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The Optimal Ordering Strategy of Outsourcing Procurement of Health Education and Behavior Intervention Products

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ABSTRACT
Health communication and behavior intervention are main measures adopted in health education. Behavior intervention among these measures is the direct one to effect individual and group behaviors. Patients demand more than health information communication, but rely on health intervention service and related products. This essay starts from vertical extension of service industrial chain. And attribute health intervention products with characters of newsboy and random demand to outsourcing, the third party health management company (3PH). In addition, we establish mathematical model to describe how health intervention product ordering managed by 3PH and characterized with newsboy characteristic, makes impact on strategy and performance efficiency of 3PH. We obtain result of the optimal order quantity, optimal selling price and condition fulfilled optimal proportion of loss sharing, which is able to achieve added value on health education industrial chain.
Keywords: health education, behavior intervention, outsourcing procurement, optimization of the order

INTRODUCTION

Health education is both activity and procedure to improve health level of the citizen eventually by means of health information communication and health behavior intervention to popularize healthcare information, improve their behavior and health life style[1].Direct target of health information communication is to help individual and group learn health care knowledge and establish their health concept.

Health behavior intervention refer to international measures which directly affect individual and group behavior. Health information communication among citizens contribute

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State of the literature

These studies confirm that health education is a system that includes health information dissemination, health interventions and health products. The health benefits of education depend largely on the use of healthy products. Because the health products has variety, short cycle, the market demand of the characteristics of big fluctuation of need to introduce a third party health (3PH) management, to ensure the flexible low-cost response to consumer demand.

Contribution of this paper to the literature

Consider newsboy characteristics of the health interventions products and introduce the operation mode of the 3PH, under the background of this paper studies the different health interventions products ordered to the enterprise, 3PH of the influence of decision-making and performance, get the optimal quantity of 3PH, the optimal selling price and the most optimal loss-sharing ratio, through the model, and meet the conditions of implementing health education industry chain.

to establish their health consciousness, to some degree, which lead to formation of healthier behavior and lifestyle. However, considering external factors, formation and maintenance of health behavior rely on external circumstances and multiple condition which contribute to actualize willing of forming healthier behavior into action, rather than individual or group health consciousness. And this leads to ideology of health promoting.

Currently, health education demand upgrades from the simple mode of health information communication to another multiple mode of course-practice-training-syndrome treatment. Application of internet and big data world-wide accelerates formation of health education chain.

LITERATURES REVIEWING

Health education deliver health-care knowledge to patients in order to provide them self-management measures and promote their health consciousness, which oriented society as non-pharmacologic treatment[2]. Regards of health education, that adopt a series of social education activity, and deliver health-care knowledge to society. Moreover, it helps people to understand their health status and risky health factors, which lead people to make better options for their health related behavior and healthier life style. Meanwhile, made by health education, positive influence above may decrease risky health factor, that makes it possible for people to prevent disease, increase their quality of life and promote their health status eventually[3].

Previous research[4] shows that health care of chronic disease not only rely on effective remedy, but self-management of chronic disease and regular follow-up as well. Self-management refer to patients maintain their health by correcting improper life style and behavior with appropriate health education and guide line, which is able to weaken negative influence of disease on patients' social function, emotion and relationship[5] . Self-management for chronic patients refer to measures, patients' daily behavior, that is able to prevent

complication and promote their health[6]. Regard of this, research shows that healthy lifestyle could decrease risk of stroke by 80%.

Clearly stated out significance of health behavior intervention. Dr. Roster form HMS pointed that positive change in lifestyle enable to decrease the risk of suffering from a stroke better than taking medicine [7]. Obviously, simple change in lifestyle play a role in stroke prevention. It can be seen that early, timely health education together with active prevention and intervention is able to reduce the incidence of stroke and recurrence rate significantly. Lin Yu [8] found that stroke patients and their families are generally lacking in knowledge of rehabilitation. Health-care workers should attach importance to health education of rehabilitation among stroke patients. Some research [9] show that the patients those who suffered from first stroke, generally lack of disease-prevention knowledge. Additionallypoor methods and behavior exist in their daily life, which suggested that targeted health education strategies should be provided to stroke patients.

