

# ***Evaluation of Influencing Elements on Merchandise Pricing During Internet Celebrity Live Streams: A Game Theoretical Approach***

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**Abstract:** Live broadcasting with goods has become the mainstream form of product marketing, and the pricing problem in live broadcasting with goods has attracted attention. Based on the game model constructed by brand and online celebrity, this paper analyzes the influence of live broadcast with goods on product pricing factors. The model includes pure retail mode and adding live-stream mode. The optimal pricing of the two modes is discussed when the participants pursue the maximum profit and the factors influencing the optimal pricing are discussed. The results show: the factors that affect the pricing of products increase after adding live broadcast with goods, including the effort of the anchor, the fan conversion rate and the proportion of commission. Based on the conclusion of the study, the following suggestions are made: After adding live broadcast with goods, the brand should not be limited to the cost and demand of products when making pricing decisions; When selecting online media, the brand should consider both the effort of the anchor and the conversion rate of anchor fans; When negotiating the commission percentage with the brand, the anchors should properly measure their efforts.

**Keywords:** live broadcasting with goods, product pricing, game theory

## **1. Introduction**

With the development of the Internet economy, the form of live broadcasting with goods has gradually become the mainstream. According to business data, there were more than 4 million live broadcasts on e-commerce in the first quarter of 2020 alone. By June 2020, the number of live e-commerce users in China has exceeded 300 million [1]. With the help of professional e-commerce teams, the online celebrity anchors can quickly monetize the flow. Besides bringing a lot of revenue, they can also increase the sales of the agent products. In addition, consumers can also buy products at lower prices from the live broadcast room. Live broadcasting has therefore become the main form of marketing. The pricing of live broadcast goods is not only the focus of the game between the brand side and the online celebrity, but also the most concern of consumers. Therefore, the analysis of the influence of live broadcasting on product pricing has practical significance.

## 2. Literature review

On the behavior of live broadcasting with goods, scholars have studied from different angles. Huang Minxue et al. explored the influence of different types of anchors on consumers' purchase intention and behavior in live broadcasting from an empirical perspective[2]. Chen Yingxin et al., by constructing interaction and trust model, studied the intrinsic influence mechanism of online interaction on consumer trust[3]. From the theory of service scene, Zhang Meizhen probes into the influence of live broadcasting on consumer psychology and behavior[4]. Fei Zhou et al. studied the relationship between anchors' willingness to participate in live broadcasts and social distance on social media[5].

Regarding the pricing strategy in the live broadcast, Ma Hanwu et al. proposed two hybrid channel models, retail live broadcast and agent live broadcast, and analyzed the influence of the commission ratio between the live broadcaster and the platform and the price competition coefficient on the e-commerce supply chain[6]. Wang Qinpeng et al. analyzed the optimal decision and profit of supply chain on the basis of considering the function of drainage and pricing power[7]. Zhou Hantong[8], Wang Kai et al.[9], from the dual channel supply chain perspective, probed the price of live broadcast goods.

## 3. Problem Description and Research Assumptions

### 3.1. Problem description

This study aims to analyze how the integration of live-streaming affects product pricing strategies. To this end, the study establishes models for both traditional retail and the new live-streaming sales approach, referred to henceforth as the 'live-streaming mode'.

Most of the well-known brands have a complete set of production lines and sales channels. Therefore, this paper considers supplier and retailer as "brand". In the pure retail model, the brand sells the product directly to the customer at the price of the " $p_0$ ".

In the live-streaming mode, the brand sells to customers from retail channels at the price of " $p_1$ ", and sells to customers through the network anchors at the price of " $p_2$ ". Among them, the live broadcast with goods is only for the brand to sell products, and the actual delivery and after-sales service is carried out by the brand.

Different from other online sales platforms with dual channels, online celebrity anchors are influential groups. When promoting products for brands, they can increase product sales and convert some of their fans into product consumers. The sales volume of the brand is increased due to the following features: As the huge traffic of the online celebrity anchor drives the promotion of the product, the product will be displayed to the fans when the live broadcast carries the goods, so that the fans who have never paid attention to the product will be transformed into potential consumers. At the same time, different from the wholesale and retail mode, the net celebrity anchor profit distribution mode is based on pure commission and pit fee.

