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SELF-LIVE OR KOL-LIVE? SELLING CHANNEL SELECTION IN A PLATFORM SUPPLY CHAIN CONSIDERING RETURN POLICIES

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Live-streaming sales in e-commerce have become increasingly indispensable. This paper examines the factors influencing supply chain members' choice between self-run (channel S) and KOL live streaming (channel K) in live commerce and investigates how different return policies—return refund (RR) and returnless refund (RL)—affect the platform's channel selection. It shows that brands prefer the live-streaming channel under both return policies. Under return refund, the platform favors live streaming when the KOL's influence is weak or strong, but avoids self-run live streaming when the KOL's influence is moderate. Under the returnless refund, the platform chooses self-run live streaming when the KOL's influence is moderate, and the proportion of opportunists is low. However, as the proportion of opportunists rises, the platform avoids self-run live streaming. Only when the KOL's influence is negligible, and the proportion of opportunists is high, will the brand choose to return a refund.

Keywords: Supply chain management; self-run live-streaming; KOL live-streaming; return policy; Game theory.

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1. INTRODUCTION

E-commerce platform sales now account for an increasingly significant share of the overall market. Since the epidemic, live commerce has developed rapidly in conjunction with e-commerce. According to a report by the Net Economy Society, national online retail sales reached 154,264 billion yuan in 2023, of which the live-streaming e-commerce transaction scale reached 4,916.8 billion yuan, accounting for 31.87% of the total. (Yu *et al.*, 2023) Also shows that live-streaming has a positive effect on sales in the international market.

As the live broadcast industry gradually matures, live commerce streaming is divided into two channels: brands hiring streamers and brands building their live rooms. In live-streaming, some Key Opinion Leaders (KOLs) leverage their strong social influence to attract viewers and even control product pricing for brand marketing. For example, before the "Double Eleven" shopping festival, Li Jiaqi negotiated with brands on product prices and promotional campaigns. At the same time, some brands choose self-run live-streaming channels. During the 2024 "Double Eleven" period, Taobao data showed that Lancôme and Estée Lauder achieved over 6 million in sales through their own live streams, surpassing KOL teams. The self-run live-streaming model is adopted by an in-house team that can control the sales process while saving KOL commissions. According to the data of the Net Economy Society, the merchants of store broadcasting (self-run live-streaming) accounted for 69% in 2025, and the turnover of store broadcasting in industrial zones across the country exceeded 430 billion yuan.

To meet consumers' growing demand for better shopping experiences, e-commerce platforms now let merchants offer "returnless refunds," allowing dissatisfied customers to receive a refund without returning the product. This policy safeguards consumer rights while encouraging brands to enhance product quality and service standards.

In this context, this paper investigates the following questions:

(1) Which sales channel should the brand or platforms choose under different refund policies?

(2) Which refund policies are preferred by different supply chain entities?

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(3) With different live channels, how should brands and platforms price products?

To address these issues, this paper examines three channel strategies: traditional online channels, self-run live-streaming, and KOL live-streaming for a brand that resells merchandise through an online platform under two return policies: return for refund and returnless refund. This paper analyzes decisions and profits across six channel structures by considering product return rates, consumer return costs, celebrity effects, live-streaming costs, streamers' efforts, and opportunists.

First, the results for sales channel choices are as follows. The findings show that brands prefer the live-streaming channel under both return policies. Under return refund, platforms choose self-run live-streaming or KOL live-streaming based on self-run streaming costs when KOL influence is low or high, and avoid self-run when influence is moderate. Under the returnless refund, platforms choose self-run live-streaming when the percentage of opportunists is low; as opportunists increase, and KOL influence is moderate, they avoid self-run live-streaming.

Next, the results of return policy choices are presented. Brands choose return refund only when KOL has little influence and a higher percentage of opportunists. Platforms choose return-for-refund under KOL live-streaming when influence is low, and the percentage of opportunists is not exceedingly small. They opt for return-for-refund under self-run live-streaming when both KOL influence and opportunist percentage are moderate. In all other cases, they prefer a returnless refund. KOL overwhelmingly preferred refunds under the returnless refund.

Overall, this study reveals supply chain actors' preferences for sales channels and return policies in live-streaming commerce. It also identifies the conditions influencing these preferences, providing guidance for e-commerce decision-making.

2. LITERATURE REVIEW

This study is closely related to live e-commerce, channel strategy, and return refund policy. In recent years, e-commerce live-streaming, as an emerging form of sales, has garnered significant attention for its participants' roles in the supply chain and their interaction dynamics.

2.1. E-Commerce Live-Streaming

Some scholars have focused on the behavior and incentives of streamers, such as Yang *et al.* 2022) examined the impact of different pay incentive programs on streamer effort. Some scholars (Lin *et al.*, 2024; Niu, Yu *et al.*, 2023; Wang *et al.*, 2024) have conducted research around streamer commission rates. Furthermore, Xiao *et al.* 2024) found that KOLs prefer hybrid promises while sellers prefer sales promises, and Wang *et al.* 2024) explored the contractual model choices of manufacturers when hiring KOL live-streaming.

Other researchers have investigated how live-streaming influences consumer behavior. For example, some scholars have investigated the impact of live-streaming emotions on viewers (such as Bharadwaj *et al.*, 2021; Lin *et al.*, 2021; Wang *et al.*, 2024). Wongkitrungrueng & Assarut, (2020) explored the live-streaming of small sellers and found that symbolic value affects interactions through customers' trust in sellers. Lo *et al.* 2022) revealed that interactivity in live-streaming drives consumers' impulse purchases. With the continuous development of live-streaming technology, Gu *et al.* 2024) found that large streamers can attract more viewers, while small streamers are more efficient in converting their followers to purchase.

This paper considers the multidimensional interactions between streamers and consumers and brands and platforms in e-commerce live-streaming, analyzes the influence of streamers' efforts on consumers' attractiveness, and the roles of different live-streaming cooperation modes in the interests of all parties in the supply chain.

2.2. Channel Strategy

In channel strategy, Yue *et al.* 2024) explored the impact of the introduction of live streaming on resale and agency sales models of selling, and Pan *et al.* 2022) obtained that when there exists a demand for live-streaming, switching to the traditional channel, the dual channel of live-streaming and traditional channels coexistence is no longer optimal. Liu *et al.* 2025) explored the impact of misleading product information in the market on firms' choice of live-streaming channels. Wang & Zhang (2022) found that whether a manufacturer adopts the KOL channel depends on the likelihood of mismatch elimination and the consumer's hassle cost. Furthermore, Cui *et al.* 2023) proposed that live-streaming sales is a common choice for both sellers and streamers when the hassle cost is low, or the purchasing cost is high enough, and Niu *et al.* 2023) explored the differences between AI live-streaming and KOL live-streaming.

Further, other scholars have explored the self-run live-streaming and KOL live-streaming modes in live-streaming sales on this basis. Niu *et al.* 2025) compared brands' sales strategies of choosing the top KOL live-streaming and self-run live-streaming, and found that it is not recommended to cooperate with KOL when the commission rate is low or high. Li *et al.*

2024) revealed how companies selling various products should adopt third-party and self-owned live-streaming strategies. They found that startups should choose less popular but loyal followers to work with, while mature companies should choose moderately popular KOLs for live-streaming. Zhang *et al.* 2023) investigated merchant live-streaming and KOL live-streaming and found that manufacturers' choice of live-streaming mode is related to the commission rate of the streamer and the fixed signing bonus. He *et al.* 2024) discussed brands' choices of brand-owned or KOLs for short video marketing in e-commerce platforms, showing that high-influence and low-commission KOLs can bring in more profits. Yang *et al.* 2023) explored the influence of spillover effects and consumer acceptance on retailers' and manufacturers' choice of live-streaming channels, obtaining that manufacturers preferred live-streaming modes in which retailers collaborate with streamers. Xin *et al.* 2023) examined the impact of relevant parameters on brands' choice of three different live-streaming modes (self-live-streaming, KOL live-streaming-led hybrid streaming, and KOL live-streaming-led special streaming).

To differentiate from the existing literature, this paper further analyzes how return refund and returnless refund policies differently affect consumers and platforms under self-run and KOL live-streaming strategies, thereby expanding the research perspective on live-streaming strategies.

2.3. Return and Refund Policy

This paper is also closely related to e-commerce return and refund policies. Frei *et al.* 2020) provided a variety of solutions for e-commerce returns, and Chen *et al.* (2021) explored the availability of return shipping insurance under two sales models. Li *et al.* (2022) found that high-margin products need to be provided with a more lenient return policy under certain circumstances. Guo *et al.* 2017) studied the impact of rejection fraud in cross-border e-commerce on both buyers and sellers. Lin *et al.* 2023) compared three freight insurance models and found that providing return freight insurance can increase consumer surplus under certain circumstances. Based on this, Wang *et al.* 2024) compared three strategies involving platforms, consumers, and retailers, assuming the platform covers return shipping costs. They found that when platforms bear return shipping fees, consumers' willingness to purchase increases, generating higher profits for retailers. Additionally, Khouja & Hammami(2023) examined how cash refunds and store credit refunds affect opportunistic consumer behavior.

For return and refund in live-streaming commerce, Xu *et al.* 2023) devised a prediction framework to help platforms identify products with high return rates. Liu *et al.* 2024) demonstrated that return sensitivity motivates celebrities to lower their prices and improve their product quality in live-streaming. Further, Duan & Song(2024) demonstrated that consumer returns have a significant impact on live-streaming prices by considering product returns and impulse purchases under a single traditional channel, a single live-streaming channel, and a dual-channel. Huang *et al.* 2024) compared whether competing retailers introduce a live streaming channel when both retailers offer a full refund service. In addition to exploring the preferences of platforms and merchants for the mode of sale (resale or reseller) among the three different pricing strategies, it also considers the impact of consumer returns on live streaming.

Unlike previous studies on live-streaming returns, this paper incorporates "returnless refund" into the model, examines its impact on channel strategy, and highlights how the proportion of opportunists influences channel choice, thereby enriching research in this area.

In summary, this paper examines the interactions among streamers, consumers, brands, and platforms in live-streaming commerce. It explores how cooperation modes, streamer effort, return policies, and opportunistic behavior affect channel strategies and stakeholder outcomes, providing guidance for achieving win–win results in the supply chain. Table 1 shows the gap between this paper and the related literature.

