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Competitive Effects of Live-Streaming Adoption and Product Customization: A Hotelling Duopoly Analysis

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Abstract

This study investigates how live-streaming channel adoption and product customization reshape competitive strategies in a duopoly market. Motivated by the rapid growth of live-streaming commerce and the increasing demand for personalized products, we develop a Hotelling-based analytical framework to examine manufacturers' pricing, customization, demand, and profit decisions under three scenarios: no live-streaming adoption, unilateral live-streaming adoption, and bilateral live-streaming adoption. The model explicitly incorporates consumer responsiveness to live-streaming-based customization, platform commission costs, and return-related considerations. The results show that live-streaming adoption is not universally beneficial. When only one manufacturer adopts a live-streaming channel, the adopting firm can improve product differentiation, increase pricing power, and gain a first-mover advantage, especially when consumers are highly responsive to live-streaming-based customization and platform commissions are relatively low. However, when both manufacturers adopt live streaming, the resulting increase in customization competition and channel-related costs may offset the value created by live-streaming interaction, and bilateral adoption may even reduce profits relative to the benchmark scenario. The analysis further reveals that the joint effect of consumer responsiveness and platform commission generates distinct strategic regions, including anti-coordination, Pareto-improving coordination, and a live-streaming competition trap. These findings contribute to the literature on live-streaming commerce, product customization, and competitive channel strategy by showing that the value of live-streaming adoption depends critically on market conditions and platform governance. The study also offers managerial insights for manufacturers seeking to balance digital channel adoption, customization investment, and competitive positioning.

Keywords

Live-Streaming Commerce, Product Customization, Hotelling Model, Competitive Strategy, Channel Adoption, Platform Commission

1. Introduction

In recent years, rapid advances in Internet technologies and platform-based retailing have accelerated the rise of live-streaming commerce as an important digital retail format [1]-[3]. Unlike conventional e-commerce, live-streaming commerce combines real-time product presentation, synchronous interaction, and instant feedback, allowing firms to communicate product information more vividly and respond to consumer needs more promptly [4]-[6]. These studies suggest that live-streaming commerce is not merely an extension of traditional online shopping, but a distinctive retail mechanism shaped by strong interactivity and dynamic value co-creation.

A central reason for the rapid diffusion of live-streaming commerce is its ability to reduce consumer uncertainty and strengthen purchase intention. Prior studies show that live interaction, visual product demonstration, and social presence can improve consumers' trust and perceived product value during the shopping process [4]-[6]. Other research has further shown that live-streaming environments can strengthen customer engagement, swift guanxi, emotional contagion, and impulse buying behavior [7]-[11]. In addition, trust plays a critical role in customer retention in live-streaming commerce, indicating that the channel affects not only initial purchase decisions but also longer-term consumer relationships [12].

From a managerial perspective, however, the introduction of a live-streaming channel is far from a uniformly beneficial strategy. Recent analytical studies have increasingly examined live-streaming commerce as a channel-strategy problem rather than merely a consumer-behavior phenomenon. These studies show that live-streaming adoption may interact with selling modes, product showcasing strategies, influencer cooperation, return behavior, and platform governance [13]-[20]. However, most of them do not explicitly connect live-streaming adoption with endogenous product customization in a horizontally competitive market. Similarly, the customization literature has analyzed product variety, price competition, and return decisions mainly in conventional retail or manufacturing contexts [21]-[31]. Therefore, this study differs from prior work by combining live-streaming adoption and product customization within a Hotelling duopoly framework, thereby capturing how digital interaction reshapes both consumer utility and strategic competition.

At the same time, the growing demand for personalized products has made product customization an increasingly important source of differentiation [32]. The mass customization literature has long emphasized that customization can improve product-consumer fit and increase consumers' willingness to pay [21]-[23]. At the same time, customization also creates new operational and competitive challenges, because it affects product variety, production efficiency, lead time, and market rivalry [24]-[27]. In some cases, customization may soften price competition by strengthening firm-specific appeal; in others, it may intensify rivalry by encouraging firms to overinvest in differentiation [28]-[31].

