study focuses on optimizing the efficient objective in total profit and the sustainable objective in fairness by individual satisfaction using transfer pricing simultaneously. We propose the models for determining the trade-off between total profit and individual fairness and the method how they can be expanded in a multi-site, multi-stage, large-scale global supply chain.

2. LITERATURE REVIEW

2.1 The Single-Objective in Cost Minimization and Profit Maximization

Production-allocation and production-distribution-allocation problems are the basic problems in production, supply chain planning. Many studies consider minimizing total costs, such as manufacturing, distribution, and inventory costs. Production and distribution activities are discussed and the efficiency of the whole production network is objective. Some studies shift the viewpoint from minimizing total costs to maximizing total profits. The profit-center, which controls the most important factors of business, is currently preferable to the cost-center, which helps a company identify and reduce costs. Some studies discuss production decision problems with consideration of sales planning. For example, Olhager et al. (2001) provides two perspectives on long-term capacity management for production and sales strategies and argues the importance of simultaneously focusing on production and sales planning problems. Feng et al. extends the research theory based on Olhager et al. (2001) by using constructed mathematical models to describe the production network and provides both an integrated model and a decoupling model for the production and sales planning problem. The advantage of an integrated model has been proven through numerical experiments.

2.2 The Importance of Transfer Pricing

Transfer prices seem to be the boundary between the profits of up and down stream members. Transfer pricing allows a manufacturer to generate profit (or cost) figures for each member separately, transfer prices make managers aware of the value that goods and services have for other segments of the manufacturer. The appropriate choice of transfer prices can help in the coordination of up and down stream members and these will affect not only the reported profit of each member but also the allocation of the manufacturer’s resources (Heath and Huddart, 2009). Hammami and Frein (2014) notes that there are different transfer pricing methods, such as the cost-plus, resale-price, and profit-split methods. According to the 1995 OECD guidelines, the selection of an internal pricing method always aims at identifying the most appropriate method for a particular case. No one method is suitable in every possible situation. Hammami and Frein (2014) adopts a profit-split method because transactions within an offshore manufacturer are highly inter-related and it is difficult to find comparable products for various specifics in their case study. From some other studies, we see that the cost-plus method is the traditional method that has been widely used by manufacturers. Under this method, the transfer price of the product is determined by multiplying the production cost by a fixed markup. Data also reveal that this method is appropriate if reliable information can be obtained about the markup. Miller and Matta (2008) adopt a cost-plus transfer price method in their profit maximization model that considers production and distribution planning simultaneously. They treat markups, ranging between 10% and 40%, as variables. The total profit of the manufacturer was found to be different when markups are different between subsidiaries. Setting a proper transfer price is important for a manufacturer's tactical-level decisions. However, when markups are considered as variables, the selling price to market is an exogenous, predetermined input of the model. Furthermore, there is often only one product in their model.

The aforementioned studies focus on how to improve efficiency such as total cost, total profit with single-objective functions. However, the satisfaction of individual member from a fair perspective is not considered. There is a necessary to check that the profitability of each member compared to others; unprofitable members feel unsatisfactory. In order to solve this problem, except efficiency indicator, another indicator should be considered. This study focuses on optimizing the efficient objective in total profit and the sustainable objective in fairness by individual satisfaction using transfer pricing simultaneously.

3. PROPOSED MODEL

In this section, we describe the proposed model. In section 3.1, we describe a supply chain network design model that maximizes total profit under fixed transfer price. In section in 3.2, we describe a total profit maximization model with variable transfer price. In section 3.3, we describe a multi-objective optimization model with fairness using a fuzzy programming.

3.1 Total Profit Maximization Supply Chain Network Design Model

Let $N = N_S \cup N_I \cup N_C = \{1, \cdots, n\}$ denote a set of nodes. Let $N_S \subseteq N$ be a set of external supplier nodes, $N_C \subseteq N$ be the set of external customer nodes, and $N_I \subseteq N$ be a set of internal nodes. We define an internal node as a set of nodes that can adjust the transfer price. It includes the case where they are a set of firms in the same group or different firms with strong partnerships.

Let $A = \{(i,j) | i \in N, j \in N\}$ denote a set of arcs. Let a_{ij} denote a binary constant that takes 1 if $(i,j) \in A$ and 0 otherwise. Let $S = \{s = 1, \cdots, m\}$ denote a set of items, where item is a generic term for anything processed and transported in the supply chain, such as materials, parts, and products. Let ϕ_{st} denote the number of parts t required to produce item s, and is used to represent the BOM structure. Let d_{is} be the amount of demand for item s at each customer node $i \in N_C$.

