



Article

# The Adoption and Openness of Livestreaming on the Retail Platform with Third-Party Sellers

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**Abstract:** Observing the fast development of livestreaming, this paper investigates its adoption on the retail platform and examines its impact on merchants. We develop a game-theoretic model in which a leading retailer and a third-party seller engage in price competition. Our model fully considers the initiative of live streamers in this asymmetric competition. We find that the streamer's cost and the seller's initial awareness are two key factors affecting the adoption of livestreaming. Specifically, when the streamer's cost is low, or it is intermediate and the seller's initial awareness is high, the retailer adopts and opens livestreaming and the seller also adopts it; when both factors are intermediate, the retailer adopts livestreaming but does not open it to the seller; when both factors are high, the retailer adopts and opens livestreaming but the seller does not adopt it; otherwise, the retailer does not adopt livestreaming. Our results also suggest that the presence of livestreaming benefits the retailer but may hurt the seller especially when the seller's initial awareness is high. Our findings provide relevant and useful implications for both the platform retailer and third-party seller in their livestreaming decisions.

**Keywords:** e-commerce; livestreaming; retail platform; competition



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## 1. Introduction

Livestreaming, the latest trend in e-commerce, has found spectacular success in the recent years. In China, livestreaming is estimated to generate \$480 billion and account for 16.5% of total retail e-commerce sales in 2022 [1]. It is first launched by live streamers on social media channels but has also been broadly adopted by retailers as a daily selling strategy [2]. According to the Taobao Live 2021 Annual Report, they provided more than 100,000 livestreams in 1 year, with average daily views of over 500,000 h. Each time consumers enter the home page or open a product page on Taobao, they can see a conspicuous banner or tag labeling *Livestreaming*. This new selling strategy transforms e-commerce by allowing consumers to watch and shop at the same time, thus offering retailers a new way to inform and entertain consumers via real-time interactions [3]. Through livestreaming, retailers can not only access new consumers but they can also enhance consumer shopping experience and influence consumer attitudes toward the retailers or their products. In this process, live streamers play a critical role and control the performance of the livestream [4]. They combine shopping with audience participation by using the chat and like functions. This entertains the consumers and encourages them to perceive extra value in livestream shopping, including real-time communication, enjoyment, the sense of belonging, etc., [5,6].

With the development of livestreaming, some platform retailers (e.g., Amazon and JD.com) have been observed to adopt this new selling strategy on their retail platforms. The retail platform acts as both a platform retailer and a marketplace which permits third-party sellers to sell products. By adopting livestreaming, the platform retailer can gather a lot of

streamers around the platform and cooperate with them to promote sales. In addition, some of the platform retailers further open livestreaming to third-party sellers on their platforms. Thus, third-party sellers can also choose to adopt livestreaming and cooperate with live streamers on the platforms. For example, JD.com starts JD Live in 2017 and allows its third-party sellers to participate. Dyson, Sephora, and many other third-party sellers on JD.com adopt livestreaming through JD Live. Conceivably, firms adopt livestreaming because it can help to increase sales. However, the performance of livestreaming totally depends on the streamers. Whether the additional profits from livestreaming can compensate for the livestreaming fee charged by the streamer remains unclear. In addition, the platform retailer and the third-party seller are competitors on the retail platform and as the platform owner, the retailer usually has a competitive advantage because it is more well-known and trusted by consumers than the seller. It seems that the use of livestreaming by the third-party seller could reduce the retailer's competitive advantage. Thus, the reasons and trade-offs of the platform retailer opening livestreaming to the third-party seller are not obvious.

In light of this, we aim to examine the rationale for the adoption and openness of livestreaming on the retail platform and answer the following questions. First, under what conditions does the platform retailer adopt livestreaming and open it to the third-party seller? Second, under what conditions does third-party seller on the retail platform adopt livestreaming? Third, how does livestreaming affect the profits in the competition between the retailer and third-party seller?

To answer these questions and better understand the emergence of livestreaming on the retail platform, we develop a game-theoretic model to analyze the competition between a leading retailer and a relatively small third-party seller. The leading retailer has both an awareness advantage and a valuation advantage over the small seller. The awareness advantage means that the retailer is known by more consumers than the seller since the retailer usually has a much more popular brand. The valuation advantage comes from the reputation and customer services of retailer being much better. The retailer strategically decides whether to adopt and then whether to open livestreaming. If livestreaming is open, the seller then decides whether to adopt livestreaming. In this study, we also fully consider the initiative of live streamers when modeling the effects of livestreaming.

We characterize the conditions under which the retailer adopts and opens livestreaming and those under which the seller adopts livestreaming. We find that it is the seller's initial awareness and the livestreaming cost coefficient that matters. First, the seller will adopt livestreaming when its initial awareness is low or relatively high. As the initial awareness of the seller increases, the incentive of the seller to adopt livestreaming decreases when the initial awareness is low and increases when the initial awareness is high. Second, when the livestreaming cost coefficient is low, the retailer always opens livestreaming for the seller, regardless of the seller's initial awareness. When the livestreaming cost coefficient is intermediate or high, the retailer only opens livestreaming when the seller's initial awareness is high. Lastly, the retailer adopts livestreaming when the livestreaming cost coefficient is relatively low or the seller's initial awareness is high. Our research contributes to the literature in the area of livestreaming. Limited prior research in livestreaming examines factors that determine the conditions under which livestreaming is profitable. However, the factors in different market environments have not been fully discussed. Our paper fills the gap and focuses on the livestreaming choice in a setting of asymmetric competition on the retail platform.

Furthermore, we analyze the effects of livestreaming on the prices and profits of the retailer and the seller. The results show that the emergence of livestreaming always (weakly) benefits the retailer. However, for the third-party seller, although livestreaming offers the seller a chance to promote sales, it does not necessarily benefit the seller, especially when the seller's initial awareness is high. The case in which livestreaming hurts the seller emerges both when livestreaming is only adopted by the retailer and when livestreaming is adopted by the retailer and the seller. Our study contributes to the extant literature

on platform business. One important part of this research area is about platform models including the wholesale model, agency model, and hybrid model. Our research enriches the hybrid platform research by introducing livestreaming strategy into the platform and examining its impact on the platform members.

The rest of this paper is organized as follows. The next section summarizes the relevant research. Then, we present the model and consider three scenarios. Following this, we analyze the equilibrium outcomes and present the conditions for the choices of the retailer and the seller. We further examine the effects of livestreaming on the profits of the retailer and the seller. Lastly, we conclude this research with a discussion on managerial implications.

## 2. Related Literature

Our study is mainly related to two research areas: livestreaming and retail platform business models.

The first related research area involves livestreaming. Livestreaming enables consumers to watch and purchase online at the same time and thus creates a new shopping environment. A large body of research in online retailing and e-commerce has focused on the characteristics of livestreaming and the motivation of consumers to participate [7,8]. Social interaction with related attributes is stressed as an important factor in motivating consumers' engagement in livestream shopping [9–12]. For example, Hu and Chaudhry [10] empirically demonstrated that social, structural, and financial bonds have direct or indirect effects on consumer engagement in livestream shopping via affective commitment. Trust transfer and enhancement are also verified in affecting the consumers' livestream shopping intention [13–15]. Other affecting factors include reductions in consumers' psychological distance [16], reductions in consumer perceived uncertainties [17], the substitutability of personal examination [18], as well as product factors, such as product-source fit and product-content fit [19].

Other papers have studied the adoption and effects of livestreaming [20–23]. Several factors have been identified to examine the conditions under which livestreaming is profitable, including live streamer characteristics and consumer sophistication in quality perception [20], the live streamer's ability to sell, consumers' preference value, and consumers' costs [22]. Some researchers have focused on the interactions between livestreaming and other strategies. For example, Zhang et al. [24] examined the effects of livestreaming adoption on the optimal online channel structures of multinational firms. Based on the motivations for and advantages of livestreaming, we further focus on the perspective of retail platforms to study the adoption of livestreaming. We enrich this research area by investigating the role of livestreaming in a market consisting of a leading platform retailer and a small third-party seller. The main difference between our research and other analytical models is that we focus on the interaction between livestreaming and asymmetric competition on the retail platform and we fully consider the initiative of live streamers in modeling the effects of livestreaming.

The second related research area is about platform business models. Some researchers [25,26] have compared two strategies for market intermediation, the traditional wholesale model in which retailers act as intermediaries by reselling, and the new agency model in which sellers sell directly to buyers via a platform. The agency model arises with the retail platform getting more and more powerful in the e-commerce era. It charges the manufacturers a fraction of the revenue for allowing them to sell directly to the buyers on the platform [27–29]. Wei et al. [30] considered the roles of suppliers' channel and illustrated their preference toward the platform business model. Chen et al. [31] indicated that the intensity of fairness concerns and platform fees affect the platform's optimal business model choice. The other factors that affect the platform's business model choice include marketing activity information [32], third-party information [33], order-fulfillment costs, upstream competition intensity [34], product distribution costs, unit retail prices, and competition conflicts [35].

With the development of retail platform business models, there has been a lot of research into the openness of hybrid platforms, which emerge when platforms operate both wholesale model and agency model. For example, some researchers have studied why retailers open their platforms to third-party sellers [36–38]. Song et al. [39] indicated that the spillover effect plays a critical role in the openness of retail platform and the selling strategies of third-party sellers. Chen and Guo [40] found that low-cost advertising through new media is crucial in driving leading retailers to open their platforms and form partnerships with third-party sellers. Following the previous research, we enrich the hybrid platform e-commerce research area by investigating the hybrid platform's choice in introducing livestreaming and opening it to the third-party seller. Different from previous studies, we focus on the emerging livestreaming strategies on hybrid retail platforms and analyze their effects on the profits of the retailers and the sellers.

### 3. Model

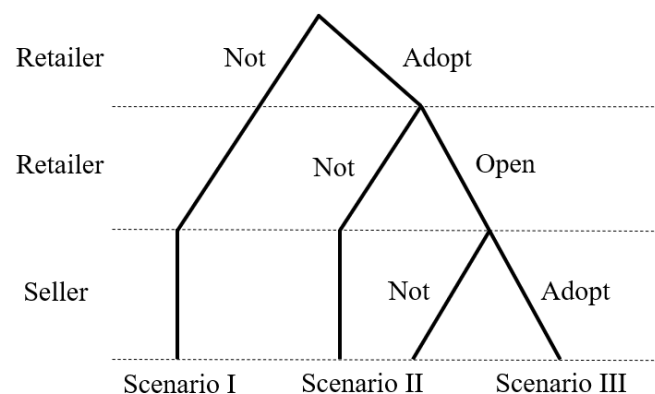
We consider a market comprising a platform retailer and a third-party seller who also sells on the platform. Both of them sell an identical product on the platform and the retailer charges the seller a commission rate  $\theta$  for each unit sale on its platform. Compared with the seller, the retailer has both an awareness advantage and a valuation advantage. The awareness advantage comes from its well-known brand, which results in more consumer awareness than the small seller. The valuation advantage comes from the reputation of the retailer, including good customer services, return policy, etc.

