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Buying Group Design Considering the Member's Interest

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ABSTRACT

Enhancing the speed and competition in an exhibition of services and products motivated the companies to provide high-quality products to the customers. One of the effective strategies to reach these goals is to create working groups. These groups can help the companies to improve the quality and exposure of their services along with reducing the costs. This approach is applicable in the healthcare area as well. Group buying is one of the main strategies that many healthcare institutes are trying to control the costs and quality of their products. In this study, considering the objectives of procurement costs, the distance of drugstores and the member's interest to cooperate in a purchasing group is proposed. To optimize the model objectives simultaneously, the LP-Metric goal programming approach is utilized. Finally, the case study of drug's group buying is presented to show the proposed model effectiveness.

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1. INTRODUCTION

Supply chain management is a set of guidelines to coordinate supply chain members with the aims of reducing costs and providing high-quality service. Required items procurement in a timely fashion is one of the major topics of interest to stakeholders in the supply chain. Thus, numerous models of buying strategy have been presented in the supply chain. The healthcare system is one of the world's most complex supply chains. In recent years, significant improvements have been made in the healthcare sector which has been associated with increased cost. Optimization problem in the healthcare system has become one of the most important issues for governments. Therefore, it is essential to monitor the health costs due to the quantitative and qualitative expansion of the healthcare services. To apply the supply chain management principles in the healthcare sector, it has been suggested by researchers to reduce costs and improve service quality simultaneously [1].

The cost reduction and high-quality service provision are two incompatible objective functions in the healthcare sector. In the past few decades, there has been continuous growth in the healthcare costs as a percentage of GDP[2] [2]. According to HIGPA[3], the second most dollar bill is used to purchase goods and services in the hospitals. Due to the high healthcare costs, it is essential to buy professionals. Schneller [3] illustrates that product standardization and entering into group buying organization contracts are the most effective strategies to reduce the healthcare cost. Thus, creating buying groups in healthcare system can help to get both of those objectives. Group buying is a horizontal cooperation between several institutions in one or more stages of the buying process, by combining and sharing of purchasing volume, information, market and demand risks [4-6]. The group buying is used in the healthcare systems, schools, government organization, and businesses in other retail industries [7-11].

In the group buying system, coordinating across supply chain members can effectively reduce the buyer's and supplier's costs, such as ordering, buying, transporting, setting up and holding cost. It's easier to order in group buying because a large organization can make the ordering process easier through efficient methods. As well as a large order organization can have strong relationships with vendors which will be more responsive due to collective purchasing power. A group

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[2] Gross Domestic Product
[3] Health Industry Group Purchasing Association

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buying organization collects a number of member's demand for different commodities, and contracts with suppliers, through which members can purchase products with group price. The group purchasing organization usually provides discounts for pharmacy, medical equipment, nutrition, and laboratories.

The following is a summary of the literature review in this field. A lot of empirical and theoretical studies in the field of group buying focus on acquisition costs reduction and buying power enhancement that justifies the formation of coordinating buying, buyers alliance and horizontal integration [12-17]. However, most of these studies do not consider the competition between buyers. A group buying organization is an institution that obtains remarkable discounts from vendors using collective buying power [18]. These organizations are used in variety industries, including healthcare sector, foodservice or grocery store, electrical industry and non-profit world. According to the healthcare spending report, group buying organizations have made savings by 55.2$ billion in 2012[4]. Also, prior studies showed that industries can take advantages of group buying organization methods by improving efficiencies [19].

The role of buying group organizations is similar to supply chain intermediates. The intermediates are coordinator agent among a group of suppliers and customers [20]. The group buying organizations focus more on the group side and the number of group members has a significant impact on pricing. Buying groups have a concern for member relations, such as it is possible that some group members are competitors and don't have potential interest to be together in the same group. Moreover, mistrust among group members can be one of the major barriers for buying groups [21]. Some companies don't like to coordinate with their competitors. However, there is almost no competition among government agencies. Therefore, group buying organizations are growingly forming in public sector.