Let p_{ijs} be the transfer price of item s from node i to node j. We assume p_{ijs} as a constant in this section, while it is decision variable in the next and subsequent sections. We assume that the trade is done on a COF basis and that the shipping source bears the cost of transportation. We also assume that the node i that receives the item pays an import tax on the purchase price of the item. A corporate tax is imposed on profits for node $i \in N_I$.

Indices and Sets

- $N = \{1, \cdots, n\}$: A set of nodes
- N_C : A set of external customer nodes
- N_I : A set of internal nodes
- N_S : A set of external supplier nodes
- $S = \{s = 1, \cdots, m\}$: A set of items
- $A = \{(i,j) | i \in N, j \in N\}$: A set of arcs

Parameters

- f_{is} : Setup cost of production line of item s in production node i

- v_{is} : Unit variable cost of item s in production node i
- c_{ijs} : Unit transportation cost of item s from node i to node j
- t^I_{ijs} : Tariff rate of item s between node i to node j
- ϕ_{st} : Number of parts t required by item s in production process
- d_{is} : Demand of item s in sales node i
- q_{is} : Production capacity of item s in production node i
- t^C_i : Corporate tax in node i
- p_{ijs} : Transfer prices of item s from node i to node j

Decision Variables

- x_{ijs} : Transportation volume of item s from node i to node j
- y_{is} : 1 if production line of item s is set up in production node i
- z_i : Profit of node i after tax
- z_0 : Total profit after tax
- R_i : Sales of node i
- F_i : Fixed cost of production of node i
- V_i : Variable cost of production of node i
- C_i : Transportation cost of node i
- B_i : Procurement cost of node i

$$\text{max. } z_0 \quad (1a)$$
$$\text{s.t. } z_0 = \sum_{i\in N_I} z_i \quad (1b)$$
$$z_i = (1 - t^c_i) \times (R_i - F_i - V_i - C_i - B_i) \quad \forall i \in N_I \quad (1c)$$
$$R_i = \sum_{j\in N}\sum_{s\in S} p_{ijs}x_{ijs} \quad \forall i \in N_I \quad (1d)$$
$$F_i = \sum_{s\in S} f_{is}y_{is} \quad \forall i \in N_I \quad (1e)$$
$$V_i = \sum_{j\in N}\sum_{s\in S} v_{is}x_{ijs} \quad \forall i \in N_I \quad (1f)$$
$$C_i = \sum_{j\in N}\sum_{s\in S} c_{ijs}x_{ijs} \quad \forall i \in N_I \quad (1g)$$
$$B_i = \sum_{l\in N}\sum_{s\in S}(1 + t^I_{lis})p_{lis}x_{lis} \quad \forall i \in N_I \quad (1h)$$
$$\sum_{i\in N} a_{ij}x_{ijs} - \phi_{st}\sum_{l\in N} a_{li}x_{lit} = 0, \quad \forall i \in N_I, \forall s \in S, \forall t \in S \quad (1i)$$
$$\sum_{i\in N} a_{ij}x_{ijs} \geq d_{js}, \quad \forall j \in N_C, \forall s \in S \quad (1j)$$
$$\sum_{j\in N} x_{ijs} \leq q_{is}y_{is}, \quad \forall i \in N \quad (1k)$$
$$x_{ijs} \geq 0, \quad \forall (i,j) \in A, \forall s \in S \quad (1l)$$
$$y_{is} \in \{0,1\}, \quad \forall i \in N, \forall s \in S \quad (1m)$$

The objective function (1a) indicates that the overall after-tax profit is maximized. Constraint equation (1b) shows that the sum of the after-tax profit of each internal node is the overall after-tax profit. Constraint equation (1c) shows the calculation of the after-tax profit of each internal node. Constraint equation (1c), (1d), (1e), (1f), (1g), and (1h) show the sales, fixed cost of production, variable cost of production, transportation cost, procurement cost and profit after tax for each internal node. Constraint equation (1i) shows the conservation equation for the flow of the item. Constraint equation (1j) indicates that the demand is satisfied. Constraint equation (1k) indicates that the capacity limit for each node is satisfied. Constraint equation (1l) shows that x_{ijs} takes a non-negative value. The constraint equation (1m) shows the binary condition of y_{is}. Since problem (1) is a Mixed Integer Linear Programming problem, it can be solved efficiently using a off-the-shelf solver.

