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Researches on a Purchasing Office Location Problem

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Abstract. In this paper, a purchasing office location problem that the multinational corporations consider setting up some purchasing offices in China under the economy globalization is investigated. A 0-1 integer programming model, which objective is to minimize the total cost including renting or purchasing hardware and software cost, labor costs and travel costs, is built via analyzing the relevant factors of influencing the instauration of the offices. The proposed model, which is solved by ILOG Company's optimization software CPLEX, is examined its validity on an experimental example.

Keywords: Purchasing Office; Location; Model; CPLEX

1. Introduction

With the development of economy globalization, multinational corporations are expanding their influence in the whole world in order to efficiently utilize global resources. As a result, global purchasing has become an important way to gain competitive advantage. In the recent decades, more and more multinational corporations begun to establish their purchasing offices in China since China owns abundant products, cheap labor forces, encouraged policies, stable political environment and etc. [1].

When considering the location of the purchasing offices, the companies always require considering how to ensure their long-term good development and the long-term good cooperation with their manufacturers in the future. Once the manufacturers are widely distributed, the companies always tend to set up the purchasing offices as close to these manufacturers as possible in order to promote the convenience of quality control and order management. In addition, it is also helpful for the companies to investigate the market information, such as the product price, the new product trend and so on, in time.

Thus it can be seen that the location of purchasing office will influence significantly the companies on the operating cost, products purchasing, service quality and etc. When the company decision-maker whether to establish their purchasing offices in a certain city, the operation costs, which includes of the rent, cost of software and hardware, manpower expenses, errand expenses and so on, are always considered.

Recently, the works on the site selection problems had been widely concerned, while the major researches focused on the distribution centers location problem [2-6] and the works on the purchasing office location problem (POLP), how the multinational corporations establish their purchasing offices in China, were hardly taken into account. In this paper, the model and algorithm on this POLP is investigated in detail. The paper is organized as follows: the next section presents a mathematical model on the POLP and the solution method for the proposed model and the corresponding numerical simulation results are given in Section 3. The final section summarizes this paper with the future works.

2. Mathematical Model of POLP

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Here we will consider how to choose K purchasing offices from M candidate cities with the total minimal operational cost. The basic assumptions of POLP model are given as follows:

1) Each manufacturer must be charged by only one purchasing office;

2) If a manufacture be charged by one purchasing office, the purchasing office must be established.

We also assume that the purchasing office will meet the following conditions:

1) The cost of hiring senior executive and the cost of software are fixed, which are not affected by the location of purchasing office;

2) The rent, the cost of administrative employee and the cost of hardware are only related to the location of purchasing office;

3) The number of employee in each purchasing office and the number of manufacturers charged by one purchasing office are both not restricted;

4) The costs of purchase employee and inspection employee are only related to the location of purchasing office and the numbers of purchase employee and inspection employee are only related to the number of manufacturers charged by them.

5) The travel times required by the goods purchasing and inspecting are fixed and the total travel number of each purchase employee and each inspection employee is restricted every year.

The decision variables are given as follows: x_i={0,1} denotes whether the purchasing office (PO) i is set up; y_{ij}={0,1} denotes whether the manufacturer j is charged by PO i; i=1,2,…, M; j=1,2,…, N.

The other parameters are described as follows: let M and N denote the numbers of the manufacturers and the candidate POs respectively, let i and j denote the indexes of candidate POs and manufacturers, let m denote the cost of employing an office manager which includes of his salary and bonus, let α denote the correlation coefficient between the numbers of purchase employees and manufacturers, let β denote the correlation coefficient between the numbers of quality inspection employees and manufacturers, let r_i denote the rent of establishing PO i, let e_i denote the cost of software and hardware needed by PO i, let i_i and b_i denote the costs of hiring purchase and quality inspection employee in PO i respectively, let v_j denote the purchase amount of the manufacturer j each year, let c_{ij} and d_{ij} denote the travel type and cost from the PO i to the manufacturer j respectively.

