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STOCHASTIC DESIGN OF A GLOBAL CLOSED LOOP SUPPLY CHAIN: PLANNING AND MANAGING THE REVERSE NETWORK AT FUJI XEROX

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Abstract

Inspired by the reverse supply chain network at Fuji Xerox Co. we develop a dynamic stochastic model of the network for a production, collection, disassembly and remanufacture of a photocopier produced and sold in both Japan and Thailand. We consider the inventory requirements and costs of saleable products as well as capacity requirements and costs in production, collection, disassembly and remanufacture in both countries. Together with the influence of lead-times, shipping, import duties and transfer cost prices we investigate the proportion of collected products that should be shipped from Japan for disassembly and remanufacture, for a given transfer price as well as the influence of the time in the market and the return rate from the customers. Our numerical analysis is based on representation cost figures from Fuji Xerox.

Keywords: closed loop supply chain, global supply chain, stochastic model, Fuji Xerox Co.

1 INTRODUCTION

Optimization within a certain section that was practiced in the past is no longer sufficient for a firm to survive in such a drastic changeful environment of market like now, while optimization of entire chain of supply from material to consumer is necessary. This concept is called Supply Chain Management (SCM) and has been getting more important in recent years. Furthermore, nowadays, we are faced with big problems of environmental pollution and destruction. Against this backdrop, it is an urgent need to construct Recycling-Based Society.

The SCM used to cover only for production, distribution, consumption, and disposal. But, in the case of construction of Recycling-Based Society system, this perception of SC is no longer sufficient to meet the demand. We have to target for a process flow of disposal, collection, remanufacturing, and distribution and add these to the forward flow of SC. This SC which makes closed cycle is called Closed-Loop Supply Chains (CLSC). CLSC is the key aspect of environmental sustainability, and CLSC is required to introduce a global viewpoint because of internationalization of corporate activities. However it is not easy because the business environment depends on each country, for example, the manufacturing and remanufacturing cost, and the corporation tax rate are not the same.

Recently, various methodologies and examples concerning modeling CLSC have recently been reported. Guide and Van Wassenhove［6］ study the CLSC as sustainable operations. Remanufacturing operational issues include reverse logistics, test, sort, disposition activities, product disassembly, and remanufacturing processes. Kiesmuller and Minner [7] researched about optimization of quantity of manufacturing and remanufacturing that minimize the total cost in remanufacturing system. Minner and Kleber [8] researched about optimal control policy of manufacturing, remanufacturing, and disposal in remanufacturing system. Fleischmann and Minner [4] consider the importance of inventory theory to CLSC. Oshita et al. [11] and Kainuma et al. [10] researched decision policy of order in hybrid system that uses new components and reused components. Ferguson [3] identified strategic issues in CLSC with remanufacturing. Geyer et al. [5] develop a strategic model of economic remanufacturing under limited components durability and finite product life cycles. Concerning Global Supply Chain (GSC), Scholz-Reiter et al. [1] researched the informational cooperation between manufacturing and logistics in GSC. Vidal and Goetschalckx [2] researched the optimization of transportation cost allocation, transfer pricing, and quantity of transportation in GSC. However, the researches about deploying CLSC through multi-country, i.e., the researches about design of Global Closed-Loop Supply Chain Network (GCLSCN) are not so much.

In this research, we develop a GCLSCN model by multinational firm which has 4 kinds of subsidiaries: supplier, assembly factory, retailer, and remanufacturing factory and deploys the CLSCN through four countries. In this model we consider corporation tax of each country. The objective function is sum of net income after taxes of each subsidiary. And we attempt to optimize the traffic volume between each subsidiary, the transportation cost allocation, and the transfer price for maximization of the objective function.

2 GCLSCN MODEL

We can give Fuji Xerox Co., Ltd. as an example of a firm that is managing GCLSCN [9]. Against the back drop of globalism, Fuji Xerox thinks that they should manage decrease international impact on the environment on the same level as that in Japan. Based in this concept, Fuji Xerox had managed reduction of environmental impact in not only in Japan but also other countries.

