Optimization of Medicine Logistics Procurement Strategy under the Response of Market State*

Ruifeng Li, Juanjuan Yan and Zhongyang Pei
School of Medicine Management, Shanxi University of Traditional Chinese medicine, Taiyuan, Shanxi Province, China
lirf521@sohu.com, maggyli@qq.com

Abstract - Only the scientific forecast of the supply and demand state of medicine in health service market can improve the medicine supply chain in the medicine logistics. By conducting mixed-strategy solution of medicine procurement in different market states with the matrix game, the procurement patterns of medicine logistics enterprises are optimized. Thus this will be of great importance to the supply and demand balance of medicine and the adjustment of health service system in Shanxi Province and even the whole country.

Index Terms - procurement optimization; medicine logistics; medicine supply; matrix game

1. Introduction

With the introduction of the five reform priorities in the medical and health system by the State Council, all provinces accelerate the formulation of the reform program in line with local conditions to improve the primary health care service system and to ensure people's demand of health care. In this demand, in addition to that the medicine quality and price must be ensured, timely delivery and access is also a vital part of the medicine supply system.

This paper takes Shanxi Province as an example. After in-depth research of drug supply system of Shanxi Zhendong Pharmaceutical Logistics Co., Ltd., we conducted optimization study of the procurement in the pharmaceutical logistics.

2. Background and Current Status

Shanxi Zhendong Pharmaceutical Logistics Co., Ltd. is a large comprehensive pharmaceutical business company mainly on pharmaceutical wholesale purchasing, warehousing, logistics and distribution services. Headquartered in Taiyuan, with the other three pharmaceutical subsidiaries in Hebei, Linfen and Changzhi, the company's customer network covers more than 80 counties and cities, 7200 small and medium-sized hospitals, township hospitals, chain medicine agencies and community clinics in Shanxi Province; the company has achieved the province-wide 24-hour door-to-door, point-to-point direct distribution business, and become the company with the most wide pharmaceutical terminal coverage and the strongest service capacity of Shanxi Province. With accumulated years of credit resources and public praise, it has established cooperative relationships 1680 important pharmaceutical industry enterprises of the country, including Chinese Medicine, CSPC, Harbin Pharmaceutical Factory, etc.; now it has 10,300 types of medicines. These generous supply chain resources have become a reliable guarantee for Zhendong Pharmaceutical to develop by leaps and bounds.

There is the problem: According to our research, now the procurement of the company is based on orders. Since the pharmaceutical market demand frequently fluctuates, the orders are collected once a week, sometimes with temporary rush orders; taking into account the various costs and industry practices, the procurement is generally conducted once a month. So the reality is to conduct procurement in advance. If the purchase amount cannot guarantee the supply, the supply of medical services and the benefit of the company will be affected; if the purchase amount exceeds the demand too much, the medicine will occupancy the capital thus resulting in poor cash flow, and it cannot be refunded once the medicine expires, thus to cause bad debts. This requires developing scientific procurement strategy based on market forecast [1, 2].

3. Scenario Analysis of Procurement Strategy in Pharmaceutical Logistics

According to the above-mentioned operation status of the company, the medicine procurement strategy set is defined as:

$$S_1 = \{\alpha_1, \alpha_2, \alpha_3, \alpha_4, \alpha_5\}$$

In which, α_1, α_2 respectively represent the medium-quantity and large-quantity procurement strategies under the status out of stock (small-quantity procurement is not applied when the medicine is out of stock); $\alpha_3, \alpha_4, \alpha_5$ respectively represent the small-quantity, medium-quantity and large-quantity procurement strategies under the status of the edge of stock (not yet out of stock).

Take the order-prompted demand status (forecast) of the medicine market as the strategy set S_2:

$$S_2 = \{\beta_1, \beta_2, \beta_3\}$$

$\beta_1, \beta_2, \beta_3$ respectively represent the market states of poor sales, general sales, and good sales.

According to our research data, the procurement payoff matrix A (unit: million) is as follows:

* This work is partially supported by the Soft Science Research Project of Shanxi Province (2011041072-02) and innovative team-building project of Shanxi University of Traditional Chinese Medicine.

$$A = \begin{bmatrix} 80 & 100 & 100 \\ 50 & 80 & 150 \\ 70 & 80 & 80 \\ 60 & 90 & 100 \\ 30 & 70 & 140 \end{bmatrix}$$

Considering the short-term profits of the company, the values in A are all positive. In A, since

$$\max_i \min_j a_{ij} = \min_j \max_i a_{ij}$$

The optimal pure strategy exists, with the saddle point of (α_1, β_1) and the value of 80.

However, from the perspective of long-term benefit and market position of the company, although the stored medicines occupy certain amount of capital, adequate procurement volume, which still has important market significance for the demands of customers, is necessary. Therefore, pharmaceutical logistics enterprises generally apply the procurement strategy with no out of stock. Based on these considerations, we cannot simply take the short-term profits of the company as the values in the payoff matrix; because out of stock will have a negative impact on the company, the long-term comprehensive benefits based on the procurement volume should be considered. According to further research, the modified strategy set and payoff matrix are as follows:

$S_1' = \{\alpha_1', \alpha_2', \alpha_3'\}$, $\alpha_1', \alpha_2', \alpha_3'$ respectively represent the small-quantity, medium-quantity and large-quantity procurement strategies under the state of no out of stock.