"China chronic disease prevention and treatment protocol (2012-2015)"stated that medicine clinic should operate health education, prevention, health care, medical treatment, rehabilitation. Additionally, the medicine organization should provide precise health education and chronic disease health-care consultation, which is able to combine prevention, intervention and remedy together. Patients directly learn health-care knowledge from Health information communication and establish appropriate health concept, however, recovery of patients demand more on behavior intervention than knowledge communication. The ultimate goal of health education is not only reflect on accumulation of knowledge, but, more importantly,on products, services which enable people to achieve good behavior and lifestyle which lead to reducing and elimination ofhealth risky factors.

RESEARCH DESIGN

The industrial chain of health education consists of three main parts, the dissemination of health information, the services, and the products as well, of health behavior interventions. Among three parts, the services of health behavior interventions play a core role, as which is shown in **Figure 1**. Because of the wide range of health education industrial chains, the fierce competition in the market requires enterprises to concentrate resources on the development of core business. Considering that the services and products of health intervention have newsboy product features, its uncertainty of demands has always been a difficult problem in the value management of industrial chain, the third party outsources in health management (hereinafter referred to as the "3PH") become the primary choice to focus resources and to reduce the cost.

This essay illustrated the case of enterprise that sales health intervention products with newsboy provider. We identify 3PH as a newsboy provider, which is supplying health products and apart from enterprise. Health behavior intervention services provider will order management outsourcing newsboy products to 3PH and pay commission costs to 3PH.Also we build up a profit model between the enterprise and 3PH, which is describing the role of 3PH in the order management of newsboy product, and analyzing the impact of the enterprise