We consider GCLSCN applied to four countries and four kinds of subsidiaries. Subsidiaries are supplier, assembly factory, retailer, and remanufacturing factory. The suppliers manufacture parts, and sell them to the assembly factory.

The assembly factories assemble finished products using the parts, and sell them to retailer. The retailers sell the finished products to customers in their markets. Furthermore, they collect end-of-use products from customers, and sell them remanufacturing factories. At

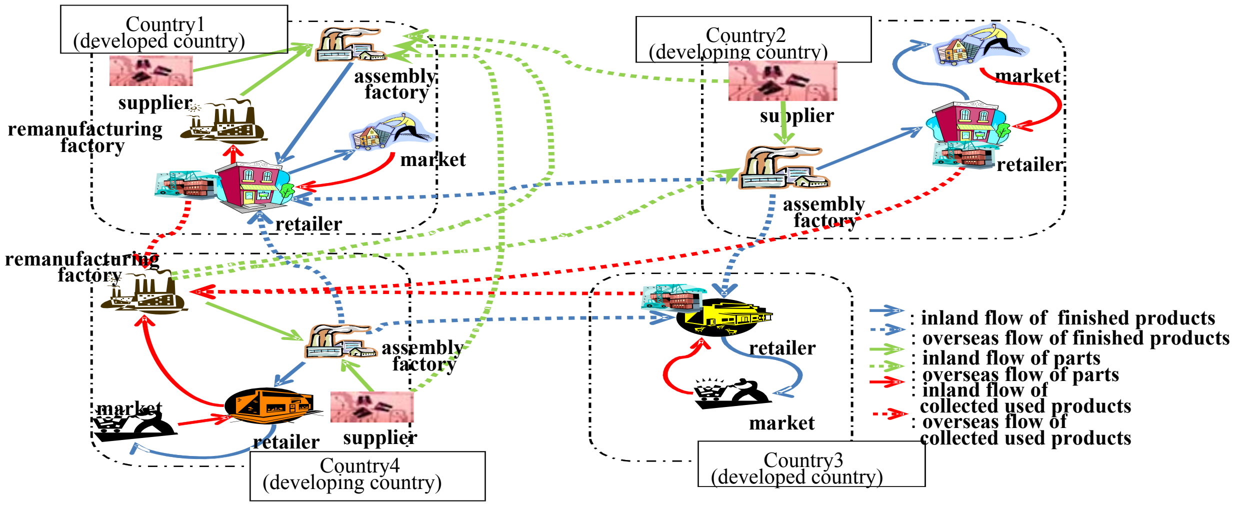

Figure 1 : GCLSCN model.

remanufacturing factories, end-of-use products are disassembled and checked, and return to usable condition. Then the remanufactured parts are sold to assembly factories. In this way, the end-of-use products return to markets.

Four countries which apply the GCLSCN model are divided into developed counties and developing countries. Furthermore, the two developed countries are divided into the country which has supplier, assembly factory, retailer, and remanufacturing factory (country1) and the country which has only retailer (country3). The two developing countries are divided into the country which has supplier, assembly factory, retailer, and remanufacturing factory (country2) and the country which has only supplier, assembly factory, and retailer (country4).

In our model, we suppose that the headquarters exists in country1, and country1 is Japan. So, the net income after tax of each country is converted into yen finally. However, with respect to other country, we don't suppose specific counties. Figure1 shows the GCLSCN model.

In case that the remanufacturing factory imports collected products from overseas retailer, the remanufacturing factory locates a container in the country where the retailer exists. And then, after end-of-use products collected to the container, the remanufacturing factory transports them to own country. The remanufacturing factory bears the cost of transportation from container to own country.

In our model, we consider corporation tax of each country, the transportation cost allocation, and the transfer price. Transfer price is a price that a subsidiary of a firm charges for a product or service supplied to a buying subsidiary of the same firm overseas located in the other country. Firm can save payment for taxes managing in a politic way. Vidal and Goetschalckx [2] proposed GSC model applied to two countries and two subsidiaries considering transfer price and corporation taxes. Figure2 shows the Vidal's model.