3.2 Total Profit Maximization Supply Chain Network Design Model with Transfer Price Decisions

The model in the previous section assumed transfer prices as a constant. In this section, we describe the total profit maximization model with the transfer price as the decision variable. If the transfer price is used as the decision variable, a non-linear term, $p_{ijs}x_{ijs}$, will be included in the definition of sales R_i in equation (1d) and the purchase cost in equation (1h). For this reason, we linearize it using the following procedure.

First, we discretize the set of transfer price. Let $P_{ijs} = \{p_{ijsk} = p_{ijs1}, \cdots, p_{ijsK_{ijs}}\}$ denote a set of candidate transfer prices for item s from node i to node j. Let $\mathrm{K_{ijs}} = \{k = 1, \cdots, K_{ijs}\}$ denote the subscript set of price options. Let π_{ijsk} be a binary variable that takes 1 when taking a price option k for item s from base i to base j and 0 otherwise. Note that since we assume that the purchase price from external suppliers and the selling price to external customers cannot be changed in this study, the number of price options is set to 1. Using these definitions, the determination of the transfer price can be defined in the following equations (2) and (3).

$$p_{ijs} = \sum_{k \in \mathrm{K}_{ijs}} \pi_{ijsk} p_{ijsk}, \qquad \forall i, j, s \tag{2}$$
$$\sum_{k \in K_{ijs}} \pi_{ijsk} = 1, \qquad \forall i, j, s \tag{3}$$

Also, the term $p_{ijs}x_{ijs}$ can be redefined as the equation (4).

$$p_{ijs}x_{ijs} = \sum_{k \in \mathrm{K}_{ijs}} p_{ijsk} \pi_{ijsk} x_{ijs}, \qquad \forall i, j, s \tag{4}$$

We define a constant indicating the upper bound $X_{ijs} = \min(d_{js}, q_{is})$ of x_{ijs}. We also define a variable r_{ijsk} to substitute $p_{ijs}x_{ijs}$ using the following equations (5)(6)(7) and (8).

$$r_{ijsk} \le \pi_{ijsk} X_{ijs} \tag{5}$$
$$r_{ijsk} \le x_{ijs} \tag{6}$$
$$r_{ijsk} \ge x_{ijs} - X_{ijs}(1 - \pi_{ijsk}) \tag{7}$$
$$r_{ijsk} \ge 0 \tag{8}$$

Using the above expressions, we can formulate Total Profit Maximization Supply Chain Network Design Model with Transfer Price Decisions as the equations (9).

$$\begin{aligned}
\text{max.} \quad & z_0 && && \text{(9a)} \\
\text{s.t.} \quad & \text{(1b)-(1m)} && && \text{(9b)-(9m)} \\
& \sum_{k \in K_{ijs}} \pi_{ijsk} = 1, && \forall (i,j) \in A, \forall s \in S && \text{(9n)} \\
& r_{ijsk} \le \pi_{ijsk} X_{ijs}, && \forall (i,j) \in A, \forall s \in S, \forall k \in \mathrm{K_{ijs}} && \text{(9o)} \\
& r_{ijsk} \le x_{ijs}, && \forall (i,j) \in A, \forall s \in S, \forall k \in \mathrm{K_{ijs}} && \text{(9p)} \\
& r_{ijsk} \ge x_{ijs} - X_{ijs}(1 - \pi_{ijsk}), && \forall (i,j) \in A, \forall s \in S, \forall k \in \mathrm{K_{ijs}} && \text{(9q)}
\end{aligned}$$

$$r_{ijsk} \geq 0, \qquad \forall (i,j) \in A, \forall s \in S, \forall k \in \mathrm{K_{ijs}} \qquad (9r)$$
$$\pi_{ijsk} \in \{0,1\} \qquad \forall (i,j) \in A, \forall s \in S, \forall k \in \mathrm{K_{ijs}} \qquad (9s)$$

The constraint equation (9n) indicates that one price option is selected. Constraint expressions (9o), (9p) and (9q) show the same linearization as in (5), (6) and (7). The constraint equation (9r) shows the non-negativity of r_{ijsk} and the constraint equation (9s) shows the binary nature of π_{ijsk}. Since problem (9) is Mixed Integer Linear Programming, it can be solved efficiently using off-the-shelf solvers.