These insights are particularly relevant in the context of live-streaming commerce. In practice, firms are increasingly using live-streaming channels to promote and implement customized offerings, because live interaction allows them to observe consumer preferences more effectively and communicate product attributes more vividly [13]-[18]. In this sense, livestream-based product customization can become a powerful differentiation instrument. However, it is also costly. Customization-oriented live-streaming interaction often requires additional investment in design, communication, service, and channel operation, and its profitability may be weakened by platform commissions and return-related considerations [19] [20].

Against this background, an important strategic issue arises when competing manufacturers simultaneously introduce live-streaming channels and engage in product customization. Although live-streaming interaction may enhance demand and strengthen differentiation, it may also intensify competition by making products more directly comparable and by encouraging firms to compete more aggressively in customization and pricing [17] [19] [20]. Meanwhile, the customization literature suggests that greater differentiation effort does not necessarily translate into higher profits, especially when competitors respond strategically [22] [23] [28]. Therefore, whether live-streaming interaction and customization investment improve firm outcomes depends not only on their demand-enhancing effects, but also on how they reshape strategic interaction between rival firms.

Despite the richness of the existing literature, two important gaps remain. First, the live-streaming commerce literature has mainly focused on consumer behavior, channel design, showcasing strategies, and influencer cooperation [13]-[20]. Second, the product customization literature has largely examined competition in more traditional retail or manufacturing settings [21]-[31]. Limited research has examined the interaction between live-streaming adoption and product customization as a joint competitive strategy. In particular, we still know little about how live-streaming interaction and customization investment jointly affect manufacturers' pricing behavior, demand allocation, and profitability in a horizontally competitive market.

Motivated by this gap, this study investigates manufacturers' strategic decisions after introducing a live-streaming channel in a competitive market. Using a classical Hotelling framework [33], we analyze how consumer sensitivity to livest ream-based customization, the level of live-streaming interaction, and customization investment affect market demand, equilibrium pricing, and firm profits under different channel-adoption scenarios. More specifically, this study addresses three questions. First, how does consumer sensitivity to livestream-based customization affect market demand and manufacturers' profits? Second, under unilateral and bilateral adoption of live-streaming interaction, how should manufacturers determine their optimal customization levels and pricing strategies? Third, when both manufacturers engage in customization-oriented live-streaming interaction, will their strategic choices lead to excessive competition and thereby reduce overall market performance?

This study contributes to the literature in three ways. First, it links the live-streaming commerce literature with the product customization and horizontal competition literature by examining livestream-based product customization as a competitive strategy rather than merely a promotional practice. Second, it highlights that live-streaming interaction should be understood as an endogenous strategic variable whose value depends on customization decisions and competitive responses. Third, it identifies the conditions under which customization-oriented live-streaming interaction enhances differentiation and improves profitability, as well as the conditions under which it induces excessive competition. Therefore, this study not only extends the theoretical understanding of competition in live-streaming commerce, but also provides managerial implications for manufacturers seeking to optimize channel adoption, resource allocation, and competitive positioning in digital retail markets.

2. Problem Description

This study examines the competitive decision-making problem of two rival manufacturers offering customized products in the presence of a live-streaming channel. We consider a Hotelling-type duopoly market in which the two manufacturers are located at the two endpoints of the unit interval, *i.e.*, manufacturer 1 is located at 0 and manufacturer 2 is located at 1. Following the standard Hotelling framework, we focus on a symmetric product setting in which the two manufacturers sell functionally identical products through conventional online channels. In addition to these traditional e-commerce channels, both manufacturers may choose to introduce a live-streaming channel.

To capture different channel-adoption patterns, we consider the following three competitive scenarios.

1) **Benchmark scenario B.** Neither manufacturer adopts a live-streaming channel. In this case, consumers make purchase decisions based on retail prices, preference matching, and return risk.

2) **Unilateral live-streaming scenario N.** Only one manufacturer adopts the live-streaming channel. Without loss of generality, we assume that manufacturer 1 introduces the live-streaming channel and provides product customization, whereas manufacturer 2 continues to operate only through the conventional online channel.

3) **Bilateral live-streaming scenario L.** Both manufacturers adopt live-streaming channels and both provide product customization services.