A and B are subsidiaries of an identical multinational corporation. A which is located in countryA manufactures products and transports them to B. B which is located in a different countryB pay transfer price for the products to A

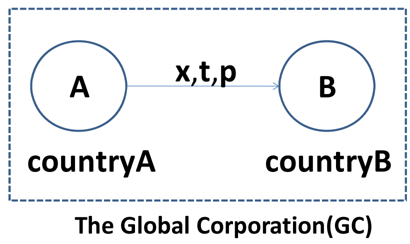

Figure 2 : GSC model (Vidal and Goetschalckx, 2001).

and receive them. In this case, if the corporation tax rate of countryA is larger than countryB, it is possible to save payment for taxes by managing transfer price and transportation cost allocation in an appropriate range and allocating profit to B.

In this paper, we formulate the sum of net income after tax of subsidiaries of four different countries as the objective function. And we attempt to optimize the traffic volume between each subsidiary, the transportation cost allocation, and the transfer price for maximization of the objective function.

3 NOTATION

We use the following notation through this paper.

H : set of suppliers, indexed by *h*.

$H(i)$: set of suppliers that send parts to assembly factory *i*.

I : set of assembly factories, indexed by *i*.

$I(h)$: set of assembly factories using parts provided by supplier *h*.

$I(k)$: set of assembly factories using remanufactured parts provided by remanufacturing factory *k*.

$I(j)$: set of assembly factories that send finished products to retailer *j*.

J : set of retailers, indexed by *j*.

$J(l)$: set of retailers that serve market *l* with finished products and collect end-of-use products from market *l*.

$J(k)$: set of retailers that send collected products to remanufacturing factory *k* directly.

$J(m,k)$: set of retailers that send collected products to remanufacturing factory *k* via container *m*.

$J(i)$: set of retailers that sell finished products provided by assembly factory *i*.

K : set of remanufacturing factories, indexed by *k*.

$K(i)$: set of remanufacturing factories that send remanufactured parts to assembly factory *i*.

$K(j)$: set of remanufacturing factories that receive collected products from retailer *j*.

$K(j,m)$:set of remanufacturing factories that receive collected products from retailer *j* via container *m*.

L : set of markets, indexed by *l*.

$L(j)$: set of markets that purchase finished products from retailer *j*, and provide end-of-use products to retailer *j*.

M : set of containers, indexed by *m*.

$M(j,k)$: set of containers that receive collected products from retailer *j* and send them remanufacturing factory *k*.

Parameters:

DEM_l : quantity of demand in market *l*.

COL_l : quantity of end-of-use products collected in market *l*.

DR_{hi} : import duty rate on the value of parts transported from supplier *h* to assembly factory *i*. In this way, DR expresses also import duty rate on the value of finished products transported from assembly factory *i* to retailer *j*, that on the value of remanufactured parts transported from remanufacturing factory *k* to assembly factory *i* and that on the collected products transported from retailer *j* to remanufacturing factory *k*.

FC_h : fixed cost of supplier *h*. In this way, FC expresses also fixed cost of assembly factory *i*, that of retailer *j* and that of remanufacturing factory *k*.

MC_m : maintenance cost of container *m*.

IC_{hi} : inventory cost per a unit of part transported from supplier *h* to assembly factory *i*. In this way, IC expresses also inventory cost per a unit of finished product transported from assembly factory *i* to retailer *j*, that per a unit of finished product sold by retailer *j* to market *l*, that per a unit of remanufactured part transported from remanufacturing factory *k* to assembly factory *i* and that per a unit of collected product transported from retailer *j* to remanufacturing factory *k*.

HC_j : handling cost of finished product in retailer *j*.

SP_l : market price of finished product in market *l*.

PC_h : production cost of one part in supplier *h*. In this way, PC expresses also production cost of one finished product in assembly factory *i*.

DC_k : decompose and check cost of collected product in remanufacturing factory *k*.

