# A Study on a Decision Support Model for Strategic Alliance in Express Courier Service

Friska Natalia Ferdinand[1], Ki Ho Chung[2], Hyun Jeung Ko[3] and Chang Seong Ko[4]

[1]*Dep.of Industrial Engineering, Pusan National University, Daehak-ro, Geumjeong-gu, Busan, 609 – 735, Korea*

[2]*Dep. of Management Information Systems, Kyungsung University, Daeyeon-dong, Nam-gu, Busan, 608-736, Korea*

[3]*Dep. of Logistics, Kunsan National University, 558 Unversity Avenue, Gunsan, Jeonbuk, 573-701, Korea*

[4]*Dep. of Industrial & Management Engineering, Kyungsung University, Daeyeon-dong, Nam-gu, Busan, 608-736, Korea*

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Abstract: The market competition of express courier service has become severe so that an express delivery company is consistently under pressure to operate its service network as efficient as possible. In this regard, the strategic alliance among small and medium companies can be a useful way in order to maintain their competitiveness. To cope with such challenges, this study proposes a decision support model to examine the feasibility of merging under-utilized courier service centers and collaborating consolidation terminals with strategic alliances among them. The proposed models can be formulated as multi-objective programming models maximizing the minimum expected profit increase of each participating company. A solution procedure based on the maxmin criterion is developed by using a genetic algorithm. The applicability and efficiency of the proposed models is demonstrated through illustrative numerical examples.

## 1 INTRODUCTION

The market of express courier service in Korea has been expanding 20% or higher annually, which is much faster increase than in other industry areas. It however becomes already saturated because a large number of companies are entering into the Korea market. As a result, they are facing with high competition with respect to low margin and high quality of customer service (Chung et al., 2011). Therefore, to cope with these substantial competition pressures, strategic alliance is proposed as an effective solution to the challenges faced by small and medium sized enterprises in express courier service. In this paper, the network design models with strategic alliance are proposed to improve the efficiency of the logistics networks among small and medium express courier service companies. An express courier network generally consists of customer zones, service centers, and consolidation terminals. The proposed model adopts a win-win alliance relationship for the participating companies, and suggests how to increase the net profit of each company by harnessing their low demand and under-utilized service centers, and sharing consolidation terminals with available processing capacities. In order to do this, a multi objective programming model and the solution procedure was developed based on genetic algorithm approach and coded in matlab 7.0 with numerical examples in this study.

There have been a few of researches on the topic of strategic alliances in logistics. Some researchers, such as Chopra and Meindl (2004), Min (1996), and Simchi-Levi et al. (2003), pointed out that the companies which owned and operated their facilities independently may benefit from the strategic alliance scheme which is conceptually similar to facility sharing. And optimal capacity allocation as a solution methodology for dealing with facility sharing was proposed by Cachon and Lariviere (1999). With respect to the cutoff time adjustments in an express courier network design, a couple of researches have been conducted (Ko et al., 2010); (Ko et al., 2011).

In particular, a study related to the express courier service network design reflecting strategic alliance was performed by Chung et al. (2009), and they proposed a network design model for strategic alliances among express courier service companies by monopoly of service centers. And then, Chung et al. (2010) extended their previous study to the problem of sharing service centers where an integer


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programming model and its solution procedure based on a fuzzy set theoretic approach were developed, and their study was performed under the assumption that only service centers selected as candidates for strategic alliance are considered. Later, Chung at al. (2011) proposed a nonlinear integer programming model for strategic alliance for the survival of multiple service centers and a fuzzy set theoretic solution procedure is used. And, Ferdinand et al. (2012) extended Chung et al. (2011)'s work by applying a genetic algorithm method in order to consider the efficient operations of consolidation terminals with respect to strategic alliance. They proposed a decision making model which dealt with closing/opening multiple service centers and sharing consolidation terminals simultaneously.

Therefore, this study extends Ferdinand et al.(2012)'s work by considering the closing of consolidation terminals, but taking the survival of only single service center into account for strategic alliance. In detail, it is first carried out that only a single service center can survive in each merging region, and then the opened service centers are assigned to single or multiple consolidation terminals within their capacity limitations.