Table 1. The gap between this paper and the related literature

Article	Live Streaming Channel Strategy Structure	Consumer Returns	Return Policy	Opportunistic Consumers	Win-Win Strategy
Wang & Zhang,(2022)	√				
Yang *et al.* 2023)	√	√			√
Khouja & Hammami(2023)		√	√	√	
(Hao & Yang, 2023)	√	√			√
Li *et al.* 2024)	√				

Article	Live Streaming Channel Strategy Structure	Consumer Returns	Return Policy	Opportunistic Consumers	Win-Win Strategy
(Duan & Song, 2024)	√	√			
This paper	√	√	√	√	√

3. MODEL SETTING AND NOTATIONS

Consider a brand selling a product through an online platform under the resale model, facing three choices of sales channels: traditional online sales (channel B), self-run live-streaming (channel S), or KOL live-streaming (channel K), as shown in Figure 1.

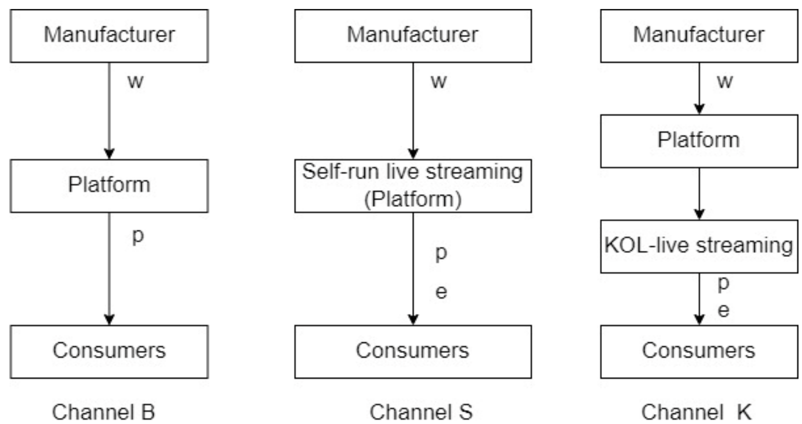

Figure 1. Three sales channel options for the Platform

The decision sequence is illustrated in Figure 2. As the leader in the Stackelberg game, the brand first determines the wholesale price w, then selects among the three sales channels. In the traditional online channel, the platform determines the retail price p. In the self-run live-streaming channel, the platform first sets the retail price p and then determines the employee's live-streaming effort e. In the KOL live-streaming channel, due to the KOL's strong influence and bargaining power, the platform and KOL jointly determine the retail price p, then the KOL determines the live-streaming effort e.

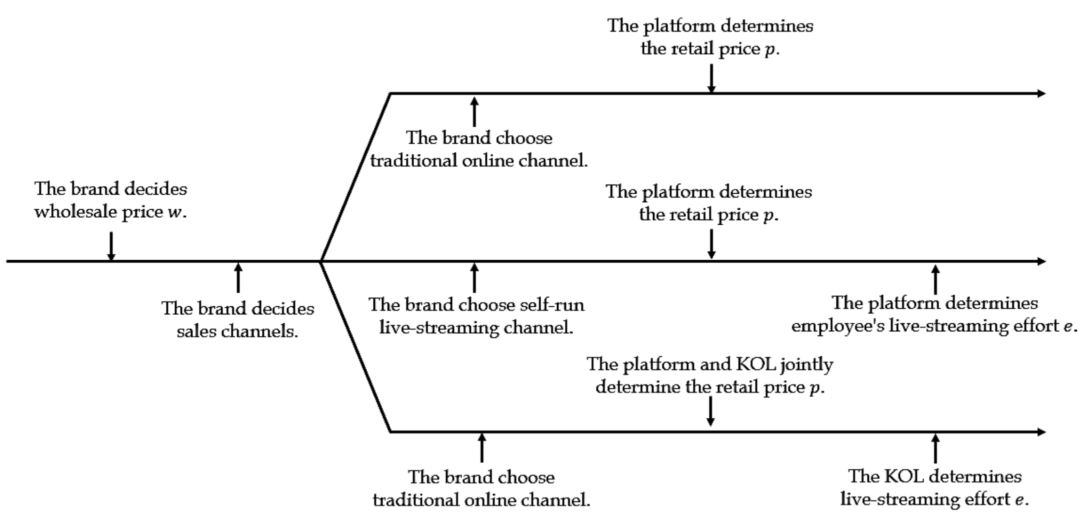

Figure 2. Supply chain decisions sequence

Assume that consumers' initial expectation of the product is $v(0 < v < 1)$, with a total market capacity of 1. Setting a as the consumer return rate, the probability of reserving the good is $1 - a$. Under return refund, the consumer utility of reserving the good is $v - p$. Consumers who return the good have to pay the return cost $h(0 < h < 1 - a)$, and they choose to return the good only if the return cost is lower than the satisfaction level(X. Guo *et al.*, 2024). Currently, consumer utility is $(1 - a)(v - p) - a(-p + p - h)$. Under returnless refund, a proportion ρ of opportunistic consumers among those who would return items cheat the refund using false information without returning the goods, while the remaining $1 - \rho$ are honest consumers who save on return costs under both refund and returnless refund. Thus, the utility of consumers under the returnless refund scenario is $(1 - a)(v - p) - a(1 - \rho)(-p + p) + a\rho(v - p + p)$.

In the live-streaming channel, the streamer attracts customers through promotional efforts, such as enhancing live room features or providing quality assurances e, to increase consumer utility. In KOL live-streaming, the celebrity effect and social benefits are represented by $\lambda(\lambda > 1)$, reflecting the influence of KOL live-streaming. As a result, the initial consumer utility in this channel is λv. Table 2 summarizes the symbols and their definitions.

Therefore, under "Return Refund" (RR), we express the utility functions for consumers under the three sales channels as follows:

$$U^{RR-B} = (1 - a)(v - p) - ah, \tag{1}$$

$$U^{RR-S} = (1 - a)(v - p) - ah + e, \tag{2}$$

$$U^{RR-K} = (1 - a)(\lambda v - p) - ah + e. \tag{3}$$

Under "Returnless Refund" (RL), the utility functions obtained by consumers under the three sales channels are shown below:

$$U^{RL-B} = (1 - a)(v - p) + a\rho v, \tag{4}$$

$$U^{RL-S} = (1 - a)(v - p) + a\rho v + e, \tag{5}$$

$$U^{RL-K} = (1 - a)(\lambda v - p) + a\rho\lambda v + e. \tag{6}$$

Table 2. Summary of Notations

Notations	Definition
Decision variables	
$\boldsymbol{w^i}$	Wholesale prices, $i \in \{\mathrm{RR-B, RR-S, RR-K, RL-B, RL-S, RL-K}\}$
$\boldsymbol{e^i}$	Live-streaming and quality assurance efforts, $i \in \{\mathrm{RR-B, RR-S, RR-K, RL-B, RL-S, RL-K}\}$
$\boldsymbol{p^i}$	Sales price, $i \in \{\mathrm{RR-B, RR-S, RR-K, RL-B, RL-S, RL-K}\}$
$\boldsymbol{U^i}$	Consumer utility, $i \in \{\mathrm{RR-B, RR-S, RR-K, RL-B, RL-S, RL-K}\}$
$\boldsymbol{d^i}$	Demand, $i \in \{\mathrm{RR-B, RR-S, RR-K, RL-B, RL-S, RL-K}\}$
$\boldsymbol{\Pi_j^i}$	Profit of j under channel i
Parameters	
$\boldsymbol{v}$	The initial utility of the product purchased by the consumer $(0 < v < 1)$
$\boldsymbol{\lambda}$	KOL Influence $(\lambda > 1)$
$\boldsymbol{a}$	Return rate of products ($0<a<1$)
$\boldsymbol{\rho}$	Proportion of opportunistic consumers ($0<\rho<1$)

Notations	Definition
$\boldsymbol{h}$	Consumer return costs($0 < h < 1 - a$)
$\boldsymbol{k}$	KOL live-streaming fixed shelf space charges ($k > 0$)
$\boldsymbol{\phi}$	KOL live-streaming sales commission rate ($0<\phi<1$)
$\boldsymbol{c}$	The cost of brand self-run live-streaming ($c > 0$)
$\boldsymbol{s}$	Salvage value of returned products ($0<s<w$)
Superscript	
$\boldsymbol{i}$	The platform's sales channel i, $i \in \{\mathrm{RR-B, RR-S, RR-K, RL-B, RL-S, RL-K}\}$
{RR, RL}	Return Policies. Return Refund and Returnless Refund
{B, S, K}	Brand's Sales Channel, traditional online sales, self-run live-streaming, and KOL live-streaming
Subscript	
$\boldsymbol{j}$	Supply chain subject j, $j \in \{\mathrm{M(brand), P(platform), K(KOL)}\}$

4. EQUILIBRIUM ANALYSIS UNDER RETURN REFUND

This section discusses the platform's three sales channel options under return and refund. When a consumer returns a product and pays the return cost, the merchant provides a full refund. RR-B in Section 4.1 is to denote traditional online sales, and RR-S and RR-K in Sections 4.2 and 4.3 denote self-run live-streaming and KOL live-streaming, respectively.

4.1. Channels(RR-B) - Traditional Online Channels

Equation (1) defines the market demand in the traditional online channel:

$$d^{RR-B} = \frac{1 - a - ah - p + ap}{1 - a}. \tag{7}$$

The profit function of brands and platforms is as follows:

$$\Pi_M^{RR-B}(w) = wd^{RR-B}, \tag{8}$$

$$\Pi_P^{RR-B}(p) = (1 - a)d^{RR-B}p - wd^{RR-B} + sad^{RR-B}. \tag{9}$$

The platform's profit includes the salvage value of returned goods and the sales revenue after accounting for the wholesale cost.

Lemma 1. *In the RR-B model, the equilibrium solutions and profits are:*

$w^{RR-B*} = \frac{1}{2}\big(1 + a(-1 - h + s)\big)$, $p^{RR-B*} = \frac{-3+a(3+3h+s)}{4(-1+a)}$, $d^{RR-B*} = \frac{-1+a(1+h-s)}{4(-1+a)}$, $\Pi_M^{RR-B*} = \frac{\big(-1+a(1+h-s)\big)^2}{8(1-a)}$, *and* $\Pi_P^{RR-B*} = \frac{\big(-1+a(1+h-s)\big)^2}{16(1-a)}$.

4.2. Channel (RR-S) - Self-run live-streaming

When the platform chooses self-run live-streaming, the platform expends the cost c. When the consumer returns the product, the platform obtains the salvage s of the returned goods.