TC_{hi} : transportation cost per a unit of part transported from supplier *h* to assembly factory *i*. In this way, TC expresses also transportation cost per a unit of finished product transported from assembly factory *i* to retailer *j* and that per a unit of finished product transported from retailer *j* to market *l*.

TC_{jk} : transportation cost per a unit of collected products transported from retailer *j* to remanufacturing factory *k* directly.

TC^C_{jmk} : transportation cost per a unit of collected products transported from retailer *j* to container *m*. These collected products are sent to remanufacturing factory *k* via container *m*.

TC_{ki} : transportation cost per a unit of remanufactured part transported from remanufacturing factory *k* to assembly factory *i*.

CO_l : collection cost of end-of-use product in market *l*.

TR_h : corporate tax rate of the home country of supplier *h*. In this way, TR expresses also corporate tax rate of the home country of assembly factory *i*, that of the home country of retailer *j*, and that of the home country of remanufacturing factory *k*.

E_h : exchange rate of home country of supplier *h* against yen [monetary units of the respective country/yen]. In this way, E expresses also exchange rate of home country of assembly factory *i*, that of home country of retailer *j*, and that of home country of remanufacturing factory *k*.

Decision Variables:

x : traffic volume between each subsidiary.

y : transportation cost allocation.

t : transfer price.

z : net income before tax (NIBT).

We give a full detail of decision variables in the following section.

4 MODEL FORMULATION

In this research objective function is sum of net income after tax (NIAT) of each subsidiary. Decision variables are the traffic volume between each subsidiary, the transportation cost allocation, the transfer price and NIBT of each subsidiary.

The traffic volume is expressed by *x*. The first index expresses origin of transportation and the second index expresses destination of transportation. For example, x_{hi} expresses the volume of parts that are transported from supplier *h* to assembly factory *i*. However, x_{jmk} expresses the volume of collected products that are transported from retailer *j* to remanufacturing factory *k* via container *m*.

The transportation cost allocation is expressed by *y*. The first index expresses origin of transportation and the second index expresses destination of transportation. Furthermore, comma above expresses the cost allocated to destination of transportation. For example, y_{hi} expresses amount of transportation cost between supplier *h* and assembly factory

i allocated to supplier h, and y'_{hi} expresses amount of transportation cost between supplier h and assembly factory i allocated to assembly factory i. However, y_{jmk} and y'_{jmk} express the transportation cost allocation for collected products that are transported from retailer j to remanufacturing factory k via container m.

The transfer price is expressed by t. The index expresses the subsidiary which is origin of transportation. For example, t_h expresses transfer price of part transported from supplier h. In this research, as a requirement for the justification of transfer price to tax authorities, all the transfer prices from a given origin must be the same for all the destinations.

The NIBT of each subsidiary is expressed by z. The index expresses subsidiary. Where, $z^+ = \max\{z,0\}$ and $z^- = -\min\{z,0\}$. For example, z_h^+ expresses profit before tax of supplier h and z_h^- expresses loss of supplier h.

We formulate objective function using NIBT of each subsidiary in the following. The corporate tax is imposed on only NIBT is larger than zero. Because of their definition, z^+ and z^- must not be positive simultaneously. But note that in any optimal solution z^+ and z^- cannot be positive simultaneously.

The objective function can be written as

$$\begin{aligned} Maximize\ \ NIAT = &\sum_{h\in H}\left[(1-TR_h)z_h^+ - z_h^-\right] + \sum_{i\in I}\left[(1-TR_i)z_i^+ - z_i^-\right] \\ &+ \sum_{j\in J}\left[(1-TR_j)z_j^+ - z_j^-\right] + \sum_{k\in K}\left[(1-TR_k)z_k^+ - z_k^-\right]. \end{aligned} \tag{1}$$

The followings show the main constraints. Equality constraints from (2) to (5) express the NIBT of each subsidiary.