An optimal combination of members can lead to a high-performance group. Thus, to have an efficient and sympathetic group, organization efficiency increases and can succeed in a competitive environment. It can produce a knowledge which cannot be achieved from analysis of existing data [22]. Alaei and Setak [23] designed a supply chain coordination mechanism. They studied the advertising and pricing decisions in a retailer-manufacturer supply chain. Noroozi et al. [24] proposed order acceptance for an integrated production-distribution system in which batch delivery is implemented. Azadnia [25] provided a multi-objective model for the integrated problem of multi-period, multi-product order lot-sizing and sustainable supplier selection under inflationary condition. Safaei et al. [26] presented a group purchasing organization design with aims to reduce the costs and distance between a groups member.

The current study embedded the notion of drugstore's interest to form the buying groups. The proposed model aims to optimize three objective functions of distance, interest and cost function. The distance function minimizes the total distance between the pairwise of the drugstores in the same group. The supply, transportation and ordering costs are considered as cost factors in the cost function. However, considering the interest is an important factor in forming a buying group. The interest function groups the drugstores that are willing to cooperate together. In fact, the members are reluctant to cooperate with their competitors because they don't want to help their rivals [27]. Therefore, the model considers interest function to group drugstores who agree to cooperate together and will be classified in the same group.

The organization of this paper is as follows. Problem description is given in Section 2. The mathematical model is described in Section 3. Section 4 presents an LP-metric method to solve the model. A case study is presented in Section 5. The conclusion is drawn in Section 6.

2. PROBLEM DESCRIPTION

In this study, a group buying model is provided for a number of drugstores. The purpose of this model is to design the buying groups and organize items procurement and reduce purchasing costs. In this model, a set of members with different features, ones who are more similar according to specified criteria will place in the same group. In each group, the members are most similar to each other and the least similar to other group's members.

Here are some criteria to group the drugstores. These criteria are the distance and interest among members to be in a group. Moreover, one of the main goals which puwshes the members to form a group is reduction in costs. Thus, ones who are closest to each other in term of distance and agree to cooperate together are more likely placed in the same group. In the proposed model, the perpendicular distance formula is applied for the distance between two drugstores. Besides, the interest is defined in a way that it equals to zero if each drugstore agrees to cooperate with other drugstores and equals to one if it isn't willing to cooperate with others. In fact, members are reluctant to cooperate with their competitors because they don't want to help their rivals. Drugstores in the same group can buy items in a collective approach by aggregating the demand.

Drugstores are grouped in terms of distance and interest out there, but the most important issue in group buying is to reduce costs. Thus, the model considers the best way to place drugstores in groups so that it has the

[4]https://c.ymcdn.com/sites/higpa.siteym.com/resource/resmgr/research/hsca_cost_savings_group_purc.pdf. 2014

greatest possible to reduce costs. The considered costs are purchasing, transportation, ordering, shortage and administrative costs. The transportation cost is considered based on transportation cost per product unit. Therefore, the order quantity variable is required to calculate the total transportation cost and the shortage cost is presented based on cost per product unit as well. Some items in the ordering cost are the cost to prepare a buy order and requisition (such as phone cost and travel cost to order items) and the cost of labor needed to inspect items at the receipt time and the cost to follow-up an order. Therefore, in a single period model, there is an order cost per group. Including the fixed administrative cost can be pointed to the cost of buying advice and research for quality products.

3. MODEL

In this study, the drugstores have been grouped to purchase requirements that served the purpose of minimizing their costs. The drugstores are placed in a group in term of their distance and interest. The relationship between drugstores has been obtained using questionnaire. The purpose of group formation is to minimize costs. Therefore, there are three objective functions in this model. The drugstores are grouped based on the first two objective functions and the third objective function minimizes the costs. The problem's notations and equations are listed as follow.