A continuum of consumers with unit mass is in the market and each of them has a unit demand for the product. They only purchase from a firm when they are aware of the firm. When they are aware of both the retailer and the seller, they purchase from the firm with the higher utility. Because of the retailer's awareness advantage, all consumers are aware of the retailer whereas initially, only a proportion  $\alpha$  of consumers are aware of the seller, where  $\alpha \in (0, 1)$ . We use  $v$  to denote the highest value that consumers can get when they purchase the product. Regarding the valuation advantage, consumers derive the highest value  $v$  when purchasing from the retailer. When they purchase from the seller, the valuation they derive is discounted since the seller's return policy, customer service, etc., are not as good as the retailer, and this consumers' perceived valuation discount differs. Let  $\delta$  denote this valuation discount, then consumers derive  $\delta v$  when purchasing from the seller, where  $\delta$  is uniformly distributed over  $[0, 1]$  across all consumers. This is used to depict the vertical differentiation of the product offerings from the retailer and the seller and capture the essential idea when everything else is equal, consumers prefer to purchase high-quality products over low-quality products [39,40]. Without loss of generality, we normalize  $v$  to 1 and the marginal costs of selling the product to 0.

If the retailer adopts livestreaming, it cooperates with live streamers to serve its consumers on the platform. If the retailer then further opens livestreaming to the third-party seller, the seller can also engage with live streamers to enhance sales. Live streamers charge a commission rate  $r$  for each sale and help to increase consumer awareness through product exposure and increase consumer perceived utility by streaming. When the seller adopts livestreaming by cooperating with the streamer, the consumers who are aware of the streamer become aware of the seller. We assume that the awareness of the streamer is 1 and thus for the seller, livestreaming increases its awareness from  $\alpha$  to 1 and increases its consumer utility by  $e_s$ . For the retailer, since it is already known by all consumers, livestreaming increases consumer utility by  $e_r$ . The variable  $e$  measures the live streamers' livestreaming effort and is decided by the live streamers considering their livestreaming costs  $ce^2$ . This consumer-perceived utility increase does not involve product quality or customer service but rather comes from the entertainment that is provided by livestreaming, for example, real-time communication and enjoyment [5,6]. This entertainment value is determined by the live streamers' effort, including the introduction and trial of the product, the strength of interaction, etc. We use  $c$  to denote the cost coefficient of the live streamers on the platform. The streamers trade off their payoff and the effort required in the

livestream. To reflect the fact that engaging in livestreaming can increase consumer utility, we assume that all consumers watch livestreaming and make their purchase decisions during livestreaming events, as long as the retailer or the seller adopts livestreaming.

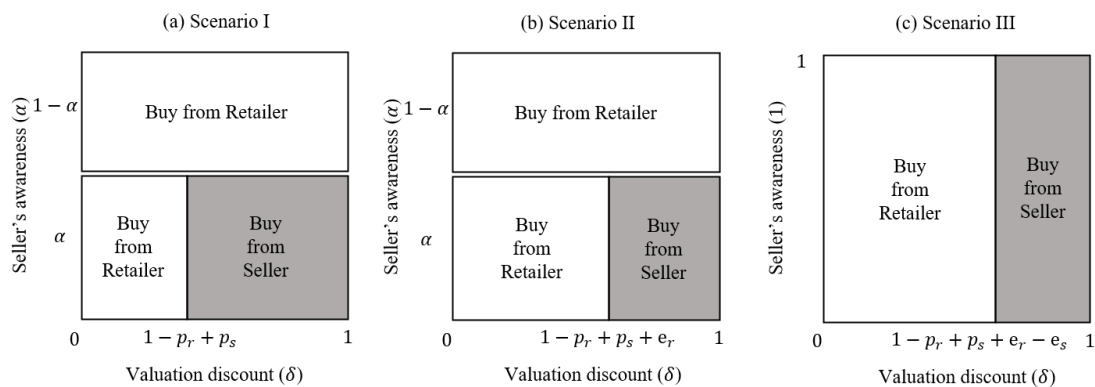
Figure 1 illustrates the decision processes of the retailer and the seller. The retailer first chooses whether to adopt livestreaming on the platform. If it does, it then decides whether to open livestreaming to the third-party seller. When livestreaming is open, the seller chooses whether to adopt livestreaming or not. After these livestreaming decisions have been made, both firms set their prices  $p_r$  and  $p_s$ , followed by the live streamers determine their livestreaming effort  $e_r$  and  $e_s$  if livestreaming is adopted. Lastly, the consumers make their purchase decisions. We also rule out the scenario in which the third-party seller adopts livestreaming outside the platform (e.g., through cooperation with TikTok). If the seller chooses to livestream from outside the platform, it is always better for them to directly process orders themselves during the livestreaming event to avoid the platform commission. That way business is conducted outside the platform and does not affect competition within the platform. Additionally, in practice, livestream platforms (e.g., TikTok) forbid sellers from livestreaming their goods on retail platforms (e.g., Taobao and JD.com) and ask sellers to instead open stores on their livestream platforms. This involves another research question about the competition between retail platforms and livestream platforms, which we do not consider in this study.



**Figure 1.** Decision tree of the retailer and the seller.

In practice, sellers can keep the majority of their sales revenue. To reflect this, we assume that both the commission rate of the retail platform and the commission rate of the live streamer are less than half, i.e.,  $\theta < 1/2$  and  $r < 1/2$ , respectively. We further assume that  $c > \frac{r(3-3r-\theta)}{4-4r-2\theta}$ , which represents the rationality constraint of the live streamers to keep their services for the firms.

We consider three scenarios in this study: the case without livestreaming (Scenario I); the case in which only the retailer adopts livestreaming (Scenario II); the case in which both the retailer and the seller adopt livestreaming (Scenario III). Note that Scenario II represents two cases in Figure 2: the case in which the retailer adopts livestreaming but does not open livestreaming to the seller and the case in which the retailer adopts livestreaming and opens it to the seller but the seller does not adopt livestreaming. Since the outcomes of these two cases are the same, we use Scenario II to represent both cases and analyze them separately afterward.



**Figure 2.** Market segmentation in the different scenarios.

The main notations used in this paper are summarized in Table 1.

**Table 1.** Summary of notations.

Notation	Definition and Comments
$\theta$	Retail platform's commission rate
$r$	Live streamer's commission rate
$\alpha$	Seller's initial awareness
$v$	Product valuation (which is normalized to 1)
$\delta$	Valuation discount when consumers purchase from the seller
$c$	Livestreaming cost coefficient of the streamers
$e_r$	Consumer's utility increase brought by the streamer's livestreaming for the retailer
$e_s$	Consumer's utility increase brought by the streamer's livestreaming for the seller
$p_r$	Product price of the retailer
$p_s$	Product price of the seller
$D_r$	Demand for the product from the retailer
$D_s$	Demand for the product from the seller
$\pi_r$	Retailer's profit without livestreaming
$\hat{\pi}_r$	Retailer's profit when only the retailer adopts livestreaming
$\tilde{\pi}_r$	Retailer's profit when both the retailer and the seller adopt livestreaming
$\pi_s$	Seller's profit without livestreaming
$\hat{\pi}_s$	Seller's profit when only the retailer adopts livestreaming
$\tilde{\pi}_s$	Seller's profit when both the retailer and the seller adopt livestreaming
$\hat{\pi}_{lr}$	Live streamer's profit in cooperation with the retailer when only the retailer adopts livestreaming
$\tilde{\pi}_{lr}$	Live streamer's profit in cooperation with the retailer when both the retailer and the seller adopt livestreaming
$\tilde{\pi}_{ls}$	Live streamer's profit in cooperation with the seller when both the retailer and the seller adopt livestreaming

#### 4. Equilibrium Analysis

We first examine the livestreaming effort and pricing competition in the subgames and present the equilibrium outcomes of the three scenarios. Then, we examine the equilibrium outcomes of the livestreaming and openness decisions in the early stages and sequentially identify the conditions for the seller's adoption of livestreaming, the retailer's livestreaming openness, and the retailer's adoption of livestreaming.

##### 4.1. Livestreaming Effort and Pricing Competition

We use backward induction to obtain the equilibrium outcomes of the three scenarios. For ease of exposition, we use  $\pi_r$  and  $\pi_s$  as the profits of the retailer and the seller in Scenario I (without livestreaming), respectively;  $\hat{\pi}_r$ ,  $\hat{\pi}_s$ , and  $\hat{\pi}_{lr}$  are used as the profits of the retailer, the seller and the live streamer who cooperate with the retailer in Scenario II (when only the retailer adopts livestreaming);  $\tilde{\pi}_r$ ,  $\tilde{\pi}_s$ ,  $\tilde{\pi}_{lr}$ , and  $\tilde{\pi}_{ls}$  are used as the profits of the retailer, the seller and the live streamers who cooperate with the retailer and the seller in Scenario III (when both the retailer and the seller adopt livestreaming).



#### 4.1.1. Scenario I: Without Livestreaming

Without livestreaming,  $(1 - \alpha)$  consumers are only aware of the retailer and purchase products from it. For the other  $\alpha$  consumers who are aware of both the retailer and the seller, they obtain a value of  $1 - p_r$  when purchasing from the retailer and a value of  $\delta - p_s$  when purchasing from the seller. When  $1 - p_r \geq \delta - p_s$ , which is  $\delta \leq 1 - p_r + p_s$ , the consumers purchase from the retailer and the others purchase from the seller. Figure 2a illustrates the market segmentation in this scenario. We obtain the demands of both the retailer and the seller as follows:

$$\begin{aligned} D_r &= (1 - \alpha) + \alpha(1 - p_r + p_s) \\ D_s &= \alpha(p_r - p_s) \end{aligned} \quad (1)$$

Therefore, the profit functions of the retailer and the seller are as follows:

$$\begin{aligned} \pi_r &= p_r D_r + \theta p_s D_s \\ \pi_s &= (1 - \theta) p_s D_s \end{aligned} \quad (2)$$

We can then obtain the equilibrium prices and profits in Lemma 1 by optimizing both the prices of the retailer and the seller and maximizing their profits.