The NIBT of supplier is given as

$$\begin{aligned} \sum_{i\in I(h)}\left(\frac{t_h}{E_h} - \frac{PC_h + IC_{hi}}{E_h}\right)x_{hi} - \sum_{i\in I(h)}\left(\frac{1}{E_h}\right)y_{hi} - \left(\frac{1}{E_h}\right)FC_h \\ = z_h^+ - z_h^-,\ h\in H. \end{aligned} \tag{2}$$

The NIBT of assembly factory is given as

$$\begin{aligned} &\sum_{j\in J}\left(\frac{t_i}{E_i} - \frac{PC_i + IC_{ij}}{E_i}\right)x_{ij} - \sum_{j\in J}\left(\frac{1}{E_i}\right)y_{ij} - \sum_{h\in H(i)}\left(\frac{1}{E_h}\right)y'_{hi} - \sum_{k\in K(i)}\left(\frac{1}{E_k}\right)y'_{ki} \\ &- \sum_{h\in H}\left(\frac{1}{E_h}\right)\left[(1+DR_{hi})t_h + DR_{hi}TC_{hi}\right]x_{hi} \\ &- \sum_{k\in K(i)}\left(\frac{1}{E_k}\right)\left[(1+DR_{ki})t_k + DR_{ki}TC_{ki}\right]x_{ki} \\ &- \left(\frac{1}{E_i}\right)FC_i = z_i^+ - z_i^-,\ \ i\in I. \end{aligned} \tag{3}$$

The NIBT of retailer is given as

$$\begin{aligned} &\sum_{l\in L(j)}\left(\frac{1}{E_j}\right)(SP_l - HC_j - TC_{jl} - IC_{jl})x_{jl} \\ &- \sum_{i\in I(j)}\left(\frac{1}{E_i}\right)\left[(1+DR_{ij})t_i + DR_{ij}TC_{ij}\right]x_{ij} - \sum_{i\in I(j)}\left(\frac{1}{E_i}\right)y'_{ij} \\ &+ \sum_{m\in M}\left(\frac{1}{E_j}\right)t_j x_{jm} + \sum_{k\in K(j)}\left(\frac{1}{E_j}\right)t_j x_{jk} - \left(\frac{1}{E_j}\right)CO_l COL_l \\ &- \sum_{m\in M(j,k)}\left(\frac{1}{E_j}\right)y_{jmk} - \sum_{k\in K(j)}\left(\frac{1}{E_j}\right)y_{jk} - \left(\frac{1}{E_j}\right)FC_j \\ &= z_j^+ - z_j^-,\quad j\in J. \end{aligned} \tag{4}$$

The NIBT of remanufacturing factory is given as equation(5).

$$\begin{aligned} &\sum_{i\in I(k)}\left(\frac{t_k}{E_k} - \frac{IC_{ki} + DC_k}{E_k}\right)x_{ki} - \sum_{i\in I(k)}\left(\frac{1}{E_k}\right)y_{ki} - \sum_{j\in J(m)}\left(\frac{1}{E_j}\right)y'_{jmk} - \sum_{j\in J(k)}\left(\frac{1}{E_j}\right)y'_{jk} \\ &- \sum_{j\in J(m)}\sum_{m\in M(j,k)}\left(\frac{1}{E_j}\right)\left\{\left[(1+DR_{jk})(t_j + TC^c_{jmk})\right]x_{jmk} + MC_m\right\} \\ &- \sum_{j\in J(k)}\left(\frac{1}{E_j}\right)t_j x_{jk} - \left(\frac{1}{E_k}\right)FC_k = z_k^+ - z_k^-,\ \ k\in K. \end{aligned} \tag{5}$$

Since the optimization problem is neither convex nor concave, it is difficult to obtain an optimal solution. So we use genetic algorism (GA) to solve the problem.

5 NUMERICAL ANALYSES

In this research, we use GA to solve the optimization problem.

The GA is a solution method that starts with solution sets which are gained randomly, and research the values of evaluation function. Next, two solution sets which make evaluation function better are coupled and new solution sets are made. Repeating these processes, GA researches better solutions.