3. 1. Notations

❖ Sets:

p,l	Set of suppliers
k,n	Set of group buying organization
i,m	Set of drugstores

❖ Parameters:

D_i	Demand of drugstore i
S_p	Capacity of the supplier p
dis_{ij}	Distance from drugstore i (a_i,b_i) to drugstore j (a_j,b_j) which is calculated in the fallowing manner: $\rightarrow dis_{ij}=\lvert a_i-a_j\rvert+\lvert b_i-b_j\rvert$
R_{ij}	Relationship between the drugstore i and drugstore j
V_{pk}	Unit buying cost from supplier p by group buying organization k
TS_{pk}	Unit transporting cost from supplier p to group buying organization k
A_k	Fixed administrative cost
f_{pk}	Fixed ordering cost from supplier p to group buying organization k
CB_i	Unit shortage cost in drugstore i
M	A large number
λ_i	The lower limit of the service level for drugstore i

❖ Decision variables:

CF_k	Binary variable: equal to one if group buying organization k has at least one drugstore and otherwise it equal to zero
X_{ik}	Binary variable: equal to one if drugstore i is assigned to group buying organization k and otherwise it equal to zero
OQ_i	Order quantity of drugstore i
Q_{pk}	The number of items that group buying organization k buys from supplier p
W_{pk}	Binary variable: equal to one if group buying organization buys from supplier p and otherwise it equal to zero.
B_i	Shortage quantity in drugstore i

3. 2. Equations

❖ Objective functions:

$$\min f_1(X)=\sum_{k=1}^{n}\sum_{i=1}^{m}\sum_{j\neq i}^{m}\left(dis_{ij}X_{ik}X_{jk}\right) \quad (1)$$

$$\min f_2(X)=\sum_{k=1}^{n}\sum_{i=1}^{m}\sum_{j\neq i}^{m}(R_{ij}X_{ik}X_{jk}) \quad (2)$$

$$\min f_3(X)=\sum_{k=1}^{n}\sum_{p=1}^{l}V_{pk}Q_{pk}+\sum_{k=1}^{n}\sum_{p=1}^{l}T_{pk}Q_{pk}+\sum_{k=1}^{n}A_kCF_k+\sum_{p=1}^{l}\sum_{k=1}^{n}f_{pk}W_{pk}+\sum_{i=1}^{m}CB_iB_i \quad (3)$$

❖ Constraints:

$$\sum_{k=1}^{n}X_{ik}=1 \qquad \forall i \quad (4)$$

$$\sum_{i=1}^{m}X_{ik}\leq m \qquad \forall k \quad (5)$$

$$\sum_{k=1}^{n}CF_k\leq m \quad (6)$$

$$X_{ik}\leq M\cdot CF_k \qquad \forall i,k \quad (7)$$

$$W_{pk}\leq M\cdot CF_k \qquad \forall p,k \quad (8)$$

$$\sum_{i=1}^{m}OQ_iX_{ik}=\sum_{p=1}^{l}Q_{pk} \qquad \forall k \quad (9)$$

$$\sum_{p=1}^{l}Q_{pk}\leq M\cdot CF_k \qquad \forall k \quad (10)$$

$$Q_{pk}\leq M.W_{pk} \qquad \forall p,k \quad (11)$$

$$D_i=OQ_i+B_i \qquad \forall i \quad (12)$$

$$\frac{OQ_i}{D_i} \geq \lambda_i \qquad \forall i \qquad (13)$$

$$\sum_{k=1}^{n} Q_{pk} \leq S_p \qquad \forall p \qquad (14)$$

$$Q_{pk}, OQ_i, B_i \geq 0 \qquad \forall i,k,p \qquad (15)$$

$$CF_k, X_{ik}, W_{pk} \in \{0,1\} \qquad \forall i,k,p \qquad (16)$$

The objective functions (1) and (2) state that the drugstores in a group are similar in terms of distance and their interest. The objective function (3) minimizes the costs which consist of supply cost, transporting cost, fixed administrative cost and ordering cost. Constraint (4) implies that each drugstore belongs to only one buying group organization. Constraint (5) states that the maximum number of m drugstores can be in each buying group organization. Equation (6) shows the maximum number of buying group organization. Equation (7) represents that drugstore i can be in buying group organization *k* if it is created. Constraint (8) illustrates that buying from supplier p is done after creating organization *k*. Constraint (9) guarantees that order quantity in each group buying organization equals to the sum of drugstores orders that are members of that organization. Constraint (10) states that Q_{pk} can take value when organization *k* is created. Constraint (11) illustrates when organization k buys from supplier p, the organization order quantity from supplier p can take positive value. Equation (12) ensures the inventory balance in each node that the demand of each drugstore is equal to the shortage and order quantities in each drugstore. Equation (13) shows the minimum level of service in each drugstore. Equation (14) shows the maximum capacity which is provided by suppliers. Equations (15) and (16) determine the types of decision variables.

3. 3. Linearization As specified in the proposed model, the objective functions (1) and (2) as well as the constraint (9) are nonlinear. To reformulate objective functions (1) and (2) as linear functions, a binary variable C_{ijk} is defined. To add the new binary variable, two constraints will be included in the model. Rewriting of the objective functions and constraints associated with it are as follows:

$$\min f_1(X) = \sum_{k=1}^{n}\sum_{i=1}^{m}\sum_{j\neq i}^{m}\left(dis_{ij}C_{ijk}\right) \qquad (17)$$

$$\max f_2(X) = \sum_{k=1}^{n}\sum_{i=1}^{m}\sum_{j\neq i}^{m}\left(r_{ij}C_{ijk}\right) \qquad (18)$$

Associated constraints:

$$X_{ik} + X_{jk} \leq 1 + C_{ijk} \qquad \forall i,j,k \qquad (19)$$

$$2C_{ijk} \leq X_{ik} + X_{jk} \qquad \forall i,j,k \qquad (20)$$

Constraint (9) can be converted to its equivalent linear form by defining a non-negative variable, Y_{ik} as follows:

$$Y_{ik} \geq OQ_i - M(1 - X_{ik}) \qquad \forall i,k \qquad (21)$$

$$Y_{ik} \leq OQ_i \qquad \forall i,k \qquad (22)$$

$$Y_{ik} \leq MX_{ik} \qquad \forall i,k \qquad (23)$$

4. THE LP-METRIC METHOD

In this study, the proposed model is a multi-objective optimization. There are several methods to handle a multi-objective model. In this study, the Lp-metric approach is employed instead of weighted goal programming approach. The goal parameter in the goal programming is determined by decision makers, thus the decision maker opinion will affect the final solution. However, there is no goal parameter in the Lp-metric method. Moreover, all objective functions' deviations from ideal solutions are normalized in the Lp-metric. This is a drawback that goal programming approach cannot handle it.

Thus, in the Lp-metric approach, the model is explained by regarding the objective functions separately in both maximization and minimization cases in the names of $Z_1^{\max}$, $Z_1^{\min}$, $Z_2^{\max}$, $Z_2^{\min}$, $Z_3^{\max}$ and $Z_3^{\min}$. Then, a single objective model is applied instead of the multi-objective, as well as the constraints of the model are considered. The proposed method is as follows:

$$\min Lp = \left[w_1 \left[\frac{f_1(x) - Z_1^{\min}}{Z_1^{\max} - Z_1^{\min}} \right]^p + w_2 \left[\frac{Z_2^{\max} - f_2(x)}{Z_2^{\max} - Z_2^{\min}} \right]^p + w_3 \left[\frac{f_3(x) - Z_3^{\min}}{Z_3^{\max} - Z_3^{\min}} \right]^p \right]^{1/p}$$

$$h_o(X) = (\geq or \leq) 0$$

where $0 \leq w_i \leq 1$ is the weight of objective function *i* and $0 \leq p \leq \infty$ is the importance of each objective function deviation from its ideal value.

