Research on Collaborative Optimization of Drug Logistics Company and Hospital based on Value-Added Services under New Medical Reform

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Abstract: Under the new medical reform policy, hospital without the rights to add drugs' price hopes to eliminate drug inventory in order to minimize the associated cost of drugs through the JIT delivery of drug Logistics Company. However, drug logistics companies are unwilling to implement JIT delivery on the basis of the original business volume as this would lead to an increasing unilateral cost significantly. In order to solve the conflicts of two parties, we design the proposal that drug Logistics Company offers value-added services to hospital and patient, which include JIT delivery for hospital and sending inspection reports and prescription for patients. Then the hospital will give delivery right of all drugs to this Logistics Company. On the base of that, the paper sets a bi-level programming model with the objective of profit maximizing to realize the collaborative optimization of two parties.

Keywords: Value-added services; new medical reform; Drug logistics; Collaborative optimization

I. Introduction

Under the new medical reform plan [1], the state will establish content of basic drugs, and essential drugs will be produced in fixed manufacturers. Then centralized procurement and direct delivery will be implemented in order to reduce intermediate links. The government will draft unified retail price of basic drugs at a reasonable profit of production process, and hospitals now have no rights to determine the price of drugs, which has a large influence on hospitals [2]. Before the price of drugs that hospitals sell can be 15% more than purchasing price. And the majority of revenue of hospital is also derived from the sale of drugs. However, now with the implementation of new medical reform, hospitals are almost impossible to get profit from selling drugs. To maximize profits the hospital must eliminate all costs associated with the drugs. In hospitals, the cost related to drugs is inventory cost, so hospitals eager to abolish the pharmacy warehouse to eliminate or minimize the inventory of drugs.

For drug Logistics Company, its delivery size is relatively small. Now government requires drug Logistics Company to bid for drug delivery business, which causes Pharmaceutical logistics company profits to fall. The best way to eliminate or minimize drug inventory of hospitals is to implement JIT delivery by pharmaceutical logistics company. However states currently have no relevant policy. If government insists on implementing JIT delivery, this would greatly increase correspondingly the cost of logistics enterprises. Otherwise the related inventory cost is a simple drag for hospital.

II. Collaborative optimization proposal of Drug Logistics Company and Hospital based on Value-Added Service

We consider pharmaceutical logistics companies to provide value-added services for hospitals. Scope of value-added services includes JIT delivery to hospitals or being taken over the pharmacy by the pharmaceutical logistics company, sales forecast for the hospital, sending inspection reports to patients, direct distribution of chronic continuous prescriptions to patients at home and the storage and transfer of clinical documents. Hospital takes over the purchasing rights of all drugs to the pharmaceutical logistics company.

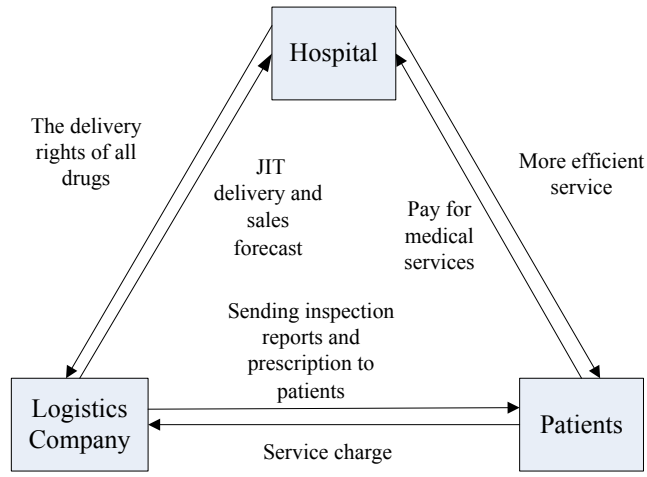

Figure 1 Collaborative optimization proposal of drug Logistics Company and hospital based on value-added service

Significant increase of drugs volume will be a major source of profit for pharmaceutical logistics company. So we consider that hospital will not pay for the service of implementing JIT delivery or taking over the pharmacy by the pharmaceutical logistics enterprise. The value-added

service program can not only solve the contradiction which pharmaceutical logistics company and hospital have on the issue of maximizing their own interests, but also bring enormous benefits and profits to both sides.

Such value-added services implemented by pharmaceutical logistics company will give the benefits of a tripartite: (1) Eliminating the troubles for the patients, particularly for those disabled, to get the medicine and inspection reports from hospital. And the value-added services greatly facilitate their treatment.

(2)Eliminating the inventory of hospital and saving the cost of redundant stock. Sales forecast, managing medical records, clinical documentation allocation and other value-added services implemented by pharmaceutical logistics company can greatly improve the efficiency of hospital's service level. As value-added service implemented by pharmaceutical logistics company is a great convenience to the patient, it can expand the hospital's reputation and visibility, which surely brings the increasing number of hospital treatment received.

(3)For pharmaceutical logistics company, the larger delivery volume of drugs will make its profits increase. Besides, the value-added services for hospitals and patients will become another major source of its profit.