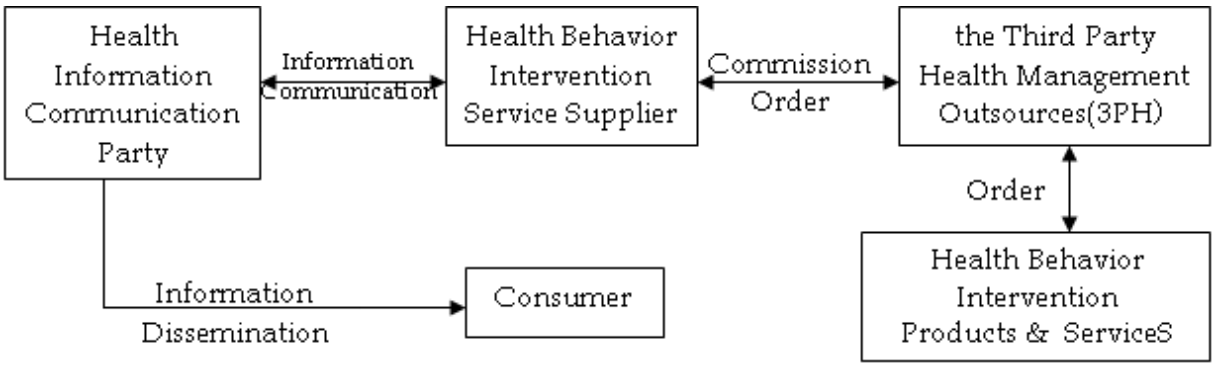

Figure 1. Health Education Industry Chain

and 3PH while they order outsourcing. 3PH is in charge of making the optimal ordering and profit maximization, meanwhile, the enterprise works out the best price which is based on the order of 3PH to achieve the profit maximization. 3PH should undertake the duty if the goods are backlog or out of stock, when 3PH was making the decision of ordering. However, 3PH also loses some incomes when the ordering becomes less because of the shortage. Therefore, the article just assumes that 3PH offers compensation to the health behavior intervention services provider when the goods are over stocking. In this way of outsourcing cooperation, health behavior intervention service providers not only outsource the order management but also outsource a certain part of the sales risk. Meanwhile, 3PH is not only the product sales agent but also the co-undertaker of enterprise risk. By analyzing the profit model of health behavior intervention service provider and 3PH, in this paper, we manage to get the optimal order quantity of 3PH, the optimal selling price of health behavior intervention service and the optimal ratio of loss sharing. At the same time, by comparing the 3PH management order and the health behavior intervention service provider to manage the ordered mathematical model, This paper concludes that under the premise of certain proportion of loss sharing and entrusted expenses, 3PH management order can bring more revenue to the enterprise and 3PH.

Flynn[10]studied the relationship between three dimensions of SCI, operational and business performance, from both a contingency and a configuration perspective. Sun[11] Based on the mathematical model and its solution, the mutual impact between the multiple decoupling points in the supply chain network is investigated through sensitivity analysis. As the objective of a BOSC(build-to-order supply chain management) strategy is to meet the requirements of individual customers by leveraging the advantages of outsourcing and information technology, Gunasekaran[12] made the trade-off between responsiveness and the cost of logistics needs further study. Ventura[13] considered the inherent connection between supplier selection and inventory management in supply chain networks, minimized the total variable cost, including purchasing, production, inventory, and transportation costs. Wei[14] observed the increasing competition in the market usually results in high fluctuations of inventory and demand in supply chain systems. Yimer[15], Hwarng[16], Kamath[17], Xu[18],

Huang[19] and Ivanov[20] studied respectively in terms of flexibility and low cost ,with the characteristics of supply chain delivery.

MODEL

Now we assume a health service supplier（enterprise）who sales a kind of newsboy product w. We assume quantity demanded of product w as d, unit wholesale price as c ,unit shipping charge as t ,unit retail price as p, order quantity as q. Enterprise outsource health product ordering to 3PH and pay 3PH for management fee s, while 3PH offer shipping cost v of product w .The enterprise sets optimal selling price to maximize its profit by adopting 3PH ordering strategy. When over storage occurs, 3PH is responsible for the total comprehensive loss of the enterprise, which will be calculated by the fixed proportion θ. While products shortage occurs, 3PH is not responsible for compensation for loss.

Mills advance uncertainty and pricing theory in the year of 1959, which assume demand function of newsboy products as $d = y(p) + \varepsilon$, $y(p)$ is the decreasing function of retail price p, while ε is the random variable. Regard of this, density function is $f(\varepsilon)$ while distribution function is $F(\varepsilon)$. What mentioned above reveal that demand of newsboy products are consisted of two parts, deterministic demand of price changes $y(p)$ and uncertain demand ε.

This essay adopt assumption suggested by Mills, which make enterprise meet the requirement of $d = y(p) + \varepsilon$, resulting in mean value ε as 0. On the other hand $y(p)$ is able to reflect mean value of ε either. We assume random variable ε uniform to distribution, which obtain the function as $f(\varepsilon) = \begin{cases} \dfrac{1}{2\gamma}, -\gamma < \varepsilon < \gamma \\ 0, \text{els} \end{cases}$, $\gamma > 0$. In this function, γ represents the value of uncertainty. As the value of γ grows in this function, meanwhile, demand-size fluctuation and corresponding risk grows. linear demand function $y(p) = a - ap$, $a > 0$, $b > 0$.

When demand as $d = y(p) + \varepsilon$ met requirement of $d \geq 0$,we obtain a result that $a - bp - \gamma \geq 0$ which equal to $\gamma \leq a - bp$.

Profit Model of Enterprise

The profit of enterprise is depended on the order quantity of demand and 3PH, so can analysis of the relationship between demand and order quantity.