**Lemma 1.** *Without livestreaming, the equilibrium prices are*

$$\begin{aligned} p_r^* &= \begin{cases} \frac{2}{\alpha(3-\theta)} & \text{if } \alpha > \frac{2}{3-\theta} \\ 1 & \text{otherwise} \end{cases} \\ p_s^* &= \begin{cases} \frac{1}{\alpha(3-\theta)} & \text{if } \alpha > \frac{2}{3-\theta} \\ \frac{1}{2} & \text{otherwise} \end{cases}, \end{aligned} \quad (3)$$

and the equilibrium profits are

$$\begin{aligned} \pi_r^* &= \begin{cases} \frac{4-\theta}{\alpha(3-\theta)^2} & \text{if } \alpha > \frac{2}{3-\theta} \\ 1 - \frac{\alpha(2-\theta)}{4} & \text{otherwise} \end{cases} \\ \pi_s^* &= \begin{cases} \frac{1-\theta}{\alpha(3-\theta)^2} & \text{if } \alpha > \frac{2}{3-\theta} \\ \frac{\alpha(1-\theta)}{4} & \text{otherwise} \end{cases}. \end{aligned} \quad (4)$$

All proofs are in Appendix A.

The retailer remains in a leading position in the competition with the seller because of both its awareness and product valuation advantages. Thus, we obtain  $p_r^* > p_s^*$  in equilibrium. When the awareness advantage is significant (i.e.,  $\alpha \leq \frac{2}{3-\theta}$ ), the retailer focuses on its exclusive  $(1 - \alpha)$  consumers and forgoes the competition with the seller as it could maximize its profit by simply charging a monopoly price (i.e.,  $p_r^* = 1$ ). In this situation, it is intuitive that when the awareness of the seller  $\alpha$  increases, the profit of the retailer decreases (i.e.,  $\frac{\partial \pi_r^*}{\partial \alpha} < 0$ ) and the profit of the seller increases (i.e.,  $\frac{\partial \pi_s^*}{\partial \alpha} > 0$ ). In contrast, when the retailer does not have a significant awareness (i.e.,  $\alpha > \frac{2}{3-\theta}$ ), the competitive  $\alpha$  consumers become unneglectable and the retailer competes aggressively with the seller by setting the price at less than 1. The higher the  $\alpha$  value, the more intense the competition. Both the prices of the retailer and the seller decrease with  $\alpha$  (i.e.,  $\frac{\partial p_r^*}{\partial \alpha} < 0$  and  $\frac{\partial p_s^*}{\partial \alpha} < 0$ ). In this situation, the profit of the retailer still decreases with the increase in  $\alpha$  (i.e.,  $\frac{\partial \pi_r^*}{\partial \alpha} < 0$ ); however, the profit of the seller also decreases with the increase in  $\alpha$  (i.e.,  $\frac{\partial \pi_s^*}{\partial \alpha} < 0$ ). The reason for this is that the seller's loss from the intense competition is greater than the benefit brought by the higher awareness.

#### 4.1.2. Scenario II: When Only the Retailer Adopts Livestreaming

When only the retailer adopts livestreaming, the retailer pays a charge rate  $r$  to the live streamer for each sale. The live streamer then decides the optimal livestreaming effort  $e_r$  as the increase in consumer utility. The retailer's awareness advantage remains and  $(1 - \alpha)$  consumers only purchase from the retailer. The rest  $\alpha$  consumers get  $1 - p_r + e_r$  when purchasing from the retailer and  $\delta - p_s$  when purchasing from the seller. Among these consumers, the ones with  $1 - p_r + e_r \geq \delta - p_s$ , which is  $\delta \leq 1 - p_r + p_s + e_r$ , purchase from the retailer. As illustrated in Figure 2b, the demands of the retailer and the seller are derived as follows:

$$\begin{aligned} \hat{D}_r &= (1 - \alpha) + \alpha(1 - p_r + p_s + e_r) \\ \hat{D}_s &= \alpha(p_r - p_s - e_r) \end{aligned} \quad (5)$$

The profits of the retailer and the seller are then derived as follows:

$$\begin{aligned} \hat{\pi}_r &= (1 - r)p_r \hat{D}_r + \theta p_s \hat{D}_s \\ \hat{\pi}_s &= (1 - \theta)p_s \hat{D}_s \\ \hat{\pi}_{lr} &= rp_r \hat{D}_r - ce_r^2 \end{aligned} \quad (6)$$

In this case, we start with the live streamer optimizing its livestreaming effort and obtain its best response function  $\hat{e}_r^* = \frac{r\alpha}{2c}p_r$ . Then, the retailer and the seller optimize their prices by substituting the response function into the profits function. We can then summarize the equilibrium in this case as shown in Lemma 2.

**Lemma 2.** When only the retailer adopts livestreaming, the equilibrium prices and livestreaming effort are

$$\begin{aligned} \hat{p}_r^* &= \begin{cases} \frac{8c^2(1-r)}{\alpha(2c-r\alpha)[r\alpha\theta+2c(3-3r-\theta)]} & \text{if } \alpha > \alpha_0 \\ \frac{2c}{2c-r\alpha} & \text{otherwise} \end{cases} \\ \hat{p}_s^* &= \begin{cases} \frac{2c(1-r)}{\alpha[r\alpha\theta+2c(3-3r-\theta)]} & \text{if } \alpha > \alpha_0 \\ \frac{1}{2} & \text{otherwise} \end{cases} \\ \hat{e}_r^* &= \begin{cases} \frac{4cr(1-r)}{(2c-r\alpha)[r\alpha\theta+2c(3-3r-\theta)]} & \text{if } \alpha > \alpha_0 \\ \frac{r\alpha}{2c-r\alpha} & \text{otherwise} \end{cases}, \end{aligned} \quad (7)$$

and the equilibrium profits are

$$\begin{aligned} \hat{\pi}_r^* &= \begin{cases} \frac{4c^2(1-r)^2[r\alpha\theta+2c(4-4r-\theta)]}{\alpha(2c-r\alpha)[r\alpha\theta+2c(3-3r-\theta)]^2} & \text{if } \alpha > \alpha_0 \\ \frac{4c(2-\alpha)(1-r)+\alpha\theta(2c-r\alpha)}{4(2c-r\alpha)} & \text{otherwise} \end{cases} \\ \hat{\pi}_s^* &= \begin{cases} \frac{4c^2(1-r)^2(1-\theta)}{\alpha[r\alpha\theta+2c(3-3r-\theta)]^2} & \text{if } \alpha > \alpha_0 \\ \frac{\alpha(1-\theta)}{4} & \text{otherwise} \end{cases} \\ \hat{\pi}_{lr}^* &= \begin{cases} \frac{8c^2r(1-r)[4c^2(2-2r-\theta)-r^2\alpha^2\theta-2cra(3-3r-2\theta)]}{\alpha(2c-r\alpha)^2[r\alpha\theta+2c(3-3r-\theta)]^2} & \text{if } \alpha > \alpha_0 \\ \frac{2cra(2c-r\alpha-\alpha c)}{(2c-r\alpha)^2} & \text{otherwise} \end{cases}, \end{aligned} \quad (8)$$

$$\text{where } \alpha_0 = \frac{\sqrt{4cr(1-r)\theta+c^2(3-3r-\theta)^2}-c(3-3r-\theta)}{r\theta}.$$

Again, the awareness advantage of the retailer remains and the valuation advantage increases when only the retailer adopts livestreaming. Similar to Scenario I, when the retailer's awareness advantage is significant (i.e.,  $\alpha \leq \alpha_0$ ), the retailer sets a monopoly price in this equilibrium. In this situation, with the help of livestreaming, the maximum perceived consumer utility when purchasing from the retailer becomes  $1 + e_r$ . Thus, the monopoly price becomes  $\hat{p}_r^* = \frac{2c}{2c-r\alpha}$  in this equilibrium. The change in the seller's profit is the same as that in Scenario I and it increases with the initial awareness  $\alpha$  when  $\alpha$  is small (i.e.,  $\frac{\partial \hat{\pi}_s^*}{\partial \alpha} > 0$  when  $\alpha \leq \alpha_0$ ) and decreases with  $\alpha$  otherwise (i.e.,  $\frac{\partial \hat{\pi}_s^*}{\partial \alpha} < 0$  when  $\alpha > \alpha_0$ ).



Intuitively, the consumer utility increase brought by livestreaming in the equilibrium decreases with  $c$  (i.e.,  $\frac{\partial \hat{e}_r^*}{\partial c} < 0$ ) because  $c$  measures the cost coefficient of livestreaming. Therefore, the profit of the retailer decreases with  $c$  (i.e.,  $\frac{\partial \hat{\pi}_r^*}{\partial c} < 0$ ). The profit of the seller increases with  $c$  when  $\alpha > \alpha_0$  (i.e.,  $\frac{\partial \hat{\pi}_s^*|_{\alpha > \alpha_0}}{\partial c} < 0$ ) and does not change with  $c$  when  $\alpha \leq \alpha_0$  (i.e.,  $\frac{\partial \hat{\pi}_s^*|_{\alpha \leq \alpha_0}}{\partial c} = 0$ ). This is because when  $\alpha \leq \alpha_0$ , the retailer forgoes the competition with the seller and the seller's price and profit would not be affected by the retailer's adoption of livestreaming.

#### 4.1.3. Scenario III: When Both the Retailer and the Seller Adopt Livestreaming

If the retailer adopts livestreaming and also opens livestreaming to the seller, the case in which both adopt livestreaming could arise. In this case, the benefits for the retailer include a consumer utility increase of  $e_r$  while the benefits for the seller include both a consumer utility increase of  $e_s$  and a consumer awareness increase from  $\alpha$  to 1. Both the retailer and the seller pay a rate  $r$  for each of their sales to their cooperative live streamers and the live streamers choose the optimal best livestreaming effort  $e_r$  and  $e_s$ . All consumers are aware of both the retailer and the seller and they purchase from the retailer when  $1 - p_r + e_r \geq \delta - p_s + e_s$ , which is  $\delta \leq 1 - p_r + p_s + e_r - e_s$ , while the others purchase from the seller. As illustrated in Figure 2c, the demands in this scenario are derived as follows:

$$\begin{aligned}\tilde{D}_r &= 1 - p_r + p_s + e_r - e_s \\ \tilde{D}_s &= p_r - p_s - e_r + e_s\end{aligned}\quad (9)$$

Therefore, we derive the profits of each player as follows:

$$\begin{aligned}\tilde{\pi}_r &= (1 - r)p_r D_r + \theta p_s D_s \\ \tilde{\pi}_s &= (1 - \theta - r)p_s D_s \\ \tilde{\pi}_{lr} &= r p_r D_r - c e_r^2 \\ \tilde{\pi}_{ls} &= r p_s D_s - c e_s^2\end{aligned}\quad (10)$$

In this case, we start with the live streamers optimizing their livestreaming efforts and get the best response functions  $\tilde{e}_r^* = \frac{r}{2c} p_r$  and  $\tilde{e}_s^* = \frac{r}{2c} p_s$ . Then, the retailer and the seller optimize their prices by substituting the response functions into the profit functions. We can then summarize the equilibrium in this case as shown in Lemma 3.