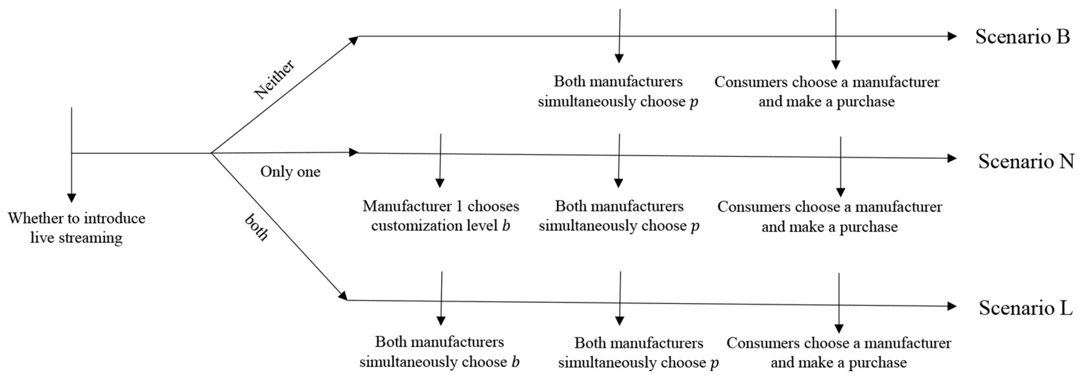


Figure 1. Game sequence.

The two manufacturers engage in a Nash game. The sequence of decisions is illustrated in **Figure 1**. First, the manufacturers decide whether to adopt the live-streaming mode. Second, they determine their **customization levels**, denoted by b. Finally, they simultaneously choose their retail prices p.

Without loss of generality, manufacturer 1 is located at 0 and manufacturer 2 is located at 1. As shown in **Figure 2**, the total mass of consumers in the market is normalized to 1, and consumers are uniformly distributed along the unit interval $[0,1]$. Let $x \in [0,1]$ denote a consumer's relative preference for manufacturer 1; then $1-x$ represents the relative preference for manufacturer 2. Each consumer purchases one unit from one of the two manufacturers. Accordingly, if the indifferent consumer is located at x, the demand functions of the two manufacturers are given by $D_1 = \int_0^x 1\,\mathrm{d}x = x$, $D_2 = \int_x^1 1\,\mathrm{d}x = 1-x$.

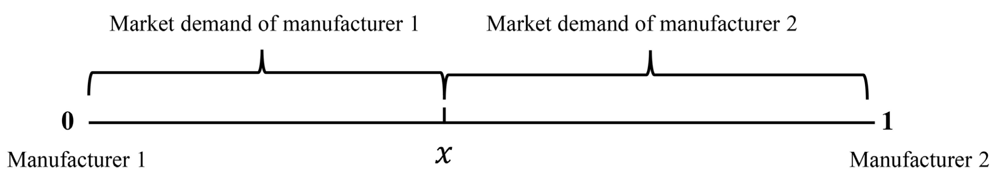


Figure 2. Hotelling model.

We use t ($t > 0$) to measure the unit mismatch cost between consumers and manufacturers. The parameter t captures consumers' sensitivity to horizontal differentiation between the two manufacturers. A lower value of t indicates that consumers care less about the difference between the two manufacturers, implying more intense market competition.

Because consumers cannot fully evaluate the product before receiving it, product returns may occur after purchase. In this model, live-streaming adoption does not imply that product returns disappear. Rather, live-streaming interaction is assumed to reduce consumers' perceived mismatch and return-related disutility by providing real-time product information and customization guidance, while the manufacturer still bears the corresponding commission and customization costs. Let θ denote the consumer satisfaction rate, so that $1-\theta$ represents the probability of return. If a consumer returns the product, a return cost m is incurred. Let v denote the consumer's valuation of the product, and let s denote the salvage value of the returned product.

When a manufacturer adopts the live-streaming channel and offers livestream-based product customization, let b denote its customization level. The total investment cost of customization is assumed to be $C(b)=\frac{kb^2}{2}$, with $C'(b)>0$ and $C''(b)>0$. This quadratic cost specification captures increasing and convex customization investment costs and is standard in related analytical models. Without loss of generality, we set $k=1$, which simplifies the analysis without affecting the main results.

