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Research on the Model of Reverse Logistics Networks Planning Based on Recycling Waste Household Appliances

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Abstract. In the case of four kinds discarded appliances of TV set, refrigerators, air conditioners and washing machines, build a reverse logistics network model of waste household appliances recycling by planning to establish three nodes of collection points, recycling centers and dismantling treatment plants. The reverse model with the minimum total cost as the objective, including recycling costs, transportation costs, the node infrastructure investment costs, operating costs, government subsidies and renewable resource recycling revenue. Finally, the operation analysis of an example shows that the model is effective and reasonable. The model provides an important theoretical reference to solve the reverse logistics network planning, the optimal siting of new node and distribution optimization problem.

Introduction

In recent years, with the rapid development of society and the progress of science and technology information, consumers are increasingly demanding personalized and diversified electronic products, which greatly accelerated the upgrading of electronic products, more and more electronic products are abandoned, followed by a large number of waste electrical appliances [1]. The past five years, the number of electronic waste has been increased from 16% to 28%, which is four times the rate of increase of the whole society's overall waste, electronic waste has become the world's fastest growing garbage [2]. At the same time, more and more end-product manufacturers establish a recycling system of electronic waste. During the process of establishment of the electronic waste recycling system, the research of reverse logistics is very necessary to enterprise.

Reverse logistics network research mainly includes the problem of minimization of the total cost, profit maximization, environmental pollution minimization, this paper will be based on the recovery of waste electrical appliances [3], starting from a reverse logistics network planning, to research the model of minimize the total cost of reverse logistics network optimization.

Describing problem

Waste electrical appliances from the collection point transport to the recycling center, recycling center for storage of waste electrical appliances custody, detection and classification operations. In the dismantling treatment plants, through disassemble TV sets, refrigerators, air conditioners and washing machine, recovery of indium, silver, copper, aluminum, iron and other precious metals, plastics, glass and other renewable resources.

In this paper, the recycling of waste household appliances logistics network model includes four levels, collection points, recycling centers, dismantling treatment plants and renewable resources sales market. The model takes into account the following aspects: First of all, to meet the new facility location limit. Second, waste home appliances recycling can only adopt by the way of disassembly. Finally, the waste household appliances of each node flow balance, and to meet the recycling center and dismantling treatment plant maximum capacity constraints [4].

Building model

Model assumptions. The assumption of model as shown below: (1) Study of a single cycle of waste household appliance recycling reverse logistics. (2)The number and position of collection points and sales market is known, the number of waste household appliances in collection points and recycling price is known, the alternative locations of recycling center and dismantling treatment plant is known. (3)Waste household appliances can only be transport from collection points to recycling centers, again from the recycling centers transport to dismantling plants, finally renewable resources are transported to market. (4)The plant of recycling center and dismantling capacity is known. (6)Logistics transportation distance and the freight between network nodes is known. (6)The sales of renewable resources are in short supply, and the unit price is known.

Model parameters. Model parameters and its meaning of the model are as follows:

i: The location of collection point. j: The alternative location of recycling center. k: The alternative location of dismantling treatment plant. z: The location of sales market. m: Kinds of waste household appliances. R^m: The cost-recovering of product m. Q_i^m: The quantity of m in collection point i. C_{ij}: The unit cost of from i transport to j, unit is Yuan/ton-km. Q_{ij}^m: The quantity of m from i transport to j. W_n^m: The weight of the dismantling of M, unit is kg. D_{ij}: The distance from i to j. B_j: The cost of building a recycling center. f_j: 0-1 variables, j represents whether to establish a recycling center, if establish is 1, if not establish is 0. C_i^m: The operating cost of m in the collection point i. S^m: The government subsidies of unit m. I^n: The Sales revenue of unit n, unit is Yuan/ kg. $MaxR_j$: The maximum capacity of j.

Model formula. The model based on the recycling of waste household appliances, and the minimum total cost as the goal. The model as follows:

$$F=\text{Min}[R+T+B+V-S-I] \tag{1}$$

The expression of R, T, B, V, S, I is:

$$R=\sum_{i=1}^{I}\sum_{m=1}^{M}R^m*Q_i^m \tag{2}$$

$$T=\sum_{j=1}^{J}\sum_{i=1}^{I}\sum_{m=1}^{M}(C_{ij}*W^m*Q_{ij}^m*D_{ij}*f_j)+\sum_{k=1}^{K}\sum_{j=1}^{J}\sum_{m=1}^{M}(C_{jk}*W^m*Q_{jk}^m*D_{jk}*f_j*f_k) \tag{3}$$

$$B=\sum_{j=1}^{J}(B_j*f_j)+\sum_{k=1}^{k}(B_k*f_k) \tag{4}$$

$$V=\sum_{m=1}^{M}\sum_{i=1}^{I}(C_i^m*Q_i^m)+\sum_{j=1}^{J}\sum_{m=1}^{M}\sum_{i=1}^{I}(C_j^m*Q_{ij}^m*f_j)+\sum_{k=1}^{K}\sum_{m=1}^{M}\sum_{j=1}^{J}(C_k^m*Q_{jk}^m*f_k) \tag{5}$$

$$S=\sum_{m=1}^{M}\sum_{i=1}^{I}S^m*Q_i^m \tag{6}$$

$$I=\sum_{n=1}^{N}\sum_{k=1}^{K}I^n*W_k^n \tag{7}$$

$$W_k^n=\sum_{m=1}^{M}\sum_{j=1}^{J}(W_n^m*Q_{jk}^m*f_k),\quad n\in\{1,2,\ldots,N\},\quad k\in\{1,2,\ldots,K\} \tag{8}$$