From Equation (2), the demand is as:

$$d^{RR-S} = \frac{1-a+e-ah}{1-a} - p. \tag{10}$$

Brand profit and platform profit are:

$$\Pi_M^{RR-S}(w) = wd^{RR-S}, \tag{11}$$

$$\Pi_P^{RR-S}(p,e) = (1-a)d^{RR-S}p - wd^{RR-S} - c + sad^{RR-S} - e^2/2. \tag{12}$$

Platform profits are gained based on the RR-B structure, after subtracting self-broadcast costs and live-streaming effort costs.

Lemma 2. *In the RR-S model, the equilibrium solutions and profits are:*

$w^{RR-S^*} = \frac{1}{2}\big(1 + a(-1-h+s)\big)$, $p^{RR-S^*} = \frac{2+a(-5-2h+a(3+3h+s))}{2-6a+4a^2}$, $e^{RR-S^*} = \frac{-1+a(1+h-s)}{-2+4a}$, $d^{RR-S^*} = \frac{-1+a(1+h-s)}{-2+4a}$, $\Pi_M^{RR-S^*} = \frac{(-1+a(1+h-s))^2}{4-8a}$ *and* $\Pi_P^{RR-S^*} = \frac{1-8c+a^2(1+h-s)^2+2a(-1+8c-h+s)}{8-16a}$.

4.3. Channel (RR-K) - KOL live-streaming

The platform needs to pay shelf space charges $k(k>0)$ and a percentage $\phi(0<\phi<1)$ of sales when hiring a KOL. From Equation (3), we can get the market demand is:

$$d^{RR-K} = \frac{e-ah-p+ap+\lambda-a\lambda}{(1-a)\lambda}. \tag{13}$$

Platform profit is the profit from sales minus the cost of hiring KOL, including influencer commissions and fixed shelf space charges. In this scenario, KOL pays the cost of live streaming efforts. The profit for the brand, the platform, and the KOL is:

$$\Pi_M^{RR-K}(w) = wd^{RR-K}, \tag{14}$$

$$\Pi_P^{RR-K} = (1-a)d^{RR-K}p - \phi d^{RR-K}p - wd^{RR-K} + sad^{RR-K} - k\,, \tag{15}$$

$$\Pi_k^{RR-K}(p,e) = \phi d^{RR-K}p + k - \frac{e^2}{2}. \tag{16}$$

Lemma 3. *In the RR-K model, the equilibrium results are as follows:*

$$w^{RR-K^*} = \frac{1}{2}\big(\lambda - a(h-s+\lambda)\big), p^{RR-K^*} = \frac{a(h+s)+(-1+a)(1+a(3h+s))\lambda+3(-1+a)^2\lambda^2}{2(-1+a+2(-1+a)^2\lambda)},$$

$e^{RR-K^*} = \frac{-\lambda+a(h-s+\lambda)}{2+4(-1+a)\lambda}$ *and* $d^{RR-K^*} = \frac{-\lambda+a(h-s+\lambda)}{2+4(-1+a)\lambda}$.

Substituting the equilibrium solution into the profit function will get the profit of the platform and the brand.

4.4. Channel Strategy Options under Return Refund

This subsection compares the optimal equilibrium solutions and profits of the three channels under return refund, observing the brand's and platform's optimal channel selection strategies.

4.4.1. Comparative Analysis of Equilibrium Solutions

Proposition 1. (1) *Among three sales channels, KOL live-streaming had the highest wholesale price* w^{RR-K^*} *for brands.*
(2) *When* $0 < a < \frac{(6-h-\sqrt{-24+(-6+h-s)^2}+s)}{12}$, $p^{RR-K^*} > p^{RR-S^*} > p^{RR-B^*}$. *When* $\frac{(6-h-\sqrt{-24+(-6+h-s)^2}+s)}{12} < a < \frac{1}{2}$, *if* $1 < \lambda < \frac{2-3a-ah+as}{3(1-3a+2a^2)}$, $p^{RR-S^*} > p^{RR-K^*} > p^{RR-B^*}$, *if* $\lambda > \frac{2-3a-ah+as}{3(1-3a+2a^2)}$, $p^{RR-K^*} > p^{RR-S^*} > p^{RR-B^*}$.
(3) *When* $1 < \lambda < \frac{-3+2a}{-2+2a}, 0 < s < \frac{-1+a+ah}{-2+a}$, $d^{RR-S^*} > d^{RR-K^*} > d^{RR-B^*}$. *When* $\lambda > \frac{-1-a+a^2}{-a+a^2}, 0 < h < \frac{1-2a^2+a^3-a\lambda+2a^2\lambda-a^3\lambda}{3a-2a^2-2a\lambda+2a^2\lambda}$, *if* $0 < s < h + \frac{-1+a}{a(3+2a(-1+\lambda)-2\lambda)}$, $d^{RR-S^*} > d^{RR-K^*} > d^{RR-B^*}$, *if* $h + \frac{-1+a}{a(3+2a(-1+\lambda)-2\lambda)} < s < \frac{-1+a+ah}{-2+a}$, $d^{RR-S^*} > d^{RR-B^*} > d^{RR-K^*}$. *Under return refund,* $e^{RR-S^*} > e^{RR-K^*}$, *self-run live-streaming effort is always larger than a KOL live-streaming.*

In KOL live-streaming, brands can achieve higher profits with KOL's influence while increasing wholesale prices. In Proposition 1 (2), the KOL live-streaming price is highest when the return rate a is small, or when the return rate a and λ are also higher. The self-run live-streaming price is highest when the return rate a is higher but λ is lower. When a is small, consumers tend to keep the product, and higher prices can bring higher profits. When a and λ are large, KOL's strong influence can bring higher profits despite higher prices. When a is large and λ is small, the platform faces high return losses and must pay commissions to KOL. To offset this, it lowers the price to boost sales, reduces the return rate, and cuts commission expenses. Proposition 1 (3) shows that high demand coincides with a high return rate when either both KOL live-streaming influence and salvage value are low, or influence is high while return cost is low and salvage value remains low. In response, the platform raises prices and takes other measures to reduce returns, resulting in lower demand for KOL live-streaming compared to self-run live-streaming. When KOL has higher influence, low return cost, and high salvage value (high-value goods), the return cost has less impact on consumer decisions. KOL's strong influence does not significantly drive short-term purchases, leading to higher demand in non-live-streaming scenarios instead.

4.4.2. Optimal Channel Strategy

Proposition 2. *When* $1 < \lambda < \lambda_1$, $\Pi_M^{RR-S^*} > \Pi_M^{RR-K^*} > \Pi_M^{RR-B^*}$, *when* $\lambda > \lambda_1$, $\Pi_M^{RR-K^*} > \Pi_M^{RR-S^*} > \Pi_M^{RR-B^*}$, $\lambda_1 = \frac{1-a-2ah+2a^2h^2+2as-4a^2hs+2a^2s^2}{1-3a+2a^2}$.

Brands are more likely to choose KOL live-streaming when KOL's influence is high enough. Brands' profits in the live-streaming channel are consistently higher than in the traditional online channel.

Proposition 3.
(1). *When* $0 < c < c_1$, $\Pi_P^{RR-S^*} > \Pi_P^{RR-B^*}$, *and when* $c > c_1$, $\Pi_P^{RR-B^*} > \Pi_P^{RR-S^*}$. *When* $0 < k < k_1$ *and* $0 < \phi < \phi_1$, $\Pi_P^{RR-K^*} > \Pi_P^{RR-B^*}$, *when* $0 < k < k_1$ *and* $\phi_1 < \phi < 1$ *or* $k > k_1$, $\Pi_P^{RR-K^*} < \Pi_P^{RR-B^*}$. *(See appendix for* c_1, k_1, ϕ_1*)*
(2). *When KOL influence is moderate, the platform prefers self-run live-streaming when the cost of self-run live-streaming* c *is small, and no live-streaming when* c *is large. When KOL's influence* λ *is small or particularly large, the platform prefers live-streaming channels: if* c *is small, the platform chooses self-run live-streaming; when* c *exceeds a certain threshold, it chooses KOL live-streaming.*

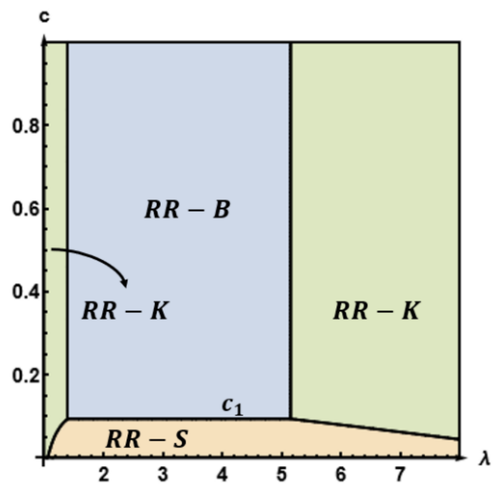

Figure 3. Platform's sales channel strategy choice under return refund
$(a = 0.25, h = 0.2, s = 0.2, k = 0.1, \phi = 0.15)$

From Proposition 3 (1), we find that the platform prefers KOL live-streaming when the shelf space charges and profit sharing paid to KOL are small; otherwise, it prefers no live-streaming channel. As shown in Figure 3, self-run live-streaming yields higher profits for the platform only when its cost is low; otherwise, the platform favors small or top KOLs for live-streaming. If KOL has moderate influence and the cost of self-run live-streaming is high, the platform will not choose live-streaming.

4.4.3. Win-Win Channel Strategy

Proposition 4. *When KOL's influence is small and the cost of self-run live-streaming is low, brands and platforms will choose self-run live-streaming. When KOL is more influential, and the cost of self-run live-streaming is high, brands and platforms will choose KOL live-streaming.*

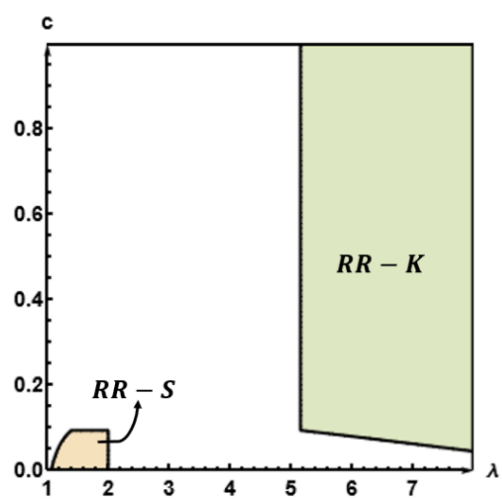

Figure 4. Win-win strategy options for brands and platforms under return and refund
$(a = 0.25, h = 0.2, s = 0.2, k = 0.1, \phi = 0.15)$

Figure 4 shows that brands and platforms cannot achieve agreement on the traditional online channel. When KOL's influence is small and self-run live-streaming costs are low, brands and platforms prefer platform self-run live-streaming. When KOL is more influential, and the cost of self-run live-streaming is high, both brands and platforms achieve higher profits in KOL live-streaming.

