Research on probability product differentiation based on power equilibrium

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Abstract. Overall the benefit of Supply Chain Based on probabilistic production and power equilibrium, the influencing factors of the decision-making of probabilistic productions are studied in this paper. Firstly, the correlation function of profit is formed by solving the lowest utility of products. Then numerical simulation and example research are carried out. The results show that, there is a positive correlation property between the two types of products which formed probabilistic production and supply chain efficiency. At the same time, manufacture and retailer should also pay attention to the proportion of the two types of products in order to achieve the best overall benefit. The conclusion in this paper has practical significance, it has a significant impact on the decision-making under the power equilibrium.

1 Introduction

With the rapid development of technology and information, probabilistic selling has gradually come into people's vision. It plays an important role in many fields. A car rental company named "Thrifty" provides a probabilistic sales service, it sells two kinds of cars in different ways. Consumers have the opportunity to get the high-quality cars at the price of low-quality cars. Probabilistic sales reduce the inventory risk and the uncertainty of sales, it benefits both businesses and consumers in the long run. Probabilistic sales have become an essential sales strategy for enterprises and the related research is also increasing.

Currently, many scholars pay attention to the relevant factors that affect consumers in probabilistic sales. Wang et al. [2] divided consumers into different types according to different degree of loss aversion. Huang et al. [3] analyzed the pricing strategy from the perspective of customer response. Won et al. [4] studied the empirical advantage from the perspective of loss aversion. Besides, considering the risk and strategy of the whole supply chain, Cai et al. [5] and Zheng et al. [6] analyzed it from a more diversified perspective. Huang et al. [7] studied the complexity of dual channel supply chain, link probabilistic sales to other supply chain parameters. Zhang et al. [8] compared the inventory strategy with the probability strategy, and finally found that when the products have low similarity, the probability sales can get more profits. Fay et al. [9] and Rice et al. [10] discussed the relationship between probabilistic sales and market, and introduced probabilistic sales into deeper research.

But none of these studies involved the probability product itself. This paper focuses on probabilistic products, under the premise of power equilibrium, this paper studies the impact of product differentiation on the overall efficiency of supply chain.

2 Problem Description And Model Hypothesis

This paper focuses on probabilistic products, expounds how the supply chain should make decisions under the equilibrium of power institutions. Product 0, product 1 and product 2 are the three products. Product 1 and product 2 are different in comprehensive value. Product 2 is better than product 1. Product 0 is composed of product 1 and product 2 at random, recorded as probability product. Retail sells not only product 1 and product 2, but also probability product. This can weaken the price sensitivity of consumers. Consumers have more diversified choices when buying products and sales in the market are also more even. The model for this article is shown in Figure 1.

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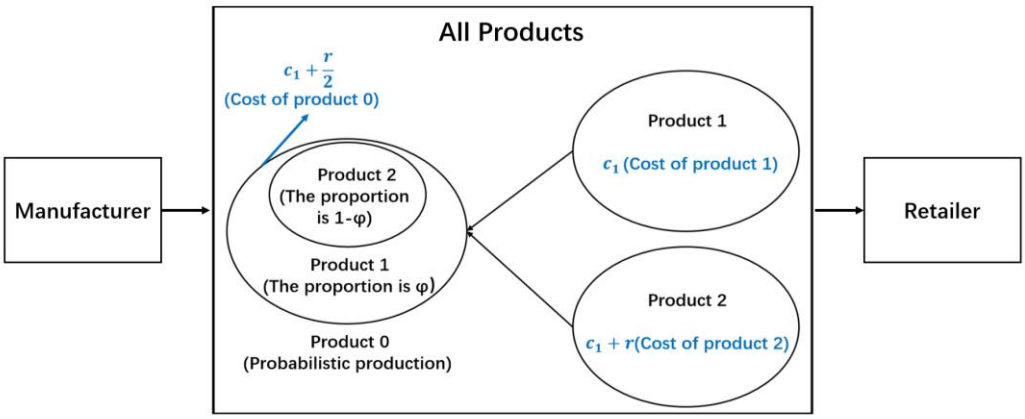

Figure 1 Model diagram of the equilibrium of power between manufacture and retailer