Based on above description, the 0-1 integer programming (IP) model of POLP is described as follows:

$$\min z = \sum_{i=1}^{M} x_i (m + r_i + e_i + i_i (\alpha \sum_{j=1}^{N} y_{ij} + 1) + b_i (\beta \sum_{j=1}^{N} y_{ij} + 1)) + \sum_{i=1}^{M} \sum_{j=1}^{N} d_{ij} y_{ij} v_j \quad (1)$$

s. t.

$$x_i = \{0,1\} \qquad i = 1,2,...,M \quad (2)$$

$$y_{ij} = \{0,1\} \qquad i = 1,2,...,M;\ j = 1,2,...,N \quad (3)$$

$$y_{ij} \le x_i \qquad i = 1,2,...,M;\ j = 1,2,...,N \quad (4)$$

$$\sum_{i=1}^{M} y_{ij} = 1 \qquad j = 1,2,...,N \quad (5)$$

where constraints (2) and constraints (3) denote that x_i and y_{ij} are 0-1 variables respectively. Constraints (4) denote that the purchasing office i must be established if there is existing one manufacturer j is charged by it. Constraints (5) denote that each manufacturer to be designed to one purchasing office.

3. Solution method of POLP model

Here we will consider how to choose K purchasing offices from M candidate cities with the total minimal operational cost. The basic assumptions of POLP model are given as follows:

CPLEX developed by ILOG Company is now one of the fastest algorithm engines to solve linear programming, integer programming, quadratic programming and secondary integer programming. Based on the characteristics of our proposed model, CPLEX is applied to solve the POLP in this paper. The relevant parameters are set as follows:

1) The salary and bonus of one office executive is one million yuan and the cost of one set of office hardware is 10 million yuan.

2) The types of travel cost can be divided into three categories. The travel cost is set to 400 yuan, from 1000 yuan to 2000 yuan and from 2500 yuan to 10000 yuan if the distance from the purchasing office to the manufacturer is less than 500 km, between 500 km and 1000 km and more than 1000 km respectively. For

each type of travel, the actual cost is always proportional to the distance.

3) The travel number of each employee is less than 12 each year.

4) The values of α and β are set to 0.1 and 0.4 respectively.

The other parameters are generated randomly using the following method: Firstly, 100 manufacturers are generated randomly in one are with 8000*8000 square kilometers and the purchase number of each manufacturer is then generated randomly. Secondly, 20 candidate purchasing offices are generated randomly in the above-mentioned area and the relevant parameters that require to be generated randomly at each purchasing office include the rent, the cost of hardware and the costs of hiring administrative, purchase and quality inspection employee. Finally, the distance between each candidate purchasing office and each manufacturer will be calculated according to their randomly-generated locations and the travel costs from the purchasing offices to the manufacturers will be also calculated based on the corresponding distances.

In the Eclipse environment, we use Java language to invoke the function base of CPLEX to solve the proposed IP model of POLP. The experimental results are described as follows:

1) Run time is 0.22 second;

2) Optimal value is 75448500 yuan;

3) The number of purchasing office is 3: purchasing office 3, 17 and 18 are established and the more detailed results are shown in Table I and Fig. 1. In Fig. 1, the square points denote the selected POs and the round points denote the manufacturers. The same color round points mean that these manufacturers are charged by the same PO with the responding color square point.

