

Research on the Game Equilibrium and Strategy Selection Among Participants in the Live Streaming Ecosystem

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Abstract

Live streaming commerce has become a core driver of digital retail growth, and traffic resources are increasingly central to shaping interactions between platforms and manufacturers. Focusing on public traffic pricing, this study examines the strategic behavior and equilibrium outcomes of platforms and manufacturers in the live streaming ecosystem, comparing decisions under uniform pricing strategy and differential pricing strategy. We develop a Stackelberg game model consisting of one platform and two manufacturers with heterogeneous traffic conversion capabilities, where the platform acts as the leader and determines the public traffic price, while the manufacturers respond as followers by choosing their retail prices. Through theoretical derivation and numerical simulation, we compare price and profit outcomes across the two strategies. The results show that the platform's optimal public traffic pricing strategy is significantly shaped by the small manufacturer's conversion efficiency. When this efficiency is low, the differential pricing strategy allows the platform to obtain higher returns, whereas the uniform pricing strategy becomes more suitable once the small manufacturer's conversion efficiency reaches a sufficiently high level. The two strategies also lead to distinct pricing behaviors for manufacturers. Under the uniform pricing strategy, product pricing is largely governed by the difference in traffic conversion efficiency between manufacturers. In contrast, under the differential pricing strategy, the public traffic price gap set by the platform becomes the dominant factor influencing their pricing decisions. We also find the differential pricing strategy can narrow the profit gap between manufacturers. Our research presents some guidelines for platforms to design traffic pricing strategies and manufacturers to make pricing decisions in live streaming supply chain.

Keywords

Live streaming; Traffic data; Pricing strategy; Stackelberg game.

1. Introduction

Live streaming has rapidly emerged as a transformative force in global e-commerce, particularly in China, where it has become a major engine of digital retail growth. By combining real-time interaction, influencer-driven product demonstrations, and personalized recommendations, live streaming reshapes consumer decision-making and accelerates online purchases. According to the China Internet Network Information Center (CNNIC), the number of live streaming e-commerce users reached 580 million in 2024,¹ accounting for more than 60% of all online shoppers, while the gross merchandise value of the industry exceeded 5.7 trillion yuan in the same year.² These developments illustrate the increasing centrality of live streaming to the broader e-commerce landscape.

In this ecosystem, traffic data functions as both a measure of influence and a core source of commercial value for platforms and manufacturers. And it is generally categorized into two types: public traffic and private traffic. Public traffic refers to the large user base accumulated and controlled by the platform, which manufacturers must pay to access in order to obtain exposure. In contrast, private traffic consists of user groups cultivated independently by manufacturers through membership programs, brand communities, or social media engagement. While public traffic enables rapid large-scale reach in the short term, private traffic provides higher user loyalty and conversion efficiency but requires continuous investment and long-term operational efforts.

As the live streaming market continues to expand, conflicts over the pricing and allocation of public traffic have intensified. A representative case is East Buy Holding Limited, a leading brand on Douyin, which publicly declared in 2022 that it would not purchase traffic. However, after the platform modified its traffic distribution strategies, its founder Yu Minhong stated in 2024 that the company would need to invest moderately in traffic, reflecting manufacturers' growing reliance on paid exposure. Industry evidence further shows that public traffic has become a major cost burden: according to a survey by Zero-T LT, traffic expenses typically account for around 20% of total operating costs for small and medium-sized manufacturers, with some exceeding 50%³.

The pressure is particularly evident in the apparel sector, where several well-known Douyin stores announced closures in 2024 due to the unsustainable cost of maintaining public traffic.⁴ These developments indicate that rising public traffic costs have substantially compressed manufacturers' profit margins and prompted many to shift toward private traffic operations as an alternative growth pathway. Inspired by the above phenomena, the current research aims to address the following research questions:

- How should the platform price public traffic, and choose between uniform and differential pricing strategies?
- How do manufacturers optimally determine product pricing when facing different public traffic pricing strategies?
- How do different public traffic pricing strategies influence the outcomes and profits of both the platform and manufacturers?

To answer the above questions, we construct a game-theoretic model of a live streaming supply chain consisting of one platform and two competing manufacturers. Within a two-stage Stackelberg framework, the platform acts as the leader and chooses its public traffic pricing scheme, while the manufacturers act as followers and determine their product prices in response. The model incorporates both public traffic provided by the platform and private traffic cultivated by manufacturers into the demand functions, thereby capturing their complementary as well as competitive effects. We focus on two public traffic pricing strategies, namely uniform pricing strategy (UP) and differential pricing strategy (DP), derive the corresponding equilibrium outcomes, and compare their impacts on the profits of the platform and manufacturers. In addition, we conduct numerical analyses to provide an intuitive characterization of how alternative traffic pricing strategies shape the decisions and profits of both the platform and manufacturers in the live streaming supply chain.

The remainder of the paper is organized as follows. In Section 2, a review of the relevant literature is provided, and the problem statement and assumptions are introduced in Section 3. Section 4 derives the optimal decisions of the platform and manufacturers under different scenarios. Section 5 discusses the resulting equilibrium properties and comparative statics. In

Section 6, numerical experiments are performed to validate the theoretical results and generate managerial insights. Finally, Section 7 provides the research conclusions, managerial implications and limitations.

2. Literature review

Our work builds upon prior research in three closely related domains: live streaming supply chains, pricing strategies and traffic pricing in supply chains, and Stackelberg game theory. Below, we review these three streams of literature and position our work within this body of research.

2.1. Live Streaming Supply Chain

Most studies on live streaming supply chains focus on channel strategy selection. Zhang and Tang [1] develop a game-theoretic model to examine whether a manufacturer should introduce a live streaming channel and show that its profitability depends on the commission rate, fixed fee, and streamer follower base. Hao and Yang [2] analyze the platforms choice between resale and agency formats under different pricing strategies and find that incorporating consumer returns may make the resale format more favorable than the conventionally preferred agency format. Some studies examine product pricing in live streaming commerce. Cui et al. [3] show that livestreaming is more attractive when consumers hassle costs are low and sellers procurement costs are high, with sellers having stronger incentives than platforms to adopt livestreaming. He et al. [4] analyze a supplier-led Stackelberg game and find that higher supplier shareholding increases channel demand and total supply chain profit but reduces retailer profit, while a larger online channel share raises the retailers price and sales volume.