2.1 Symbol Description

Table 1 Parameters and Definitions

Parameters	Definitions
c_n	Cost of product n, n=1,2
w_n	Wholesale of product n, n=1,2
m_n	Marginal profit of product n, n=1,2
p_n	Sale price of product n, n=1,2
r	Cost difference between product 1 and product 2
φ	Market share of product 1
t	Unit matching cost, indicates the consumer's sensitivity to an incomplete match
v_n	Value gained by purchasing product n，n=0,1,2
U_n	Net utility obtained by purchasing product n, n=0,1,2
π_m	Manufacture's profit
π_r	Retailer's profit
D_n	Demand for product n, n=0,1,2

2.2 Model Assumption

2.2.1 Suppose the market capacity is 1.

2.2.2 Suppose the probability product is 1, the proporyion of product 1 in product 0 is φ, the proporyion of product 2 in product 0 is (1-φ). Similar to Shu ea al. [11], when φ is larger, the difference between the proportion of product 1 and product 2 is larger, the more likely consumers are to buy probabilistic product.

2.2.3 Suppose that the difference between the production costs of product 1 and product 2 is "r", the selling prices of the three products are as follows.

$$p_1 = w_1 + m_1 + c_1$$
$$p_2 = w_1 + m_2 + c_1 + 2r$$
$$p_0 = \frac{w_1 + w_2 + c_1 + c_2}{2} + m_0$$

"w", "m", "c" represents the wholesale price, marginal profit and production cost of the three products. The expected value of the three products are as follows.

$$v_1 = 1 - tx$$
$$v_2 = 1 - t(1-x)$$
$$v_0 = \varphi v_1 + (1-\varphi)v_2$$

The net utility of purchasing three kinds of products are as follows

$$U_0 = v_0 - p_0$$
$$U_1 = v_1 - p_1$$
$$U_2 = v_2 - p_2$$

When consumers buy products, the utility of products is greater than 0. Under this condition, solving the critical point sales. The result is as follows.

Table 2 Critical point of product sales

Product	Critical point	Condition
Product 0	$x_0 = \frac{1 - t + t\varphi - w_1 - c_1 - r - m_0}{t(2\varphi - 1)}$	$x < x_0$
Product 1	$x_1 = \frac{1 - w_1 - c_1 - m_1}{t}$	$x < x_1$
Product 2	$x_2 = \frac{t - 1 + w_1 + c_1 + m_2 + 2r}{t}$	$x > x_2$

As shown in Table 2, when the utility of products is positive, consumers' choice depends on the comparison between products. The following is the quantity demanded for three products calculated at the critical point at which consumers chose different products.

$$D_0 = \frac{\varphi(2w_1 - 2 + 2c_1 + 2r + 2m_1 + t) + 2 - t - 2w_1 - 2c_1 - r - m_0 - m_1}{2t(1-\varphi)(2\varphi - 1)} \quad (1)$$

$$D_1 = \frac{t - t\varphi - m_1 + r + m_0}{2t(1-\varphi)} \quad (2)$$

$$D_2 = \frac{1 - w_1 - c_1 - m_1}{t} \quad (3)$$

3 Solution Method For Model

In order to explore the optimal strategy of the supply chain under the equilibrium of power organization, the model is solved. According to the above analysis, we can get the profit of manufacture and retailer.

$$\pi_m = \frac{w_1[\varphi(2w_1-2+2c_1+2r+2m_1+t)+2-t-2w_1-2c_1-r-m_0-m_1]}{2t(1-\varphi)(2\varphi-1)} + \frac{(w_1+r)(t-t\varphi-m_1+r+m_0)}{2t(1-\varphi)} + \frac{(2w_1+r)(1-w_1-c_1-m_1)}{2t} \quad (4)$$

$$\pi_r = \frac{m_1[\varphi(2w_1-2+2c_1+2r+2m_1+t)+2-t-2w_1-2c_1-r-m_0-m_1]}{2t(1-\varphi)(2\varphi-1)} + \frac{m_2(t-t\varphi-m_1+r+m_0)}{2t(1-\varphi)} + \frac{m_0(1-w_1-c_1-m_1)}{t} \quad (5)$$

$$\pi = \pi_m + \pi_r \quad (6)$$

4 Numerical Simulation

The purpose of the numerical simulation is to analyze the influence of the parameters studied in this paper on the total profit of the supply chain under the equilibrium of the authority. The results can be displayed visually. Come to conclusion, then the influence on decision making in practice.

For a more detailed simulation, different symbols are assigned to the following values.