5. EQUILIBRIUM ANALYSIS UNDER RETURNLESS REFUND

This section explores three sales channel options under returnless refund. Consumers do not need to send back the product when they return it, and the merchant refunds the full amount after the application is approved. Section 5.1 uses RL-B to denote traditional online sales, while Sections 5.2 and 5.3 use RL-S and RL-K to denote self-run live-streaming and KOL live-streaming channels, respectively.

5.1. Channels (RL-B) - Traditional Online Channels

The demand function for the traditional online channel can be obtained from Equation (4) is as follows:

$$d^{RL-B} = 1 + \frac{(-1+a)p}{1+a(-1+\rho)} \tag{17}$$

The profit function for brands and platforms is as follows. Compared to the platform profit in RR-B, the platform now loses a proportion ρ of the salvage value from returns.

$$\Pi_M^{RL-B}(w) = wd^{RL-B} \tag{18}$$

$$\Pi_P^{RL-B}(p) = (1-a)d^{RL-B}p - wd^{RL-B} + sad^{RL-B}(1-\rho) \tag{19}$$

Lemma 4. *In RL-B, the equilibrium solutions are:*
$w^{RL-B*} = \frac{1}{2}\big(1+a(-1+s+\rho-s\rho)\big), p^{RL-B*} = -\frac{3+a(3+s)(-1+\rho)}{4(-1+a)},\ d^{RL-B*} = \frac{1+a(-1+s+\rho-s\rho)}{4+4a(-1+\rho)},$
$\Pi_M^{RL-B*} = \frac{(-1+a(-1+s)(-1+\rho))^2}{8+8a(-1+\rho)}$ *and* $\Pi_P^{RL-B*} = \frac{\big(-1+a(-1+s)(-1+\rho)\big)^2}{16\big(1+a(-1+\rho)\big)}$.

5.2. Channel (RL-S) - Self-Run Live-streaming

Under returnless refund, the platform receives salvage s only if $a(1-\rho)$ portion of consumers choose to return the product.
From Equation (5), the demand is as:

$$d^{RL-S} = 1 + \frac{e+(-1+a)p}{1+a(-1+\rho)} \tag{20}$$

Brand and platform profits for:

$$\Pi_M^{\mathrm{RL-S}}(w) = wd^{RL-S} \tag{21}$$

$$\Pi_P^{\mathrm{RL-S}}(p,e) = (1-a)d^{RL-S}p - wd^{RL-S} - c + sa(1-\rho)d^{RL-S} - e^2/2 \tag{22}$$

Platform profits can be gained based on the RL-B structure, after subtracting self-broadcast costs and live-streaming effort costs.

Lemma 5. *In RL-S, the equilibrium solutions are:*
$w^{RL-S^*} = \frac{1}{2}\left(1 + a(-1 + s + \rho - s\rho)\right), p^{RL-S^*} = \frac{2+a(5+a(3+s)(-1+\rho))(-1+\rho)}{2(1-a)(1+2a(-1+\rho))},\ e^{RL-S^*} = \frac{1+a(-1+s+\rho-s\rho)}{2+4a(-1+\rho)},$
$d^{RL-S^*} = \frac{1+a(-1+s+\rho-s\rho)}{2+4a(-1+\rho)},\ \Pi_M^{RL-S^*} = \frac{(-1+a(-1+s)(-1+\rho))^2}{4+8a(-1+\rho)}$ *and* $\Pi_P^{RL-S^*} = \frac{1-8c+a(-2(-1+8c+s)+a(-1+s)^2(-1+\rho))(-1+\rho)}{8+16a(-1+\rho)}.$

5.3. Channel (RL-K) - KOL Live-streaming

We can obtain the market demand from Equation (6):

$$d^{RL-K} = 1 + \frac{e + (-1 + a)p}{\lambda + a\lambda(-1 + \rho)} \tag{23}$$

Brands, platforms, and KOL profits for:

$$\pi_M^{\mathrm{RL-K}}(w) = wd^{RL-K} \tag{24}$$

$$\Pi_P^{\mathrm{RL-K}} = (1 - a)d^{RL-K}p - \phi d^{RL-K}p - wd^{RL-K} + sa(1 - \rho)d^{RL-K} - k \tag{25}$$

$$\Pi_K^{\mathrm{RL-K}}(p, e) = \phi d^{RL-K}p + k - \frac{e^2}{2} \tag{26}$$

Similarly, in this scenario, the platform bears the commission split and shelf space charges for hiring the KOL. KOL contributes live-streaming effort costs.

Lemma 6: *In RL-B, the equilibrium solutions are:*
$w^{RL-K^*} = \frac{1}{2}\left(\lambda - a(s - \lambda)(-1 + \rho)\right), p^{RL-K^*} = -\frac{\lambda(-1+3\lambda)+a(s(-1+\lambda)+\lambda(-1+6\lambda))(-1+\rho)+a^2\lambda(s+3\lambda)(-1+\rho)^2}{2(-1+a)(-1+2\lambda(1+a(-1+\rho)))},$
$e^{RL-K^*} = \frac{\lambda-a(s-\lambda)(-1+\rho)}{-2+4\lambda(1+a(-1+\rho))}$ *and* $d^{RL-K^*} = \frac{\lambda-a(s-\lambda)(-1+\rho)}{-2+4\lambda(1+a(-1+\rho))}.$

Substituting the equilibrium solution into the profit function gives the profits of the platform and the brand.

5.4. Channel Strategy Options for Returnless refund

This subsection compares the optimal equilibrium solutions and profits under three channels under returnless refund and observes the optimal channel strategies of brands as well as platforms.

5.4.1. Comparative Analysis of Equilibrium Solutions

Proposition 5.

(1). $w^{RL-K^*} > w^{RL-S^*} = w^{RL-B^*}$.

(2). *When* $0 < \rho < \rho_1$ *or* $\rho_2 < \rho < 1$, *if* $0 < a < a_1$ *or* $a_1 < a < a_2$ *and* $\lambda > \lambda_2$ *or* $a_2 < a < 1$, $p^{RL-K^*} > p^{RL-S^*} > p^{RL-B^*}$, *and if* $a_1 < a < a_2$ *and* $1 < \lambda < \lambda_2$, $p^{RL-S^*} > p^{RL-K^*} > p^{RL-B^*}$. *And when* $\rho_1 < \rho < \rho_2$, *if* $0 < a < a_1$ *or* $a_1 < a < 1$ *and* $\lambda > \lambda_2$, $p^{RL-K^*} > p^{RL-S^*} > p^{RL-B^*}$, *if* $a_1 < a < 1$ *and* $1 < \lambda < \lambda_2$, $p^{RL-S^*} > p^{RL-K^*} > p^{RL-B^*}$. *(See appendix for* $\rho_1, \rho_2, a_1, a_2, \lambda_2$*)*

(3). *When* $0 < \lambda < \frac{1}{2}(2 + \frac{1}{1+a(-1+\rho)} + \frac{1}{as-as\rho})$, $d^{RL-S^*} > d^{RL-K^*} > d^{RL-B^*}$. *When* $\lambda > \frac{1}{2}(2 + \frac{1}{1+a(-1+\rho)} + \frac{1}{as-as\rho})$, $d^{RL-S^*} > d^{RL-B^*} > d^{RL-K^*}$.

The wholesale price of the KOL live-streaming channel is still the highest under returnless refund. Proposition 5 (2) shows that the KOL live-streaming price is highest when the proportion of opportunists is small or large, and the return rate is exceptionally low or extremely high, or when the return rate is moderate, and the KOL's influence is strong. The self-run live-streaming price is the highest when the return rate is moderate and the KOL's influence is low. When the proportion of opportunists is moderate, the KOL live-streaming price is the highest if the return rate is low or if the return rate is high and the KOL's influence is high. If the return rate is high and the KOL's influence is low, the price of self-run live-streaming is highest. Overall, when the return rate is high, and the influence of KOL is small, the platform will lower the price of KOL to attract more consumers while reducing commission and return losses. At the same time, self-run live-streaming can achieve higher profits while maintaining higher prices by optimizing the process or controlling costs. With both a high rate of returns and a high share of opportunities, KOL live-streaming sets higher prices to reduce demand to control the higher costs of returns and live-streaming. Proposition 5 (3) indicates that market demand is consistently high for the self-run streaming channel. When the KOL's influence is low, demand for the KOL live-streaming channel exceeds that of the traditional channel. However, once the KOL's influence surpasses a certain threshold, prices rise, making the KOL's live-streaming channel the least demanded.

5.4.2. The optimal channel strategies

Proposition 6. *When* $1 < \lambda < s^2 - \frac{2s(1+s)}{1+a(-1+\rho)} + \frac{(1+s)^2}{1+2a(-1+\rho)}$, $\Pi_M^{RL-S^*} > \Pi_M^{RL-K^*} > \Pi_M^{RL-B^*}$, *when* $\lambda > s^2 - \frac{2s(1+s)}{1+a(-1+\rho)} + \frac{(1+s)^2}{1+2a(-1+\rho)}$, $\Pi_M^{RL-K^*} > \Pi_M^{RL-S^*} > \Pi_M^{RL-B^*}$.

Like the results of Proposition 2, brands are consistently more profitable in the live-streaming channel. Brands prefer KOL live-streaming when KOL's influence is high enough.