Overall, existing studies mainly focus on channel selection, pricing, and compensation strategies. In contrast, the strategic interaction between platforms and manufacturers especially from the perspective of traffic pricing remains underexplored, which motivates this study.

2.2. Pricing Strategies and Traffic Pricing in Supply Chains

Extensive studies examine pricing strategies in supply chains, particularly the comparison between uniform and differential pricing. Xiao et al. [5] show that differential pricing improves platform payoffs, whereas uniform pricing enhances participant utility. Zhen and Xu [6] further demonstrate, within a Stackelberg framework, that pricing strategy choice significantly affects channel structure decisions when manufacturers and retailers consider entering third-party platforms. Related research has extended this line of inquiry to live streaming supply chains. Ye et al. [7] analyze sellers influencer selection and pricing decisions and find that differential pricing generally yields higher profits, though uniform pricing may be preferred from a social welfare perspective. Xi et al. [8] show that platforms and manufacturers exhibit different preferences for marketplace entry and pricing strategies, with outcomes depending on commission rates and channel competition intensity.

Research on traffic pricing remains limited, although some studies recognize traffic as a key demand driver in live streaming commerce. Wu et al. [9] show that increased livestream traffic significantly boosts product demand and promotional effectiveness, while Ye et al. [7] demonstrate that influencers can expand demand by purchasing traffic or exerting effort, highlighting traffic as a monetizable resource controlled by the platform. Although uniform and differential pricing have been extensively studied in supply chains, platform traffic pricing despite being a key monetizable resource in live

streaming manufacturers received limited attention. Most existing studies treat traffic as exogenous and focus on manufacturer influencer interactions, leaving platform manufacturer strategic dynamics largely unexplored. This study addresses this gap by examining platform-led traffic pricing and its interaction with suppliers decisions

2.3. Stackelberg Game Theory

Recent research has extensively adopted Stackelberg formulations to examine pricing and strategic behavior in supply chain settings. Zhang et al. [10] analyze pricing in a dual-channel supply chain with live streaming sales and show that livestreaming spillover effects and retailer market potential significantly influence equilibrium prices and profit allocation. Liu et al. [11] apply a Stackelberg model to a dual-channel supply chain with overconfident consumers, demonstrating that behavioral biases reshape demand formation and alter manufacturer–retailer strategic interactions.

In a multi-period setting, Abbasi et al. [12] develop Stackelberg–Nash models for competing closed-loop supply chains and find that both internal competition between new and remanufactured products and external brand competition critically shape equilibrium pricing and remanufacturing incentives.

Despite these advancements, prior studies primarily focus on traditional or dual-channel supply chains and do not consider the unique features of live streaming commerce, particularly the platform’s ability to price and allocate traffic as a strategic resource. Because traffic pricing shapes manufacturers’ operational decisions and plays a central role in the live streaming ecosystem, incorporating platform-led traffic pricing into a Stackelberg framework represents a meaningful extension of existing research and provides the foundation for the model developed in this study.

3. Contributions of our study

This paper makes three main contributions.

Firstly, we build a two-stage Stackelberg model where the platform, as the leader, sets public traffic prices, and manufacturers, as followers, choose product pricing.

The model embeds both public and private traffic into the demand function and characterizes their complementary and competitive roles in shaping market demand.

Secondly, we compare two platform traffic-pricing strategies—uniform pricing and differential pricing—and derive the corresponding equilibrium outcomes. The analysis reveals how key factors such as traffic conversion efficiency, cross-price sensitivity, and commission rates shape the platform’s optimal traffic-pricing strategy and the manufacturer’s pricing and operational decisions.

Findally, through theoretical analysis and numerical simulations, we generate managerial insights regarding when differential traffic pricing enhances platform profitability and how it affects manufacturers of different sizes. Our results indicate that under appropriate conditions, differential pricing can not only improve platform revenue but also reduce the profit disparity among manufacturers, thereby supporting a more balanced and sustainable live streaming ecosystem.

4. Problem statement and assumptions

4.1. Problem statement

This study adopts a dynamic perspective and develops a two-stage Stackelberg game model to analyze the interaction between the platform and manufacturers in public traffic trading and product pricing. The model characterizes the pricing decisions of both parties and compares two public traffic pricing strategies adopted by the platform, namely uniform pricing (Scenario UP) and differential pricing (Scenario DP), in terms

of their impacts on equilibrium decisions and profits. By examining the outcomes under these two schemes, the study aims to determine how the platform should design its public traffic pricing strategy and how manufacturers should optimally set their product prices under different pricing strategies.

The sequence of the game can be expressed as follows.

Step 1 (Platform as leader): The platform supplies public traffic for manufacturers' live streaming and sets the price of public traffic to maximize its profit. The platform's profit consists of two components: commission income from manufacturers' live-stream product sales and revenue from selling public traffic.

Step 2 (manufacturers as followers):

Given the platform's public traffic pricing and allocation, manufacturers conduct live-stream product sales and choose their retail prices to maximize profit. Manufacturers' profit arises solely from the sale of products through live streaming.

4.2. Assumptions

The following assumptions are imposed to facilitate the analysis.