Table 1. The experimental results with respect to the affiliation between the selected POs and manufacturers

PO	Manufacturers									
3	19	21	24	25	26	32	33	44	47	53
	56	62	66	67	69	76	81	84	99	100
17	1	2	3	4	6	9	13	16	18	23
	28	29	30	31	34	35	37	40	44	43
	45	46	50	58	61	64	70	72	73	77
	78	83	87	88	91	92	93	94	96	97
18	5	7	8	10	11	12	14	15	17	20
	22	27	33	36	38	42	48	49	51	52
	54	55	57	59	60	61	62	63	71	74
	75	79	80	82	85	86	89	90	95	98

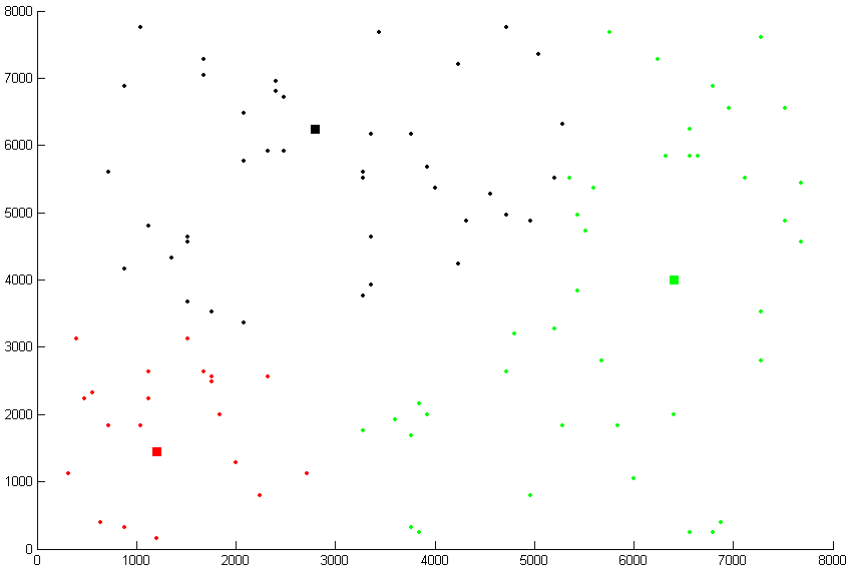

Fig. 1. The experimental results with respect to the location of the selected POs and manufacturers

From Table I and Fig. 1, it can be seen the obtained results in this paper are reasonable. The experimental results indicate that there are only three candidate purchasing offices were selected. It is very

interesting that the selected three POs have the least hiring purchase cost and quality inspection cost in all candidate POs, while their other expenses are higher. It obviously means that the selection of the candidate POs is mainly determined by the costs of purchase and quality inspection employees, which is validated by the results in Fig. 2. From Fig. 2, it can be seen that the expense with respect to the purchase and inspection cost occupies about 66% in the total expense, while the office cost which includes of the rent, the cost of employing an office manager and the cost of software and hardware occupies about 14% and the travel cost occupies about 20% in the total expense respectively.

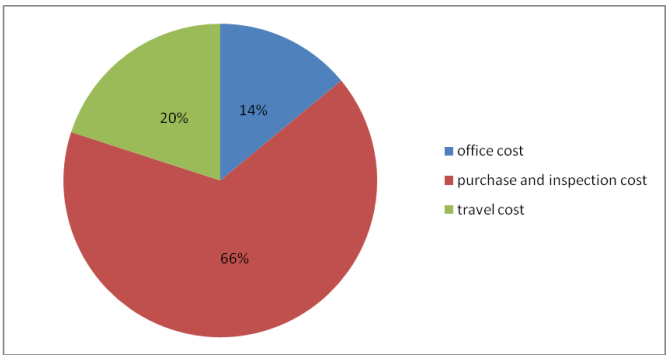

Fig. 2. The ratio of the different costs in the total expense

4. Conclusion

In the economy globalization environment, many multinational companies are considering setting up their purchasing offices in China straightly since China has become one important export country of global resources purchase. In this paper, the purchasing office location problem (POLP) is presented and a 0-1 integer programming mathematical model is proposed. Based on the experiment that CPLEX is applied to solve one random POLP case, the simulation results show that the proposed model and solution method for POLP is valid.

However, POLP involves many other factors. For example, the number of manufacturers charged by each purchasing office should be restricted; the development trend of the location city of purchasing office can bring potential profit to the companies and so on, which should be further investigated in our future work.

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