3.3 Fair Profit Maximization Supply Chain Network Design Model with Transfer Price Decisions

The problems (1) and (9) oriented towards maximizing total profits. On the other hand, there is a concern that each center will significantly sacrifice its profit. In this study, we propose a multi-objective optimization model for maximizing the profit of each location.

The multi-objective profit maximization model can be formulated as equation (10). Let $|N_I| = n'$, and let $N_I = \{i = 1, \cdots, n'\}$ for the subscript set starting from 1.

$$\text{max.} \qquad z_0, z_1, \cdots, z_{n'} \qquad (10a)$$
$$\text{s.t. (9b)-(9s)} \qquad (10b)\text{-}(10s)$$

The objective function (10a) shows the maximization of total profit and each internal node profit. Problem (10) is difficult to solve as it is because it is a multi-objective optimization model. Therefore, we apply fuzzy programming to obtain the solution.
Fuzzy Programming is a multi-objective optimization method proposed by Zimmermann (1978), which is a linear programming problem including Fuzzy Goal and Fuzzy Constraints. In problem (10), it can be interpreted as having a Fuzzy Goal, which is to make the profit of each internal node approximately more than a certain value.

$$\begin{aligned} \text{max.} \qquad & z_0 \gtrsim Z_0 && (11a) \\ & z_1 \gtrsim Z_1 \\ & \vdots \\ & z_{n'} \gtrsim Z_{n'} \\ \text{s.t.} \qquad & \text{(9b)-(9s)} && (11b)\text{-}(11s) \end{aligned}$$

Here $\lesssim$ are Fuzzy Constraints that denote "approximately less than". Such a Fuzzy Goal can be quantified by specifying the corresponding membership function. Zimmermann (1978) defined the membership function $\mu z_j(x)$, which indicates the degree of achievement of each objective function $z_j(x)$, as follows.

$$\mu_{z_i} = \begin{cases} 1 & z_i \geq z_j^{\min} \\ (z_i - z_i^{\min})/(z_i^{\max} - z_i^{\min}) & z_i^{\min} \leq z_i \leq z_i^{\max} \\ 0 & z_i \leq z_i^{\min} \end{cases}$$

$z_i^{\max}, z_i^{\min}$ are the upper and lower limits of the objective function value z_i, respectively. This is illustrated in Figure 1 where μ_{z_i} can be interpreted as the degree of truth of satisfaction with the earned profit of z_i. It can then be interpreted as unsatisfied if it falls below the lower limit of z_i^{min} and satisfied if it exceeds the upper limit of $z_i^{\max}$.

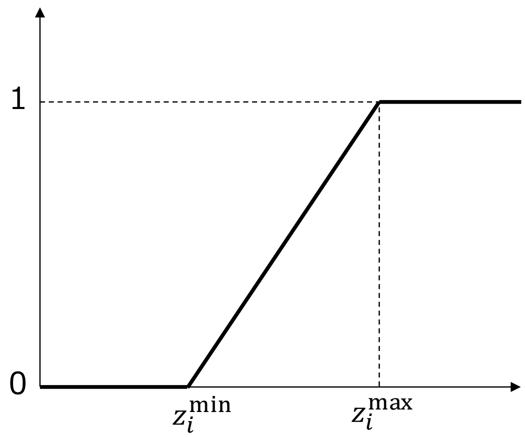

Figure 1. Membership function of z_i

Zimmermann (1978) proposed that the upper and lower bounds of each objective function, $z_i^{\max}$ and $z_i^{\min}$, should be set from payoff matrices where each row vector denote the for the solution of the problem of maximizing z_i while the other objective functions are ignored. Also, Bellman and Zadeh's decision to maximize the minimum membership function.

$$\text{max.} \quad \underset{i \in N}{min}\, \mu_{z_i} \tag{12a}$$
$$\text{s.t.} \quad \text{(9b)-(9s)} \qquad \text{(12b)-(12s)}$$

can be transformed into the following linear programming.

$$\text{max.} \quad \lambda \tag{13a}$$
$$\text{s.t.} \quad \text{(9b)-(9s)} \qquad \text{(13b)-(13s)}$$
$$\lambda\left(z_i^{\max} - z_i^{min}\right) + z_i^{\min} \leq z_i \tag{13t}$$