Assumption 1. Compared with traditional e-commerce, live streaming ecommerce offers distinct advantages. By watching live content, consumers gain access to real-time product demonstrations and explanations, which significantly enhance their shopping experience. In this process, the number of consumers joining a live stream, commonly referred to as "traffic", plays a pivotal role in driving product sales [9]. This traffic typically consists of public traffic $q_{fm}(t)$ provided by the platform and private traffic $q_{f'm}(t)$ accumulated by manufacturers m ($m = 1, 2$). Following prior studies that model market demand as a linear function of price and non-price factors such as advertising or traffic [13, 7], we assume that the demand $D_m(t)$ faced by manufacturer m at time t depends on its own price $p_m(t)$, public traffic $q_{fm}(t)$, and private traffic $q_{f'm}(t)$, and is given by

$$D_m(t) = D_0 + \omega_{fm}q_{fm}(t) + \omega_{f'm}q_{f'm}(t) - p_m(t) + \eta p_{(3-m)}(t), m = 1,2 \quad (1)$$

where $D_0 > 0$ represents the potential market demand for the product; ω_{fm} and $\omega_{f'm}$ denote the abilities of manufacturer m to convert public and private traffic, respectively, into product sales during live streaming; and $\eta \geq 0$ is the cross-price sensitivity coefficient of product demand, with $\eta = 0$ when there is only one manufacturer. Here $p_{(3-m)}(t)$ denotes the product price of the competing manufacturer.

Assumption 2.

In the context of live streaming marketing, traffic is a crucial resource that brings potential customers and sales opportunities to manufacturers, thereby generating economic value. In general, the reach of manufacturers' private traffic $q_{f'm}(t)$ is limited compared with the platform's public traffic. To enhance brand exposure and reach a broader user base, manufacturers often need to pay the platform to obtain additional public traffic. Considering the complementary relationship between public traffic and private traffic, we further assume that, for a given manufacturer, a larger scale of private traffic reduces its reliance on public traffic. At the same time, public traffic purchased by competing manufacturers may affect its own public traffic demand. In line with Assumption 1, we specify the public traffic demand function of manufacturer m at time t as follows

$$q_{fm}(t) = q_0 - p_{fm}(t) - \theta q_{f'm}(t) + \gamma p_{f(3-m)}(t), m = 1,2 \quad (2)$$

where $q_0 > 0$ represents the potential market demand for public traffic; $\theta > 0$ measures the impact of manufacturer's private traffic on its demand for public traffic; $p_{fm}(t)$ denotes the price per unit of public traffic charged by the platform to

manufacturer; and $\gamma \geq 0$ is the cross-price sensitivity coefficient of public traffic demand, $\gamma = 0$ with when the platform employs a uniform pricing strategy.

Assumption 3. From the perspective of traffic supply, the platform needs to incur certain costs to attract consumer attention, including spending on advertising, promotions, and subsidies. During live streaming, manufacturers purchase public traffic from the platform at a per-unit price $p_{fm}(t)$ to boost product sales. Following [13], we assume that the cost functions of the platform and manufacturers are linear in the relevant decision variables. Specifically, the platform’s cost $C_p(t)$ and manufacturer m ’s cost $C_m(t)$ at time t are given by

$$C_p(t) = C_0 + C_f \sum_{m=1}^2 q_{fm}(t) \tag{3}$$

$$C_m(t) = p_{fm}(t)q_{fm}(t) + C_d D_m(t) + C_{f'm} q_{f'm}(t), m = 1, 2 \tag{4}$$

where C_0 denotes the fixed cost incurred by the platform; C_f and $C_{f'm}$ represent the cost coefficients per unit of public traffic and private traffic, respectively; and C_d is the production cost coefficient per unit of product.

Table 1 provides the notations used in this paper.

Table 1: Major notations

Notation	Explanation
t	Time period.
m	Manufacturer index, $m = 1, 2$.
$D_m(t)$	Demand faced by manufacturer m at time t .
$q_{fm}(t)$	public traffic demand of manufacturer m at time t .
$q_{f'm}(t)$	Private traffic scale of manufacturer m at time t .
D_0	Potential market demand for the product, $D_0 > 0$.
q_0	Potential market demand for public traffic, $q_0 > 0$.
$p_m(t)$	Retail price per unit of the product set by manufacturer m at time t .
$p_{fm}(t)$	Price per unit of public traffic charged by the platform to manufacturer m at time t .
$\omega_{fm}, \omega_{f'm}$	Conversion coefficients of public and private traffic into product sales for manufacturer m , respectively, $\omega_{fm}, \omega_{f'm}$.
$C_p(t)$	Cost function of the platform at time t .
$C_m(t)$	Cost function of manufacturer m at time t .
C_0	Fixed cost incurred by the platform.
$C_f, C_{f'm}$	Cost coefficients per unit of public traffic and private traffic, respectively, $C_f, C_{f'm} > 0$.
C_d	Production cost coefficient per unit of product, $C_d > 0$.

θ	Impact coefficient of manufacturer m 's private traffic on its public traffic demand, $\theta > 0$.
γ	Cross-price sensitivity coefficient of public traffic demand, $\gamma \geq 0$.
η	Cross-price sensitivity coefficient of product demand, $\eta \geq 0$.

4.3. Stackelberg game model

Based on the assumptions in Section 3.2, we develop Stackelberg game models under two public traffic pricing strategies: uniform pricing (Scenario UP) and differential pricing (Scenario DP). In both scenarios, the platform acts as the Stackelberg leader, and the manufacturers act as followers.