III. Collaborative Optimization Model of Drug Logistics Company and Hospital based on Value-Added Service

Modeling program and model assumptions

In order to facilitate the construction of quantitative models, we assume that the current pharmaceutical logistics company only provides two kinds of value-added services for hospitals. Firstly, Pharmaceutical Logistics Company helps to implement JIT delivery for hospital and Hospital takes over the purchasing rights of all drugs to the pharmaceutical logistics company. Secondly, pharmaceutical logistics company sends inspection reports and prescriptions to patients at home directly. Then we will distinguish value added profit of this proposal to the pharmaceutical Logistics Company and hospital. As what we have mentioned above, this proposal will obviously give patients the benefits, but this paper does not take the benefits to patients into consideration to model.

The other assumptions are as follows. (1) Our model is based on a cycle, and all of the benefits or costs are based on the cycle to consider.
(2) The number of patients going into hospital to receive service is a daily constant.
(3) Pharmaceutical Logistics Company should be paid by patients and hospital together for its service of sending inspection reports and prescriptions to patients at home. Hospital has to pay this associated cost. Because this service can not only reduce a lot of trouble of the daily operation of the hospital to improve the efficiency of its operations, but also help expand its brand and increase the number of patients receiving services. But the costs paid by hospital are relatively small to the costs of patients. The costs are equal to the subsidies to pharmaceutical logistics company by hospital.
(4) Market is competitive and value-added logistics services provided by pharmaceutical Logistics Company to bring more patients for the hospital.
(5) We consider that hospital will not pay for the service of implementing JIT delivery by the pharmaceutical logistics enterprise, for hospital takes over the purchasing rights of all drugs to the pharmaceutical logistics company, which will make profits of pharmaceutical logistics company increase.
(6) Quantitative analysis of the benefits or costs in our model is relative. They are value-added number compared to the situation before the proposal implementation.
(7) Before the implementation of value-added services, only a small proportion of drugs in hospital are delivered by this pharmaceutical Logistics Company.
(8) Charges of value-added services by pharmaceutical Logistics Company are only related to the number of patients receiving service and the unit number of charges is constant.
(9) The costs of value-added services for pharmaceutical Logistics Company are only related to the number of patients receiving service too. But the unit cost is only fixed within a certain interval number, and the costs will get accelerated growth when exceeding the scope. We can limit this range of points as a turning point. Because pharmaceutical Logistics Company can not provide value-added services for all patients, for example pharmaceutical Logistics Company in Beijing being unable to offering service to patients in the Guangzhou receiving service in the hospital in Beijing. The high cost of its distribution makes it impossible to implement value-added services. We will set the exceeding cost of its inflection point as a power function.
(10) Consumption volume of drugs for the patient is uniform.

Parameter settings

We set the parameters as follows.
Q: The daily number of patients in hospital in a period
Q^* : The number of patients that value-added services implemented by pharmaceutical logistics company can cover in a period
r : Coverage of value-added services implemented by pharmaceutical logistics
p : Benefits rate of unit increase number of patients in hospital
h : The setback of hospital inventory cost
l : The setback of hospital pharmacy staff costs

ΔQ : The increase number of patients in hospital after implementing value-added services
m: Value-added services charges for unit number of patient to pharmaceutical Logistics Company paid by hospital
n: Value-added services charges to pharmaceutical Logistics Company paid by patients
S: Services revenue pharmaceutical logistics company received paid by hospital and patients
D: Dosage of hospital for everyday service
λ : Before the implementation of value-added services, the number of proportion of drugs in hospital is delivered by this pharmaceutical Logistics Company.
I: The added amount of distribution drugs after implementing value-added services by pharmaceutical Logistics Company
F: The coverage number when inflection point of unit cost appears after implementing value-added services by pharmaceutical Logistics Company
C: The cost for one patient when implementing value-added services by pharmaceutical Logistics Company
g: The yield for unit increase of delivery of pharmaceutical Logistics Company
T_1 : Total value-added profit for hospital after implementing value-added services
T_2 : Total value-added profit for pharmaceutical Logistics Company after implementing value-added services

Model

We first consider the value-added profit of hospital because of the implementation of value-added services by pharmaceutical logistics company. It includes increased revenue to the hospital for more patients, inventory costs setback which is a constant, pharmacy personnel costs setback which is a constant, value-added services cost to be paid to pharmaceutical Logistics Company which is a new source of cost for hospital.

We start from coverage of value-added services provided by pharmaceutical Logistics Company, which is

$$r = Q^* / Q \tag{1}$$

Thus the increased number of patients for hospital should be a function of coverage. We set the parameters a and b which will serve to express the increased number of patients as a power function of coverage

$$\Delta Q = a + b * r^2 \tag{2}$$

And b should be greater than 0. Then increased revenue for hospital because of increased patients should be $\Delta Q^* p$. The value-added services cost paid by hospital to pharmaceutical Logistics Company should be mQ^* .And the total value-added profit for hospitals should be expressed as follows.

$$T_1 = (a + b * r^2) p + h + l - mQ^* \tag{3}$$

The total value-added profit of pharmaceutical Logistics Company for implementation value-added services includes value-added services cost paid by hospital and patients, increased revenue because of larger logistics volume for hospital taking over the purchasing rights of all drugs to the pharmaceutical logistics company, the cost of pharmaceutical Logistics Company for providing value-added services and the increased cost of pharmaceutical Logistics Company for implementing JIT delivery.