## 2 PROBLEM DEFINITION

This paper is one of the extension works based on the previous studies by Chung et al. (2009, 2010, 2011) and Ferdinand et al. (2012) so that the problem situation is similar to the ones described in their studies but some additional factors are taken to account. In a courier service network of a company in Korea, there are some service centers where the daily pick-up demands are very low. In particular, the regions that have low volume shipments in service centers are called as Type I indicating the potential merging regions, and the other service centers do not belong to any merging regions called as Type II. In general, small and medium sized-enterprises (SMEs) are operating some under-utilized service centers in Type I, achieving only for customer satisfaction not generating profits. As such, the concept of strategic alliance between SMEs can be applied to the regions, Type I, for not only reducing the operation costs of under-utilized facilities without hurting their current service levels but also increasing their net profits. The strategic alliance works such a way that they participate to collaborate in pick-up operations at the open service centers in Type I as well as to share the capacities of consolidation terminals by reassigning all the service centers to the appropriate terminals. The assumptions are as follows:

a) Within a merging area, only single service center can be opened and all the other service centers are closed after the alliance.

b) All pick-up amounts of closed service centers within the same merging area are assigned to the opened service centers after the alliance.

c) At least one terminal for each company must be opened and the remaining is closed within a region after the alliance.

d) The open Type I service centers in each merging area as well as Type II service centers should be reassigned to partnering companies' available consolidation terminals within the capacity limitations.

Based on the setting, this paper proposes a non-linear integer programming model which is designed to maximize the minimum expected profit increase of each participating company. The objective function for the strategic alliance problem is maxmin criterion, and genetic algorithm is developed to solve the model. The mathematical formulation can be described as follows:

Max

$$Z_1(x)=\sum_{i\in I}\left(r_{i1}D_i-f_{i1}-\sum_{k\in T_1}w_{1k}a_{i1k}D_i\right)x_{i1}+\sum_{i\in I}\sum_{k\in T_1}w_{1k}D_iy_{i1k}+\sum_{p\in J}\sum_{l\in S_p}\sum_{k\in T_1}q_{pl1k}d_{pl}^2z_{pl1k}-\sum_{k\in T_1}a_{1k}v_{1k}+C_1$$

$\vdots$

Max

$$Z_n(x)=\sum_{i\in I}\left(r_{in}D_i-f_{in}-\sum_{k\in T_n}w_{nk}a_{ink}D_i\right)x_{in}+\sum_{i\in I}\sum_{k\in T_n}w_{nk}D_iy_{ink}+\sum_{p\in J}\sum_{l\in S_p}\sum_{k\in T_n}q_{plnk}d_{pl}^2z_{plnk}-\sum_{k\in T_n}a_{nk}v_{nk}+C_n \quad (1)$$

s.t.

$$\sum_{j\in J}x_{ij}=1, \qquad i\in I \quad (2)$$

$$\sum_{j\in J}\sum_{k\in T_j}y_{ijk}=1, \qquad i\in I \quad (3)$$

$$y_{ijk}\le v_{jk}, \qquad i\in I,\ j\in J,\ k\in T_j \quad (4)$$

$$\sum_{j\in J}\sum_{k\in T_j}z_{pljk}=1, \qquad p\in J,\ l\in S_p \quad (5)$$

$$\sum_{k\in T_j}v_{jk}=1, \qquad j\in J \quad (6)$$

$$\sum_{i\in I}D_iy_{ijk}+\sum_{p\in J}\sum_{l\in S_p}d_{pl}^2z_{pljk}\le Q_{jk}v_{jk}, \qquad j\in J,\ k\in T_j \quad (7)$$

$$x_{ij}\in\{0,1\}, \qquad i\in I,\ j\in J \quad (8)$$

$$y_{ijk}\in\{0,1\}, \qquad i\in I,\ j\in J,\ k\in T_j \quad (9)$$

$$z_{pljk}\in\{0,1\}, \qquad p\in J,\ l\in S_p,\ j\in J,\ k\in T_j \quad (10)$$

$$v_{jk}\in\{0,1\}, \qquad j\in J,\ k\in T_j \quad (11)$$

Table 1: The rules for opening/closing service centers.

| Open Service Center | | | | | Reallocated Pick-up Amount | | | |
|---|---|---|---|---|---|---|---|---|
| Cases | SC1 | SC2 | SC3 | SC4 | SC 1 | SC 2 | SC 3 | SC 4 |
| 1 | ○ | | | | *SC2+SC3+SC4* | | | |
| 2 | | ○ | | | | *SC1+SC3+SC4* | | |
| 3 | | | ○ | | | | *SC1+SC2+SC4* | |
| 4 | | | | ○ | | | | *SC1+SC2+SC3* |

# 3 ALGORITHM DEVELOPMENT

The proposed solution algorithm in this study is designed based on the work by Ferdinand et al. (2012), in which they used integer based genetic algorithm so that the parameters used in this study are similar. In detail, this study develops six steps to solve the proposed model based on the genetic algorithm where it firstly chooses which service centers (only single service center is opened) will be opened/closed in each merging area, and then, in the second step, assigns all the daily pick-up amounts to the opened Type I service centers. The third step decides which consolidation terminals are opened or closed for the allocation of shipments from service centers, and then reallocates all of service centers to the available consolidation terminals. Finally, it calculates the profits of each company based on maxmin criterion. In the proposed genetic algorithm, four genetic operators are used such as cloning, parent selection, crossover, and mutation operators. The parameter values for genetic algorithm are: the population size equals to 500; the maximum number of generations is 150; the cloning rate is set at 2%; the crossover rate and mutation rate are 60-70% and 4-7%, respectively.