• **Stackelberg game model under uniform pricing**

In the uniform pricing case (denoted by the superscript UP), two manufacturers ($m = 1, 2$) produce homogeneous products with positive cross-price sensitivity $\eta > 0$. Manufacturer 1 is a large firm with stronger traffic conversion capability, a larger fan base, and greater financial resources, while manufacturer 2 is smaller with weaker conversion capability and limited resources. Accordingly, $\omega_{f1} > \omega_{f2}$, $\omega_{f'1} > \omega_{f'2}$, and $q_{f'1}(t) > q_{f'2}(t)$. Under uniform pricing, the platform charges both manufacturers the same public traffic price, i.e., $p_{f1}(t) = p_{f2}(t) = p_f(t)$. Under Scenario UP, the platform's objective over the planning horizon $[0, T]$ is to maximize its total profit $\pi_p^{UP}(T)$, which is formulated as follows.

$$\max \pi_p^{UP}(T) = \int_0^T [\sum_{m=1}^2 (\varphi p_m(t) D_m(t)) + p_f(t) \sum_{m=1}^2 q_{fm}(t) - C_p(t)] dt \tag{5}$$

Given the platform's pricing decision, each manufacturer m ($m = 1, 2$) chooses its product price $p_m(t)$ to maximize its profit $\pi_m^{UP}(T)$, which is given by

$$\max \pi_m^{UP}(T) = \int_0^T [(1 - \varphi) p_m(t) D_m(t) - C_m(t)] dt \tag{6}$$

• **Stackelberg game model under differentiated pricing**

In the differential pricing case, denoted by the superscript DP, the platform sells public traffic to the two manufacturers at different prices, that is, $p_{f1}(t) \neq p_{f2}(t)$. The two manufacturers still produce homogeneous products and compete in prices under the same demand structure as in Section 3.2, but the public traffic demand now depends on both own and rival public traffic prices through the parameter γ . Under Scenario DP, the platform's total profit $\pi_p^{DP}(T)$ is

$$\max \pi_p^{DP}(T) = \int_0^T [\sum_{m=1}^2 (\varphi p_m(t) D_m(t)) + \sum_{m=1}^2 (p_{fm}(t) q_{fm}(t)) - C_p(t)] dt \tag{7}$$

Given the platform's differentiated public traffic prices, manufacturer m chooses its product price $p_m(t)$ to maximize its profit $\pi_m^{DP}(T)$

$$\max \pi_p^{DP}(T) = \int_0^T [\sum_{m=1}^2 (\varphi p_m(t) D_m(t)) + \sum_{m=1}^2 (p_{fm}(t) q_{fm}(t)) - C_p(t)] dt \tag{8}$$

5. Model solutions

In this section, we solve the two-stage Stackelberg game and derive the equilibrium public traffic pricing and product-pricing strategies of the platform and manufacturers under the uniform pricing (UP) and differential pricing (DP) schemes.

5.1. Equilibrium solutions under scenario UP

Based on Eq. (5) and Eq. (6), we introduce the Lagrange multipliers $\lambda_{d1}^{UP}(t)$, $\lambda_{d2}^{UP}(t)$, $\lambda_{f1}^{UP}(t)$ and $\lambda_{f2}^{UP}(t)$ to formulate the Hamiltonian functions for both the platform H_p^{UP} and the manufacturers H_1^{UP} , H_2^{UP} respectively, as shown below

$$H_p^{UP} = \varphi p_1 D_1(t) + \varphi p_2 D_2(t) + p_f(t)(q_{f1}(t) + q_{f2}(t)) - C_f(q_{f1} + q_{f2}) - C_0 + \lambda_{D1}^{UP} D_1(t) + \lambda_{D2}^{UP} D_2(t) + \lambda_{f2}^{UP} q_{f2}(t) + \lambda_{f1}^{UP} q_{f1}(t) \tag{9}$$

$$H_1^{UP} = (1 - \varphi)(p_1(t) - C_d)(D_0 + \omega_{f1} q_{f1}(t) + \omega_{f'1} q_{f'1}(t) - p_1(t)) - p_{f1}(t)(q_0 - p_{f1}(t) - \theta q_{f'1}(t)) + \lambda_1^{UP} D_1(t). \tag{10}$$

$$H_2^{UP} = (1 - \varphi)(p_2(t) - C_d)(D_0 + \omega_{f2} q_{f2}(t) + \omega_{f'2} q_{f'2}(t) - p_2(t)) - p_{f2}(t)(q_0 - p_{f2}(t) - \theta q_{f'2}(t)) + \lambda_2^{UP} D_2(t). \tag{11}$$

Using the Hamiltonian system, the equilibrium strategies of the platform and the manufacturers under scenario UP are summarized in Proposition 1.

Proposition 1. *In scenario UP, the equilibrium price of the platform and manufacturers are*

$$p_f^{UP*}(t) = \frac{((- \theta q_{f1} + q_0) \omega_{f1} + \omega_{f1} q_{f1} + 2 \eta M_2 + D_0 - 2 M_1) k_1 + 2 q_0 + 2 C_f}{2 k_1^2 + (-4 \eta k_2 + 2 \omega_{f1}) k_1 + 2 k_2 (k_2 + \omega_{f2})} + \frac{((- \theta q_{f2} + q_0) \omega_{f2} + \omega_{f2} q_{f2} + 2 \eta M_1 + D_0 - 2 M_2) k_2}{2 k_1^2 + (-4 \eta k_2 + 2 \omega_{f1}) k_1 + 2 k_2 (k_2 + \omega_{f2})} + \frac{-e^{-t} \eta (C_{d1}^{UP} + C_{d2}^{UP} + C_{f1}^{UP} + C_{f2}^{UP})}{2 k_1^2 + (-4 \eta k_2 + 2 \omega_{f1}) k_1 + 2 k_2 (k_2 + \omega_{f2})}, \tag{12}$$

$$p_1^{UP*}(t) = M_1 + \frac{\eta \omega_{f1}}{\eta^2 - 1} \frac{\omega_{f2}}{\eta^2 - 1} p_f^{UP*}(t), \tag{13}$$

$$p_2^{UP*}(t) = M_2 + \frac{\eta \omega_{f2} + \omega_{f1}}{\eta^2 - 1} p_f^{UP*}(t), \tag{14}$$

where

$$M_1 = \frac{-e^{-t} (\eta C_1^{UP} + C_2^{UP})}{(\varphi - 1)(\eta^2 - 1)} + \frac{\eta}{(\eta^2 - 1)} [\omega_{f1} (\theta q_{f'1} - q_0) - D_0 - \omega_{f1} q_{f'1}] + \frac{1}{(\eta^2 - 1)} (\omega_{f2} (\theta q_{f'2} - q_0) - D_0 - \omega_{f2} q_{f'2}) + \frac{C_d}{(\eta - 1)(\varphi - 1)},$$