$S_2' = \{\beta_1', \beta_2', \beta_3'\}$, $\beta_1, \beta_2, \beta_3$ similarly represent the market states of poor sales, general sales, and good sales respectively.

The modified payoff matrix is $A' = \begin{bmatrix} 70 & 30 & -20 \\ 20 & 100 & 0 \\ -30 & 50 & 150 \end{bmatrix}$, the negative values represent the negative impact of demand exceeding supply on the long-term comprehensive benefits of the company. The modified matrix can better reflect the actual operation of the pharmaceutical logistics enterprises.

Now in A', since $\max_i \min_j a_{ij} = 0$, and $\min_j \max_i a_{ij} = 70$, it is obvious that: $\max_i \min_j a_{ij} \neq \min_j \max_i a_{ij}$

Therefore, this is an issue of mixed-strategy with no solution in the sense of pure strategy. The probability distributions when applying the different strategies should be given to enable the company to get the maximum average win in a variety of markets states [3].

4. Mixed-strategy Solution of Procurement Strategy

For the modified payoff matrix $A' = \begin{bmatrix} 70 & 30 & -20 \\ 20 & 100 & 0 \\ -30 & 50 & 150 \end{bmatrix}$, make $k = 50$, each element in A' is added to k, thus to obtain: $A'' = \begin{bmatrix} 120 & 80 & 30 \\ 70 & 150 & 50 \\ 20 & 100 & 200 \end{bmatrix}$

Assume that the probabilities of applying $\alpha_1', \alpha_2', \alpha_3'$ in procurement are respectively x_1', x_2', x_3', and that under the worst case the average win value of procurement strategy is V, there must be: $x_1 + x_2 + x_3 = \frac{1}{V}$, and x_1', x_2', x_3' are all equal or greater than 0; $V > 0$.

Under $\beta_1', \beta_2', \beta_3'$, there respectively are:

$$120x_1' + 70x_2' + 20x_3' \geq V$$

$$80x_1' + 150x_2' + 100x_3' \geq V$$

$$30x_1' + 50x_2' + 200x_3' \geq V$$

Make $x_i = \frac{x_i'}{V}$, since $V > 0$, it can be obtained that: $x_1 + x_2 + x_3 = \frac{1}{V}$, and x_1', x_2', x_3' are all equal or greater than 0;

$$120x_1 + 70x_2 + 20x_3 \geq 1$$
$$80x_1 + 150x_2 + 100x_3 \geq 1$$
$$30x_1 + 50x_2 + 200x_3 \geq 1$$

For pharmaceutical logistics enterprises, the greater the value of V, the better, i.e. the smaller the value of $\frac{1}{V}$, the better [4]. Thus the linear programming model of $\{S_1', S_2', A''\}$ to solve the optimal medicine procurement strategy is established as follows:

$$\min z = x_1 + x_2 + x_3$$

$$\text{Constraiconditions: } \begin{cases} 120x_1 + 70x_2 + 20x_3 \geq 1 \\ 80x_1 + 150x_2 + 100x_3 \geq 1 \\ 30x_1 + 50x_2 + 200x_3 \geq 1 \\ x_1 \geq 0,\ x_2 \geq 0,\ x_3 \geq 0 \end{cases}$$

Use the software to solve the model [5], with the process as follows:

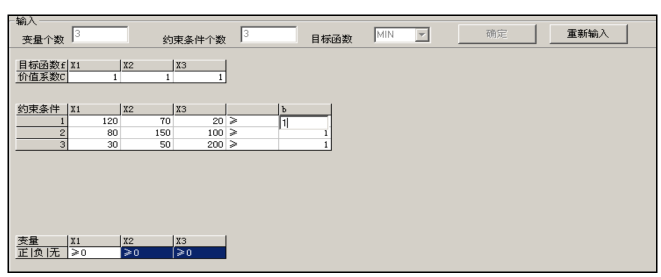

Fig. 1 Configuration of the model parameters

标准化结果：

	X1	X2	X3	X4	X5	X6	X7	X8	X9		b
Maximize	-1	-1	-1	0	0	0	-M	-M	-M		
约束条件1	120	70	20	-1	0	0	1	0	0	=	1
约束条件2	80	150	100	0	-1	0	0	1	0	=	1
约束条件3	30	50	200	0	0	-1	0	0	1	=	1

Fig. 2 Standardization of the model

开始 下一步 上一步

迭代次数	基变量	CB	X1	X2	X3	X4	X5	X6	X7	X8	X9	b	b(l)/a(l,k)
			-1	-1	-1	0	0	0	-M	-M	-M		
0	X7	-M	120	70	20	-1	0	0	1	0	0	1	1/20
	X8	-M	80	150	100	0	-1	0	0	1	0	1	1/100
	X9	-M	30	50	200	0	0	-1	0	0	1	1	1/200
		Zj	-230M	-270M	-320M	1M	1M	1M	-1M	-1M	-1M	-3M	
		Cj-Zj	230M-1	270M-1	320M-1	-1M	-1M	-1M	0	0	0		