In addition, let α denote the impact of live-streaming interaction on consumer preferences. Then the additional utility that a consumer obtains from live-streaming-enabled customization is given by αb. We further assume that the unit production cost of each manufacturer is zero. The main notation used in the model is summarized in Table 1.

Table 1. Symbol description.

Symbol	Meaning
v	Base product value
p_i^j	Selling price of manufacturer i in scenario j
x	Consumer location on the Hotelling line
t	Mismatch cost
m	Return cost
θ	Product matching probability
α	Sensitivity coefficient of live-streaming interaction
b_i^j	Customization level of manufacturer i in scenario j
$C(b)$	Customization cost function
π_i^j	Manufacturer profit function
ρ	Commission rate

3. Model Development and Analysis

For analytical convenience, let $\rho\in(0,1)$ denote the commission rate charged by the live-streaming platform. When a manufacturer adopts a live-streaming channel, its revenue from each successful sale is reduced to $(1-\rho)p$. We solve the game by backward induction. Specifically, in each scenario, manufacturers first choose whether to adopt live streaming, then determine the customization level, and finally set retail prices simultaneously.

To streamline the presentation, we focus on interior equilibria. Unless otherwise stated, we assume full market coverage, nonnegative prices, nonnegative customization levels, and interior demands, *i.e.*, $0<D_i^j<1$ for each manufacturer

$i=1,2$ and scenario $j \in \{B, N, L\}$. In addition, the second-order and regularity conditions required for the closed-form equilibria are imposed throughout the analysis, including $\Delta = 6t\theta - \alpha^2(1-\rho) > 0$ in the unilateral live-streaming scenario and $4t\theta - \alpha^2(1-\rho) > 0$ in the bilateral live-streaming scenario.

3.1. Benchmark Scenario *B*

In the benchmark scenario, neither manufacturer introduces a live-streaming channel. Consumers purchase through the conventional online channel and face return risk because product quality or fit cannot be fully verified ex ante. Accordingly, the expected utilities from purchasing from manufacturers 1 and 2 are given by

$$U_1^B = \theta\left(v - p_1^B\right) - xt - (1-\theta)m, U_2^B = \theta\left(v - p_2^B\right) - (1-x)t - (1-\theta)m, \tag{1}$$

Let the indifferent consumer be located at x. By equating the two utilities, *i.e.*,

$$\theta\left(v - p_1^B\right) - xt - (1-\theta)m = \theta\left(v - p_2^B\right) - (1-x)t - (1-\theta)m, \tag{2}$$

we obtain

$$x = \frac{t - \theta p_1^B + \theta p_2^B}{2t}, \tag{3}$$

Hence, the demand functions of the two manufacturers are

$$D_1^B = x = \frac{t + \theta\left(p_2^B - p_1^B\right)}{2t}, D_2^B = 1 - x = \frac{t + \theta\left(p_1^B - p_2^B\right)}{2t}, \tag{4}$$

Because returns occur with probability $1-\theta$, the expected unit revenue of manufacturer i is $\theta p_i^B + (1-\theta)s$. Therefore, the profit functions are

$$\pi_1^B = \left[\theta p_1^B + (1-\theta)s\right] D_1^B, \pi_2^B = \left[\theta p_2^B + (1-\theta)s\right] D_2^B. \tag{5}$$

Lemma 1

In scenario B, the equilibrium prices are $p_1^{B*} = p_2^{B*} = s - \frac{s-t}{\theta}$. Substituting these prices into the demand and profit functions yields $D_1^{B*} = D_2^{B*} = \frac{1}{2}$, $\pi_1^{B*} = \pi_2^{B*} = \frac{t}{2}$.

Lemma 1 establishes the symmetric benchmark equilibrium. Without live streaming, neither manufacturer enjoys an additional differentiation advantage, so the market is evenly split and profits are determined solely by the intensity of horizontal differentiation, measured by t.

