OPTIMIZATION OF REVERSE LOGISTICS NETWORK AND TRUCK ROUTING FOR END-OF-LIFE/SECOND HAND MOTORCYCLE IN THAILAND

College of Science and Technology, Nihon University, Student Member, Jirapat PHORNPRAPHA
College of Science and Technology, Nihon University, Regular Member, Atsushi FUKUDA
College of Science and Technology, Nihon University, Regular Member, Mikiharu ARIMURA

1. Introduction

Currently, the benefit gained from the collected product and the end-of-lease product has also become more concerned as a business strategy and after sale service. For motorcycle industry, Thailand is one of the countries that has the largest number of motorcycle populations and its number still keeps growing. For second hand market, there is one second hand motorcycle centre for collecting second hand motorcycle. However, most of collected second hand motorcycles were from the nearby area and accounted only 2% for the whole number of sold motorcycles. Therefore, the purpose of this study is to design the network for closed loop logistics for motorcycle industry in Thailand.

2. Literature review

For reverse logistics of End-of-life vehicle (ELV), among most of study about reverse logistics network, Genetic algorithm is mostly used for optimizing the network. Hyun Jeung Ko, *et al*[2] used Genetic Algorithm for integrated forward/reverse logistics network for 3PLs. The results showed that by using Genetic Algorithm, the solutions were close to the optimal solution and were able to solve the large model. G. Kannan, *et al*[1] also developed closed loop supply chain network model by utilizing Genetic Algorithm. The solution revealed that the proposed methodology performed well in terms of both quality of solutions and computational time. Farzad Dehghanian, *et al*[5] designed the tire recovery network by using Multi-objective genetic algorithm which optimize maximize economic and social benefit while minimize negative environmental impacts simultaneously. About motorcycle recycling feasibility, N. Uesugi, *et al*[4] described about motorcycle recycling in Asia and Brazil also the topic related to the disposal of motorcycle. It was shown the material that can be recovered from End of Life motorcycle in percentage per volume and it was also shown that the disposal of motorcycles in Asia and other developing countries will become larger issue in the near future. However, there are many studies about closed-loop supply chain but no study about motorcycle collection network which is different from automobile.

3. Model formulation and methodology

From most of previous studies, the model should be considered not only recovery loop but as a closed loop to enhance the efficiency for both forward and reverse flow. Figure 1 shows the flow of the product in closed loop system. Apart from another studies, to deal with uncertainty of the End-of-life/second hand motorcycle demand, Cohort Method was hence introduced to forecast the number of possible End-of-life/second hand motorcycles. Then, Genetic Algorithm is used to determine the optimal number and location of the facilities.

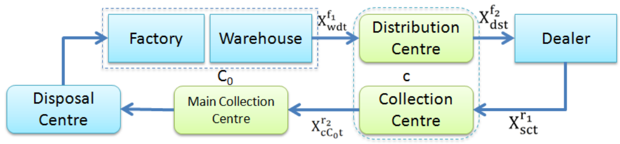

Figure 1: Closed-loop diagram

Objective function

Minimize total cost

$$\sum_{t\in T}\sum_{d\in D} T_{wdt} X^{f_1}_{wdt} + \sum_{t\in T}\sum_{d\in D}\sum_{s\in S} T_{dst} X^{f_2}_{dst} - \sum_{t\in T}\sum_{s\in S}\sum_{c\in C} T_{sct} X^{r_1}_{sct} - \sum_{t\in T}\sum_{c\in C} T_{cC_0t} X^{r_2}_{cC_0t} + \sum_{t\in T}\sum_{i\in I}(h_{it} Y_{hit}) + \sum_{t\in T}\sum_{i\in I}(f_{ht} Y_{hit}) \tag{1}$$

Where

T_{wdt} = Transport cost per unit from factory to distribution centre

$X^{f_1}_{wdt}$ = Quantity of forward transported product from factory to distribution centre

T_{dst} = Transport cost per unit from distribution centre to dealer

$X^{f_2}_{dst}$ = Quantity of forward transported product from distribution centre to dealer