(1) When the demand is less than or equal to the purchase quantity, that is $d \leq q$, product backlog appears. The loss of the enterprise is $(q-d)(t+c)$, without the other cost and the

value of the Overstocked products. The total compensation according to the proportion of compensation discussed is $\theta(q-d)(t+c)$ and the profit of enterprise is $\pi_r = dp - q(c+t) + \theta(q-d)(t+c) - s$.

(2) When demand is greater than the quantity ordered, that is $d > q$, 3PH doesn't have to compensate for the loss. The profit of 3PH is: $\pi_r = qp - q(c+t) - s$.

$$\text{so}\ ,\ \pi_r = \begin{cases} dp - q(c+t) + \theta(q-d)(t+c) - s, d \le q; \\ qp - q(c+t) - s, d > q; \end{cases}$$

$$= \begin{cases} dp - q(c+t) - (q-d)\left(p - \theta(t+c)\right) - s, \varepsilon \le q - y(p); \\ qp - q(c+t) - s, \varepsilon > q - y(p); \end{cases}$$

The expected profit of the enterprise:

$$E\pi_r = qp - q(c+t) - s - \left(p - \theta(t+c)\right)\int_{-\infty}^{q-y(p)} (q-d) f(\varepsilon) d\varepsilon \tag{1}$$

Profit Model of 3PH

3PH faces the risk of the loss of the enterprise, so the 3PH profits are also correlated with the needs of the enterprise.

(1) When the demand is less than or equal to the purchase quantity, that is $d \le q$, product backlog appears. 3PH has to pay for the loss of the enterprise, the total amount is $\theta(q-d)(t+c)$. At this point, the profit of 3PH is: $\pi_t = q(t-v) + s - \theta(q-d)(t+c)$;

(2) When demand is greater than the quantity ordered, that is $d > q$, 3PH doesn't have to compensate for the loss. The profit of 3PH is: $\pi_r = q(t-v) + s$.

$$\text{In general,}\ \pi_t = \begin{cases} q(t-v) + s - \theta(q-d)(t+c), \varepsilon \le q - y(p); \\ q(t-v) + s, \varepsilon > q - y(p); \end{cases}$$

$$\text{The expected profit of 3PH is: } E\pi_t = q(t-v) + s - \theta(t+c)\int_{-\infty}^{q-y(p)} (q-d) f(\varepsilon) d\varepsilon \tag{2}$$

Optimization analysis

Let $G(p,q)=\int_{-\infty}^{q-y(p)}(q-d)f(\varepsilon)d\varepsilon$, $G(p,q)$ denote the expectations of product requirements under the condition of demand is less than or equal to orders, it is quite clear that $G(p,q)\geq 0$. Specifically,

$$G(p,q)=\int_{-\infty}^{q-y(p)}(q-d)f(\varepsilon)d\varepsilon=(q-y(p))F(q-y(p))-\int_{-\infty}^{q-y(p)}\varepsilon f(\varepsilon)d\varepsilon$$

Substitute $G(p,q)$ into the formula (1), (2), we have:

$$E\pi_r=(p-t-c)-s-(p-\theta(t+c))G(p,q) \tag{3}$$

$$E\pi_t=(t-v)q+s-\theta(t+c)G(p,q) \tag{4}$$

Let $sum1=E\pi_r+E\pi_t$, denote the sum profits of the enterprise and the 3PH.

Assume that both the business and the 3PH are rational. In the process of their cooperation, the 3PH determines the optimal value of the purchase and maximizes the profit, and then the enterprise determines the optimal price for the sale. Because the enterprise is rational, it will select the best selling price to maximize the profits based on 3PH's purchase decision. From this point of view, their game is in accordance with the dynamic game of full information, which can be solved by backward induction.