Proposition 7. *When* $0 < c < c_2$, $\Pi_P^{RL-S^*} > \Pi_P^{RL-B^*}$, *when* $c > c_2$, $\Pi_P^{RL-B^*} > \Pi_P^{RL-S^*}$. *When* $0 < k < k_2$ *and* $0 < \phi < \phi_2$, $\Pi_P^{RL-K^*} > \Pi_P^{RL-B^*}$, *when* $k > k_2$ *and* $0 < \phi < \phi_2$ *or* $\phi_2 < \phi < 1$, $\Pi_P^{RL-K^*} < \Pi_P^{RL-B^*}$. *(See appendix for* c_2, k_2, ϕ_2*).*

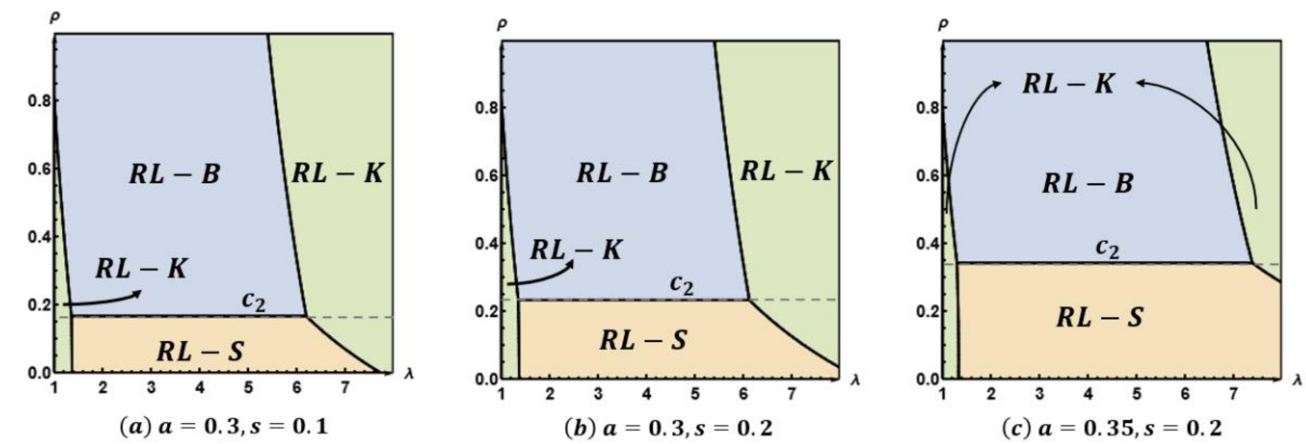

Figure 5. Channel strategy choices of platforms under return and returnless refund
$(c = 0.1, k = 0.1, \phi = 0.15)$

Under returnless refund, compared to traditional online channels, platforms choose self-run live-streaming when its cost is small, and choose KOL live-streaming when the shelf space charges and share ratio are low. As shown in Figure 5, when the proportion of opportunists is low and the KOL's influence is either small or large, the platform chooses KOL live-streaming; otherwise, it chooses self-run live-streaming. At this time, the loss caused by opportunists is slight. When KOL's influence is exceedingly small or enormous, the high price of the KOL channel yields greater profits. However, when the influence is medium, the platform prefers the self-run live-streaming channel, which has low cost and higher demand and price. When the proportion of opportunists is medium or high, the platform must bear both the return loss and the cost of live-streaming in the live-streaming channel. Only when KOL's influence is particularly high can it offset these dual losses; otherwise, the platform chooses the more secure traditional online channel. Comparing (a), (b), and (b), (c), the probability of choosing KOL live-streaming decreases as the salvage value and the return rate increase. The increase in the return rate exacerbates the platform's loss in KOL live-streaming and reduces the attractiveness of KOL live-streaming.

5.4.3. Win-Win Channel Strategy

Proposition 8. *The win-win areas for brands and platforms in the live channel are shown in Figure 6.*

From Figure 6(a), when the influence of KOL and the proportion of opportunists are small, brands and platforms prefer self-run live-streaming due to its low cost and stable profit. When KOL influence is exceptionally high, both parties choose KOL live-streaming. Contrasting (a) and (b), an increase in the return rate causes both parties to prefer self-run live-streaming. Comparing (a) and (c), when the KOL commission rate is low, and KOL's influence is weak, a high proportion of opportunists still leads to substantial return losses. However, the reduced commission rate sufficiently eases cost pressures, allowing both parties to achieve a win-win outcome in KOL live-streaming.

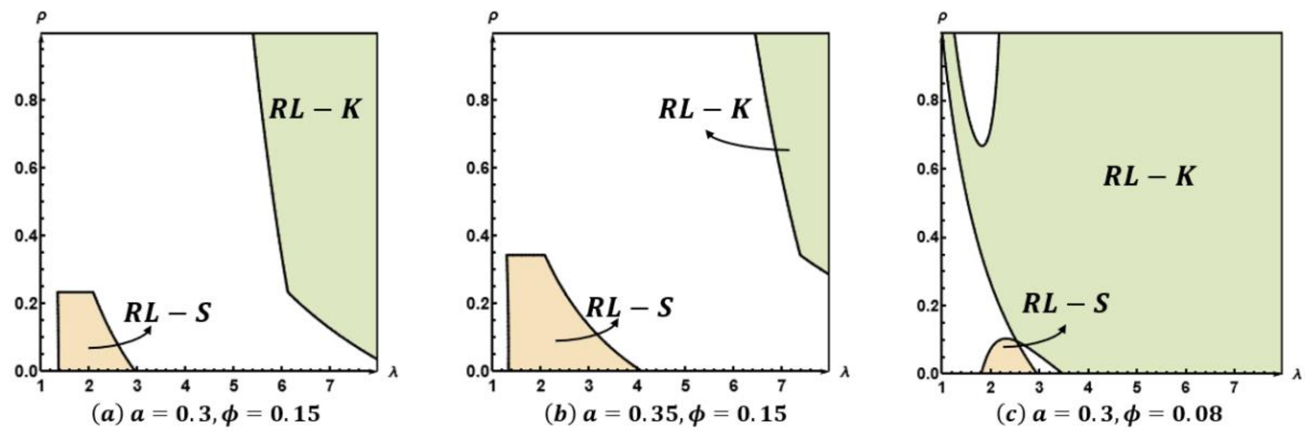

Figure 6. Win-win strategy choices for brands and platforms under returnless refund
$(c = 0.1, s = 0.2, k = 0.1)$

6. NUMERICAL ANALYSIS

This section employs numerical analysis to compare the equilibrium solutions across the six channels and investigate the preferences of brands, platforms, and KOLs for each channel.

6.1. Equilibrium Solution Analysis

Proposition 9. $w^{RL-K^*} > w^{RR-K^*}, w^{RL-S^*} > w^{RR-S^*}$, *the wholesale price of returnless refund is higher than return refund under both live-streaming channels, and the wholesale price of KOL live-streaming is the highest under returnless refund.*

Proposition 1 and Proposition 5 show that under the same return policy, the wholesale price for KOL live-streams is always the highest. Comparing wholesale prices across different return policies reveals: the wholesale price under the returnless refund policy is always higher than return refund policies, and the wholesale price for KOL live-streams under the returnless refund policy is consistently the highest, regardless of the KOL's influence level, as shown in Figure 7.

Observation 1. *The price of returnless refund is always higher than the return refund on each channel.*

The price of returnless refund is always higher than the return refund on each channel. When KOL has less influence, and the proportion of opportunists is low, platforms are more confident in profiting from soaring prices in self-run live-streaming. As the share of opportunities increases, returnless refunds have the highest prices in KOL live-streaming channels. When KOL influence increases, KOL live-streaming prices are highest under both policies, as shown in Figure 8.

Observation 2. *Under the returnless refund, demand for the self-run live-streaming channel is highest when the percentage of opportunists is exceptionally low. As this percentage increases, the self-run live-streaming channel under returnless refund continues to have the highest demand, as it is unaffected by opportunists.*

Figure 9 shows that when the proportion of opportunists is small, high streaming effort in self-run live-streaming can lead to higher demand. Furthermore, when the influence of KOL increases, the demand for self-run live-streaming and traditional channels remains unchanged, while the price of the KOL live-streaming channel increases, resulting in lower demand.

Observation 3. *Under a returnless refund policy, as the proportion of opportunists increases, KOLs will reduce their live-streaming efforts. The effort of the KOL channel significantly decreases when the influence of the KOL increases.*

As shown in Figure 10, if there are more normal purchasing customers, KOL can get more commissions by increasing the effort, while when there are more opportunists, KOL's live-streaming effort will decrease.

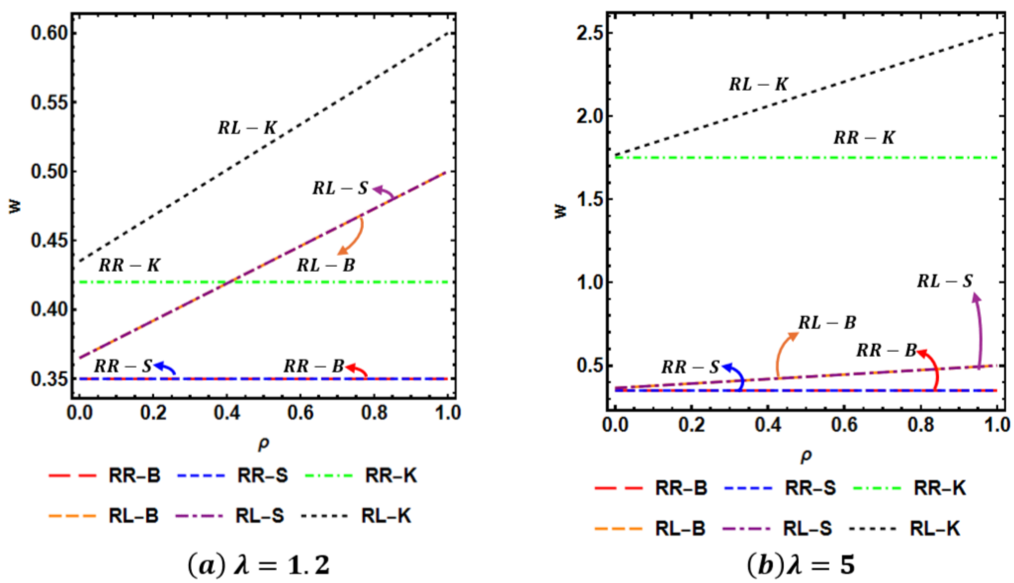

Figure 7. Effect of KOL influence λ on wholesale price w $(a = 0.3, s = 0.1, h = 0.1)$