$$\begin{aligned}
 M_2 &= \frac{-e^{-t}(\eta C_2^{UP} + C_1^{UP})}{(\varphi - 1)(\eta^2 - 1)} + \frac{\eta}{(\eta^2 - 1)} [\omega_{f_2}(\theta q_{f_2} - q_0) - D_0 - \omega_{f_2} q_{f_2}] \\
 &\quad + \frac{1}{(\eta^2 - 1)} (\omega_{f_1}(\theta q_{f_1} - q_0) - D_0 - \omega_{f_1} q_{f_1}) + \frac{C_d}{(\eta - 1)(\varphi - 1)}, \\
 k_1 &= \frac{\eta \omega_{f_1} + \omega_{f_2}}{\eta^2 - 1}, \\
 k_2 &= \frac{\eta \omega_{f_2} + \omega_{f_1}}{\eta^2 - 1}.
 \end{aligned}$$

5.2. Equilibrium solutions under scenario DP

Based on Eq. (7) and Eq. (8), we introduce the Lagrange multipliers $\lambda_{d_1}^{DP}(t)$, $\lambda_{d_2}^{DP}(t)$, $\lambda_{f_1}^{DP}(t)$ and $\lambda_{f_2}^{DP}(t)$ to formulate the Hamiltonian functions for both the platform H_p^{DP} and the manufacturers H_1^{DP} , H_2^{DP} respectively, as shown below

$$H_p^{DP} = \varphi p_1 D_1(t) + \varphi p_2 D_2(t) + p_{f_1}(t) q_{f_1}(t) + p_{f_2}(t) q_{f_2}(t) - C_0 - C_f q_{f_1}(t) - C_f q_{f_2}(t) + \lambda_{d_1}^{DP} D_1(t) + \lambda_{d_2}^{DP} D_2(t) + \lambda_{f_1}^{DP} q_{f_1}(t) + \lambda_{f_2}^{DP} q_{f_2}(t) \tag{15}$$

$$H_1^{DP} = (1 - \varphi)(p_1(t) - C_d)[D_0 + \omega_{f_1} q_{f_1}(t) + \omega_{f_1'} q_{f_1'}(t) - p_1(t)] + \lambda_1^{DP} D_1(t) \tag{16}$$

$$H_2^{DP} = (1 - \varphi)(p_2(t) - C_d)[D_0 + \omega_{f_2} q_{f_2}(t) + \omega_{f_2'} q_{f_2'}(t) - p_2(t)] + \lambda_2^{DP} D_2(t) \tag{17}$$

Using these Hamiltonians, the equilibrium strategies of the platform and the manufacturers under scenario DP are given in the following proposition 2.

Proposition 2. *In scenario DP, the equilibrium price of the platform and manufacturers are*

$$\begin{aligned}
 p_{f_1}^{DP*}(t) &= \frac{[(-\theta q_{f_1'} + q_0)\omega_{f_1} + \omega_{f_1'} q_{f_1'} + 2\eta M_4 + D_0 - 2M_3]a_1 + 2q_0 + 2C_f}{(-2a_1^2 + 4\eta a_3 + 2\gamma \omega_{f_1} - 2a_3(a_3 + \omega_{f_2}))\varphi} \\
 &\quad + \frac{[(-\theta q_{f_2} + q_0)\omega_{f_2} + \omega_{f_2'} q_{f_2'} + 2\eta M_3 + D_0 - 2M_4]a_2}{(-2a_1^2 + 4\eta a_3 + 2\gamma \omega_{f_1} - 2a_3(a_3 + \omega_{f_2}))\varphi} \\
 &\quad + \frac{e^{-t}\eta(C_{d_1}^{DP} + C_{f_1}^{DP} - C_{f_1}^{DP} - C_{f_2}^{DP})}{(-2a_1^2 + 4\eta a_3 + 2\gamma \omega_{f_1} - 2a_3(a_3 + \omega_{f_2}))\varphi}
 \end{aligned} \tag{18}$$

$$\begin{aligned}
 p_{f_2}^{DP*}(t) &= \frac{[(-\theta q_{f_1'} + q_0)\omega_{f_1} + \omega_{f_1'} q_{f_1'} + 2\eta M_4 + D_0 - 2M_3]a_1 + 2q_0 + 2C_f}{(-2a_2^2 + (4\eta a_4 + 2\gamma \omega_{f_1})a_2 - 2a_4(a_4 + \omega_{f_2}))\varphi} \\
 &\quad + \frac{[(-\theta q_{f_2} + q_0)\omega_{f_2} + \omega_{f_2'} q_{f_2'} + 2\eta M_3 + D_0 - 2M_4]a_2}{(-2a_2^2 + (4\eta a_4 + 2\gamma \omega_{f_1}) - 2a_4(a_4 + \omega_{f_2}))\varphi} \\
 &\quad + \frac{e^{-t}\eta(C_{d_1}^{DP} + C_{f_1}^{DP} - C_{f_1}^{DP} - C_{f_2}^{DP})}{(-2a_2^2 + (4\eta a_4 + 2\gamma \omega_{f_1}) - 2a_4(a_4 + \omega_{f_2}))\varphi}
 \end{aligned} \tag{19}$$

$$p_1^{DP*}(t) = M_3 + \frac{\eta \omega_{f_1} - \gamma \omega_{f_2}}{\eta^2 - 1} p_{f_1}^{DP*}(t) + \frac{\omega_{f_2} - \gamma \eta \omega_{f_1}}{\eta^2 - 1} p_{f_2}^{DP*}(t) \tag{20}$$

$$p_2^{DP*}(t) = M_4 + \frac{\eta \omega_{f_2} - \gamma \omega_{f_1}}{\eta^2 - 1} p_{f_1}^{DP*}(t) + \frac{\omega_{f_1} - \gamma \eta \omega_{f_2}}{\eta^2 - 1} p_{f_2}^{DP*}(t) \tag{21}$$