The value-added services cost paid by hospital and patients should be $(m+n)Q^*$. According to the assumption (9), the cost of pharmaceutical Logistics Company implementing value-added services for patients should be divided into two parts to consider. If the covering number of value-added services did not meet with the inflection point, the cost will be in a linear growth which is CQ^*. If the covering number of value-added services went beyond the inflection point, the cost will in an accelerated growth. It is $CQ^* + Ck(Q^* - F)^2$, and if $Q^* \geq F$, $k \geq 1$, and if $Q^* < F$, $k = 0$. The increased revenue of pharmaceutical Logistics Company for larger logistics volume is only related to the increased number of drug delivery. As the increased number of drug delivery is

$$I = D(1-\lambda) + \Delta Q * D / Q \tag{4}$$

the increased revenue should be $g*[D(1-\lambda) + \Delta Q * D / Q]$. The increased cost of pharmaceutical Logistics Company implementing JIT delivery should be related to increased number of drug delivery. The unit cost will be down as the delivery volume grows. So the total cost tends to a slowdown in the growth process. We set the increase number of cost as $d + eI - j\sqrt{I}$ (e and j should be more than 0). Then the total value-added profit should be

$$T_2 = (m+n)Q^* - [CQ^* + Ck(Q^* - F)^2] + g*[D(1-\lambda) + \Delta Q * D / Q] - [d + eI - j\sqrt{I}] \tag{5}$$

Consider the actual situation, only when the value-added profits of hospital and pharmaceutical Logistics Company are both greater than 0, can they be willing to implement this value-added services program. On this basis, in order to maximize profits, we can create bi-level programming model to achieve the collaborative optimization of hospital and pharmaceutical Logistics Company. Since the leading party of this proposal is pharmaceutical Logistics Company, we can take value-added profit maximization of pharmaceutical Logistics Company as the upper programming model and take value-added profit maximization of hospital as the lower programming model.

$$(U) \quad MaxT_2 = (m+n)Q^* - [CQ^* + Ck(Q^* - F)^2] + g*[D(1-\lambda) + \Delta D/Q] - [d + eI - j\sqrt{I}] \tag{6}$$

$$s.t. \quad r = Q^* / Q \tag{7}$$

$$\Delta Q = a + b*r^2 \tag{8}$$

$$b > 0 \tag{9}$$

$$e > 0 \tag{10}$$

$$j > 0 \tag{11}$$

$$\begin{cases} k = 0 & When \quad Q^* < F \\ k \geq 1 & When \quad Q^* \geq F \end{cases} \tag{12}$$

$$0 < \lambda < 1 \tag{13}$$

$$T_2 > 0 \tag{14}$$

$$I = D(1-\lambda) + \Delta Q * D / Q \tag{15}$$

$$(L) \quad MaxT_1 = (a + b*r^2)p + h + l - mQ^* \tag{16}$$

$$s.t. \quad r = Q^* / Q \tag{17}$$

$$b > 0 \tag{18}$$

$$T_1 > 0 \tag{19}$$

The first two constraints in upper programming model show the relationship of ΔQ 、 Q^* 、Q and r. The next three constraints are to make sure that b, e, and j must be positive. The sixth constraint is binding the values of k. The seventh constraint is that the ratio of the amount of drug distribution should be in the binding between 0 and 1. The eighth constraint shows that only if value-added profit of pharmaceutical Logistics Company is greater than zero, can it implement the program. The ninth constraint shows the increased number of drug delivery.

The first constraint in lower programming model show the relationship of Q^* 、Q and r. The second constraint is to make sure that b must be positive. The third constraint shows that only if value-added profit of hospital is greater than zero, can it implement the program.

IV. Conclusion

This paper is written under the new medical reform policy. Hospital without the rights to add drugs' price hopes to eliminate drug inventory in order to minimize the associated costs of drugs through the JIT delivery of drug Logistics Company. However, drug logistics companies are unwilling to implement JIT delivery on the basis of the original business volume as this would lead to an increasing unilateral cost significantly. In order to solve the conflicts of two parties, we design the proposal that drug Logistics Company offers value-added services to hospital and patient, which include JIT delivery for hospital and sending inspection reports and prescription for patients. Then the hospital will give delivery right of all drugs to this Logistics Company. On the base of that, the paper sets a bi-level programming model with the objective of profit maximizing to realize the collaborative optimization of two parties. But some mathematical expressions of value-added benefits and costs may not accurate. In future we can deepen the model and consider the drug Logistics Company to provide more value-added logistics services, particularly to establish information management systems for hospitals, which can be better to help hospitals improve the efficiency of logistics operations and coordinate the interests of the parties to optimize. Besides we can implement logistics simulation through the model simulation method.

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