**Lemma 3.** When both the retailer and the seller adopt livestreaming, the equilibrium prices and livestreaming efforts are

$$\begin{aligned}\tilde{p}_r^* &= \frac{4c(1-r)}{(2c-r)(3-3r-\theta)} \\ \tilde{p}_s^* &= \frac{2c(1-r)}{(2c-r)(3-3r-\theta)} \\ \tilde{e}_r^* &= \frac{2r(1-r)}{(2c-r)(3-3r-\theta)} \\ \tilde{e}_s^* &= \frac{r(1-r)}{(2c-r)(3-3r-\theta)},\end{aligned}\quad (11)$$

and the equilibrium profits of each player are

$$\begin{aligned}\tilde{\pi}_r^* &= \frac{2c(1-r)^2(4-4r-\theta)}{(2c-r)(3-3r-\theta)^2} \\ \tilde{\pi}_s^* &= \frac{2c(1-r)^2(1-r-\theta)}{(2c-r)(3-3r-\theta)^2} \\ \tilde{\pi}_{lr}^* &= \frac{4cr(1-r)[2c(2-2r-\theta)-r(3-3r-\theta)]}{(2c-r)^2(3-3r-\theta)^2} \\ \tilde{\pi}_{ls}^* &= \frac{cr(4c-3r)(1-r)^2}{(2c-r)^2(3-3r-\theta)^2}.\end{aligned}\quad (12)$$

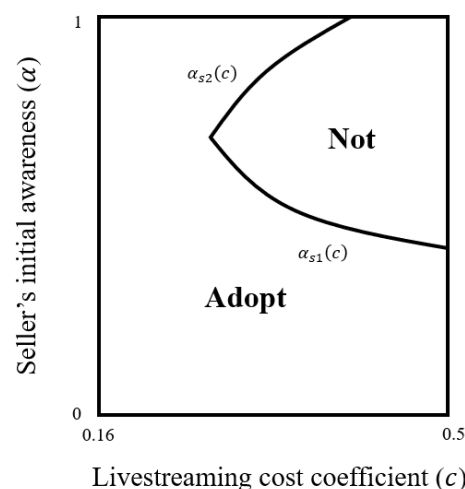
When the retailer opens livestreaming to the seller and the seller also adopts livestreaming, the retailer's awareness advantage is eliminated but the valuation advantage remains. In this case, the retailer and the seller compete for all consumers with the help of the live streamers. Because of the remaining valuation advantage, the retailer sets a higher price than the seller (i.e.,  $\tilde{p}_r^* = 2\tilde{p}_s^*$ ) and the live streamer cooperating with the retailer sets a higher livestreaming effort than the live streamer cooperating with the seller (i.e.,  $\tilde{e}_r^* = 2\tilde{e}_s^*$ ). Both the profits of the retailer and the seller decrease with the extent of the livestreaming cost coefficient (i.e.,  $\frac{\partial \tilde{\pi}_r^*}{\partial c} < 0$ ,  $\frac{\partial \tilde{\pi}_s^*}{\partial c} < 0$ ).

#### 4.2. The Adoption of Livestreaming by the Seller

With the retailer adopting and opening livestreaming, the seller then makes the decision of whether to adopt livestreaming. By comparing the seller's equilibrium profits in Scenarios II and III, we can derive the conditions for the seller's livestreaming strategy as follows:

**Proposition 1.** *If the retailer adopts livestreaming and opens it to the seller, the third-party seller adopts livestreaming when  $\alpha \leq \alpha_{s1}(c)$  or  $\alpha > \alpha_{s2}(c)$ , where  $\alpha_{s1}(c)$  is the solution to  $\tilde{\pi}_s^* = \hat{\pi}_s^*|_{\alpha \leq \alpha_0}$  and  $\alpha_{s2}(c)$  is the solution to  $\tilde{\pi}_s^* = \hat{\pi}_s^*|_{\alpha > \alpha_0}$ .*

Proposition 1 indicates that the seller adopts livestreaming when its initial awareness is either low or relatively high. The seller with intermediate initial awareness has less incentive to adopt livestreaming, as shown in Figure 3. The benefits of livestreaming for the seller include an increase in awareness and perceived consumer utility, while the losses from livestreaming include the revenue shared with the streamer and the intense competition caused by the awareness increase. When the seller's initial awareness is small (i.e., when  $\alpha \leq \alpha_0$ ), the benefit of awareness increase brought by livestreaming is salient. The low initial awareness leaves the seller with more space to improve and it plays a critical role in the seller's comparison of the benefits from livestreaming to the losses. Thus, the seller adopts livestreaming when its initial awareness is low (i.e.,  $\alpha \leq \alpha_{s1}(c)$ ). We further find that the seller always has the incentive to adopt livestreaming when its initial awareness  $\alpha$  is very small (i.e.,  $\alpha \leq \frac{4(1-r)^2(1-r-\theta)}{(1-\theta)(3-3r-\theta)^2}$ , which comes from  $\alpha \leq \lim_{c \rightarrow \infty} \alpha_{s1}(c)$ ). In this situation, even when  $c$  is extremely large and  $e_s$  goes down to 0 (where livestreaming becomes a kind of low-cost advertising), the benefits of the awareness increase outweighs the loss of sharing the revenue with the live streamer.



**Figure 3.** The adoption of livestreaming by the seller ( $r = 0.2$  and  $\theta = 0.3$ ).

When the seller's initial awareness is high (i.e., when  $\alpha > \alpha_0$ ), the retailer competes with the seller aggressively. Livestreaming increases the seller's awareness and thus, intensifies the competition between the retailer and the seller. With the reduction in the awareness increase  $(1 - \alpha)$  from livestreaming, the benefits of the awareness increase become less important. The losses caused by the intense competition become crucial in the seller's livestreaming decision. The higher the seller's initial awareness, the lower the losses. When deciding whether to adopt livestreaming, the seller with higher initial awareness shall suffer a smaller awareness increase  $(1 - \alpha)$ , and thus has more incentive to adopt livestreaming. Therefore, the seller adopts livestreaming when the seller's initial awareness is relatively high (i.e.,  $\alpha > \alpha_{s2}(c)$ ).

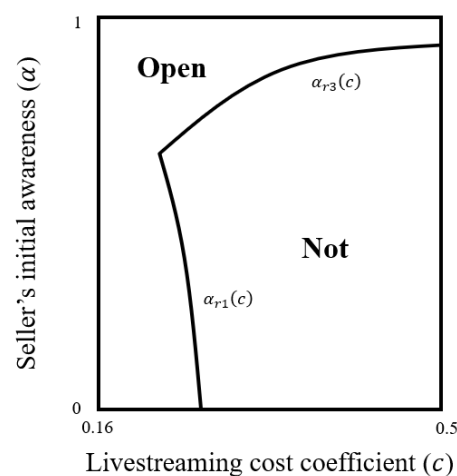
In summary, with the increase in the seller's initial awareness, the incentive for the seller to adopt livestreaming decreases when the initial awareness is low and increases when the initial awareness is high. Specifically, the benefits of the awareness increase from livestreaming diminish with the increase in the seller's initial awareness when  $\alpha$  is low. The losses from the intensified competition increase with the decrease in the seller's initial awareness when  $\alpha$  is high. This means that the seller with intermediate initial awareness enjoys fewer benefits and suffers larger losses, which explains why it has less incentive to adopt livestreaming.

#### 4.3. The Retailer's Openness of Livestreaming

When the retailer adopts livestreaming and engages live streamers on its platform, it chooses whether to open livestreaming to the seller. The openness of livestreaming to the seller only referred a functional authorization of the retail platform, which is almost costless, so we do not consider this cost. The retailer will open livestreaming to the seller as long as it can be better off when the seller adopts livestreaming. Therefore, by comparing the retailer's equilibrium profits in Scenarios II and III, we find that the retailer opens livestreaming to the third-party seller under the conditions that are summarized in Proposition 2.

**Proposition 2.** *If the retailer adopts livestreaming on its platform, it opens livestreaming to the third-party seller when  $\alpha \leq \alpha_{r1}(c)$  or  $\alpha > \min\{\alpha_{r2}(c), \alpha_{r3}(c)\}$ , where  $\alpha_{r1}(c)$  and  $\alpha_{r2}(c)$  are the solutions to  $\tilde{\pi}_r^* = \hat{\pi}_r^*|_{\alpha \leq \alpha_0}$  and  $\alpha_{r3}(c)$  is the solution to  $\tilde{\pi}_r^* = \hat{\pi}_r^*|_{\alpha > \alpha_0}$ .*

Figure 4 demonstrates Proposition 2 when  $r = 0.2$  and  $\theta = 0.3$ . The retailer opens livestreaming to the third-party seller when both the initial awareness of the seller and the livestreaming cost coefficient are relatively low or when the initial awareness of the seller is high.



**Figure 4.** The retailer's openness choice of livestreaming ( $r = 0.2$  and  $\theta = 0.3$ ).

The retailer only opens livestreaming to the seller when the adoption of livestreaming by the seller is beneficial to the retailer. On the one hand, the seller's adoption of livestreaming promotes its sales and increases commission for the retailer. This is mainly decided by the streamer's livestreaming effort, which is influenced by the cost coefficient. On the other hand, it eliminates the retailer's awareness advantage, intensifies the competition and thus, results in a loss of sales for the retailer. First, when the seller's initial awareness is relatively low, opening livestreaming hurts the retailer deeply because the livestreaming dramatically increases the awareness of the seller. In this case, the retailer only opens livestreaming to the seller when the livestreaming cost coefficient is relatively low, because the live streamer would set a large livestreaming effort, increase the seller's sales and thus, increase the retailer's commission income to an extent that exceeds the retailer's loss in sales revenue. Second, when the seller's initial awareness is high, the increase in the seller's awareness and the change in competition intensity caused by livestreaming is mild. The retailer's sales losses can easily be outweighed by the commission benefits from opening livestreaming to the seller. Therefore, the retailer is more likely to open livestreaming to the seller.

#### 4.4. The Adoption of Livestreaming by the Retailer

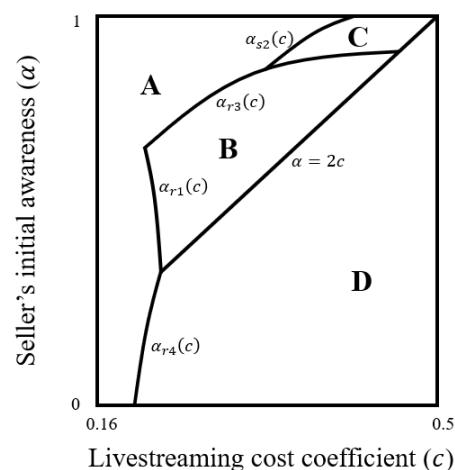
The retailer makes its livestreaming decision in the very first stage. By comparing the equilibrium outcomes from Lemmas 1, 2, and 3, we derive the following proposition.