where

$$\begin{aligned}
 M_3 &= \frac{-e^{-t}(\eta C_1^{DP} + C_2^{DP})}{(\varphi - 1)(\eta^2 - 1)} + \frac{\eta}{(\eta^2 - 1)} [\omega_{f1}(\theta q_{f'1} - q_0) - D_0 - \omega_{f1}q_{f'1}] \\
 &\quad + \frac{1}{(\eta^2 - 1)} (\omega_{f2}(\theta q_{f'2} - q_0) - D_0 - \omega_{f2}q_{f'2}) + \frac{C_d}{(\eta - 1)(\varphi - 1)} \\
 M_4 &= \frac{-e^{-t}(\eta C_2^{DP} + C_1^{DP})}{(\varphi - 1)(\eta^2 - 1)} + \frac{\eta}{(\eta^2 - 1)} [\omega_{f2}(\theta q_{f'2} - q_0) - D_0 - \omega_{f2}q_{f'2}] \\
 &\quad + \frac{1}{(\eta^2 - 1)} (\omega_{f1}(\theta q_{f'1} - q_0) - D_0 - \omega_{f1}q_{f'1}) + \frac{C_d}{(\eta - 1)(\varphi - 1)} \\
 a_1 &= \frac{\eta\omega_{f1} - \gamma\omega_{f2}}{(\eta^2 - 1)}, \\
 a_2 &= \frac{\omega_{f2} - \gamma\eta\omega_{f1}}{(\eta^2 - 1)}, \\
 a_3 &= \frac{\eta\omega_{f2} - \gamma\omega_{f1}}{(\eta^2 - 1)}, \\
 a_4 &= \frac{\omega_{f1} - \gamma\eta\omega_{f2}}{(\eta^2 - 1)}.
 \end{aligned}$$

6. Theoretical Analysis

In this section, we compare the uniform pricing (UP) and differential pricing (DP) strategies using the equilibrium solutions derived in Section 4. We analyze differences in the platforms optimal public traffic prices and manufacturers product-pricing decisions under the two schemes. By comparing the closed-form equilibria, we identify parameter thresholds under which one strategy yields higher prices or profits, and examine the roles of traffic-conversion efficiency, cross-price sensitivity, and commission rates. The theoretical results are presented below.

Proposition 3. *Under scenario UP and DP, comparing the platform’s equilibrium pricing for two manufacturers, we get*

1. When $\omega_{f2} > 4\eta - \frac{1+\gamma}{\eta^2-1} - 2(1-\gamma)^2$
 $p_{f1}^{DP*}(t) > p_{f2}^{DP*}(t)$
2. When $\omega_{f2} < 4\eta - \frac{1+\gamma}{\eta^2-1} - 2(1-\gamma)^2$ and $4\eta > \frac{1+\gamma}{\eta^2-1} + 2(1-\gamma)^2$
 $p_{f1}^{DP*}(t) < p_{f2}^{DP*}(t)$
3. When $\omega_{f2} = 4\eta - \frac{1+\gamma}{\eta^2-1} - 2(1-\gamma)^2$ and $4\eta > \frac{1+\gamma}{\eta^2-1} + 2(1-\gamma)^2$
 $p_{f1}^{DP*}(t) = p_{f2}^{DP*}(t)$

Proposition 3 shows that the platforms choice between uniform pricing (UP) and differentiated pricing (DP) is mainly driven by the small manufacturers public traffic conversion efficiency. When this efficiency is very low, allocating traffic to the small manufacturer yields limited marginal revenue, prompting the platform to set a higher traffic price for the small manufacturer and a lower one for the large manufacturer to direct traffic toward the more efficient firm. As the small manufacturers conversion efficiency improves, traffic allocation becomes more balanced, and differentiated pricing can enhance platform profit while promoting competitive balance. However, once the small manufacturer reaches a moderate and stable conversion level, the marginal gains from differentiation diminish, making uniform pricing potentially equally or more profitable while simplifying platform operations.

Proposition 4. Under Scenario UP, a comparative analysis of the equilibrium pricing strategies adopted by the two manufacturers leads to the following conclusions:

$$1. \text{ When } \frac{\omega_{f1}}{\omega_{f2}} < \frac{q_0 - (1-\theta)q_{f'2}}{q_0 - (1-\theta)q_{f'1}} \text{ and } C_2^{UP} > C_1^{UP}$$

$$p_1^{UP*}(t) > p_2^{UP*}(t).$$

$$2. \text{ When } \frac{\omega_{f1}}{\omega_{f2}} > \frac{q_0 - (1-\theta)q_{f'2}}{q_0 - (1-\theta)q_{f'1}}, p_f^{UP*}(t) < q_0 - \frac{(1-\theta)(\omega_{f1}q_{f'1} - \omega_{f2}q_{f'2})}{\omega_{f1} - \omega_{f2}}, \text{ and } C_2^{UP} < C_1^{UP}$$

$$p_1^{UP*}(t) < p_2^{UP*}(t).$$

Proposition 4 analyzes manufacturers pricing behavior under the uniform pricing (UP) mechanism. The results show that equilibrium pricing is mainly determined by the gap in public traffic conversion efficiency. When this gap is small, the large manufacturer sets a higher price, as its superior conversion efficiency under a uniform traffic price yields higher marginal returns and stronger pricing power. However, when the conversion-efficiency gap becomes sufficiently large and the traffic price remains low, the small manufacturer can moderately increase its price to compensate for its disadvantage and maintain profitability despite weaker demand. These findings suggest that under UP, the large manufacturer should enhance its traffic-conversion efficiency to sustain pricing power, whereas the small manufacturer needs to improve conversion capability or adopt more flexible pricing strategies to offset disadvantages from lower efficiency and smaller scale.