Table 3 Parameter numerical simulation table

Symbols	c_1	r	w_1	m_1	m_2	m_0	t	φ
Numerical Simulation	0	5	2	1	3	2	5	0.6

As shown in Figure 2, the manufacturer's profit is positively correlated with the change of parameter "r". When the value of "r" is between 10-12, the manufacturer's profit becomes positive for the first time. Retailer's profit is stable, and retailer has smaller risk. At the same time, retailer is more likely to make profits. The total profit is most affected by "r". In order to optimize the whole supply chain, manufacturers and retailers must coordinate to achieve the optimal profit.

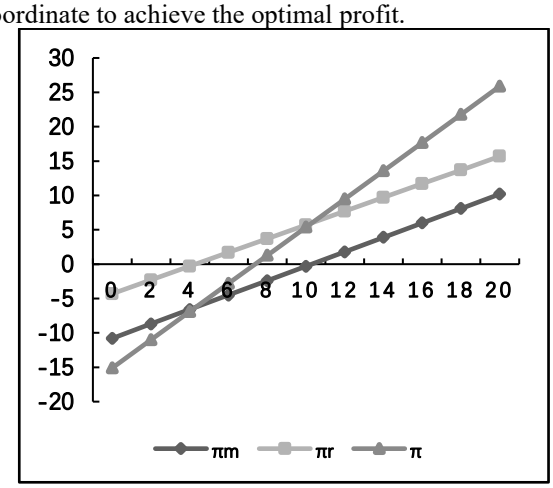

Figure 2 The change of profit influenced by parameter "r"

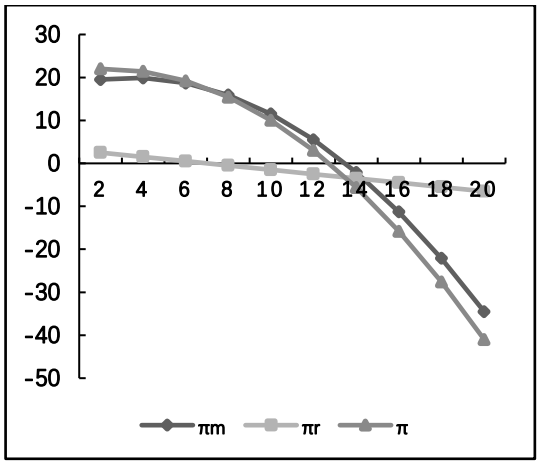

Figure 3 The change of profit influenced by parameter "w_1"

Figure 3 shows the profit change chart influenced by parameter "w_1". As can be seen from the figure, there is a negative correlation between profit and parameter. Manufacturer and retailer must strictly control the parameters to make the total profit positive.

Figure 4 shows the profit change chart influenced by parameter "φ". When the value tends to 0.5, the total profit and the manufacturer's profit tend to 0. Combined the definition of "φ", the greater the difference between product 1 and product 2 in probability products, the better. And when product 1 is more than product 2, there is more space for profit to rise.

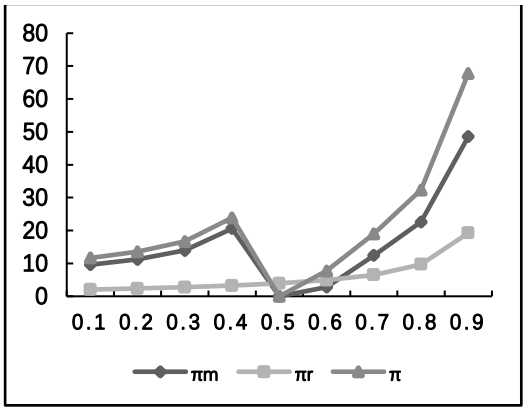

Figure 4 The change of profit influenced by parameter "φ"

5 Conclusion

Based on the theory of probabilistic products, this paper analyzes the factors that influence the total profit of the supply chain under the power equilibrium between manufacturer and retailer. The results show that the greater the difference between the two components of probabilistic products, the better for the members of the supply chain. The wholesale price of retailers will not only affect their own interests, but also have a great impact on the total profit. The combination of probability products needs to meet a certain proportion, otherwise it will damage the overall benefit. The analysis of these three factors provides a basis for the relevant problems of probability products in practice, it provides theoretical

guidance for the activities of enterprises. Enterprises can make decisions based on this research to promote the growth of benefits.

However, there are some limitations in this study, and other participants in the supply chain are not considered. Research after will improve these aspects and make them more practical.

Acknowledgment

This research is supported by National Natural Science Foundation of China under Grant 72001147 and Guangdong Planning Project of Philosophy and Social Science of China under Grant GD19YGL18.

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