3.2. Unilateral Live-Streaming Scenario *N*

We next consider the case in which only manufacturer 1 adopts a live-streaming channel and provides product customization, whereas manufacturer 2 continues to sell through the conventional online channel. In this setting, live-streaming interaction increases consumers' utility through product customization and alleviates return-related disutility on the live-streaming side. Let b_1^N denote manufacturer 1's customization level. Then consumer utilities are

$$U_1^N = \theta\left(v - p_1^N\right) - xt + \alpha b_1^N, U_2^N = \theta\left(v - p_2^N\right) - (1-x)t - (1-\theta)m. \tag{6}$$

The indifferent consumer satisfies

$$\theta\left(v - p_1^N\right) - xt + \alpha b_1^N = \theta\left(v - p_2^N\right) - (1-x)t - (1-\theta)m, \tag{7}$$

which implies

$$x = \frac{m + t + \alpha b_1^N - \theta\left(m + p_1^N - p_2^N\right)}{2t}. \tag{8}$$

Thus, the demand functions are

$$D_1^N = \frac{m + t + \alpha b_1^N - \theta\left(m + p_1^N - p_2^N\right)}{2t}, D_2^N = \frac{-m + t - \alpha b_1^N + \theta\left(m + p_1^N - p_2^N\right)}{2t}. \tag{9}$$

Manufacturer 1 pays a platform commission and incurs customization cost, while manufacturer 2 remains in the conventional channel. Their profit functions are therefore

$$\pi_1^N = (1-\rho)p_1^N D_1^N - \frac{\left(b_1^N\right)^2}{2}, \pi_2^N = \left[\theta p_2^N + (1-\theta)s\right]D_2^N. \tag{10}$$

Define $A \equiv 3t + (1-\theta)(m-s)$, $\Delta \equiv 6t\theta - \alpha^2(1-\rho)$. Using backward induction, we obtain the following result.

Lemma 2

In scenario N, the equilibrium customization level and prices are $b_1^{N*} = \frac{\alpha(1-\rho)A}{\Delta}$, $p_1^{N*} = \frac{2tA}{\Delta}$, $p_2^{N*} = s - \frac{s-2t}{\theta} - \frac{2tA}{\Delta}$. The corresponding equilibrium demands are $D_1^{N*} = \frac{\theta A}{\Delta}$, $D_2^{N*} = 1 - \frac{\theta A}{\Delta}$.

The equilibrium profits are $\pi_1^{N*} = \frac{A^2\left(4t\theta - \alpha^2(1-\rho)\right)(1-\rho)}{2\Delta^2}$,
$\pi_2^{N*} = \frac{2t\left[\theta\left(3t - (1-\theta)(m-s)\right) - \alpha^2(1-\rho)\right]^2}{\Delta^2}$.

Lemma 2 shows that unilateral live-streaming adoption creates an asymmetric market structure. Manufacturer 1 gains a differentiation instrument through customization-oriented live-streaming interaction, whereas manufacturer 2 remains exposed to return risk and cannot directly benefit from live-streaming utility.

Corollary 1

Under the interior-solution condition $\Delta > 0$, the equilibrium outcomes in scenario N satisfy $\frac{\partial p_1^{N*}}{\partial \alpha} > 0$, $\frac{\partial p_2^{N*}}{\partial \alpha} < 0$, $\frac{\partial p_1^{N*}}{\partial \rho} < 0$, $\frac{\partial p_2^{N*}}{\partial \rho} > 0$, $\frac{\partial b_1^{N*}}{\partial \alpha} > 0$, $\frac{\partial b_1^{N*}}{\partial \rho} < 0$, $\frac{\partial D_1^{N*}}{\partial \alpha} > 0$, $\frac{\partial D_2^{N*}}{\partial \alpha} < 0$, $\frac{\partial D_1^{N*}}{\partial \rho} < 0$, $\frac{\partial D_2^{N*}}{\partial \rho} > 0$, $\frac{\partial \pi_1^{N*}}{\partial \alpha} > 0$, $\frac{\partial \pi_2^{N*}}{\partial \alpha} < 0$, $\frac{\partial \pi_1^{N*}}{\partial \rho} < 0$, $\frac{\partial \pi_2^{N*}}{\partial \rho} > 0$.