Proposition 5. Under Scenario DP, a comparative analysis of the equilibrium pricing strategies adopted by the two manufacturers leads to the following conclusions:

$$1. \text{ When } \frac{p_{f1}^{UP*}(t)}{p_{f2}^{UP*}(t)} \geq \frac{1+\gamma\eta}{\eta+\gamma} \text{ and } C_2^{DP} \geq C_1^{DP}$$

$$p_1^{DP*}(t) \geq p_2^{DP*}(t).$$

$$2. \text{ When } \frac{p_{f1}^{UP*}(t)}{p_{f2}^{UP*}(t)} < \frac{1+\gamma\eta}{\eta+\gamma} \text{ and } C_2^{DP} < C_1^{DP}$$

$$p_1^{DP*}(t) < p_2^{DP*}(t).$$

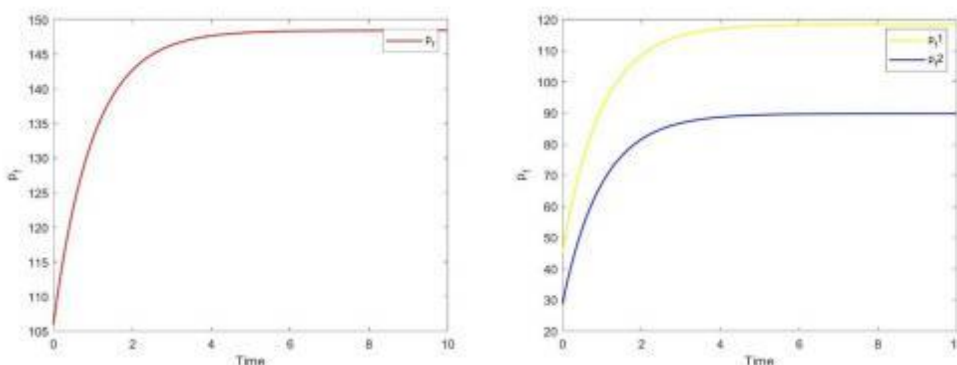
Proposition 5 analyzes manufacturers product pricing under the differentiated pricing (DP) mechanism. The results indicate that equilibrium prices are primarily driven by the gap in public traffic prices set by the platform. When this gap is large, the large manufacturer benefiting from stronger financial resources and higher traffic-conversion efficiency can better absorb traffic costs and thus sets a higher equilibrium price. When the price gap is small, this cost advantage is weakened, easing the pricing pressure on the small manufacturer. Consequently, the large manufacturer tends to lower its price to attract demand, while the small manufacturer can moderately raise its price to preserve margins. If the small manufacturer exhibits moderate traffic-conversion efficiency, the reduced cost disadvantage allows it to increase prices and partially offset scale limitations. These results suggest that platforms should cautiously design differentiated traffic pricing, as excessive price gaps may reinforce large manufacturers dominance and weaken ecosystem diversity. At the same time, improving traffic-conversion efficiency is essential for small manufacturers to adapt to platform pricing and maintain profitability.

7. Numerical analysis

In this section, we conduct numerical experiments to further illustrate and complement the analytical results. Specifically, we compare the platforms optimal prices under the two public traffic pricing strategies, namely uniform pricing (UP) and differential pricing (DP), and examine how these alternative schemes affect the profits of the platform and the two manufacturers. By contrasting the equilibrium outcomes across these scenarios, the numerical results provide a more intuitive view of how different traffic-pricing strategies influence decision-making and performance in the live streaming supply chain.

Referring to [9], we set the parameters for the numerical experiments as: $\varphi = 0.30$, $\gamma = 1.2$, $\theta = 0.8$, $\eta = 1.5$, $\omega_f = 1$, $\omega_{f_r} = 1.5$, $C_f = 0.5$, $C_d = 0.4$, $q_0 = 150$, $D_0 = 300$.

7.1. The platforms pricing under scenarios UP and DP



(a) The platform’s pricing under uniform pricing scenario (b) The platform’s pricing under differentiated pricing scenario

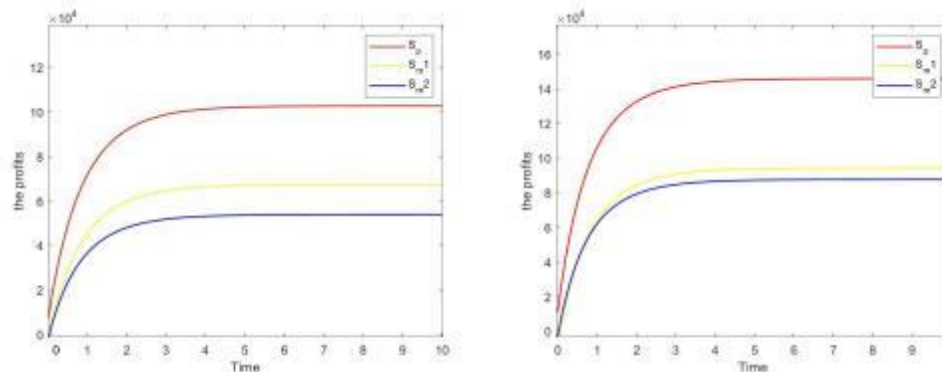
Figure 1: The pricing of the platform under uniform and differentiated pricing scenarios. Fig. 1 presents the platforms public traffic pricing paths under both the uniform pricing (UP) and differentiated pricing (DP) strategies. As shown in Fig. 1-a and Fig. 1-b, the platforms public traffic price increases initially and gradually stabilizes over time in both scenarios. Under the DP mechanism, the platform consistently sets a higher traffic price for the large manufacturer than for the small one.