### 3.2. Research Assumptions

(1) Assume that all the participants in the model are rational and are pursuing their own maximum profit.

(2) Assume that the product market is a mature market, and the products of each channel are homogeneous. The unit cost of products manufactured by the brand party is " $c$ " and the market demand is " $a$ ".

(3) The effort of celebrity anchors carry goods for the manufacturer is  $\theta$  and the commission based on the percentage of incoming is  $\lambda$ .

(4) In general, brand parties also need to pay the pit fee when they entrust the anchors to promote their products. Set  $F$  as the pit fee. In the live broadcast industry, the pit fee is generally a flat price, which is similar to the deposit paid when an agreement is reached. To simplify the model, refer to Dan et al.'s assumption  $F=0$ [10].

Based on the above assumptions, establish the demand function:

Retail mode:

$$q_0 = a - p_0 \quad (1)$$

Live-streaming mode:

$$q_1 = (a + \theta\delta) - p_1 + \mu p_2 \quad (2)$$

$$q_2 = (a + \theta\delta) - p_2 + \mu p_1 \quad (3)$$

In the formula,  $\mu$  is the price competition coefficient, i.e. the influence of the sales price of competitors on the demand function[11] (set  $0 < \mu < 0.4$ )[12];  $\delta$  is the coefficient that the efforts of the celebrity anchors are converted into the potential market demand (hereinafter referred to as the fan conversion rate). The anchors usually have professional goods-carrying skills and personal charm. They can arouse the needs of fans through their own efforts and thus turn their products to consumers[13]. Generally speaking, the head of the anchor coefficient is higher, and the waist anchor and tail anchor coefficient is lower.

Establishing the profit function:

Retail mode:

$$\pi_0 = (p_0 - c)q_0 \quad (4)$$

Live-streaming mode:

$$\pi_1 = (p_1 - c)q_1 + (p_2 - c)q_2 - \lambda p_2 q_2 \quad (5)$$

$$\pi_2 = \lambda p_2 q_2 - \frac{\theta^2}{2} \quad (6)$$

In the formula,  $\lambda$  is the percentage of commission ( $0 < \lambda < 1$ );  $\theta$  is the effort level of the celebrity anchor.  $\frac{\theta^2}{2}$  is the quadratic function of the effort level of the anchor, which is used in many documents including Wei Jing et al.[14], He et al.[15].

## 4. Model solving and analysis

### 4.1. Model solving

Retail Mode: Derivation of Equation (4) and equal to 0 is obtained: when  $p_0^* = \frac{a+c}{2}$ , there is maximum profit.

Live-streaming mode: According to the principle of game theory, the conditions of maximizing the profit of both sides are:

$$\begin{cases} \frac{\partial \pi_1}{\partial p_1} = c + a + \theta\delta + (2 - \lambda)\mu p_2 - 2p_1 - c\mu = 0 \\ \frac{\partial \pi_2}{\partial p_2} = \lambda(a + \theta\delta) - 2\lambda p_2 + \mu\lambda p_1 = 0 \end{cases}$$

When the Nash Equilibrium is solved:

$$\begin{cases} p_1 = \frac{c+a+\theta\delta+(2-\lambda)\mu p_2-c\mu}{2} \\ p_2 = \frac{a+\theta\delta+\mu p_1}{2} \end{cases}$$

The optimal pricing for maximizing the profit of the brand and the network red anchor is as follows:

$$\begin{cases} p_1^* = \frac{c+a+\theta\delta+(2-\lambda)(a+\theta\delta)\mu-2\mu c}{2+(\lambda-2)\mu} \\ p_2^* = \frac{2(a+\theta\delta)+[(\lambda-1)(a+\theta\delta)+c]\mu+[(2-\lambda)(a+\theta\delta)-2c]\mu^2}{4+(2\lambda-4)\mu} \end{cases}$$

## 4.2. Equilibrium analysis

For the pure retail mode, the only factors affecting the optimal pricing are market demand and unit cost. The larger the market demand, the higher the unit cost, the higher the optimal pricing.

For the live-streaming mode, the market demand, unit cost, anchor effort, the fan conversion rate, and commission percentage shall be considered.