Corollary 1 indicates that stronger consumer sensitivity to live-streaming-enabled customization enhances the competitive advantage of the adopting manufacturer. As α increases, manufacturer 1 optimally chooses a higher customization level, charges a higher price, attracts more demand, and earns higher profit. By contrast, manufacturer 2 loses market share and must reduce its price. A higher platform commission rate ρ has the opposite effect: it weakens the attractiveness of live-streaming adoption, reduces manufacturer 1's incentive to customize, and partially shifts demand and profitability back to manufacturer 2.

To compare the unilateral live-streaming scenario with the benchmark scenario, we obtain the following result.

Proposition 1

Suppose $\alpha > \sqrt{2(s-m)(1-\theta)\theta}$. Then, when only one manufacturer adopts the live-streaming channel, the following properties hold.

1) Price comparison: $p_1^{N*} > p_i^{B*}, i = 1,2$. Moreover, $p_1^{N*} > p_i^{B*} > p_2^{N*}$ if and only if $\rho < 1 - \frac{2(s-m)(1-\theta)\theta}{\alpha^2}$, whereas $p_1^{N*} > p_2^{N*} > p_i^{B*}$ otherwise.

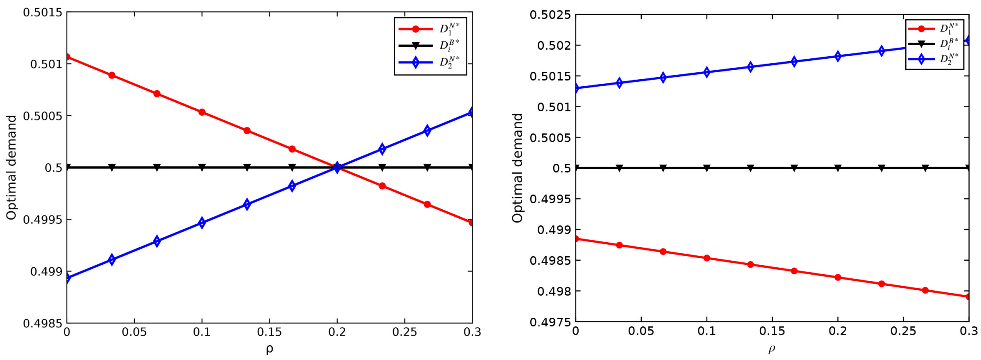
2) Demand comparison: $D_1^{N*} > D_i^{B*} > D_2^{N*}$ if and only if $\rho < 1 - \frac{2(s-m)(1-\theta)\theta}{\alpha^2}$, whereas $D_2^{N*} > D_i^{B*} > D_1^{N*}$ otherwise.

Proposition 1 shows that unilateral live-streaming adoption reshapes both the pricing structure and the demand allocation in an asymmetric way. The live-streaming manufacturer always charges a higher price than in the benchmark scenario. This result reflects the additional value created by live-streaming-enabled customization: by providing interactive product presentation and personalized services, the adopting manufacturer enhances consumers' perceived utility and thereby strengthens its pricing power.

More importantly, the relative positions of the non-adopting manufacturer's price and the two firms' market demands depend on the joint effect of consumer sensitivity to live-streaming-based customization and the platform commission rate. When the commission rate is sufficiently low, or equivalently when the net benefit of live-streaming adoption is sufficiently strong, the live-streaming manufacturer attracts more consumers than in the benchmark case, while the traditional manufacturer loses market share. In this case, the equilibrium demand ranking becomes $D_1^{N*} > D_i^{B*} > D_2^{N*}$. At the same time, the non-adopting manufacturer faces stronger competitive pressure and must reduce its price relative to the benchmark level, which yields the price ranking $p_1^{N*} > p_i^{B*} > p_2^{N*}$.

By contrast, when the commission rate is relatively high, the cost disadvantage of live-streaming adoption weakens the attractiveness of the live-streaming channel. Although the adopting manufacturer still enjoys a differentiation advantage and charges the highest price, the non-adopting manufacturer can retain or even expand its market demand by avoiding live-streaming-related costs. Under such conditions, the demand ranking reverses to $D_2^{N*} > D_i^{B*} > D_1^{N*}$, and the non-adopting manufacturer is able to charge a price above the benchmark level, leading to the ordering $p_1^{N*} > p_2^{N*} > p_i^{B*}$.