**Proposition 3.** *The retailer adopts livestreaming under the following conditions:*

- a.1. *When  $\alpha > \alpha_{r4}(c)$  if the retailer can benefit from opening livestreaming to the seller (i.e.,  $\alpha \leq \alpha_{r1}(c)$  or  $\alpha > \min\{\alpha_{r2}(c), \alpha_{r3}(c)\}$ ) and the seller can benefit from adopting livestreaming (i.e.,  $\alpha \leq \alpha_{s1}(c)$  or  $\alpha > \alpha_{s2}(c)$ );*
- a.2. *When  $\alpha > 2c$  if the retailer can benefit from opening livestreaming to the seller (i.e.,  $\alpha \leq \alpha_{r1}(c)$  or  $\alpha > \min\{\alpha_{r2}(c), \alpha_{r3}(c)\}$ ) and the seller cannot benefit from adopting livestreaming (i.e.,  $\alpha_{s1}(c) < \alpha < \alpha_{s2}(c)$ );*
- b. *When  $\alpha > 2c$  if the retailer cannot benefit from opening livestreaming to the seller (i.e.,  $\alpha_{r1}(c) < \alpha < \min\{\alpha_{r2}(c), \alpha_{r3}(c)\}$ ), where*  
 $\alpha_{s1}(c)$  *is the solution to  $\tilde{\pi}_s^* = \hat{\pi}_s^*|_{\alpha \leq \alpha_0}$ ,  $\alpha_{s2}(c)$  is the solution to  $\tilde{\pi}_s^* = \hat{\pi}_s^*|_{\alpha > \alpha_0}$ ,  $\alpha_{r1}(c)$  and  $\alpha_{r2}(c)$  are the solutions to  $\tilde{\pi}_r^* = \hat{\pi}_r^*|_{\alpha \leq \alpha_0}$ ,  $\alpha_{r3}(c)$  is the solution to  $\tilde{\pi}_r^* = \hat{\pi}_r^*|_{\alpha > \alpha_0}$  and  $\alpha_{r4}(c) =$* 

$$\begin{cases} \frac{(4-\theta)(2c-r)(3-3r-\theta)^2}{2c(3-\theta)^2(1-r)^2(4-4r-\theta)} & \alpha > \frac{2}{3-\theta} \\ \frac{4}{(2-\theta)} - \frac{8c(1-r)^2(4-4r-\theta)}{(2-\theta)(2c-r)(3-3r-\theta)^2} & \text{otherwise} \end{cases}$$
*is the solution to  $\tilde{\pi}_r^* > \pi_r^*$ .*

The retailer decides whether to adopt livestreaming by considering the subsequent openness decision and the seller's adoption decision. Proposition 3 shows that the retailer's decision whether to adopt livestreaming depends on the live streamer's cost coefficient and the seller's initial awareness. Proposition 3(a.1) summarizes the conditions under which Scenario III becomes the equilibrium outcome and the first condition  $\alpha > \alpha_{r4}(c)$  comes from  $\tilde{\pi}_r^* > \pi_r^*$ . The first conditions of (a.2) and (b) in Proposition 3 are the same ( $\alpha > 2c$ ) since the two cases (the case in which the retailer does not open livestreaming to the seller and the case in which the retailer opens livestreaming but the seller does not adopt it) both lead to the equilibrium outcome in Scenario II and that comes from  $\tilde{\pi}_r^* > \pi_r^*$ . Through the first conditions in Proposition 3, it can be seen that the retailer adopts livestreaming when the livestreaming cost coefficient is below a certain level. Intuitively, lower livestreaming cost means a higher consumer utility increase and that the benefits from livestreaming exceed the losses from sharing the revenue with the live streamer. Additionally, the retailer is more likely to adopt livestreaming when the seller's initial awareness is high. For ease of exposition, we use Figure 5 to concretely illustrate the equilibrium outcomes of Proposition 3 when  $r = 0.2$  and  $\theta = 0.3$ .



**Figure 5.** The equilibrium outcomes under different initial awareness levels and cost coefficients ( $r = 0.2$  and  $\theta = 0.3$ ).

We can conclude the conditions for the equilibrium outcomes in Figure 5 as follows. When the livestreaming cost coefficient is relatively low or it is intermediate and the seller's initial awareness is high (the A area), the retailer adopts and opens livestreaming and the seller also adopts it. However, when both the livestreaming cost coefficient and the seller's initial awareness are at an intermediate level (the B area), the retailer adopts livestreaming but does not open it to the seller. When the livestreaming cost coefficient is not low and the seller's initial awareness is high (the C area), the retailer adopts and opens livestreaming but the seller does not adopt it. Lastly (the D area), the retailer does not adopt livestreaming on its platform.

The rationales for these decisions are as follows. In the A area, the equilibrium in which both the retailer and the seller adopt livestreaming emerges when the livestreaming cost coefficient is relatively low. The reason for this is that the live streamer will set a high livestream effort, which benefits both the retailer and the seller. Although the seller with low initial awareness enjoys a huge awareness increase and causes losses for the retailer, the retailer still benefits from the increase in commission fees. In the A area, when the seller's initial awareness is high, the threshold of the livestreaming cost coefficient goes high. That is because, with the increase in the seller's initial awareness, the losses to the retailer caused by competition aggravation  $(1 - \alpha)$  decrease, so the retailer has more incentives to open livestreaming to the seller. In the B area, adopting livestreaming is beneficial to the retailer but opening livestreaming to the seller is not. The intermediate cost coefficient means that the consumer utility increase for the seller from livestreaming is not significant. Thus, the increase in commission fee for the retailer is limited and cannot compensate for the losses brought by the increased seller awareness and competition. In practice, with the development of livestreaming and the increasing acceptance of livestreaming, the costs of live streamers have decreased and then the retail platforms start to encourage third-party sellers to adopt livestreaming. Lastly, the C area indicates that even when the retailer opens livestreaming, the seller does not adopt livestreaming when it has a high initial awareness and the livestreaming cost coefficient is not very low. The reason for this is that both the increase in awareness and the increase in consumer utility are limited for the seller in this area. Therefore, the seller does not adopt livestreaming so as to avoid the fierce competition with the retailer and the need to share revenue with the live streamer.

To summarize the retailer's overall adoption decision in the super game, the retailer adopts livestreaming when the livestreaming cost coefficient is relatively low, even when the seller's initial awareness is low. Additionally, the retailer also adopts livestreaming when the seller's initial awareness is high and the livestreaming cost coefficient is not too high.

## 5. Effects of Livestreaming on the Retailer and the Seller

In this section, we use Scenario I as the benchmark and analyze the effects of livestreaming on the equilibrium profits of the retailer and the seller. By examining and comparing the equilibrium profits under different scenarios, we show how the profits of the retailer and the seller change with the livestreaming cost coefficient. The results are summarized in the following proposition.

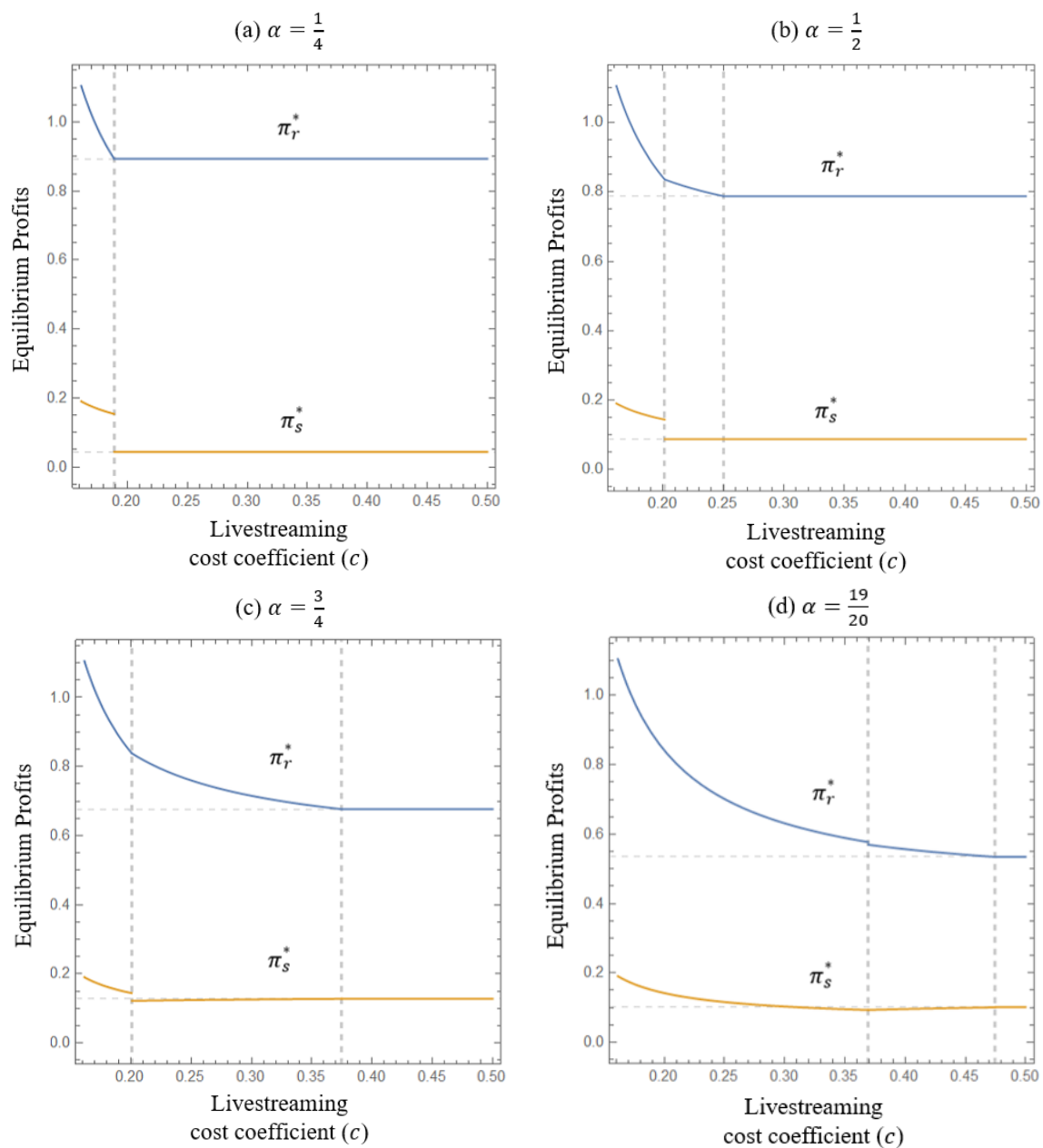
**Proposition 4.** *a. Within the equilibrium in which both the retailer and the seller adopt livestreaming, both the profits of the retailer and the profits of the seller decrease with the increase in the livestreaming cost coefficient. Within the equilibrium in which only the retailer adopts livestreaming, the profit of the retailer decreases, and the profit of the seller (weakly) increases with the livestreaming cost coefficient.*