4. PROBLEM STATEMENT

4.1 The Description Of Supply Chain Network And Item

The case study of this study is motived by the heavy industry. The target company is a global company, who has production and sales sites all over the world. There are two layers and four stages of the entire supply chain. The suppliers are in the top stream of supply chain and supply raw materials or sub-parts to the parts factories. The parts factories are divided into key parts factories and general parts factories. Key parts factories are established in developed countries such as the United States, Germany, and Japan who has technological capabilities, and general parts factories are established in developing countries such as Thailand and China. The assembly factories assemble parts from the parts factories using transfer prices and transform them to the final product. Up to this point, the production activity is over and the sales activity begins. Regional sales distributors procure final products from assembly factories using transfer prices and sell that to downstream customers. Customers are bought final products from sales distributors in market prices (Figure 2).

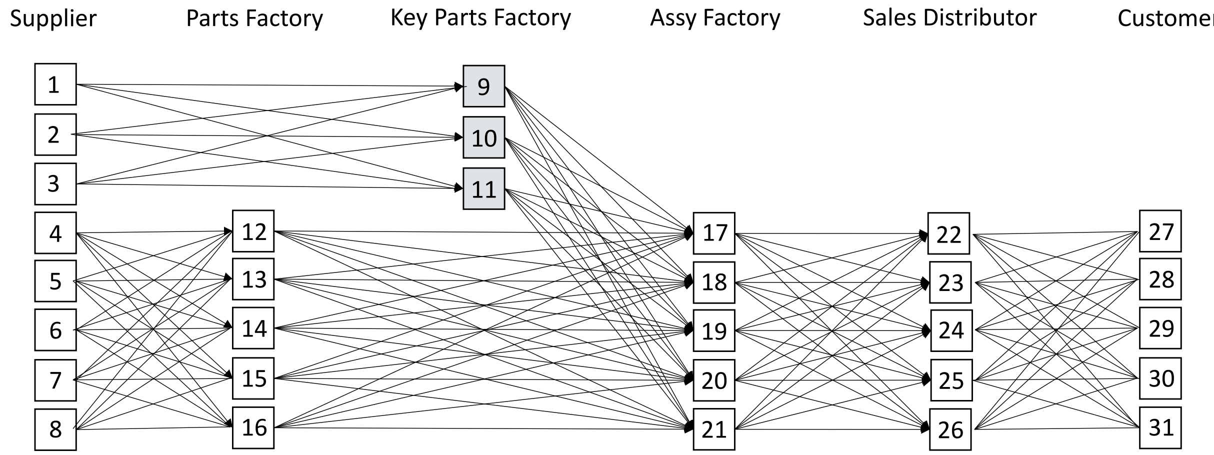

Figure 2. Global supply chain network

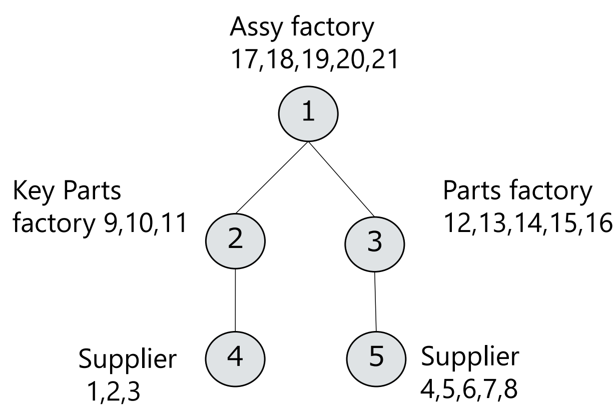

Figure 3. Bill of materials (BOM) and relationship with sites

Since the final product is consisted of quite a large number of sub-parts and parts, this study uses the concept of parts-group to simplify a bill of materials (BOM). An example is in Figure 3, if the final product is numbered 1, it consists of a key parts-group 2 and a general parts-group 3. The key parts-group 2 is further consisted of a sub-parts-group 4, and the general parts-group 3 is consisted of a sub-parts-group 5. The relationship between the BOM and the site shown using the item-site number. For example, in Figure 3, supplier 1,2,3 means that supplier 1, 2 and 3 have the capability to supply sub-parts-group 4.