Overall, **Figure 3** indicates that unilateral live-streaming adoption does not simply intensify competition in a uniform way. Instead, it creates an asymmetric market structure in which the live-streaming manufacturer always enjoys stronger pricing power, while the final allocation of market demand depends on whether the value created by live-streaming-based customization is large enough to outweigh the platform commission burden.



(a) $\alpha < \sqrt{2}\sqrt{(m-s)(-1+\theta)\theta}$ (b) $\alpha > \sqrt{2}\sqrt{(m-s)(-1+\theta)\theta}$

Figure 3. Comparison diagram of optimal demand size.

Proposition 2

If $\alpha > \sqrt{\frac{2}{3}\left(-m\theta + s\theta + m\theta^2 - s\theta^2\right)}$, then $\pi_2^{N*} < \pi_2^{B*}$ if $\rho < \frac{3\alpha^2 + 2m\theta - 2s\theta - 2m\theta^2 + 2s\theta^2}{3\alpha^2}$, and otherwise $\pi_2^{N*} > \pi_2^{B*}$.

Proposition 2 implies that manufacturer 1's live-streaming adoption may either hurt or benefit manufacturer 2. When α is large and ρ is low, manufacturer 1 can effectively convert live-streaming interaction into market-stealing power, thereby reducing manufacturer 2's profit. By contrast, when ρ becomes sufficiently high, the live-streaming side suffers from a heavy commission burden, and manufacturer 2 may benefit from a relative competitive improvement.

Proposition 3

There exist threshold values $\bar{\alpha}$ and $\bar{\rho}$ such that, for $\bar{\alpha} < \alpha < 1$, $\pi_1^{N*} > \pi_1^{B*}$ if $\rho < \bar{\rho}$, whereas $\pi_1^{N*} < \pi_1^{B*}$ if $\rho > \bar{\rho}$.

The explicit expressions of α and ρ are reported in **Appendix A**.

Proposition 3 highlights that introducing a live-streaming channel is not always profitable. Live-streaming adoption benefits the adopting manufacturer only when consumers value customization-oriented interaction sufficiently strongly and the commission rate remains sufficiently low. Otherwise, the commission payment and customization cost may outweigh the strategic gain from differentiation.

3.3. Bilateral Live-Streaming Scenario *L*

We now consider the case in which both manufacturers adopt live-streaming channels and both provide product customization. Let b_1^L and b_2^L denote the customization levels of manufacturers 1 and 2, respectively. Consumer utilities are

$$U_1^L=\theta\left(v-p_1^L\right)-xt+\alpha b_1^L, U_2^L=\theta\left(v-p_2^L\right)-(1-x)t+\alpha b_2^L, \tag{11}$$

The indifferent consumer is determined by

$$\theta\left(v-p_1^L\right)-xt+\alpha b_1^L=\theta\left(v-p_2^L\right)-(1-x)t+\alpha b_2^L, \tag{12}$$

which gives

$$x=\frac{t+\alpha b_1^L-\alpha b_2^L-\theta p_1^L+\theta p_2^L}{2t}, \tag{13}$$

Thus, demand is

$$D_1^L=\frac{t+\alpha b_1^L-\alpha b_2^L-\theta p_1^L+\theta p_2^L}{2t}, D_2^L=\frac{t-\alpha b_1^L+\alpha b_2^L+\theta p_1^L-\theta p_2^L}{2t}. \tag{14}$$

Each manufacturer pays the platform commission and incurs customization cost, so profits are

$$\pi_1^L=(1-\rho)p_1^L D_1^L-\frac{\left(b_1^L\right)^2}{2}, \pi_2^L=(1-\rho)p_2^L D_2^L-\frac{\left(b_2^L\right)^2}{2}. \tag{15}$$

Lemma 3

In scenario L, the symmetric equilibrium is $b_1^{L*}=b_2^{L*}=\frac{\alpha(1-\rho)}{2\theta}$, $p_1^{L*}=p_2^{L*}=\frac{t}{\theta}$.