Constraints:

$$M=4 \tag{9}$$

$$f_j=0,1\quad 1\le\sum f_j\le J,\ f_k=0,1\quad 1\le\sum f_k\le K \tag{10}$$

$$Q_i^m = \sum_{j=1}^{J}(Q_{ij}^m * f_j),\quad i \in \{1,2,\ldots,I\},\quad m \in \{1,2,\ldots,M\} \tag{11}$$

$$\sum_{i=1}^{I} Q_{ij}^m = \sum_{k=1}^{K}(Q_{jk}^m * f_k),\quad j \in \{1,2,\ldots,J\} \tag{12}$$

$$\sum_{i=1}^{I}\sum_{m=1}^{M} Q_{ij}^m \le MaxR_j * f(j),\quad \sum_{j=1}^{J}\sum_{m=1}^{M} Q_{jk}^m \le MaxR_k * f(k) \tag{13}$$

An instance shows up the effective and feasibility of this model in the following paper.

Case study

Collecting data. C company plans establishing recycling center and dismantling treatment plant that select the number of locations from 18 alternative locations in a certain province [5]. The maximum capacity of each recycling center and dismantling treatment plant is 1.5 million units. Only consider recycle TV sets, refrigerators, air conditioners and washing machines in the reverse logistics network. The quantity of waste household appliances as shown in Table 1.

Table 1 The quantity of waste household appliances in a certain province

Point	TV sets	Refrigerators	Air conditioners	Washing machines	Total
A	23.9	14.39	16.76	21.52	76.58
B	15.79	9.52	11.03	14.28	50.62
C	10.28	6.17	7.25	9.3	32.99
D	13.09	7.79	9.19	11.79	41.86
E	3.35	1.84	2.16	3.03	10.38
F	3.79	2.27	2.7	3.46	12.22
G	10.28	6.17	7.25	9.3	32.99
H	1.41	0.87	0.97	1.3	4.54
I	15.68	9.41	10.92	14.06	50.08
J	7.35	4.43	5.08	6.6	23.47
K	3.68	2.16	2.6	3.24	11.68
L	8	4.76	5.52	7.14	25.42
M	11.57	6.92	8.11	10.38	36.99
N	3.79	2.27	2.7	3.46	12.22
O	15.79	9.41	11.03	14.17	50.4
P	11.79	7.03	8.22	10.6	37.64
Q	11.03	6.6	7.68	9.95	35.26
R	5.84	3.45	4.11	5.29	18.71
subtotal	176.41	105.46	123.3	158.89	564.1

The average weight and recycling cost of waste household appliances as shown in Table 2.

Table 2 The average weight of waste household appliances

Category	TV sets	Refrigerators	Air conditioners	Washing machines
Weight(kg)	40	60	50	62
Cost(Yuan/uint)	65	60	100	80

The investment costs of collection point, recycling center and dismantling treatment plant , operating costs, maximum capacity, as shown in Table 3.

Table 3 Investment costs, operating costs and capacity constraints

Costs	Investment [ten thousand Yuan]	Operating [Yuan/unit]	Capacity [ten thousand]
Collection point	70	3~10	/
Recycling center	450	8~15	150
Plant	5000	17~25	150

The highway transportation, the transport rate from the collection point to recycling center is 1.45 Yuan/ ton-kilometer, from the recycling center to dismantling treatment plant is 1.21 Yuan /ton-kilometer.

The price of renewable resources such as shown in Table 4.

Table 4 The sales price of renewable resources

Category	Copper	Aluminum	Iron	Glass	Plastic
Price [Yuan/kg]	45.1	12	2.1	1	8.2

The amount of subsidy for TV is 85 Yuan/unit, refrigerator is 80 Yuan/unit, air-conditioning is 35 Yuan/unit, washing machine is 35 Yuan/unit.

Calculation results. By using the mathematical software programming accord to the model, and putting the result of data to the model, the result of the operation is as follows:

F= 0.9777035E+09，C company if establish a reverse logistics network of waste household appliances, need the minimum total cost is 97,770,350 Yuan. When j=1, 2, 7, 16, 18, 19, f_j=1, recycling centers should be established in A, B, G, P, R, S. When k=1, 2, 3, 4, f_k=1, dismantling treatment plants should be established in A, B, C, D.

Conclusion

In this paper, reverse logistics network model was established based on the recycling of waste household appliances. The model with the minimum total cost as the objective. Through the above instance analysis obtained optimal address of recycling center and dismantling treatment plant, the quantity of waste household appliances, with the goal of minimizing the total cost of the reverse logistics network. In this paper, the reverse logistics network planning model provides an important theoretical reference for the optimal facility location and distribution.

References

[1] Liu Meilian, Li Dan, Qiu Jianwei. “Reverse logistics programming model of electronic wastes with fuzy parameters,” J. Journal of Traffic and Transportation Engineering. 2011,11(3):93-99.

[2] Liao Chenglin, Jiang Mingyuan. “Reverse logistics network design with recovery rate taken into account,” J. Industrial Engineering Journal. 2011,14(5):47-51.

[3] Semra Aral, Bar Tan, Fikri Karaesmen. “Modeling and Analysis of an Auction-Based Logistics Market,” J. European Journal of Operational Research, 2008, 191(1): 272-294.

[4] Boran, F.E. “An ıntegrated ıntuitionistic fuzzy multi criteria decision making method for facility location selection” J . Math Comput. Appl. 2011, 16(2): 487–496.

[5] Cardoso, S.R, Barbosa-Póvoa, A.P.F.D., Relvas, S. “Design and planning of supply chains with integration of reverse logistics activities under demand uncertainty,” J. European Journal of Operational Research. 2013, 226 (3): 436–451.