5. CASE STUDY

In this section, a case study of drugs group buying in drugstores is provided. The data are collected from the drugstores and drug distribution companies. Some of the

estimated costs such as fixed ordering cost and transporting cost are recorded in the accounting system of drugstores and suppliers. Other projected costs in the model with reviews and inquiries from drugstores and suppliers have been estimated. This study suggests a group buying organization structure for fourteen drugstores of the Chalus city which can buy drugs from three competitive suppliers.

Required items at any drugstores are presented in Table 1. The demand data is determined as the average monthly demand for past three years, and the unit shortage cost for a drug is estimated. The fixed administrative cost to establish a business relationship in group buying organization *k* is estimated to be 500,000 *Rials* and the capacities of suppliers 1, 2 and 3 are 10,000 and 8,000 and 9,000 units, respectively. Also, the fixed ordering costs from suppliers to group buying organization are 35,000, 36,000 and 35,500 *Rials* respectively. The costs of buying from suppliers are 21,600, 21,700 and 21,650 *Rials*. The unit transporting costs of items are estimated 12, 13 and 12 *Rials*. The minimum level of providing services in each drugstore is 0.95 percent. The distances between the drugstores are shown in Table 2. Also, the relationship between the drugstores is provided in Table 3. According to the above-mentioned data, all computations were run via LINGO 12 on a PC 2.5 GH i5 and 4 GB RAM under Win XP 7.

Firstly, the objective functions of the model were solved separately in both maximization and minimization cases. Then, the model was solved using the Lp-metric method by setting $w_1 = 0.25$, $w_2 = 0.35$, $w_3 = 0.45$ and $p = 1$. Due to the high importance in the cost, its weight was considered more than other weights. Also, because of the small size of the city and the proximity of drugstores, weight of distance was found to be small. The results of the objective functions have been reported in Table 4. As shown in Table 4, the costs are reduced with group formation in comparison with the fourteen single drugstores. According to this table, in the case of individual purchases, the total cost of drugstores is equal to 379,314,200 *Rials*, whereas the total cost reduces by 9,505,900 in group buying. The lowest cost without taking into account the distance and interest objective functions is equal to 368,223,000 *Rials* in which all drugstores are placed in a group but the cost increases by 1,585,300 *Rials* by taking into account the interest and distance objectives.

Table 5 shows the number of groups, the members of each group and order quantity of each group buying organization.

TABLE 1. Monthly demand profile

Drugstore	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Demand	1400	900	1800	1000	900	700	1500	1700	1200	2200	1900	700	800	400

TABLE 2. The distances among drugstores

Drugstore	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	0	70	100	60	90	140	50	100	170	240	1000	1200	1700	2000
2		0	70	60	130	180	110	160	230	310	1070	1270	1770	1970
3			0	90	160	210	150	200	270	340	1100	1300	1800	1900
4				0	70	120	50	100	170	300	1060	1260	1700	1960
5					0	50	80	130	200	330	1090	1290	1760	2030
6						0	120	170	240	370	1130	1330	1770	2080
7							0	50	120	250	1010	1210	1680	2010
8								0	70	200	960	1160	1600	2060
9									0	130	890	1090	1530	2130
10										0	760	960	1460	2200
11											0	200	700	1000
12												0	500	1200
13													0	1700
14														0

As specified in this table, it is composed of four groups in which each of the groups 1 and 4 have four members and groups 2 and 3 have three members. Optimal values of the order and shortage quantities in each drugstore are shown in Table 6. This solution indicates that level service of all drugstores is equal or greater than 0.95. Table 7 shows the buying quantity that group buying organization k buys from supplier p. As shown in Table 7, supplier 1 has the highest sale because it offers the lowest price.