*b. Compared to the case without livestreaming, livestreaming always benefits the retailer, always (weakly) benefits the seller with low initial awareness ( $\alpha \leq \alpha_0$ ), and it might benefit the seller with high initial awareness ( $\alpha > \alpha_0$ ) only when the livestreaming cost coefficient is low.*

Figure 6 illustrates Proposition 4 by showing the changes in profits with the livestreaming cost coefficient under different initial awareness levels of the seller when  $r = 0.2$  and  $\theta = 0.3$ . First, when the equilibrium outcome is that both the retailer and the seller adopt livestreaming (i.e., the left-hand areas of the panels in Figure 6a–d), a higher livestreaming cost coefficient hurts both the retailer and the seller. Intuitively, with a lower livestreaming cost coefficient, the live streamer could determine a higher livestreaming effort and thus, improve the merchant's profit. When the livestreaming cost coefficient is very high, the livestreaming effort will be correspondingly low and less attractive to the merchants. Second, when the equilibrium outcome is that only the retailer adopts livestreaming (i.e., the middle areas of the panels in Figure 6b–d), the retailer suffers from a higher livestreaming cost coefficient but as the competitor, the seller may benefit from it. Note that the change in profit under this equilibrium outcome differs for the different initial awareness levels of the seller. When the seller has an intermediate initial awareness (i.e., the middle area of the panel in Figure 6b), its profit remains unchanged. The reason for this is that with a significant awareness advantage, the retailer pursues monopoly profit from its exclusive consumers and forgoes the competition with the seller. Therefore, the retailer's livestreaming has no influence on the seller in this equilibrium. When the seller's initial awareness is high (i.e., the middle areas of the panels in Figure 6c,d), the seller's profit increases with the livestreaming cost coefficient. Third, the equilibrium outcome that neither the retailer nor the seller adopts livestreaming occurs when the livestreaming cost coefficient is relatively high (i.e., the right areas of the panels in Figure 6a–d).

Livestreaming offers the retailer an opportunity to better serve its consumers and improve profits. However, although livestreaming offers the seller a chance to promote sales, it does not necessarily benefit the seller when the seller's initial awareness is high. This means that the emergence of livestreaming might hurt the third-party seller. Intuitively, the seller's profit may decrease when only the retailer adopts this new selling strategy. The seller does not adopt livestreaming because either the retailer does not open livestreaming or the livestreaming cost coefficient is exorbitant. Livestreaming expands the retailer's valuation advantage and leads to the seller's market loss. Moreover, even within the equilibrium in which the seller also adopts livestreaming, the seller's profit might still be lower than that in the scenario without livestreaming (i.e., when  $c = 0.35$  in Figure 6d). This happens when the seller's initial awareness is high and the livestreaming cost coefficient is not low. In this situation, the seller has to adopt livestreaming to avoid an increase in its valuation disadvantages resulting from the retailer's adoption of livestreaming. However, compared to the scenario without livestreaming, the seller's losses caused by intense competition and sharing revenue with the live streamer exceed the benefits from livestreaming and thus, hurt the profit of the seller.





**Figure 6.** The effects of the livestreaming cost coefficient on the equilibrium profits ( $r = 0.2$  and  $\theta = 0.3$ ).

## 6. Conclusions

In this study, we develop a game-theoretic model to analyze the strategic rationales for the decisions regarding the adoption and openness of livestreaming made by a leading retailer and a small third-party seller. Using our model, we find that the seller would like to adopt livestreaming when its initial awareness is either low or relatively high. With the increase in the seller's initial awareness, the incentive of the seller to adopt livestreaming decreases when the initial awareness is low and increases when the initial awareness is high. For the retailer, when the livestreaming cost coefficient is low, it always opens livestreaming for the seller, regardless of the seller's initial awareness level. When the livestreaming cost coefficient is either intermediate or high, the retailer only opens livestreaming when the seller's initial awareness is high. The results also show that the retailer adopts livestreaming when the livestreaming cost coefficient is relatively low. When the seller's initial awareness is high, the retailer would be more likely to adopt livestreaming.

Our research could have implications for both retail platform owners and market participants. First, market leaders should fully embrace the revolution of livestreaming and the opportunity to improve business. In the past, giant retail platforms have enjoyed the competitive advantages that resulted from their market dominance. With the emergence of livestreaming, market leaders now need to choose between maintaining their traditional models to defend their market dominance and accepting the new trend of livestreaming to build a win-win situation with their market participants.

Second, this research could also provide sellers who operate their businesses on e-commerce platforms an alternative perspective on this emerging livestreaming. The emergence of livestreaming could offer them the chance to improve their business. There is no doubt that sellers should stay positive and welcome this new selling strategy; however, adopting livestreaming could also be a challenge. It could cause fierce competition with the market leaders and, in turn, hurt the third-party sellers, especially those who have already established considerable market shares. Instead of rushing into this new trend, sellers should be more conscious and consider their initial awareness level and the livestreaming costs before adopting this strategy.

Our work has some limitations. For example, we do not consider the competition between multiple third-party sellers on the platform. We also do not consider the competition between two platforms or examine the external factors that affect the adoption and openness of livestreaming by a platform. Our research has several testable hypotheses, which can be complemented by rigorous empirical testing. All of these suggestions are possible directions for future research.

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## Appendix A

### Appendix A.1. Proof of Lemma 1

**Proof of Lemma 1.** The seller's optimal price is characterized by the first-order condition of  $\pi_s$  in Equation (2):

$$\frac{d\pi_s}{dp_s} = \alpha(1 - \theta)(p_r - p_s) - \alpha(1 - \theta)p_s = 0$$

Therefore, we conclude that  $p_s^* = \frac{p_r}{2}$ .

The retailer's optimal price is characterized by the first-order condition of  $\pi_r$  in Equation (2):

$$\frac{d\pi_r}{dp_r} = (1 - \alpha) + \alpha(1 - p_r + p_s) - \alpha p_r + \alpha \theta p_s = 0$$

By solving the equations, we obtain

$$p_r^* = \frac{2}{\alpha(3-\theta)}$$

$$p_s^* = \frac{1}{\alpha(3-\theta)}$$

Since the maximal value a consumer perceives from buying a product is 1, we have  $p_r^* \leq 1$ . Therefore, if  $\alpha > \frac{2}{3-\theta}$ , then  $p_r^* = \frac{2}{\alpha(3-\theta)}$  and  $p_s^* = \frac{1}{\alpha(3-\theta)}$ . If  $\alpha \leq \frac{2}{3-\theta}$ , then  $p_r^* = 1$  and  $p_s^* = \frac{p_r}{2} = \frac{1}{2}$ . By substituting the optimal prices into Equation (2), we derive the equilibrium profits shown in Equation (4).  $\square$

#### Appendix A.2. Proof of Lemma 2

**Proof of Lemma 2.** The optimal livestreaming effort of live streamer is characterized by substituting the demands in Equation (5) into the profit functions in Equation (6):

$$\frac{d\hat{\pi}_{lr}}{de_r} = r\alpha p_r - 2ce_r = 0$$

Therefore, we can conclude that  $\hat{e}_r^* = \frac{r\alpha}{2c} p_r$ .

The seller's optimal price is characterized by the first-order condition of  $\hat{\pi}_s$  in Equation (6) after substituting  $\hat{e}_r^* = \frac{r\alpha}{2c} p_r$ :

$$\frac{d\hat{\pi}_s}{dp_s} = \alpha(1-\theta) \left( p_r - p_s - \frac{r\alpha}{2c} p_r \right) - \alpha(1-\theta)p_s = 0$$

Therefore, we can conclude that  $\hat{p}_s^* = \frac{2c-r\alpha}{4c} p_r$ .

The retailer's optimal price is characterized by the first-order condition of  $\hat{\pi}_r$  in Equation (6) after substituting  $\hat{e}_r^* = \frac{r\alpha}{2c} p_r$ :

$$\frac{d\hat{\pi}_r}{dp_r} = (1-r) \left[ (1-\alpha) + \alpha \left( 1 - p_r + p_s + \frac{r\alpha}{2c} p_r \right) - \alpha \left( 1 - \frac{r\alpha}{2c} p_r \right) \right] + \alpha\theta \left( 1 - \frac{r\alpha}{2c} p_r \right) p_s = 0$$

By solving the equations, we obtain

$$\begin{aligned} \hat{p}_r^* &= \frac{8c^2(1-r)}{\alpha(2c-r\alpha)[r\alpha\theta+2c(3-3r-\theta)]} \\ \hat{p}_s^* &= \frac{2c(1-r)}{\alpha[r\alpha\theta+2c(3-3r-\theta)]} \\ \hat{e}_r^* &= \frac{4cr(1-r)}{(2c-r\alpha)[r\alpha\theta+2c(3-3r-\theta)]} \end{aligned}$$

Since the maximal value a consumer perceives from buying a product with livestreaming is  $1 + e_r$ , we have  $\hat{p}_r^* \leq 1 + \hat{e}_r^*$ , i.e.,  $\alpha > \alpha_0 = \frac{\sqrt{4cr(1-r)\theta+c^2(3-3r-\theta)^2}-c(3-3r-\theta)}{r\theta}$ . Therefore, if  $\alpha > \alpha_0$ , then  $\hat{p}_r^* = \frac{8c^2(1-r)}{\alpha(2c-r\alpha)[r\alpha\theta+2c(3-3r-\theta)]}$ ,  $\hat{p}_s^* = \frac{2c(1-r)}{\alpha[r\alpha\theta+2c(3-3r-\theta)]}$  and  $\hat{e}_r^* = \frac{4cr(1-r)}{(2c-r\alpha)[r\alpha\theta+2c(3-3r-\theta)]}$ . If  $\alpha \leq \alpha_0$ , then  $\hat{p}_r^* = \frac{2c}{2c-r\alpha}$ ,  $\hat{p}_s^* = \frac{2c-r\alpha}{4c} p_r = \frac{1}{2}$  and  $\hat{e}_r^* = \frac{r\alpha}{2c} p_r = \frac{r\alpha}{2c-r\alpha}$ . By substituting the optimal prices and livestreaming effort values into Equation (6), we derive the equilibrium profits shown in Equation (8).  $\square$

#### Appendix A.3. Proof of Lemma 3

**Proof of Lemma 3.** The optimal livestreaming effort of live streamers is characterized by substituting the demands in Equation (9) into the profit functions in Equation (10):

$$\frac{d\tilde{\pi}_{lr}}{de_r} = rp_r - 2ce_r = 0$$

$$\frac{d\tilde{\pi}_{ls}}{de_s} = rp_s - 2ce_s = 0$$

Therefore, we can conclude that  $\tilde{e}_r^* = \frac{r}{2c}p_r$  and  $\tilde{e}_s^* = \frac{r}{2c}p_s$ .