T_{sct} = Transport cost per unit from dealer to collection centre

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Dept. of Trans. Eng. and Socio-Tech., College of Science and Technology, Nihon University
(739C 7-24-1 Narashinodai, Funabashi-shi, Chiba 274-8501 Japan, TEL/FAX 047-469-5355

$X^{r_1}_{sct}$ = Quantity of returned product from dealer to collection centre

T_{cC_0t} = Transport cost per unit from collection centre to main collection centre

$X^{r_2}_{cC_0t}$ = Quantity of returned product from collection centre to main collection centre (C_0)

h_{it} = Construction cost for Hybrid facility

f_{ht} = Operation cost for Hybrid distribution/collection facility

Y_{dit} = Decision valuable {0, 1}

Y_{cit} = Decision valuable {0, 1}

Y_{hit} = Decision valuable {0, 1}

u_{dt} = maximum capacity for distribution centre

u_{ct} = maximum capacity for collection centre

u_{C_0t} = maximum capacity for main collection centre

For objective function, according to Salema, *et al* [3], the model is two-level model: in forward flow, the decision variables between factory and distribution centre ($X^{f_1}_{wdt}$) and the decision variables between distribution centre and each dealer ($X^{f_2}_{dst}$) are independent. In reverse flow, the decision variables between dealer and collection centre ($X^{r_1}_{sct}$) and the decision variables between collection centre and main collection centre are also independent. With this design, the calculation times are reduced. Besides, this model is design for as a multi-period model. For the routing optimization, Traveling Salesman Problem was used to optimize the route of the truck.

4. Case study and results

For Thailand network, factory and warehouse are located at the centre. Number of nodes are 1506 and number of links is 2102.

As seen in figure 3, the travel cost is minimum when the number of facility is 6, regardless the total cost are high due to increased construction cost. Nonetheless, this increased cost can be compensated by the profit for long term. The results in figure 2 show the optimal location of these six facilities and the area coverage of each facility. By choosing one of these 6 areas, the routing of the truck was optimized.

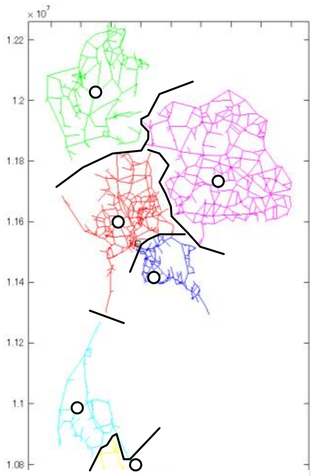

Figure 2: Area coverage from each Distribution centre

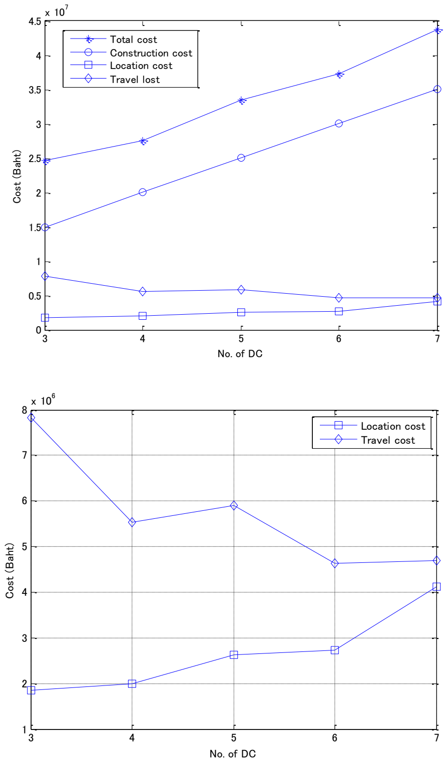

Figure 3: Each cost for 5 different scenarios and Travel cost and location cost for each scenarios

5. Conclusion and further study

In this study, after facility network was optimized, routing was also optimized. Traveling Salesman Problem was used as a method to optimize the route of the truck. However, in this study, only one area was considered and more accuracy is required. For the further study the route for truck for the whole area will be considered and the accuracy will be improved. In addition, the model will be considered as a multi-period model.

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