TABLE 3. The interest among drugstores

Drugstore	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	0	0	0	1	1	1	0	1	1	0	1	1	1	1
2		0	1	0	1	1	0	1	1	0	0	1	1	1
3			0	0	0	1	1	1	1	1	1	1	1	1
4				0	0	1	1	1	1	1	1	1	1	1
5					0	0	1	1	1	1	1	1	0	1
6						0	1	0	0	1	1	1	1	0
7							0	1	1	0	1	1	1	1
8								0	0	0	1	1	1	1
9									0	1	1	0	1	1
10										0	1	1	1	1
11											0	0	0	0
12												0	0	0
13													0	0
14														0

TABLE 4. Objective function values

Objective function	$f_s(X)$	W_s	$f_s^{min}(X)$	$f_s^{max}(X)$
Distance	14,260	0.25	0	143,120
Non-interest	0	0.3	0	130
Cost	369,808,300	0.45	368,223,000	379,314,200

TABLE 5. Best cooperative solution

GPO	1	2	3	4
Order quantity of group k	5,940	3,564	3,669	3,762
best cooperating solution	1,2,7,10	6,8,9	3,4,5	11,12,13,14

TABLE 6. Order and shortage quantity in the drugstores

Drugstore	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Order quantity	1,386	891	1,782	990	891	693	1,485	1,683	1,188	2,178	1,881	693	792	396
Shortage quantity	14	9	18	10	9	7	15	17	12	22	19	7	8	4

TABLE 7. Number of item purchased by GPOs

GPO / **Supplier**	1	2	3	4
1	5,940			3,762
2				
3		3,564	3,663	

Because supplier 2 offers the highest price and given that the total capacity of suppliers 1 and 3 is greater than total order drugstores, it fails to sell any its items.

6. CONCLUSIONS

In this study, a multi-objective model is proposed to optimize the procurement costs of drugstores. The cost function consists of ordering cost, transporting cost, administrative cost, and shortage cost. The buying groups are proposed to reduce these costs. The drugstores were placed into several groups based on the distance and the interest between them. By grouping the drugstores, the costs can be decreased significantly.

The proposed model is examined by applying it to a case study. The results show the efficiency of this model. LINGO 12 software was utilized to solve this model but the execution time of model was too long. Applying Meta heuristic algorithms such as NSGAII algorithm can remarkably reduce the execution time. Moreover, to present a more practical and realistic model, uncertainty in parameters such as demand can be considered. The quality of shared information can change the directions in forming the groups. Considering this issue can be a promising future work.

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Members Interest

چکیده

افزایش سرعت و رقابت در ارائه خدمات و محصولات، شرکت‌ها را برای ارائه محصولات با کیفیت به مشتریان برمی‌انگیزد. یکی از راه‌های موثر برای رسیدن به این اهداف، ایجاد گروه‌های کاری است که می‌توانند شرکت‌ها را در بهبود کیفیت محصولات و خدمات و کاهش هزینه‌ها یاری نماید. این رویکرد در حوزه بهداشت و درمان نیز عملی است. خرید گروهی یک استراتژی مهم است که بسیاری از موسسات بهداشتی و درمانی با کمک آن به دنبال دستیابی به مهار هزینه‌ها و بهبود کیفیت کالاهای خریداری شده‌اند. در این مطالعه تشکیل گروه‌ها با توجه به اهداف هزینه‌های خرید، فاصله داروخانه‌ها و درنظرگرفتن علاقه‌مندی اعضاء برای مشارکت با سایر اعضای گروه ارائه شده است. به منظور بهینه سازی اهداف، از رویکرد برنامه‌ریزی آرمانی LP-Metric استفاده شده است. در پایان، مطالعه موردی خرید گروهی داروها برای نشان دادن کاربرد و اثربخشی مدل مربوطه ارائه می‌شود.

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