We describe the ways of encoding, crossover, mutation, and termination check which are used in our research.

(1) Encoding

In this research, we use direct value encoding, i.e., we express chromosome using decision variables directly.

(2) Crossover

In this research, we use single point crossover, i.e., one crossover point is selected and two chromosomes cross at the selected point.

(3) Mutation

In this research, we practice mutation of chromosomes in the range of each decision variable.

(4) Selection

We use roulette wheel selection, i.e., chromosomes are selected according to their fitness.

(5) Termination Check

As termination check, we use generation number. We stop GA when the generation number come up to 40000. In advance, we checked rate of variability is less than 1% for 10000 generations if we continue GA until 40000 generations.

5.1 Simulation Results

The table1 shows the set of main parameters which are used our simulation. $\overline{T}$ and $\underline{T}$ in the Table1 are upper bound and lower bound of each transfer price.

We decide follow preconditions for fixing parameters.

- The cost for activity of subsidiaries, for example, production cost of parts, production cost of finished products and remanufacturing cost in developed countries are higher than that in developing countries.
- The oversea transportation costs are higher than the inland ones.
- The selling prices in the developed country are higher than that in the developing country.
- The quantity of demands and collected products in developed countries are higher than that in developing countries.

Table 1 : Parameters.

	Country1	Country2	Country3	Country4
PC_h	20	15	-	15
PC_i	20	15	-	15
DC_k	5	-	-	3
HC_j	5	3	5	3
FC_h	5000	3000	-	3000
FC_i	5000	3000	-	3000
FC_j	5000	3000	5000	3000
FC_k	5000	-	-	3000
SP_l	300	200	300	200
$\overline{T}_h$	30	20	-	20
$\underline{T}_h$	20	15	-	15
$\overline{T}_i$	55	40	-	40
$\underline{T}_i$	45	30	-	30
$\overline{T}_j$	10	4	10	4
$\underline{T}_j$	7	2	7	2
$\overline{T}_k$	30	-	-	15
$\underline{T}_k$	20	-	-	10
DEM_l	15000	7000	10000	7000
COL_l	500	350	500	350

In this research, we consider exchange rate. The exchange rate of country1 is 1 because we suppose country1 is Japan and has the headquarters. And we define the exchange rate of country2 is 0.08[monetary units of the country2/yen], the one of country3 is 0.01 and the one of country4 is 0.4. Note that in table1, we express all costs, selling prices and transfer prices in yen for comprehensibility.

In addition, we define the corporation tax is 0.6 in country1 and 3, and 0.4 in country2 and 4. The internal transportation cost in country1 and country3 are 3yen, country2 and country4 are 1yen. Furthermore, the oversea transportation cost is 10yen and the number of parts for producing a finished product is 2. The simulations were performed on AMD FX™-8100 Eight-Core Processor, 2.8GHz, 4GB RAM running under Python.

Figure 3 shows the calculation process of GA. Concerning the parameters of GA, we define that the population is 150, the rate of mutation is 0.04 and the rate of crossover is 1.0. The time for all calculation is 3527.4 seconds.

We checked solution space using Response Surface Method (RSM) to confirm the optimality of the GA solution. Figure 4 and 5 show the results of executing RSM about following 4 decision variables.

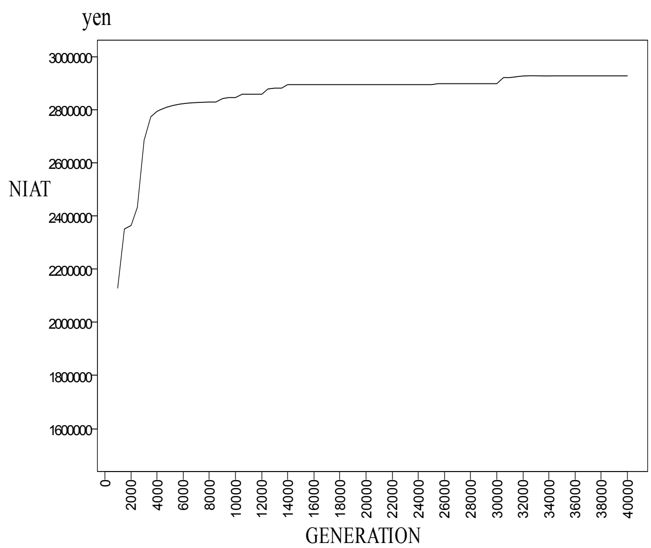

Figure 3 : The calculation process of GA.