Note that $f(\varepsilon)=\begin{cases}\dfrac{1}{2\gamma}, & -\gamma<\varepsilon<\gamma\\ 0, & \text{el se}\end{cases}$, we have: $F(q-y(p))=\dfrac{q-y(p)+\gamma}{2\gamma}$ (5)

$$G(p,q)=\frac{(q-y(p)+\gamma)^2}{4\gamma} \tag{6}$$

$$G_q'(p,q)=F(q-y(p))=\frac{q-y(p)+\gamma}{2\gamma} \tag{7}$$

$$G_p'(p,q)=bF(q-y(p))=b\frac{q-y(p)+\gamma}{2\gamma} \tag{8}$$

$$G_p'(p,q)=bF(q-y(p))=b\frac{q-y(p)+\gamma}{2\gamma}$$

According to formula (7), we have：

$$\frac{\partial E\pi_t}{\partial q}=(t-v)-\theta(t+c)G_q^{'}(p,q)=(t-v)-\theta(t+c)F\left(q-y(p)\right)$$

When $\frac{t-v}{\theta(t+c)}\geq 1$is satisfied, we always have $\frac{\partial E\pi_t}{\partial 1}\geq 0$. This means that 3PH will increase the amount of the purchase to maximize its own profit. When the 3PH take its risk, θ should satisfy $\theta>\frac{t-v}{t+c}$. In this paper, let us assume that $\theta>\frac{t-v}{t+c}$, that is, $\frac{t-v}{\theta(t+c)}<1$. According to $\frac{\partial E\pi_t}{\partial 1}=0$, we can find the optimum order quantity q^* satisfies $F\left(q^*-y(p)\right)=\frac{t-v}{\theta(t+c)}$.

According formula (5), there is $q^*=2\gamma\frac{t-v}{\theta(t+c)}+y(p)-\gamma$.

When the enterprise guides the 3PH, the best order of purchase should satisfy $q^*=2\gamma\frac{t-v}{\theta(t+c)}+y(p)-\gamma$. In the rational case, the enterprise will choose the best price based on 3PH.Substitute q^* into formula (3), thus：

$$E\pi_r=(p-t-c)q^*-s-\left(p-\theta(t+c)\right)G\left(p,q^*\right)=(p-t-c)q^*-s-\left(p-\theta(t+c)\right)\frac{y(t-v)^2}{\theta^2(t+c)^2}$$

Let $\frac{\partial E\pi_r}{\partial 1}=0$, the best price is: $p^*=\frac{1}{2b}\left(a-\gamma+b(t+c)\right)+2\gamma\frac{t-v}{\theta(t+c)}-\frac{\gamma(t-v)^2}{\theta^2(t+c)^2}\Bigg)$.

After the enterprise decides the best selling price, 3PH makes the order decision according to the price, Substitute p^* into q^*, we have:

$$q^*=2\gamma\frac{t-v}{\theta(t+c)}+y(p)-\gamma=\frac{(a-\gamma)}{2}-\frac{b(c+t)}{2}+\frac{\gamma(t-v)}{\theta(t+c)}-\frac{\gamma(t-v)^2}{2\theta^2(t+c)^2}\Bigg)$$

The equilibrium result of the game is the optimal order of 3PH and the best selling price for the enterprise should satisfy:

$$q^*=2\gamma\frac{t-v}{\theta(t+c)}+y(p)-\gamma=\frac{(a-\gamma)}{2}-\frac{b(c+t)}{2}+\frac{\gamma(t-v)}{\theta(t+c)}-\frac{\gamma(t-v)^2}{2\theta^2(t+c)^2}\Bigg) \tag{9}$$

$$p^* = \frac{1}{2b}\left(a-\gamma+b\left(t+c\right)\right)+2\gamma\frac{t-v}{\theta\left(t+c\right)}-\frac{\gamma\left(t-v\right)^2}{\theta^2\left(t+c\right)^2}\Bigg) \tag{10}$$

The best profit of the enterprise is：

$$\max E\pi_r = \left(p^*-t-c\right)q^*-s-\left(p^*-\theta\left(t+c\right)\right)\frac{\gamma\left(t-v\right)^2}{\theta^2\left(t+c\right)^2} \tag{11}$$