This pricing pattern reflects the platforms strategic consideration of manufacturers heterogeneous capabilities. By charging a higher traffic price to the large manufacturer who possesses stronger operational capacity and higher conversion efficiency the platform can extract additional value without undermining overall market performance. In contrast, the small manufacturer is weaker in traffic conversion and operational investment. To maintain ecosystem diversity and avoid excessive market concentration, the platform offers a relatively lower traffic price to the small manufacturer. This support helps

7.2. Impact of t on the profits of the platform and manufacturers under scenarios UP and DP

Fig. 2 illustrates the profit trajectories of the platform and the two manufacturers over time under the uniform pricing (UP) and differentiated pricing (DP) scenarios. Fig. 2-a reports the profit paths under the UP mechanism, while Fig. 2-b presents those under the DP mechanism. Across both scenarios, the platform consistently earns higher profits than the manufacturers,

and manufacturer 1's profit remains above that of manufacturer 2 due to its stronger traffic conversion capability. Furthermore, profits for all parties the platform and both manufacturers are higher under DP than under UP. These findings indicate that adopting a differentiated pricing strategy not only improves the platforms overall profitability but also contributes to long-term ecosystem stability by promoting more equitable outcomes among manufacturers.



(a) Profits of platform and manufacturer under uniform pricing scenario (b) Profits of platform and manufacturer under differentiated pricing scenario

Figure 2: Profits of platform and manufacturer under scenarios UP and DP

8. Conclusion

This study develops a two-stage Stackelberg game model to analyze the interaction between platform public traffic pricing and manufacturers product-pricing decisions in a live streaming supply chain. Theoretical analysis and numerical simulations jointly yield both theoretical insights and managerial implications.

First, the platforms choice between uniform pricing (UP) and differential pricing (DP) is primarily driven by the small manufacturers public traffic conversion efficiency. When the small manufacturer exhibits low conversion efficiency, the platform prefers DP to allocate traffic toward the more efficient large manufacturer. As the small manufacturers conversion efficiency improves, UP becomes more suitable, as it helps maintain competitive balance and avoid excessive market concentration. This suggests that platforms should dynamically adjust traffic-pricing strategies according to manufacturers conversion capabilities.

Second, manufacturers product-pricing behaviors differ across pricing regimes. Under UP, pricing outcomes are mainly determined by differences in conversion efficiency, whereas under DP, they are largely shaped by the traffic price gap set by the platform. A larger price gap strengthens the large manufacturers pricing power, while a smaller gap alleviates cost pressure on the small manufacturer, enabling it to raise prices to sustain profitability. In both regimes, strengthening private traffic operations can help small manufacturers improve effective conversion efficiency and pricing flexibility.

Third, numerical results show that DP can enhance platform profitability and, under certain conditions, increase manufacturers profits especially for the small manufacturer while significantly narrowing the profit gap between manufacturers. These findings indicate that DP not only benefits the platform but also supports a more balanced and sustainable live streaming ecosystem.

Although this study provides valuable insights into traffic-pricing strategies in live streaming e-commerce, several limitations remain. First, the analysis focuses on a single platform and two manufacturers; extending the framework to multi-platform and multi-

manufacturer environments would yield a more comprehensive understanding of marketplace competition. Second, consumer heterogeneity and behavioral responses are not explicitly modeled. Incorporating consumer choice behavior could deepen the understanding of how traffic pricing and product pricing jointly influence demand formation. These extensions present promising directions for future research.

9. Declarations

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Data availability. Enquiries about data availability should be directed to the authors.

References

- [1] T. Zhang, Z. Tang, Should manufacturers open live streaming shopping channels?, *Journal of Retailing and Consumer Services* 71 (2023) 103229.
- [2] C. Hao, L. Yang, Resale or agency sale? equilibrium analysis on the role of live streaming selling, *European Journal of Operational Research* 307 (3) (2023) 1117–1134.
- [3] X. Cui, Y. Li, X. Li, S. Fang, Livestream e-commerce in a platform supply chain: A product-fit uncertainty reduction perspective, *International Journal of Production Economics* 258 (2023) 108796.
- [4] H. Lihong, L. Zhouyan, G. Zhaopeng, Pricing and coordination strategy of retailers dual-channel supply chain with vertical shareholding of supplier, *Journal of Systems & Management* 32 (5) (2023) 880.
- [5] H. Xiao, M. Xu, H. Yang, Pricing strategies for shared parking management with double auction approach: Differential price vs. uniform price, *Transportation Research Part E: Logistics and Transportation Review* 136 (2020) 101899.
- [6] X. Zhen, S. Xu, Who should introduce the third-party platform channel under different pricing strategies?, *European Journal of Operational Research* 299 (1) (2022) 168–182.
- [7] F. Ye, L. Ji, Y. Ning, Y. Li, Influencer selection and strategic analysis for live streaming selling, *Journal of Retailing and Consumer Services* 77 (2024) 103673.
- [8] X. Xi, Y. Zhang, The interplay between marketplace channel addition and pricing strategy in an e-commerce supply chain, *International Journal of Production Economics* 258 (2023) 108807.
- [9] G. Wu, W. Yang, X. Hou, Y. Tian, Agri-food supply chain under live streaming and government subsidies: Strategy selection of subsidy recipients and sales agreements, *Computers & Industrial Engineering* 185 (2023) 109647.
- [10] X. Zhang, P. He, L. Xu, Livestreaming service spillover and pricing decisions in a dual-channel supply chain: A stackelberg game approach, *International Journal of Production Economics* 247 (2022) 108412.
- [11] B. Liu, W. Zhang, X. Fan, Pricing strategy in a dual-channel supply chain with overconfident consumers, *Omega* 110 (2022) 102627.
- [12] N. Abbasi, M. M. Lotfi, D. Shishebori, M. Honarvar, A. Forghani, Optimal pricing and remanufacturing decisions in supply chains: navigating internal and external competition in duopoly markets using a Stackelberg nash game theoretical framework, *Journal of Remanufacturing* 14 (2) (2024) 253–292.
- [13] N. M. Modak, S. Sinha, T. Senapati, V. Simic, D. Pamucar, Game theoretical analysis in two-echelon sustainable supply chains to manage and coordinate strategic decisions, *Computers & Industrial Engineering* 192 (2024) 110204.