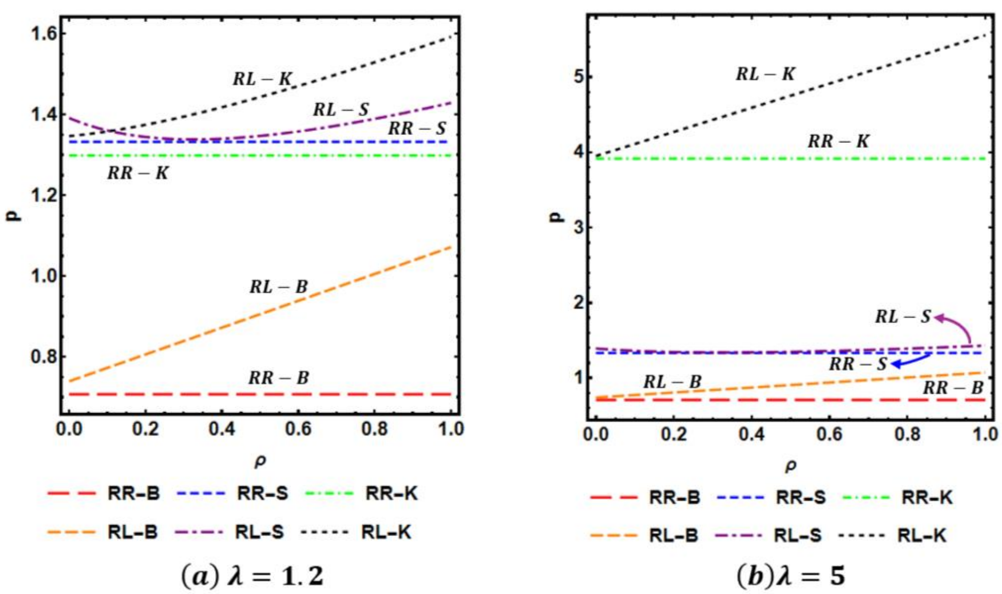

Figure 8. Effect of KOL influence λ on retail price p $(a = 0.3, s = 0.1, h = 0.1)$

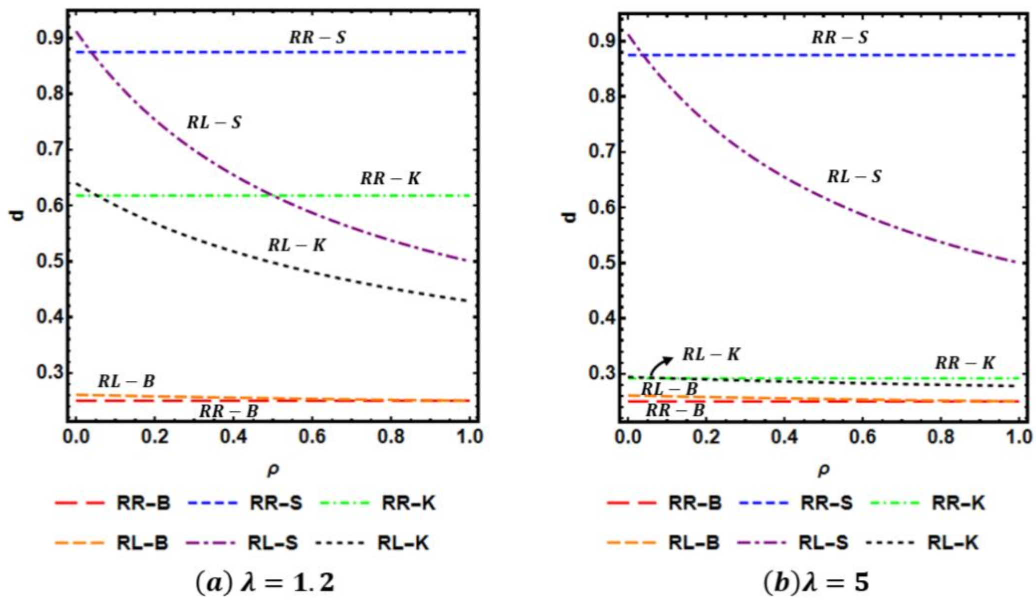

Figure 9. Impact of KOL influence λ on demand d $(a = 0.3, s = 0.1, h = 0.1)$

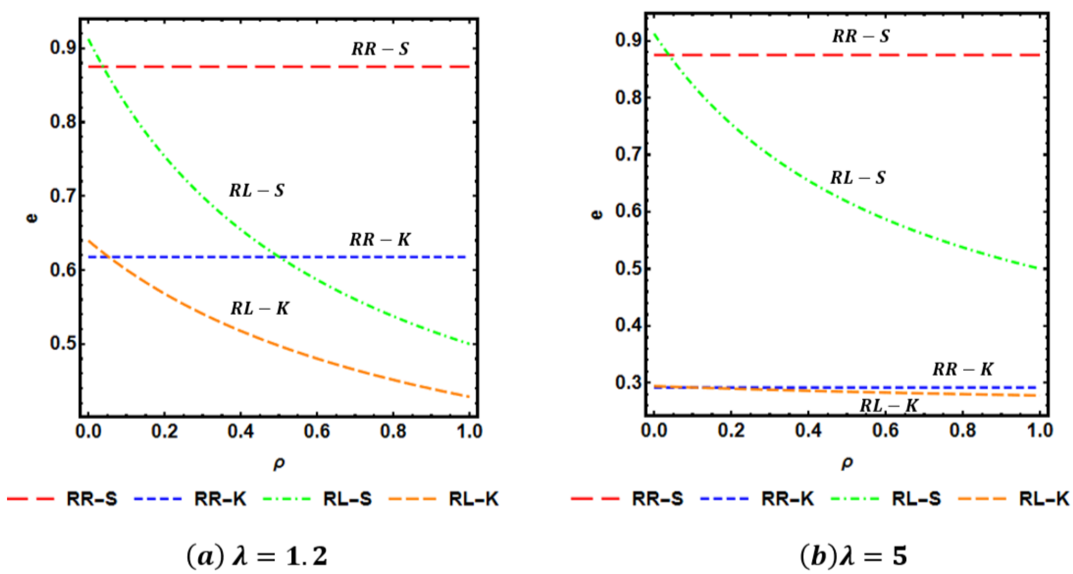

Figure 10. Effect of KOL influence λ on effort e $(a = 0.3, s = 0.1, h = 0.1)$

6.2. All Channel Strategy

6.2.1. Brand's All-Channel Strategies

In Figure 11, brands do not choose KOL live-streaming under a return or refund. Figure 11(a) shows that when the percentage of opportunists is low, brands prefer a returnless refund policy with a higher wholesale price and choose between self-run or KOL live-streaming depending on the KOL's influence. With the increase in opportunists, the demand for self-run live-streaming with a returnless refund decreases dramatically. Then, if KOL's influence is low, brands prefer self-run live-streaming under return refund, and when influence is high, they prefer KOL live-streaming with return refund. Comparing Figure 11(a) and (b), the increase in return rate leads to an increase in opportunists, and brands prefer self-run live-streaming with a return refund. In contrast (a)(c), increased return costs make returnless refunds more attractive. Compare (a) and (d), as salvage increases, the demand under return refund stabilizes, and brands prefer self-run live-streaming under return refund.

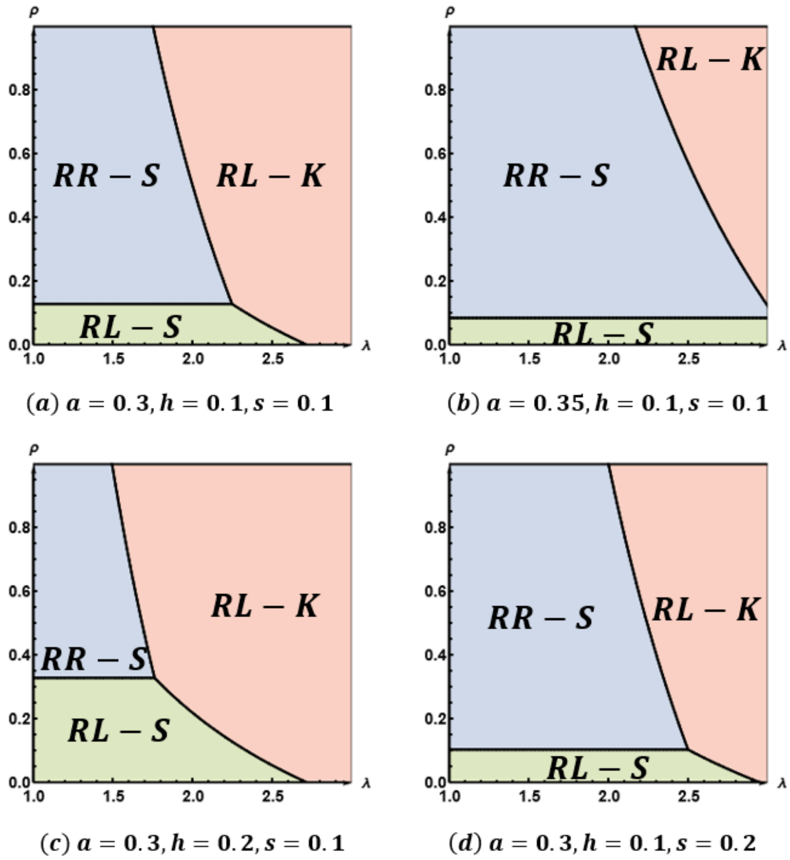

Figure 11. Brand All Channel Strategies

6.2.2. Platform's All Channel Strategy

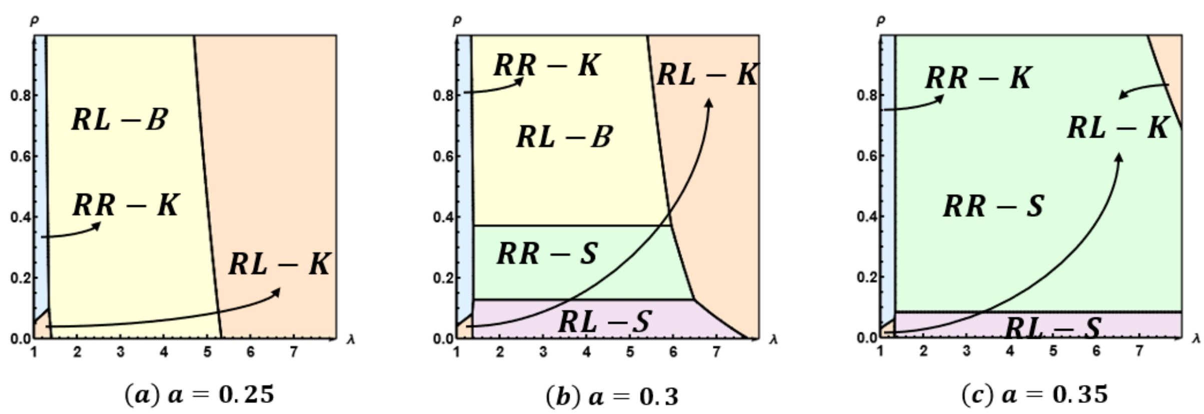

Figure 12. Platform All Channel Strategies

$(s = 0.1, k = 0.1, h = 0.1, \phi = 0.15, c = 0.1)$

In Figure 12, platforms choose different return policies and sales channels for different return rates, but the traditional online channel for return refund is never the best choice. When the return rate is low (Figure 12 (a)), platforms favor returnless refund. Only when KOL is less influential, and the proportion of opportunists is not too small, will the decrease in demand and loss of malicious refunds cause platforms to turn to KOL live-streaming to return refunds to maintain revenue.