The best profit of the3PH is： $\max E\pi_t = \left(t-v\right)q^*+s-\frac{\gamma\left(t-v\right)^2}{\theta^2\left(t+c\right)^2}$ (12)

The sum of their profits is：

$$\max\left(sum1\right) = sumE\pi_r + sumE\pi_t = \left(p^*-c-v\right)q^*-p^*\frac{\gamma\left(t-v\right)^2}{\theta^2\left(t+c\right)^2} \tag{13}$$

Enterprise subscription model

If an enterprise does not entrust 3PH to manage the order, determine the best order quantity and sales price to maximize the expected profit, and bear all the losses itself. Thus, there is no 3PH compensation and commission fee, and the profits π_r of the enterprise should satisfy:

$$\pi_r = \begin{cases} dp-q\left(c+t\right), d\le q; \\ qp-q\left(c+t\right), d>q; \end{cases} = \begin{cases} qp-q\left(c+t\right)-\left(q-d\right)p, \varepsilon \le q-y\left(p\right); \\ qp-q\left(c+t\right), \varepsilon > q-y\left(p\right); \end{cases}$$

And the expected profit of the enterprise is：

$$E\pi_r = qp-q\left(c+t\right)-p\int_{-\infty}^{q-y(p)}\left(q-d\right)f\left(\varepsilon\right)d\varepsilon = qp-q\left(c+t\right)-pG\left(p,q\right)$$

profit π_t of 3PHsatisfies: $\pi_t = \left(t-v\right)q$.又 $\frac{\partial E\pi_r}{\partial q} = \left(p-c-t\right)-pG_q^{'}\left(p,q\right)$,

$\frac{\partial E\pi_r}{\partial q} = q-G\left(p,q\right)-pG_q^{'}\left(p,q\right)$,

If an enterprise wants to maximize profits, q^* and p^* should satisfy the following conditions: $\begin{cases} \dfrac{\partial E\pi_r}{\partial q^*} = 0 \\ \dfrac{\partial E\pi_r}{\partial p^*} = 0 \end{cases}$ .Let us assume that: $\begin{cases} \dfrac{\partial E\pi_r}{\partial q} = 0 \\ \dfrac{\partial E\pi_r}{\partial p} = 0 \end{cases}$

And according to formula (6), (7) and (8), we have:

The optimal sales price p^* satisfies : $2bp^{*3} - (a + bc + bt)p^{*2} + \gamma(t + c)^2 = 0$ (14)

The optimal order quantity q^* satisfies : $q^* = 2\gamma\dfrac{p^* - c - t}{p^*} - \gamma + a - bp^*$ (15)

Assume that: $sum2 = E\pi_r + E\pi_t = (p - c - v)q - pG(p, g)$, that is, $sum2$ is the sum of the profits of the two parties when 3PH does not participate in the order. The best profit for the enterprise satisfies:

$$\max E\pi_r = q^*\left(p^* - c - t\right) - \frac{\gamma\left(p^* - c - t\right)^2}{p^*} \tag{16}$$

The best profit for 3PH satisfies: $\max E\pi_t = q^*(t - v)$ (17)

The best profits of the enterprise and the 3PH satisfy:

$$\max sum2 = q^*\left(p^* - c - v\right) - \frac{\gamma\left(p^* - c - t\right)^2}{p^*} \tag{18}$$

EVALUATED MEASUREMENTS

When the 3PH manages the order, the cost of the commission is determined by the enterprise and the 3PH.Inspecting the best expected profits of the enterprise and 3PH, ignoring the commission charge, by comparing the two kinds of order mode profits of both sides, you can get the reasonable range of entrust cost changes, within the scope of the negotiations both sides consultations determine the size of the cost.