t_{h_1} : transfer price of a part transported from supplier of country1.

t_{j_3} : transfer price of a collected product transported from retailer3.

$y_{h_1 i_1}$: amount of transportation cost between supplier of country1 and assembly factory of country1, allocated to supplier.

$y_{h_2 i_2}$: amount of transportation cost between supplier of country2 and assembly factory of country2, allocated to supplier.

Table 2 shows the best NIAT and the value of decision variables as instances of result of the simulation.

Table 2 : The best NIAT and the value of decision variables.

Best NIAT	¥2926806.24
t_{h_1}	¥25.30
t_{j_3}	¥7.09
$y_{h_1 i_1}$	¥6805.74
$y_{h_2 i_2}$	¥452.83

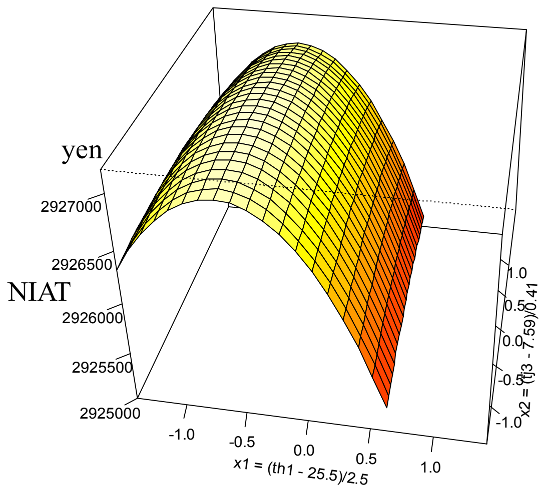

Figure 4 : The result of executing RSM about t_{h_1} and t_{j_3}.

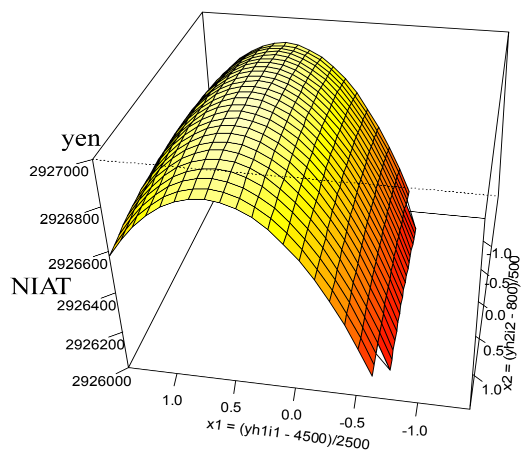

Figure 5 : The result of executing RSM about $y_{h_1 i_1}$ and $y_{h_2 i_2}$.

5.2 Discussion

Figure3 shows that the solution converges sufficiently when we continue GA process for 40000 generations. And Figure4 and 5, the results of executing of RSM, show that solution space has an apex around the solution found by GA. From this, we can conclude that the solution found by GA is close to optimal and the result of GA is precision.

Furthermore, Figure3 shows the NIAT takes ¥2892558.19 that is near 99% of the best NIAT at the 14000th generation and we can find there are slight improvements after that generation. If we execute GA process for 40000 generations, it takes about 1 hour. But we can get good solution for less generation number.

In the case that multinational firm deploys GCLSCN, there is a need to get solution rapidly to planning within limited time as well as to get the best solution to planning carefully. Our model is sufficiently useful in each case.