### 4.2.1. Market demand

$p_1^*, p_2^*$  take the derivations of  $a$  separately give:

$$\begin{cases} \frac{\partial p_1^*}{\partial a} = \frac{1+(2-\lambda)\mu}{2+(\lambda-2)\mu} \\ \frac{\partial p_2^*}{\partial a} = \frac{2+(\lambda-1)\mu+(2-\lambda)\mu^2}{4+(2\lambda-4)\mu} \end{cases}$$

The above formulas are always greater than zero when  $0 < \lambda < 1$ ,  $0 < \mu < 0.4$ , so  $p_1^*, p_2^*$  increase with the increase of market demand. This shows that the retail channel pricing and live-streaming goods pricing will both increase due to the increase in market demand, with other factors unchanged.

### 4.2.2. Unit cost

$p_1^*, p_2^*$  take the derivations of  $c$  separately give:

$$\begin{cases} \frac{\partial p_1^*}{\partial c} = \frac{1-2\mu}{2+(\lambda-2)\mu} \\ \frac{\partial p_2^*}{\partial c} = \frac{\mu-2\mu^2}{4+(2\lambda-4)\mu} \end{cases}$$

The above formulas are always greater than zero when  $0 < \lambda < 1$ ,  $0 < \mu < 0.4$ , so  $p_1^*, p_2^*$  all increase with the increase of unit cost. This shows that the retail channel pricing and live-streaming pricing increase due to the increase in unit costs, with other factors unchanged.

#### 4.2.3. Effort of the anchor

$p_1^*, p_2^*$  take the derivations of  $\theta$  separately give:

$$\begin{cases} \frac{\partial p_1^*}{\partial \theta} = \frac{\delta[1+(2-\lambda)\mu]}{2+(\lambda-2)\mu} \\ \frac{\partial p_2^*}{\partial \theta} = \frac{\delta[(2-\lambda)\mu^2+(\lambda-1)\mu+2]}{4+(2\lambda-4)\mu} \end{cases}$$

The above formulas are always greater than zero when  $0 < \lambda < 1$ ,  $0 < \mu < 0.4$ , so  $p_1^*, p_2^*$  all increase with the increase of the anchor effort. This shows that the retail channel pricing and live broadcast with the goods pricing increase due to the increase of the effort of the broadcaster.

#### 4.2.4. The fan conversion rate

$p_1^*, p_2^*$  take the derivations of  $\delta$  separately give:

$$\begin{cases} \frac{\partial p_1^*}{\partial \delta} = \frac{\theta[1+(2-\lambda)\mu]}{2+(\lambda-2)\mu} \\ \frac{\partial p_2^*}{\partial \delta} = \frac{\theta[(2-\lambda)\mu^2+(\lambda-1)\mu+2]}{4+(2\lambda-4)\mu} \end{cases}$$

The above formulas are always greater than zero when  $0 < \lambda < 1$ ,  $0 < \mu < 0.4$ , so  $p_1^*, p_2^*$  all increase with the increase of conversion rate. This shows that the higher the conversion rate is, the higher the pricing of retail channels and live broadcast channels will be. This also means that the higher the influence of the broadcaster will be the higher the optimal pricing.

That is, When the conversion rate of the popular anchors is low, the celebrity anchors do not promote the products and cannot attract fan traffic, so that the pricing of the live broadcast channel is low, while the retail channel will lower the pricing accordingly. When the conversion rate of the popular anchors is high, the celebrity anchors play a huge role in promoting and draining the products. The offline channels observe the increase of potential market demand and raise the price..

#### 4.2.5. Commission percentage

$p_1^*, p_2^*$  take the derivations of  $\lambda$  separately give:

$$\begin{cases} \frac{\partial p_1^*}{\partial \lambda} = \frac{\mu[2\mu c - 3(a + \theta\delta) - c]}{[2+(\lambda-2)\mu]^2} \\ \frac{\partial p_2^*}{\partial \lambda} = \frac{\mu^2[2\mu c + c - 3(a + \theta\delta)]}{2[2+(\lambda-2)\mu]^2} \end{cases}$$

When  $0 < \theta < \frac{2\mu c - c - 3a}{3\delta}$ , with the commission percentage increases,  $p_1^*$  and  $p_2^*$  both increases.