Platform preferences are more complex when the return rate increases in Figure 12 (b). The platform always chooses KOL live-streaming when the influence of KOL is small, prefers returnless refund when the percentage of opportunists is small, and prefers return refund when the percentage is significant. As KOL's influence increases, platforms choose self-run live-streaming under returnless refund when the percentage of opportunists is small, choose self-run live-streaming under return refund when the percentage is medium, and choose traditional online channels under returnless refund when the percentage is significant. When the percentage of opportunists is small, platforms pay low KOL commissions and face minimal return losses. They can profit from the high price of self-run live-streaming with a returnless refund. When the percentage increases, the higher returnless refund price offsets losses but reduces demand. KOL influence is insufficient to boost profits, so platforms switch to self-run live-streaming with a return refund. When the percentage is remarkably high, high return losses and extra live-streaming costs make it unprofitable. The traditional online channel becomes the optimal choice, as higher prices compensate for the loss of goods. KOL live-streaming under a returnless refund is optimal when KOL's influence exceeds a certain threshold. When return rates are high (Figure 12(c)), higher return losses force live-streaming channels under returnless refunds to raise prices, which further reduces demand. As a result, platforms prefer self-run live-streaming under a return refund, which offers higher prices and more stable demand.

6.2.3. KOL's Return Policy Strategy

As shown in Figure 13, KOLs prefer returnless refund in most cases, and only prefer return refund when their influence is low, and the proportion of opportunists is tiny. This is because KOLs with low influence need to invest more effort to attract consumers, and a return refund is more cost-advantageous when there are very few false returns. With increased return costs and lower commission rates, the area where KOLs choose return refunds will increase.

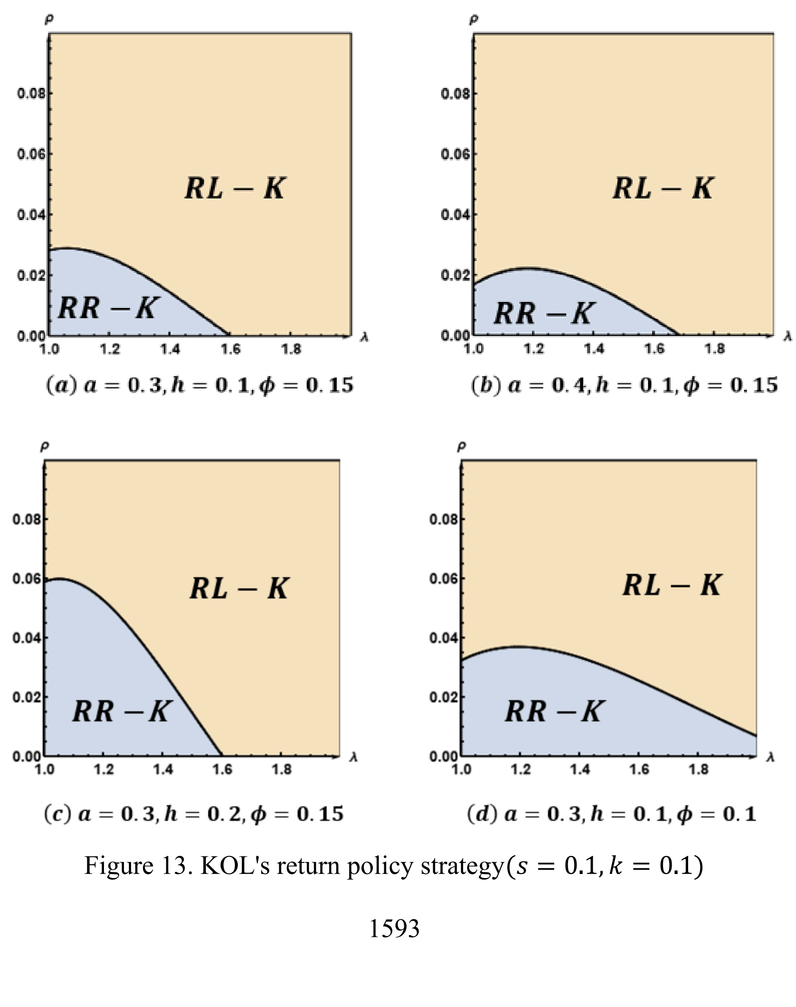

Figure 13. KOL's return policy strategy($s = 0.1, k = 0.1$)

6.2.4. Win-Win Strategies

The win-win area for platforms, brands, and KOL streamers is shown in Figure 14:

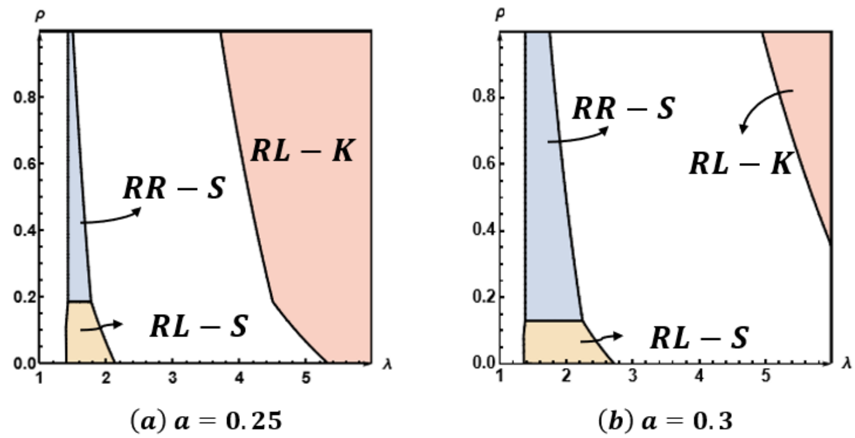

Figure 14. A Win-win strategy for brands, platforms, and KOL streamers
$(s = 0.1, k = 0.1, h = 0.1, \phi = 0.15, c = 0.1)$

In Figure 14, platforms and brands prefer self-run live-streaming when a KOL's influence is small. When the proportion of opportunists is small, self-run live-streaming under returnless refund can generate higher revenues for platforms and brands through soaring prices and high demand. With the percentage of opportunists increasing, higher prices lead to lower demand and higher returns and refund losses, making both parties more inclined to self-run live-streaming under return refund. Furthermore, when the influence of KOL is exceptionally high, KOL live-streaming under returnless refund can achieve the triple win.

7. CONCLUSIONS AND FUTURE RESEARCH

This paper explores how brands and platforms make choices between traditional online, self-run live-streaming, and KOL live-streaming channels under the resale model with returnless refund and return refund. Unlike previous literature, this study integrates the celebrity effect, the influence of opportunists, the cost of live-streaming, commission rates, and the cost of consumer returns. By constructing six-channel models (RR-B, RR-S, RR-K, RL-B, RL-S, RL-K), we analyzed wholesale prices, selling prices, market demand, live-streaming efforts, and profits to explore each subject's channel and policy preferences under different conditions. This provides important managerial insights for supply chain decision-making in e-live-streaming commerce.

7.1. Conclusion

Regardless of the return policy, the wholesale price of KOL live-streaming channels is always higher. For platforms, live-streaming channel prices are always higher than those of traditional online channels. Prices for self-run and KOL live-streaming are influenced by the return rate and the KOL's influence. Under return refund, KOL live-streaming prices are highest when the return rate is low, or when the return rate is high, and the KOL's influence is strong. Self-run live-streaming prices are highest when the return rate is high, and the KOL's influence is weak. Under a returnless refund, the price is also influenced by the percentage of opportunists. With a moderate percentage, the platform's pricing strategy is like a return refund scenario. When the percentage is low or high, KOL live-streaming has the highest price if the return rate is incredibly low or remarkably high, or if the return rate is moderate and the KOL's influence is strong. Self-run live-streaming has the highest price if the return rate is moderate and the KOL's influence is weak. In addition, the pricing of brands and platforms is higher under a returnless refund.

In channel strategy selection, brands prefer the KOL live-streaming channel, with their specific choice depending on the KOL's influence. Under return refund, the platform prefers live-streaming channels when the KOL's influence is low or high, choosing KOL live-streaming if self-run streaming costs are high. When the KOL's influence is moderate, the platform does not choose KOL live-streaming. Moreover, under a returnless refund, the platform prefers live-streaming when the proportion of opportunists is small. As the proportion increases, it favors traditional channels and KOL live-streaming.

In the choice of return policy, brands choose a return refund when the KOL has less influence and a higher percentage of opportunists; otherwise, they favor a returnless refund. KOL favors a returnless refund, choosing a return refund only when the influence is not extraordinarily strong and the percentage of opportunists is tiny. Platforms choose KOL live-streaming with return refunds when KOL's influence is minimal, and the percentage of opportunists is not exceedingly small. They choose self-run live-streaming with a return refund when both the KOL's influence and the proportion of opportunists are moderate. In all other cases, they prefer a returnless refund.

In addition, when KOL's influence is small, both the brand and the platform achieve a win-win in self-run live-streaming under a returnless refund if the proportion of opportunities is small. If the proportion is high, both sides choose self-run live-streaming with a return refund. Only when the influence of the KOL is particularly high will the brand, the platform, and the KOL reach a consensus in KOL live-streaming under a returnless refund.

7.2. Managerial implications

This study provides managerial implications for platforms, brands, and influencers in e-commerce live-streaming. First, platforms should dynamically adjust cooperation strategies, using "base commission plus performance share" for high-impact influencers and content support for medium-impact ones, which aligns with practices on Taobao and TikTok. Next, brands should select channels based on return rates and price sensitivity: low-return or premium products suit high-impact influencers, whereas high-return or price-sensitive products are better for self-run live-streaming. In addition, influences' impact affects both selection and bargaining power. Low-impact influencers can attract brands through dependable after-sales returns and refunds, while high-impact influencers should focus on content and reputation under a returnless refund. Overall, coordinating platform policies, brand strategies, and influencer content and credibility enables all parties to achieve long-term cooperation and sustainable performance.

7.3. Future Research

This study also has limitations. First, the study assumes that only one KOL stream in the market. In reality, brands may hire multiple streamers to expand the market, and the scenario of competing live-streaming channels can be explored. In addition, heterogeneous consumer preferences for different live-streaming channels deserve further investigation. Finally, the application of recent technologies such as AI and blockchain in live-streaming commerce is also worth exploring.