4. 2 Input data

The data of the target nodes, arcs, and items are as follows:

- Number of nodes: 31
- Final product: 1
- Parts-group: 2
- Sub-parts-group: 2
- Set up cost of production (millions of yen): node17,18,19,20,21 (Item1: 39101~40990),

node9,10,11 (Item2: 43950~47130), node12,13,14,15,16 (Item3: 39178~40413)

- Unit variable cost of production (millions of yen): node17,18,19,20,21 (Item1: 3~4), node9,10,11 (Item2: 5), node12,13,14,15,16 (Item3: 0.2~1.9)
- Unit transportation cost between sites (millions of yen): From node22,23,24,25,26 to node27,28,29,30,31 (Item1: 0.3~1.8); From node9,10,11,12,13,14,15,16 to node17,18,19,20,21 (Item2: 0.3~1.8); From node17,18,19,20,21 to node 22,23,24,25,26(Item3: 3~4); From node1,2,3 to node9,10,11 (Item4: 1~2); From node4,5,6,7,8 to node12,13,14,15,16 (Item5: 0.2~2.1)
- Tariff rates between sites (%): From node22,23,24,25,26 to node27,28,29,30,31 (Item1: 0%~37%); From node9,10,11,12,13,14,15,16 to node17,18,19,20,21 (Item2: 0%~37%); From node17,18,19,20,21 to node 22,23,24,25,26(Item3: 0%~37%); From node1,2,3 to node9,10,11 (Item4: 0%); From node4,5,6,7,8 to node12,13,14,15,16 (Item5: 0%~37%)
- Demand for end customers (piece): node27,28,29,30,31 (Item1: 4286~17143)
- Production capacity (piece): node17,18,19,20,21 (Item1: 3486~18843), node9,10,11 (Item2: 20248~21748), node12,13,14,15,16 (Item3: 3686~19043)
- Unit procurement price of parts (millions of yen): From node1,2,3 to node9,10,11 (Item4: 12~16); From node4,5,6,7,8 to node12,13,14,15,16 (Item5: 3~7.8)
- Unit sales price in end customer market: From node22,23,24,25,26 to node27,28,29,30,31 (final product: 125.64~139.20)
- Corporate tax rate: 0.20~0.28

In addition, the candidate sets of transfer prices are prepared in three levels: Low, Middle, and High, and the corresponding unit production cost is calculated by the profit margin on 0.1,0.2, 0.3, respectively.

5. NUMERICAL EXPERIMENTS

5. 1 The impact of fixed transfer prices on each site

In order to check the impact of each site under fixed transfer prices, a supply chain network design model with fixed transfer prices which proposed in Section 3.1 is used. The results are shown in Table 10 (TP fixed). When the transfer price is fixed (Middle level), the total profit of the network is 8186190, the profit of each site is 0 to 5300850. From the results, it can be seen that the profit of the sites 20,23, 24,25 is value 0 which are the lowest ones, however. the profit of the site 22 is 5300850, which is the highest one.

Because site 20 is an assembly factory, the tariff rate of which is the highest in assembly factories, therefore the procurement cost from the parts factory is high. While the production capacity is substantial in other assembly factories, it can be interpreted that it is not necessary to use the site 20.

Sites 23, 24, 25 and 22 are the same type as regional sales distributors, however the gap of profit is sharply large. The reason is that the average selling prices of site 22 are higher than other sales distributors, and the procurement prices which are related with transfer prices have great possibility be lower. Therefore, if the sales capacity is substantial in each sales distributor especially in site 22, the final product will be more preferable to sell via site 22 instead of sites 23, 24, 25. As a result, the profit of site 22 is considerable, on the contrary, it is possible that the profit of site 23, 24, 25 is terrible.

5.2 Effectiveness of Transfer Pricing

Transfer pricing as a decision variable is considered with supply chain design model in this experiment that to verify when the transfer prices are fluctuating, whether the total profit be increased. As the results showed in Table 10 (TP variable), with decision of transfer prices, the total profit of the supply chain network is increased 327160 compared to when the transfer price is fixed (Middle Level). It can be explained by that (1) the total profit is different due to the different transfer prices, and (2) the total profit can be increased if the transfer price is considered as a decision variable at the same time with the supply chain network design. In other words, it can prove that the effectiveness of the profit maximization model with transfer pricing.

For each site, the increased profit of the whole network is contributed by 13/14 sites. In other words, approximately 93% of the sites contributed to the increase in profits of 327160. This can be thought that the ideal transactions are occur among the members of up and downstream supply chain with Win2Win.