6 CONCLUSIONS

In recent years, various problems such as the global warming and environmental destruction are becoming more serious. Therefore the environmental problems attract public attention. In order to solve these problems, construction of Recycling-Based Society is urgent need, and CLSC gets attention as the means of constructing the Recycling-Based Society. Moreover, considering recent internationalization of corporate activity, CLSC operated in only one country is no longer enough. A research of design and management of GCLSCN considering cross-national differences is need.

In this research, we develop a GCLSCN model which is applied to 4 kinds of subsidiaries and deploys the CLSC through four countries which are different in economic power and business environment from each other. The remanufacturing in developing country is more reasonable than in developed country. But, we had to consider cost of production and demands and so on of each country when we decide the volume of products collected in developed countries, transported to developing countries and remanufactured there.

In addition, in this paper we considered corporation tax of each country, transfer price and transportation cost allocation. And we formulated the sum of net income after taxes of all subsidiaries as the objective function, and we attempt to optimize the traffic volume between each subsidiary, the transportation cost allocation and the transfer price for maximization of the objective function. As the result of the computational simulation, we confirm the efficiency of the proposed optimization. For the corporations that try to desige a good benchmark for their decision making. n and manage GCLSCN, the result of our simulation will b

In this paper we considered production cost, demands, returns, corporation tax, transfer price and transportation cost allocation as the features of GCLSCN. But, our model considers only single-period planning. To manage GCLSCN, it is necessary to consider that quantity of demands and collected products vary on multi-period. Further research should develop more pragmatic GCLSCN model that consider the affects of variance of business environment, and optimize that.

ACKNOWLEDGEMENTS

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REFERENCES

[1] Scholz-Reiter B,, Frazzon E. M. and Makuschewitz T., (2010), “Integrating manufacturing and logistic systems along global supply chains”, *CIRP journal of Manufacturing Science and Technology*, Vol.2, pp.216-223

[2] Vidal, C. J., Goetschalckx M., (2001) “A global supply chain model with transfer pricing and transportation cost allocation”, *European Journal of Operational Research*, Vol.129, pp.134-158

[3] Ferguson, M. (2009), “Strategic Issue in Closed-Loop Supply Chains with Remanufacturing”, Working Paper, College of Management, Georgia Tech, Atlanta, GA30332

[4] Fleischmann, M., and Minner, S. (2004), Inventory management in Closed Loop Supply Chains, in Dyckhoff, H., Lacker, R. and Reese, J. (Ed.), *Supply Chain Management and Reverse Logistics*, Springer, Heidelberg, pp115-138

[5] Geyer, R., Van Wassenhove, L. N. and Atasu, A. (2007), “The economic of remanufacturing under limited component durability and finite product life cycle”, *Management Science*, Vol. 53, No. 1, pp. 88-100

[6] Guide, D. and Van Wassenhove, L. N. (2006), “Closed-Loop Supply Chain: An introduction to the feature issue (Part 1)”, *Production and Operations Management*, Vol. 15, No. 3, pp. 345-350

[7] Kiesmuller, G.P. and Minner ,S. (2003), “Simple Expression for Finding Recovery System Inventory Control Parameter Values”,*Journal of the Operational Research Society*, Vol.54, No.1, pp.83-88

[8] Minner S. and Rainer Kleber, (2001), “Optimal control of production and remanufacturing in a simple recovery model with linear cost function”, *OR Spektrum*, Vol.23, pp.3-24

[9] Kerr W. and Ryan C., (2001), “Eco-efficiency gains from remanufacturing A case study of photocopier remanufacturing at Fuji Xerox Australia”, *Journal of Cleaner Production*, Vol.9, pp.75-81

[10] Kainuma, Y., Ahsan, K. and Tawara N., (2011) “Development of the Cascade Reuse Hybrid Manufacturing/Remanufacturing System”, *Proceedings of the 21st International Conferrence on Production Research*, CD-ROM

[11] Oshita, Y. and Kainuma, Y. (2008), “Optimal Ordering Policy for Cascade Reuse in Closed-loop Supply Chain”, *Proceedings of the 3rd World Conference on POM*