## 3.1 Chromosome Design

In this study, we consider four companies for strategic alliance for which the chromosome consists of four parts dealing with decision variables shown in Figure 1. The first through third parts are designed for Type I where five regions of each company are considered, and the last part is for Type II where ten regions are considered in each company. In addition, each company are currently running two consolidation terminals. In the first part, the first to the fifth genes describe which service center will be opened in each merging region where one service center is allowed to be opened according on the rule in Table 1.

The values of five genes, considering that single service center is opened in each merging region, can be selected from 1 to 4 based on the available cases shown in Table 1 since there four companies. For example, Figure 1 shows that the first five genes have integer values such as 1, 3, 2, 4 and 1 which means, in region 1 through region 5, company 1's service center is opened (SC1), while in region 2, 3, and 4, the opened service centers are company 3's, company 2's, and company's 4 (SC3, SC2, and SC4) respectively.

| Merging Region | | | | | | | | | | | | | | | | Non-Merging Region | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Service Center | | | | | Available Terminal | | | | Terminal Allocation | | | | | | | Terminal Allocation | | | | | | |
| 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 5 | ... | 20 | 1 | 2 | 3 | 4 | 5 | ... | 40 |
| 1 | 3 | 2 | 4 | 1 | 3 | 1 | 2 | 1 | 6 | 7 | 2 | 2 | 2 | ... | 6 | 2 | 8 | 6 | 3 | 6 | ... | 6 |
| R1 | R2 | R3 | R4 | R5 | C1 | C2 | C3 | C4 | R1C1 | R1C2 | R1C3 | R1C4 | R2C1 | | R5C4 | R1C1 | R1C2 | R1C3 | R1C4 | R2C1 | | R10C4 |

Figure 1: Chromosome representation.

The second part in Figure 1 describes which consolidation terminals will be opened in each region where single or two terminals are allowed to be opened according to the rule in Table 2. The value of five genes can be selected from 1 to 3 based on the available cases. Case 1 and Case 2 show only single terminal is opened, while, in Case 3, two consolidation terminals are opened.

In Figure 1, the values of sixth through ninth gens are randomly generated, in which the genes have values such as 3, 1, 2, and 1. This means that two terminals (Terminal 1 and 2) are opened in Company 1, while in Company 2, 3, and 4 only one terminal (Terminal 3, 6, and 7) are opened respectively based on Table 2. The third and fourth parts in Figure 1 show that the allocations of service centers to consolidation terminals for the merging and non-merging regions.

## 3.2 Crossover and Mutation Operators

This study applied a three-point crossover where the first point is used to assign which service centers can be opened; the second point is used to assign which consolidation terminals will be available; the last point is used for reassigning the Type I and Type II service centers to the opened consolidation terminals. The crossover process can be seen in

Table 2: The rules for opening/closing terminals.

| Case | Company 1's Opened Terminal | Company 2's Opened Terminal | Company 3's Opened Terminal | Company 4's Opened Terminal |
|---|---|---|---|---|
| 1 | 1 | 3 | 5 | 7 |
| 2 | 2 | 4 | 6 | 8 |
| 3 | 1 & 2 | 3 & 4 | 5 & 6 | 7 & 8 |

Figure 2.

For the first point, the general method that many people already adopt is used. However, in the second and third point, a different way should be applied. For example, the gene 7 of parent 1, the value is three, which means two the available terminals are 3 and 4 in the company, while in parent 2, the value is two, meaning that only terminal 4 is available. As such, if a usual crossover is directly used, it will cause some errors because the numbers of available terminals are different. Therefore, this process needs some restrictions to get the possibility of searching a wider solution space.

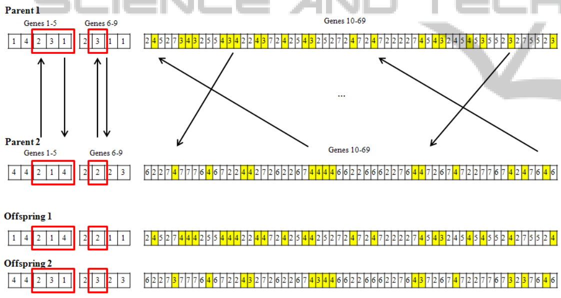


Figure 2: Crossover method.