Table 10. Profit and membership function of individual and total site

	Profit (Millions of yen)			Membership function value		
Node i	**TP fixed**	**TP variable**	**Fuzzy**	**TP fixed**	**TP variable**	**Fuzzy**
9	260194	294555	104905	0.86	1.00	0.21
10	55192	64662	244209	0.01	0.05	0.81
11	259302	290484	232398	0.86	0.98	0.76
12	76005	84988	78591	0.75	0.95	0.81
13	51739	61161	30573	0.78	1.00	0.28
14	100539	115774	112308	0.55	0.75	0.70
15	50441	58706	68392	0.44	0.61	0.80
16	28235	35047	22559	0.83	1.00	0.70
17	560980	622599	323980	0.90	1.00	0.54
18	375698	415814	62536	0.91	1.00	0.21
19	811153	887117	766383	0.77	0.88	0.71
20	0	0	454327	0.05	0.05	0.86
21	255750	281488	240307	0.91	0.99	0.86
22	5300850	5300850	1088940	1.00	1.00	0.21
23	0	0	994984	0.00	0.00	0.21
24	0	0	972358	0.00	0.00	0.21
25	0	0	893126	0.00	0.00	0.21
26	106	106	1059110	0.00	0.00	0.21
Total	8186190	8513350	7749980	0.81	1.00	0.55

5.3 Effectiveness of The Multi-Objective Optimization Model Considering Fairness

Experiment is conducted using fuzzy-programming to verify whether fair network design can be performed, including the satisfaction of each site, rather than the single-objective of total profit. As the results showed in Table 10 (Fuzzy), where only 14/18 sites are originally profitable in MILP model, but all of 18/18 sites are profitable in Fuzzy model. In MILP model, the gap of the maximum profit site and the minimum is equal to 5300850 - 0 = 5300850, the difference between the maximum satisfaction level and the minimum is 1-0 = 1, however, in Fuzzy model, the gap becomes smaller to 1088940-22559 = 1066382, the difference of satisfaction level is 0.863 – 0.205 = 0.658, which can see from membership function in Table 10. These results verify the effectiveness of the multi-objective optimization model considering fairness using fuzzy-programming.

Each site acquires their minimum satisfaction with maximum profit under fairness. There is no sacrifice in profit violently, but the total profit will be sacrificed a little instead. In MILP model, the membership function of whole supply chain is 1, and total profit is 8513300, but in fuzzy model that are 7749980 and 0.55253.

6. CONCLUSION

In this study, we focused on balancing the trade-off of fairness and total profit on supply chain network design problem using transfer pricing, which has not be considered in previous studies, and proposed the multi-objective optimization model considering fairness using Mixed Integer Linear Programming and Fuzzy-Programming in steps.

From the experimental results, we were able to verify that the transfer price has a considerable impact on the profit shifting among members of supply chain, and that the total profit can be maximized by transfer pricing. In addition, the proposed multi-objective optimization model that takes fairness into consideration can benefit each member with minimal satisfaction while nice total profit.

Based on experimental results, some suggestions can be got as follows:

Implication (1), When designing a supply chain network, it is more efficient to determine the optimal production sites and sales sites with transfer pricing which is an important economic factor, so it is possible to avoid less efficient sites at the planning stage. However, if the decision makers want to capture the potential market by setting up more sites, it is considered to limit the capability or capacity of individual site such as sales capacity, to increase the site efficiency of less efficient.

Implication (2), Transfer pricing in a single-objective optimization model has a significant impact on the sum of the total profit, the total profit is maximized and looks great, but it cannot be ignored that individual sites are violently sacrificing profits. In addition to the efficient indicator of total profit, a sustainable indicator called "fairness" is also important. If these sustainable indicators are not taking into account, it is considered difficultly for companies to long-term development.

Implication (3), It is important to balance overall and individual interests, but it is not good to significantly sacrifice the overall benefits because of fairness. Sustainable indicators called "fairness" should be valued on the back of efficient indicators of total profit, so that companies can have a better economic cycle. If total profit declines significantly after considering fairness, the decision makers should to check that whether the production resource of the site or the business environment are deteriorating, and the candidate production and sales sites should be reconsidered again.

In the future studies, an analysis of the relationship between market prices and transfer prices, and proposals for profit distribution between different groups seems to be interesting. Besides the satisfaction of the individual member, other factors should be considered to express fairness, and also, other sustainable indicators besides fairness in multi-objective models to be added, is expected. To develop the solution method such as the game theory in addition, is also welcome.

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