The seller's optimal price is characterized by the first-order condition of  $\tilde{\pi}_s$  in Equation (6) after substituting  $\tilde{e}_r^* = \frac{r}{2c}p_r$  and  $\tilde{e}_s^* = \frac{r}{2c}p_s$ :

$$\frac{d\tilde{\pi}_s}{dp_s} = (1 - \theta - r) \left( p_r - p_s - \frac{r}{2c}p_r + \frac{r}{2c}p_s \right) - \left( 1 - \frac{r}{2c} \right) (1 - \theta - r)p_s = 0$$

The retailer's optimal price is characterized by the first-order condition of  $\tilde{\pi}_r$  in Equation (6) after substituting  $\tilde{e}_r^* = \frac{r}{2c}p_r$  and  $\tilde{e}_s^* = \frac{r}{2c}p_s$ :

$$\frac{d\tilde{\pi}_r}{dp_r} = (1 - r) \left[ \left( 1 - p_r + p_s + \frac{r}{2c}p_r - \frac{r}{2c}p_s \right) - \left( 1 - \frac{r}{2c} \right) p_r \right] + \left( 1 - \frac{r}{2c} \right) \theta p_s = 0$$

By solving the equations, we obtain

$$\begin{aligned} \tilde{p}_r^* &= \frac{4c(1-r)}{(2c-r)(3-3r-\theta)} \\ \tilde{p}_s^* &= \frac{2c(1-r)}{(2c-r)(3-3r-\theta)} \\ \tilde{e}_r^* &= \frac{2r(1-r)}{(2c-r)(3-3r-\theta)} \\ \tilde{e}_s^* &= \frac{r(1-r)}{(2c-r)(3-3r-\theta)} \end{aligned}$$

By substituting the optimal prices and livestreaming effort values into Equation (10), we derive the equilibrium profits shown in Equation (12).  $\square$

#### Appendix A.4. Proof of Proposition 1

**Proof of Proposition 1.** If the retailer adopts livestreaming and opens it to the seller, the seller only adopts livestreaming when it is profitable, which is  $\tilde{\pi}_s^* > \hat{\pi}_s^*$ .

When  $\alpha \leq \alpha_0$ , by solving  $\tilde{\pi}_s^* > \hat{\pi}_s^*|_{\alpha \leq \alpha_0}$  in Equations (8) and (12), we obtain  $\alpha \leq \alpha_{s1}(c)$ , where  $\alpha_{s1}(c)$  is the solution to  $\tilde{\pi}_s^* = \hat{\pi}_s^*|_{\alpha \leq \alpha_0}$  and  $\alpha_{s1}(c) = \frac{8c(1-r)^2(1-r-\theta)}{(2c-r)(1-\theta)(3-3r-\theta)^2}$ . We can verify  $\frac{\partial \alpha_0}{\partial c} > 0$  and  $\frac{\partial \alpha_{s1}(c)}{\partial c} < 0$ .

When  $\alpha > \alpha_0$ , by solving Equations (8) and (12), we obtain  $\frac{\partial \tilde{\pi}_s^*}{\partial \alpha} = 0$  and  $\frac{\partial \hat{\pi}_s^*|_{\alpha > \alpha_0}}{\partial \alpha} < 0$ . Thus, by solving  $\tilde{\pi}_s^* > \hat{\pi}_s^*|_{\alpha > \alpha_0}$ , we obtain  $\alpha > \alpha_{s2}(c)$ , where  $\alpha_{s2}(c)$  is the solution to  $\tilde{\pi}_s^* = \hat{\pi}_s^*|_{\alpha > \alpha_0}$ .

Since  $\alpha_{s2}(c)$  is the solution to  $\tilde{\pi}_s^* = \hat{\pi}_s^*|_{\alpha > \alpha_0}$ ,  $\tilde{\pi}_s^*(\alpha_{s2}(c), c)$  is the same as  $\hat{\pi}_s^*(\alpha_{s2}(c), c)|_{\alpha > \alpha_0}$ . We can then obtain

$$\frac{\partial \tilde{\pi}_s^*(\alpha_{s2}(c), c)}{\partial c} = \frac{\partial \hat{\pi}_s^*(\alpha_{s2}(c), c)|_{\alpha > \alpha_0}}{\partial c}$$

Therefore,  $\frac{\partial \tilde{\pi}_s^*}{\partial \alpha} \frac{\partial \alpha_{s2}(c)}{\partial c} + \frac{\partial \tilde{\pi}_s^*}{\partial c} = \frac{\partial \hat{\pi}_s^*|_{\alpha > \alpha_0}}{\partial \alpha} \frac{\partial \alpha_{s2}(c)}{\partial c} + \frac{\partial \hat{\pi}_s^*|_{\alpha > \alpha_0}}{\partial c}$  and thus, we obtain  $\frac{\partial \alpha_{s2}(c)}{\partial c} = \frac{\frac{\partial \hat{\pi}_s^*|_{\alpha > \alpha_0}}{\partial \alpha} - \frac{\partial \tilde{\pi}_s^*}{\partial \alpha}}{\frac{\partial \hat{\pi}_s^*|_{\alpha > \alpha_0}}{\partial \alpha} - \frac{\partial \tilde{\pi}_s^*}{\partial c}}$ .

Similarly, since  $\alpha_0$  is the solution to  $\hat{\pi}_s^*|_{\alpha > \alpha_0} = \hat{\pi}_s^*|_{\alpha \leq \alpha_0}$ , we can obtain  $\frac{\partial \alpha_0}{\partial c} = \frac{\frac{\partial \hat{\pi}_s^*|_{\alpha > \alpha_0}}{\partial c} - \frac{\partial \hat{\pi}_s^*|_{\alpha \leq \alpha_0}}{\partial c}}{\frac{\partial \hat{\pi}_s^*|_{\alpha > \alpha_0}}{\partial \alpha} - \frac{\partial \hat{\pi}_s^*|_{\alpha \leq \alpha_0}}{\partial \alpha}}$ .

From Equations (8) and (12), we can easily obtain  $\frac{\partial \hat{\pi}_s^*|_{\alpha > \alpha_0}}{\partial \alpha} < 0$ ,  $\frac{\partial \hat{\pi}_s^*|_{\alpha > \alpha_0}}{\partial c} > 0$ ,  $\frac{\partial \hat{\pi}_s^*|_{\alpha \leq \alpha_0}}{\partial \alpha} > 0$ ,  $\frac{\partial \hat{\pi}_s^*|_{\alpha \leq \alpha_0}}{\partial c} = 0$ ,  $\frac{\partial \hat{\pi}_s^*}{\partial \alpha} = 0$  and  $\frac{\partial \hat{\pi}_s^*}{\partial c} < 0$ . Therefore, we can prove that  $\frac{\partial \alpha_{s2}(c)}{\partial c} > \frac{\partial \alpha_0}{\partial c} > 0$ .

Together, because  $\frac{\partial \alpha_{s2}(c)}{\partial c} > \frac{\partial \alpha_0}{\partial c} > 0 > \frac{\partial \alpha_{s1}(c)}{\partial c}$ , we can conclude the conditions as in Proposition 1.  $\square$

#### Appendix A.5. Proof of Proposition 2

**Proof of Proposition 2.** If the retailer adopts livestreaming on its platform, it opens livestreaming to the third-party seller when it is profitable, which is  $\tilde{\pi}_r^* > \hat{\pi}_r^*$ .

When  $\alpha \leq \alpha_0$ , by solving Equations (8) and (12), we obtain

$$\left( \tilde{\pi}_r^* - \hat{\pi}_r^*|_{\alpha \leq \alpha_0} \right) \Big|_{\alpha=0} = \frac{2c(1-r)^2(4-4r-\theta)}{(2c-r)(3-3r-\theta)^2} - (1-r)$$

Therefore, when  $c < \frac{r(3-3r-\theta)^2}{2(3-3r-\theta)^2-2(1-r)(4-4r-\theta)}$ ,  $\left( \tilde{\pi}_r^* - \hat{\pi}_r^*|_{\alpha \leq \alpha_0} \right) \Big|_{\alpha=0} > 0$  and when  $c > \frac{r(3-3r-\theta)^2}{2(3-3r-\theta)^2-2(1-r)(4-4r-\theta)}$ ,  $\left( \tilde{\pi}_r^* - \hat{\pi}_r^*|_{\alpha \leq \alpha_0} \right) \Big|_{\alpha=0} < 0$ . Since  $\tilde{\pi}_r^*$  and  $\hat{\pi}_r^*|_{\alpha \leq \alpha_0}$  are both continuous for  $\alpha$ , there exists a curve  $c_r(\alpha)$  in this parameter space which makes  $\tilde{\pi}_r^* = \hat{\pi}_r^*|_{\alpha \leq \alpha_0}$  and, when  $c < c_r(\alpha)$ ,  $\tilde{\pi}_r^* > \hat{\pi}_r^*|_{\alpha \leq \alpha_0}$ .

Furthermore,  $\tilde{\pi}_r^* > \hat{\pi}_r^*|_{\alpha \leq \alpha_0}$  is equal to  $\frac{2c(1-r)^2(4-4r-\theta)}{(2c-r)(3-3r-\theta)^2} > \frac{4c(2-\alpha)(1-r)+\alpha\theta(2c-r\alpha)}{4(2c-r\alpha)}$ , which can be transformed into the form  $A\alpha^2 + B\alpha + C > 0$ , where

$$\begin{aligned} A &= r\theta(2c-r)(3-3r-\theta)^2 \\ B &= 4c(1-r)(2c-r)(3-3r-\theta)^2 - 2c\theta(2c-r)(3-3r-\theta)^2 - 8cr(1-r)^2(4-4r-\theta) \\ C &= 16c^2(1-r)^2(4-4r-\theta) - 8c(1-r)(2c-r)(3-3r-\theta)^2 \end{aligned}$$

Since  $A > 0$ , we can conclude that when  $\alpha \leq \alpha_{r1}(c)$  or  $\alpha > \alpha_{r2}(c)$ ,  $\tilde{\pi}_r^* > \hat{\pi}_r^*|_{\alpha \leq \alpha_0}$ , where  $\alpha_{r1}(c)$  and  $\alpha_{r2}(c)$  are the solutions to  $\tilde{\pi}_r^* = \hat{\pi}_r^*|_{\alpha \leq \alpha_0}$ . Note that  $\alpha_{r1}(c) = c_r^{-1}(\alpha)|_{\alpha < -\frac{B}{2A}}$  and  $\alpha_{r2}(c) = c_r^{-1}(\alpha)|_{\alpha > -\frac{B}{2A}}$ . Because  $0 < \theta < \frac{1}{2}$ ,  $0 < r < \frac{1}{2}$ ,  $0 < \alpha < 1$  and  $c > \frac{r(3-3r-\theta)}{4-4r-2\theta}$ , we can prove that  $\frac{\partial \alpha_{r2}(c)}{\partial c} > \frac{\partial \alpha_0}{\partial c} > 0 > \frac{\partial \alpha_{r1}(c)}{\partial c}$ .