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Appendix A. PROOFS

Proof of Lemma 1

The platform's profit function in RR-B (Eq. 9) partials derivative to p: $\frac{\partial \Pi_P^{RR-B}}{\partial p} = 1 - 2p - a(1 + h - 2p + s) + w$, $\frac{\partial^2 \Pi_P^{RR-B}}{\partial p^2} = 2(-1 + a)$. When $\frac{\partial^2 \Pi_P^{RR-B}}{\partial p^2} < 0$, let $\frac{\partial \Pi_P^{RR-B}}{\partial p} = 0$ to find p. Substituting p, into the brand profit function (Eq. 9) by taking the partial derivative of w can be obtained: $\frac{\partial \Pi_M^{RR-B}}{\partial w} = \frac{-1+a(1+h-s)+2w}{2(-1+a)}$, $\frac{\partial^2 \Pi_M^{RR-B}}{\partial w^2} = \frac{1}{-1+a}$, When $\frac{\partial^2 \Pi_M^{RR-B}}{\partial w^2} < 0$, let $\frac{\partial \Pi_M^{RR-B}}{\partial w} = 0$ to get w Substituting the equilibrium solution into the demand and profit functions gets Lemma 1.

Proof of Lemma 2

The platform's profit function in RR-S (Eq. 12) partials derivative to e : $\frac{\partial \Pi_P^{RR-S}}{\partial e} = -e + \frac{p-ap+as-w}{\lambda - a\lambda}$, $\frac{\partial^2 \Pi_P^{RR-S}}{\partial e^2} = -1$, let $\frac{\partial \Pi_P^{RR-S}}{\partial e} = 0$ to get e, Substituting e into the platform profit, we obtain p and w in the order of Lemma 1. Substituting the equilibrium solution into the demand and profit functions, we obtain Lemma 2.

Proof of Lemma 3

Substitute the sum of platform and KOL's profit function (Eqs. 15, 16) in RR-K to obtain the partial derivation of e: $\frac{\partial \Pi_P^{RR-K}}{\partial e} = \frac{e-ae+(-1+a)p-as+w}{-1+a}$, $\frac{\partial^2 \Pi_P^{RR-K}}{\partial e^2} = -1$, let $\frac{\partial \Pi_P^{RR-K}}{\partial e} = 0$ to get e, substituting e into the sum of platform and KOL's profit, and also obtaining p before substituting it into brand's profit to obtain w. Substitute the equilibrium solution into the demand and profit function to obtain Lemma 3.

Proof of Proposition 1

In (2), under the condition of satisfying the existence of an equilibrium solution leads to $p^{RR-B^*} < p^{RR-K^*}$, $p^{RR-B^*} < p^{RR-S^*}$, let $p^{RR-K^*} - p^{RR-S^*} = \frac{(-1+\lambda)(-2+3\lambda+a(3+h-s-9\lambda+6a\lambda))}{2(-1+2a)(1+2(-1+a)\lambda)}$, $2(-1 + 2a)(1 + 2(-1 + a)\lambda) > 0$. Just check the symbol of $Y = -2 + 3\lambda + a(3 + h - s - 9\lambda + 6a\lambda)$. Reorganization of the formula gives $Y = -2 + 3a + ah - as + (3 - 9a + 6a^2)\lambda$, $(3 - 9a + 6a^2) > 0$, $-2 + 3a + ah - as < 0$, Y is increasing with λ. When $\lambda = 1$, $Y_{\lambda=1} = 1 + 6a^2 + a(-6 + h - s)$. It can be obtained that Y is a concave function concerning a and has two solutions: $\frac{1}{12}\left(6 - h - \sqrt{-24 + (-6 + h - s)^2} + s\right)$, $\frac{1}{12}\left(6 - h + \sqrt{-24 + (-6 + h - s)^2} + s\right)$. Only $\frac{1}{12}\left(6 - h - \sqrt{-24 + (-6 + h - s)^2} + s\right)$ Satisfies the condition when an equilibrium solution exists. $Y_{\lambda=1} > 0$ when $a = 0$, hence $Y_{\lambda=1}$ decreases with a, $Y_{\lambda=1} > 0$ when $0 < a < \frac{1}{12}\left(6 - h - \sqrt{-24 + (-6 + h - s)^2} + s\right)$, $Y_{\lambda=1} < 0$ when $\frac{1}{12}\left(6 - h - \sqrt{-24 + (-6 + h - s)^2} + s\right) < a < \frac{1}{2}$, Y is increasing with λ so $p^{RR-K^*} > p^{RR-S^*}$. When $Y_{\lambda=1} < 0$, there exists $\lambda = \frac{2-3a-ah+as}{3(1-3a+2a^2)} > 1$so that$Y = 0$,if$1 < \lambda < \frac{2-3a-ah+as}{3(1-3a+2a^2)}$, $p^{RR-S^*} > p^{RR-K^*}$, if $\lambda > \frac{2-3a-ah+as}{3(1-3a+2a^2)}$, $p^{RR-K^*} > p^{RR-S^*}$. The proof of (3) is similar to (2).

Proof of Proposition 2

$\Pi_M^{RR-K^*} - \Pi_M^{RR-S^*} = -\frac{(-1+a)(-1+\lambda)\left(-1+a(1+2h-2s-3\lambda)+\lambda+2a^2\left(-(h-s)^2+\lambda\right)\right)}{4(-1+2a)(1+2(-1+a)\lambda)}$. The sign is determined by $-1 + a(1 + 2h - 2s - 3\lambda) + \lambda + 2a^2(-(h - s)^2 + \lambda)$, let $Y' = -1 + a + 2ah - 2a^2(h - s)^2 - 2as + (1 - 3a + 2a^2)\lambda$. Let $Y' = 0$ to find $\lambda_1 = \frac{1-a-2ah+2a^2h^2+2as-4a^2hs+2a^2s^2}{1-3a+2a^2}$ to get Proposition 2.

Proof of Proposition 3

The comparison of the values of $\Pi_P^{RR-S^*}, \Pi_P^{RR-B^*}$ and $\Pi_P^{RR-S^*}, \Pi_P^{RR-B^*}$ is similar to Proposition 1, 2, which can get $c_1 = \frac{1-2a+a^2-2ah+2a^2h+a^2h^2+2as-2a^2s-2a^2hs+a^2s^2}{16-48a+32a^2}, k_1 = \frac{1}{16(-1+a)(1+2(-1+a)\lambda)^2}(-1+\mathrm{a}(1+\mathrm{h}-\mathrm{s}))^2 - 4(-1+a)\left(-1+a\left(2(1+h-s)+a\left(-1+(-2+a)h^2-2h(1+(-2+a)s)+s(2+(-2+a)s)\right)\right)\right)\lambda + 4(-1+a)^2\left(1+a(-2+a+a(h-s)^2)\right)\lambda^2 - 4(-1+a)^4\lambda^3, \phi_1 = \frac{1}{(4(a(h+s)+(-1+a)(1+a(3h+s))\lambda+3(-1+a)^2\lambda^2)(-\lambda+a(h-s+\lambda)))}(1+16k+a(a(1+h-s)^2-2(1+h+8k-s))-4\lambda-4(16k+a(-3-2h-32k+2s+a(3+4h+16k+2(h-s)^2+a^2(h-s)^2-4s-a(1+3h^2+h(2-6s)+s(-2+3s)))))\lambda+4(-1+a)^2(1+16k+a(a-2(1+8k)+a(h-s)^2))\lambda^2-4(-1+a)^4\lambda^3)$

Proof of Lemma 4

Like Lemma 1.

Proof of Lemma 5

Like Lemma 2.

Proof of Lemma 6

Like Lemma 3.

Proof of Proposition 5

Like Proposition 1. $\rho_1 = \frac{1}{12}\left(6-\mathrm{s}-\sqrt{12+\mathrm{s}(12+\mathrm{s})}\right)$, $\rho_2 = \frac{1}{12}(6-\mathrm{s}+\sqrt{12+\mathrm{s}(12+\mathrm{s})}$, $a_1 = \frac{6+\mathrm{s}+\sqrt{12+12\mathrm{s}+\mathrm{s}^2}}{12-12\rho}$, $a_2 = \frac{6+\mathrm{s}-\sqrt{12+12\mathrm{s}+\mathrm{s}^2}}{12-12\rho}$, $\lambda_2 = \frac{2-a(-3+s)(-1+\rho)}{3+3a(3+2a(-1+\rho))(-1+\rho)}$.

Proof of Proposition 6

Like Proposition 2.

Proof of Proposition 7

Similar to Proposition 3. $c_2 = \frac{\left(-1+a(-1+s)(-1+\rho)\right)^2}{16\left(1+a(-1+\rho)\right)\left(1+2a(-1+\rho)\right)}$, $\phi_2 = \frac{x}{4(1+a(-1+\rho))(\lambda^2-3\lambda^3+a(2+2s-9\lambda)\lambda^2(-1+\rho)+a^2(s^2(-1+\lambda)+\lambda^2+4s\lambda^2-9\lambda^3)(-1+\rho)^2+a^3(s-\lambda)\lambda(s+3\lambda)(-1+\rho)^3)}, k_2 = \frac{x-4(1+a(-1+\rho))(-\lambda+a(s-\lambda)(-1+\rho))(\lambda(-1+3\lambda)+a(s(-1+\lambda)+\lambda(-1+6\lambda))(-1+\rho)+a^2\lambda(s+3\lambda)(-1+\rho)^2)\phi}{(16(-1+a)(1-2\lambda(1+a(-1+\rho)))^2(1+a(-1+\rho)))}, x = -\left(-1+4\lambda(1+(-1+\lambda)\lambda)+4a^5(s^2-\lambda)(-1+\lambda)\lambda(-1+\rho)^4+4a^4\lambda(-1+\rho)^3\left(-1+2s+(-1+\lambda)\lambda(-5+\rho)+s^2(-4+3\lambda+\rho-\lambda\rho)\right)-a^2(-1+\rho)\left(-3+s^2(1+4(-2+\lambda)\lambda)(-1+\rho)+\rho+2s(2-12\lambda-\rho+8\lambda\rho)-4\lambda\left(3(-2+\rho)+2(-1+\lambda)\lambda(-5+3\rho)\right)\right)+a\left(3-2\rho+2s(-1+4\lambda+\rho-4\lambda\rho)+4\lambda\left(-4+3\rho+(-1+\lambda)\lambda(-5+4\rho)\right)\right)-a^3(-1+\rho)^2\left(-1+8\lambda(2+5(-1+\lambda)\lambda)+s\left(2+8\lambda(-3+\rho)\right)-4(1-2\lambda)^2\lambda\rho+s^2\left(-1+4\lambda(5-3\lambda-3\rho+2\lambda\rho)\right)\right)\right)$.