When  $\frac{2\mu c - c - 3a}{3\delta} < \theta < \frac{2\mu c + c - 3a}{3\delta}$ , with the commission percentage increases,  $p_1^*$  decreases and  $p_2^*$  increases.

When  $\theta > \frac{2\mu c + c - 3a}{3\delta}$ , with the commission percentage increases,  $p_1^*$  and  $p_2^*$  both decreases.

That is, when the effort of the anchor is less than  $\frac{2\mu c - c - 3a}{3\delta}$ , the pricing of retail channels and the pricing of live broadcast will increase with the increase of commission percentage. This is because the increase of commission proportion will bring more cost to the brand than the profit from the increase of sales volume. Therefore, the only way to recover the lost profit is to raise the market price.

When the effort of the anchor is greater than  $\frac{2\mu c - c - 3a}{3\delta}$  and less than  $\frac{2\mu c + c - 3a}{3\delta}$ , the pricing of retail channels decreases with the increase of the commission percentage, and the pricing of live broadcasts increases with the increase of the commission percentage. At this time, the cost caused by the increase of the commission proportion is already smaller than the profit brought by the increase of the sales volume for the brand. The brand does not need to raise the price to recover the loss but is not willing to pay for the higher and higher commission. The only way to make up the effort cost of the anchor is to raise the price of the live broadcast with the goods. Therefore, the retail price dropped, and the price of live broadcast goods increased; When the effort of the anchor is greater than  $\frac{2\mu c + c - 3a}{3\delta}$ , the pricing of retail channels and the pricing of live broadcasts will decrease with the increase of commission percentage. At this point, the anchor makes enough efforts to make the brand side of the revenue enough, so the brand side is willing to reduce the price at the same time is also willing to pay higher and higher commission to the anchor, so the prices of both channels are down.

## 5. Conclusions and recommendations

This paper constructs the game model between the celebrity anchor and the brand, and compares the differences between the pure retail mode and the live-streaming mode, and draws the following conclusions:

- ① In both the pure retail mode and the live-streaming mode, the increase in market demand and unit cost will lead to an increase in product pricing. This is determined by the supply and demand theory of the market and will not be different with the change of sales model.
- ② Compared with the pure retail mode, the factors that affect the pricing of products in the live-streaming mode are increased. The increase of the fan conversion rate and the effort of the anchor will increase the pricing of both channels in the live-streaming mode.
- ③ The influence of commission percentage on product pricing depends on the efforts of the anchor: When the effort of the anchor is less than  $\frac{2\mu c - c - 3a}{3\delta}$ , the pricing of retail channels and the pricing of live broadcasts will increase with the increase of commission percentage. When the effort of the anchor is greater than  $\frac{2\mu c - c - 3a}{3\delta}$  or less than  $\frac{2\mu c + c - 3a}{3\delta}$ , the pricing of the retail channel decreases with the increase of the commission percentage, the pricing of the live channel increases with the increase of the commission percentage. When the effort of the anchor is greater than  $\frac{2\mu c + c - 3a}{3\delta}$ , the pricing of the retail channel and the live channel increases with the increase of the commission percentage.

Based on the above conclusions, this paper suggests:

- ① After adding the live broadcast with goods, the brand should not be limited to the cost and demand of the product when making pricing decisions.
- ② When choosing cooperative online celebrity anchors, the brand should both consider the effort level of the anchor and the conversion rate of the anchor fans. For anchors with high fan conversion rate (such as celebrity with ten millions of fans), the brand can reduce the requirements for the anchors themselves; For anchors with low fan conversion rate, in order to maximize profits, the brand should strengthen supervision and requirements on anchors to improve their efforts, such as requirements on the time or duration of product live broadcast and requirements on product introduction scripts.
- ③ When negotiating the commission proportion with the brand, the celebrity anchor should reasonably measure their own efforts to avoid the situation that the brand is unwilling to cooperate due to the mismatch between the commission proportion and the effort level.

The disadvantage of this paper is that it does not consider the influence of other factors such as consumer preference and pricing power on the game results and does not carry out further numerical analysis. In future research, we can consider adding the decision of consumers to form a three-way

game, and also add other variables such as different brands and different quality products. Therefore, this study has some limitations, and the research may not be comprehensive and perfect enough.

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