Get $\max E\pi_r^0$ and $\max E\pi_t^0$ to be the best profit for the enterprise and 3PH when the delegate cost is not considered. So

$$\max E\pi_r^0 = q^*\left(p^* - c - t\right) - \left(p^* - \theta\left(c+t\right)\right)\frac{\gamma\left(t-v\right)^2}{\theta^2\left(t+c\right)^2} \tag{19}$$

$$\max E\pi_t^0 = \left(t-v\right)q^* - \frac{\gamma\left(t-v\right)^2}{\theta\left(t+c\right)} \tag{20}$$

The risk sharing ratio affects to the best price, quantity and profit

By $a=100, b=1, c=10, t=5, v=2, \gamma=20$, so $\theta > \frac{t-v}{t+c} = \frac{1}{5}$, we can get $p^* = \frac{95}{2} + \frac{4}{\theta} - \frac{2}{5\theta^2}$, $q^* = \frac{65}{2} + \frac{4}{\theta} + \frac{2}{5\theta^2}$ by the formula (9), (10), (19), (20), so $\max E\pi_r^0 = q^*\left(p^* - 15\right) - \frac{4\left(p^* - 15\theta\right)}{5\theta^2}$, $\max E\pi_t^0 = 3q^* - \frac{12}{\theta}$. And p^* getmeet $\frac{4500}{p^{*2}} + 2p^* - 115 = 0$, $q^* = \frac{20\left(p^* - 30\right)}{p^*} + 100 - p^*$ by the formula (14), (15), (16), (17). $\max E\pi_r = q^*\left(p^* - 15\right) - \frac{10\left(p^* - 15\right)^2}{p^*}$, $\max E\pi_t = 3q^*$。 The approximate solution $p^* \approx 56.8$ obtained by MATLAB software, therefore $\max E\pi_r = q^*\left(p^* - 15\right) - \frac{10\left(p^* - 15\right)^2}{p^*} = 1891$, $\max E\pi_t = 3q^* = 157.8$

As people are paying more attention to health-care education nowadays, its industrial chain is forming a closed cycle – from simply spreading the health-care education knowledge to health-care intervention services and hence extend to health-care intervention products. The nature of newsboy products in health-care education products promotes the development of professional services providers, in this case, third party health-care products and service providers (3PH). Outsourcing service is becoming a major tool for companies using 3PH in order to minimize cost and gain competitive advantage. The uncertainty for the need of newsboy products has brought great challenges to order management within a enterprise since the purchase order directly affects the profits. If the enterprise uses 3PH to manage the purchase of newsboy products, it can apportion the risk of uncertainty between the enterprise and 3PH. Such the enterprise has achieved outsourcing order management and partial risk outsourcing at the same time. 3PH manages the enterprise's order activities and at the same time shares the risks. This way of cooperation will definitely influence decision making

between the enterprise and 3PH as well as profit making. However, existing articles is lack of research on such influences. For this problem, this article establishes a model on profits between the enterprise and 3PH when 3PH manages the order of newsboy products. It analyses the influence on both parties under such cooperation by using a mathematic model. This article focused on analyzing the risk of uncertainty and loss sharing proportion in order to obtain the best retail price, as well as the influence between 3PH's maximum order amount and both parties' total profit. The result shows loss sharing proportion is playing an important role in the cooperation between both parties. If 3PH undertake less loss, then it cannot share the risks and the benefits of risk sourcing cannot be performed. On the other hand, if the proportion of loss is too large will urge 3PH to reduce order quantity excessively causing profit loss in both parties. Therefore, only reasonable proportion of loss sharing will bring maximum profit. Yet this article contains some deficiencies. It ignored the cost of inventory in order to simplify the model. Also it only considered the risks in uniform distribution. So the model raised in this article still needs to be developed further. But the model and conclusion in this article filled the research blank within the area of management on 3PH's order on newsboy products. It will further guide the understanding on a enterprise's order management and development.

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