Fig. 3 Simplex for solving the initial base variable of the model

1	X7	-M	117	65	0	-1	0	.1	1	0	-.1	.9	.9/65
	X8	-M	65	125	0	0	-1	.5	0	1	-.5	.5	.5/125
	X3	-1	.15	.25	1	0	0	-.005	0	0	.005	.005	.005/.25
		Zj	-182M-.15	-190M-.25	-1	1M	1M	-.6M+.005	-1M	-1M	.6M-.005	-1.4M-.005	
		Cj-Zj	182M-.85	190M-.75	0	-1M	-1M	.6M-.005	0	0	1.6M+.00		
2	X7	-M	83.2	0	0	-1	.52	-.16	1	-.52	.16	.64	.64/83.2
	X2	-1	.52	1	0	0	-.008	.004	0	.008	-.004	.004	.004/.52
	X3	-1	.02	0	1	0	.002	-.006	0	-.002	.006	.004	.004/.02
		Zj	83.2M-.5	-1	-1	1M	.52M+.00	16M+.002	-1M	52M-.006	.16M-.00	-.64M-.008	
		Cj-Zj	33.2M-.46	0	0	-1M	52M-.006	.16M-.00	0	1.52M+.00	.84M+.00		
3	X1	-1	1	0	0	-.012	.006	-.002	.012	-.006	.002	.008	
	X2	-1	0	1	0	.006	-.011	.005	-.006	.011	-.005	0	
	X3	-1	0	0	1	0	.002	-.006	0	-.002	.006	.004	
		Zj	-1	-1	-1	.006	.003	.003	-.006	-.003	-.003	-.012	
		Cj-Zj	0	0	0	-.006	-.003	-.003	-1M+.006	-1M+.003	-1M+.003		

Fig. 4 Three iterations in the solution process of the model

结果输出

**********************最优解如下**********************

目标函数最优值为：.012

变量	最优解	相差值
x1	.008	0
x2	0	.278
x3	.004	0

约束	松弛/剩余变量	对偶价格
1	0	-.006
2	0	-.003
3	0	-.003

目标函数系数范围：

变量	下限	当前值	上限
x1	.54	1	1.5
x2	.722	1	1.577
x3	.516	1	2.667

常数项数范围：

约束	下限	当前值	上限
1	.36	1	1
2	1	1	2.231
3	.355	1	1

Fig. 5 Solution results of the model

We obtained the result: $x_1 = 0.008,\ x_2 = 0,\ x_3 = 0.004$

Since $\frac{1}{V} = x_1 + x_2 + x_3$, then

$$V = \frac{1}{x_1+x_2+x_3} = \frac{1}{0.012} = 83.333$$

And $x_i' = V \cdot x_i$, so we calculated to obtain that $x_1' = 0.667, x_2' = 0, x_3' = 0.333$

The probabilities of applying small-quantity, medium-quantity and large-quantity procurement strategies $\alpha_1', \alpha_2', \alpha_3'$ under the state of no out of stock are respectively 0.667, 0, and 0.333.

The value of this mixed-strategy is $V - k = 33.333$. The solution of optimal mixed-strategy of the modified matrix game $\{S_1', S_2', A'\}$ is thus completed.

5. Conclusions

This paper studies the scenario analysis and strategy solution of medicine procurement strategies in pharmaceutical logistics enterprises under different market states of medicine demand. What needs particular note is that in order to facilitate the solution of the model, the values in the payoff matrix (including the modified payoff matrix) are all integral multiples of 100,000, which can only reflect the general situation of the comprehensive benefit of the company, but not the actual specific values; in addition, the benefit in the operation of the medicine logistics company is influenced by various factors, we only research from the point of view of game between the procurement bulk and the market demand, which has certain limitations. We will further improve it in the future in-depth research.

In this paper, we apply the matrix mixed-strategy solution to make innovation and trial in developing the procurement strategy, which is of reference value to the optimization of supply mode of pharmaceutical logistics industry, and has a positive significance for the supply of medical health service and the regulation of supply and demand of the medicine market of Shanxi Province and other areas in China.

References

[1] Xiaoli Wang, Shihua Ma. Optimal Logistics Service Capacity Sourcing with Demand Information Updates. Industrial Engineering and Management, 2010, vol. 15, no. 3, pp. 31-34

[2] Gunnar S. Collaborative logistics management and the role of third-party service providers. International Journal of Physical Distribution & Logistics Management, 2006, vol. 36, no. 2, pp. 77-90

[3] Minjie Zhu, Liwei Zhang. Research on Optimization Risk Decision of Purchase Logistics Based on Opportunity Loss Mastrix. Logistics Sci-Tech, 2008, no. 4, pp. 71-74

[4] Botang Han. Management Operational Research (Third Edition). Beijing:Higher Education Press, 2010, pp. 358-360

[5] Ruiqiong Liu. The Software Solving of linear programming problem . China Science and Technology Information, 2010, no. 22, pp. 101-102