As mentioned before, the mutation process also has some restrictions where not all of the genes can be flipped by randomly. In particular, the sixth until ninth genes will not have mutation process because there is a dependency with the tenth until sixty-ninth genes, dealing with which terminals will be available. For avoiding the errors, the first step is to select the six genes with random, where two genes will be randomly selected from the section of service centers, and the other four genes are selected from the parts of merging and non-merging terminal allocation areas. In doing so, the procedure is divided it into three parts, the first part is from the first until fifth genes; the second part is from the tenth to twenty-eighth genes; the third part is from the tenth to sixty ninth genes. In the second and third parts, all of the genes depend on the distances between the terminals and the service centers. In this regard, the mutation performs one of the following actions:

a) If both terminals are available based on distance rules for merging region and non-merging region, then they switch positions in the solution.

b) If both terminals are not available in distance, then they are not changed randomly but it takes a specially designed process.

## 4 NUMERICAL EXAMPLE

For the numerical example, there are four express courier service companies where each company has two consolidation terminals with the different fixed costs for all terminals in Table 3. The set of the consolidation terminals of Company 1 is {1, 2}; the set of Company 2 is {3, 4}; the set of Company 3 is {5, 6}. The set of Company 4 is {7, 8}. Every opened service center of each company should be allocated to a consolidation terminal. The daily pick-up amount for each Type I service center is determined in the range between 10 and 50 units while for each Type II between 100 and 500 units through random-number generation. In addition, service center closedown results in the reduction of daily fixed cost for maintaining and operating the service centers, so these cost reductions should be converted into net profit value. These are obtained by generating random-number between \$50 and \$100 per day. Terminal capacity is equally assigned to 3,500 units for the consolidation terminals of the four companies.

In this scenario, all the terminals will not be available for each company within the region because of the terminal distance. The assumptions for this scenario are as follows:

a) The consolidation terminal is available for its company

b) If the other company's terminal distance is more than 70 km then it will be not available in that region.

The overall procedures are coded in Matlab 7.0 and all the results are shown in the Figure 3. The optimal solution for maxmin criterion can be obtained using GA, and the result after GA implementation is

Table 3: Fixed operating costs of terminals for each company.

| Company 1 | | Company2 | | Company 3 | | Company 4 | |
|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| 1672 | 1896 | 1337 | 1021 | 1714 | 1905 | 1483 | 1259 |

shown in Table 4(a) and 4(b). Only in the merging region 1, Company 1's service center is selected to be open while in the region 3 and 4, company 4's service center is selected and company 2's service center is selected in regions 2 and 5 respectively. The available terminals in this case are terminal 2, 3, 4, 6, and 7. Based on maxmin criterion, the total profit of $134,567 represents the total sum of the profit for each company, where the profits for each company are $34,459, $26,128, $28,862, and $45,119 respectively.

Table 4: The summary of test result.

a) Available Terminals for Each Company

| Company | Available Terminal |
|---|---|
| 1 | 2 |
| 2 | 3 & 4 |
| 3 | 6 |
| 4 | 7 |

b) Type I Service Centers

| Merging Region | Opened Service Center | Terminal Allocation |
|---|---|---|
| 1 | 1 | 2 |
| 2 | 2 | 3 |
| 3 | 4 | 6 |
| 4 | 4 | 7 |
| 5 | 2 | 3 |

c) Type II Service Centers

| Non-Merging Region | Terminal Allocation | | | |
|---|---|---|---|---|
| | C1 | C2 | C3 | C4 |
| 1 | 2 | 6 | 6 | 2 |
| 2 | 7 | 7 | 2 | 7 |
| 3 | 6 | 7 | 3 | 3 |
| 4 | 4 | 3 | 6 | 6 |
| 5 | 2 | 2 | 2 | 6 |
| 6 | 6 | 3 | 6 | 2 |
| 7 | 2 | 6 | 6 | 2 |
| 8 | 2 | 3 | 4 | 2 |
| 9 | 6 | 3 | 6 | 6 |
| 10 | 2 | 3 | 7 | 7 |

## 5 CONCLUSIONS

This study developed a decision making model for strategic alliance among express courier companies

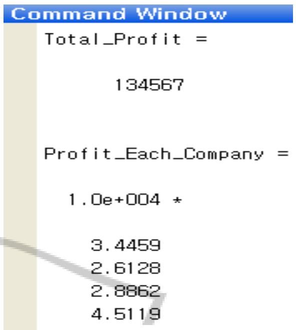


Figure 3: The outputs by GA implementation.

by using GA and its efficient solution procedure which aimed to maximize the expected profit from express courier services by merging the service centers. It also determined whether the existing consolidation terminals were still opened or not in Type I and Type II regions. The solution procedure was developed using GA and coded in Matlab 7.0. As a result, the model and solution procedure enabled express courier companies to earn maximized profit by merging the service centers and also by reducing the number of consolidation terminals.

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