When  $\alpha > \alpha_0$ , by solving Equations (8) and (12), we obtain

$$\left( \tilde{\pi}_r^* - \hat{\pi}_r^*|_{\alpha > 0} \right) \Big|_{\alpha=1} = \frac{2c(1-r)^2(4-4r-\theta)}{(2c-r)(3-3r-\theta)^2} - \frac{4c^2(1-r)^2[r\theta + 2c(4-4r-\theta)]}{(2c-r)[r\theta + 2c(3-3r-\theta)]^2} > 0$$

$$\lim_{c \rightarrow \infty} \left( \tilde{\pi}_r^* - \hat{\pi}_r^*|_{\alpha > 0} \right) \Big|_{\alpha=\alpha_0} = \frac{(1-r)^2(4-4r-\theta)}{(3-3r-\theta)^2} - \frac{(1-r)^2(4-4r-\theta)}{\alpha(3-3r-\theta)^2} < 0$$

because  $0 < \theta < \frac{1}{2}$ ,  $0 < r < \frac{1}{2}$ ,  $0 < \alpha < 1$  and  $c > \frac{r(3-3r-\theta)}{4-4r-2\theta}$ .

Therefore, there exists a curve  $\alpha_{r3}(c)$  in this parameter space which makes  $\tilde{\pi}_r^* = \hat{\pi}_r^*|_{\alpha > \alpha_0}$  and, when  $\alpha > \alpha_{r3}(c)$ ,  $\tilde{\pi}_r^* > \hat{\pi}_r^*|_{\alpha > \alpha_0}$ . Similar to Appendix A.4, we can then prove that  $\frac{\partial \alpha_{r3}(c)}{\partial c} > \frac{\partial \alpha_0}{\partial c}$ .

Together, because  $\frac{\partial \alpha_{r3}(c)}{\partial c} > \frac{\partial \alpha_0}{\partial c}$  and  $\frac{\partial \alpha_{r2}(c)}{\partial c} > \frac{\partial \alpha_0}{\partial c} > 0 > \frac{\partial \alpha_{r1}(c)}{\partial c}$ , we can conclude Proposition 2.  $\square$

#### Appendix A.6. Proof of Proposition 3

**Proof of Proposition 3.** a.1. When the seller can benefit from adopting livestreaming and the retailer can benefit from opening livestreaming to the seller, the retailer adopts

livestreaming if  $\tilde{\pi}_r^* > \pi_r^*$ . From Equations (4) and (12), when  $\alpha > \frac{2}{3-\theta}$ , by solving  $\tilde{\pi}_r^* > \pi_r^*$  at  $\alpha > \frac{2}{3-\theta}$ , we can derive  $\alpha > \frac{(4-\theta)(2c-r)(3-3r-\theta)^2}{2c(3-\theta)^2(1-r)^2(4-4r-\theta)}$ . When  $\alpha \leq \frac{2}{3-\theta}$ , by solving  $\tilde{\pi}_r^* > \pi_r^*$  at  $\alpha \leq \frac{2}{3-\theta}$ , we can derive  $\alpha > \frac{4}{(2-\theta)} - \frac{8c(1-r)^2(4-4r-\theta)}{(2-\theta)(2c-r)(3-3r-\theta)^2}$ .

According to Proposition 1, the seller can benefit from adopting livestreaming if  $\alpha \leq \alpha_{s1}(c)$  or  $\alpha > \alpha_{s2}(c)$ . According to Proposition 2, the retailer can benefit from opening livestreaming to the seller if  $\alpha \leq \alpha_{r1}(c)$  or  $\alpha > \min\{\alpha_{r2}(c), \alpha_{r3}(c)\}$ .

Therefore, we can conclude (a.1) in Proposition 3.

a.2. and b. When the retailer can benefit from opening livestreaming to the seller and the seller cannot benefit from adopting livestreaming, or when the retailer cannot benefit from opening livestreaming to the seller, the retailer adopts livestreaming if  $\hat{\pi}_r^* > \pi_r^*$ . From Equations (4) and (8), we can derive  $\alpha > 2c$  by solving  $\hat{\pi}_r^* > \pi_r^*$ .

According to Proposition 1, the seller cannot benefit from adopting livestreaming if  $\alpha_{s1}(c) < \alpha < \alpha_{s2}(c)$ . According to Proposition 2, the retailer can benefit from opening livestreaming to the seller if  $\alpha \leq \alpha_{r1}(c)$  or  $\alpha > \min\{\alpha_{r2}(c), \alpha_{r3}(c)\}$ , and cannot benefit from opening livestreaming to the seller if  $\alpha_{r1}(c) < \alpha < \min\{\alpha_{r2}(c), \alpha_{r3}(c)\}$ .

Therefore, we can conclude (a.2) and (b) in Proposition 3.  $\square$

#### Appendix A.7. Proof of Proposition 4

**Proof of Proposition 4.** a. According to Lemma 3, within the equilibrium in which both the retailer and the seller adopt livestreaming:

$$\begin{aligned}\frac{\partial \tilde{\pi}_r^*}{\partial c} &= \frac{\partial \frac{2c(1-r)^2(4-4r-\theta)}{(2c-r)(3-3r-\theta)^2}}{\partial c} = -\frac{2r(1-r)^2(4-4r-\theta)}{(2c-r)^2(3-3r-\theta)^2} < 0 \\ \frac{\partial \tilde{\pi}_s^*}{\partial c} &= \frac{\partial \frac{2c(1-r)^2(1-r-\theta)}{(2c-r)(3-3r-\theta)^2}}{\partial c} = -\frac{2r(1-r)^2(1-r-\theta)}{(2c-r)(3-3r-\theta)^2} < 0\end{aligned}$$

According to Lemma 2, within the equilibrium in which only the retailer adopts livestreaming:

$$\begin{aligned}\frac{\partial \hat{\pi}_r^*}{\partial c} &= \begin{cases} \frac{\partial \frac{4c^2(1-r)^2[r\alpha\theta+2c(4-4r-\theta)]}{\alpha(2c-r\alpha)[r\alpha\theta+2c(3-3r-\theta)]^2}}{\partial c} < 0 & \text{if } \alpha > \alpha_0 \\ \frac{\partial \frac{4c(2-\alpha)(1-r)+\alpha\theta(2c-r\alpha)}{4(2c-r\alpha)}}{\partial c} < 0 & \text{otherwise} \end{cases} \\ \frac{\partial \hat{\pi}_s^*}{\partial c} &= \begin{cases} \frac{\partial \frac{4c^2(1-r)^2(1-\theta)}{\alpha[r\alpha\theta+2c(3-3r-\theta)]^2}}{\partial c} > 0 & \text{if } \alpha > \alpha_0 \\ \frac{\partial \frac{1}{4}\alpha(1-\theta)}{\partial c} = 0 & \text{otherwise} \end{cases}\end{aligned}$$

because  $\theta < \frac{1}{2}$ ,  $r < \frac{1}{2}$  and  $c > \frac{r(3-3r-\theta)}{4-4r-2\theta}$ .

Therefore, we conclude Proposition 4(a).

b. For the retailer, the equilibrium in which the retailer and the seller both adopt livestreaming can only emerge when  $\tilde{\pi}_r^* > \pi_r^*$  and  $\tilde{\pi}_r^* > \hat{\pi}_r^*$ . The equilibrium in which only the retailer adopts livestreaming can emerge when  $\hat{\pi}_r^* > \pi_r^*$  and  $\hat{\pi}_r^* > \tilde{\pi}_r^*$ . No matter in which equilibrium, livestreaming always benefits the retailer.

For the seller, we separately compare  $\hat{\pi}_s^*$  and  $\tilde{\pi}_s^*$  with  $\pi_s^*$  to derive the effects of livestreaming.

By comparing  $\hat{\pi}_s^*$  and  $\pi_s^*$ , we obtain

$$\hat{\pi}_s^* \begin{cases} > \pi_s^* & \text{if } \frac{2}{3-\theta} < \alpha < 2c \\ = \pi_s^* & \text{if } \alpha \leq \frac{2}{3-\theta} \text{ and } \alpha \leq \alpha_0 \\ < \pi_s^* & \text{otherwise} \end{cases}$$



Together with the conditions for the equilibrium scenarios in Proposition 3, we can conclude that within the equilibrium in which only the retailer adopts livestreaming, the profit of the seller is the same as that in the case without livestreaming when  $\alpha \leq \alpha_0$  and the profit of the seller is lower than that in the case without livestreaming when  $\alpha > \alpha_0$ .

By comparing  $\tilde{\pi}_s^*$  and  $\pi_s^*$ , we obtain

$$\tilde{\pi}_s^* \begin{cases} > \pi_s^* & \text{if } c \leq \bar{c}_s \\ \leq \pi_s^* & \text{otherwise} \end{cases}$$

$$\text{where } \bar{c}_s = \begin{cases} \frac{r\alpha(1-\theta)(2c-r)(3-3r-\theta)^2}{2\alpha(1-\theta)(3-3r-\theta)^2 - 8(1-r)^2(1-r-\theta)} & \text{if } c \leq \frac{2}{3-\theta} \\ \frac{r(1-\theta)(3-3r-\theta)^2}{2(1-\theta)(3-3r-\theta)^2 - 2\alpha(1-r)^2(1-r-\theta)(3-\theta)^2} & \text{otherwise} \end{cases}.$$

Together with the conditions for the equilibrium scenarios in Proposition 3, we can conclude the following results within the equilibrium in which the retailer and the seller both adopt livestreaming:

When  $\alpha \leq \alpha_0$ , the profit of the seller is higher than that in the case without livestreaming.

When  $\alpha > \alpha_0$ , the profit of the seller is higher than that in the case without livestreaming if  $c \leq \bar{c}_s$  and it is lower if  $c > \bar{c}_s$ .

Therefore, we can conclude Proposition 4(b).  $\square$

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