The equilibrium demands are $D_1^{L*}=D_2^{L*}=\frac{1}{2}$, and the equilibrium profits are $\pi_1^{L*}=\pi_2^{L*}=\frac{\left(4t\theta-\alpha^2(1-\rho)\right)(1-\rho)}{8\theta^2}$.

Lemma 3 indicates that once both manufacturers adopt live streaming, the market returns to a symmetric structure. Although both firms invest in customization and can raise prices relative to the conventional channel, the differentiation advantage created by unilateral adoption disappears.

Corollary 2

In scenario L, the equilibrium outcomes satisfy $\frac{\partial b_1^{L*}}{\partial\alpha}=\frac{\partial b_2^{L*}}{\partial\alpha}>0$, $\frac{\partial b_1^{L*}}{\partial\rho}=\frac{\partial b_2^{L*}}{\partial\rho}<0$, $\frac{\partial\pi_1^{L*}}{\partial\alpha}=\frac{\partial\pi_2^{L*}}{\partial\alpha}=-\frac{\alpha(1-\rho)^2}{4\theta^2}<0$, $\frac{\partial\pi_1^{L*}}{\partial\rho}=\frac{\partial\pi_2^{L*}}{\partial\rho}=-\frac{2t\theta-\alpha^2(1-\rho)}{4\theta^2}<0$.

Corollary 2 reveals a key difference from the unilateral-adoption case. Although a larger α induces both manufacturers to increase customization, bilateral live-streaming competition may generate an over-customization effect: each firm invests more aggressively to avoid losing demand, but because the market remains symmetric, the additional value created by customization is dissipated through competition and commission payments. As a result, stronger consumer sensitivity to live-streaming interaction does not necessarily improve profits under bilateral adoption.

To compare the bilateral live-streaming scenario with the benchmark scenario, we obtain the following result.

Proposition 4

For each manufacturer, $p_i^{L*} > p_i^{B*}$.

Proposition 4 implies that bilateral live-streaming adoption raises equilibrium prices relative to the benchmark. When both manufacturers provide live-streaming interaction and customization, consumers obtain additional utility from both sides of the market, which increases their willingness to pay.

Proposition 5

If $\alpha < \sqrt{4t\theta - 4t\theta^2}$, then $\pi_i^{L*} > \pi_i^{B*}$ if $\rho < 1 + \frac{2\left(-t + \sqrt{t\left(t - \alpha^2\right)}\right)\theta}{\alpha^2}$, whereas $\pi_i^{L*} < \pi_i^{B*}$ otherwise.

Proposition 5 indicates that bilateral live-streaming adoption is beneficial only when the commission rate is sufficiently low and the customization effect remains moderate. When α becomes too large, competition in customization intensifies and both manufacturers incur excessive cost, so the bilateral-adoption equilibrium may generate lower profits than the benchmark.

3.4. Comparative Analysis across Scenarios

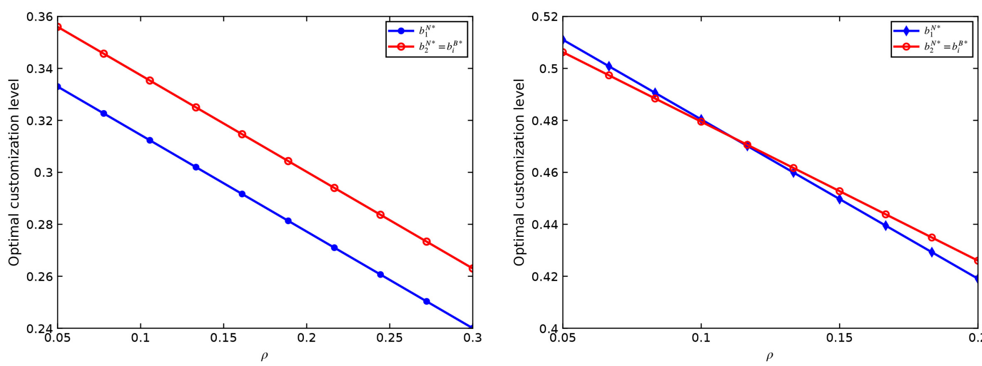
The comparison between scenarios N and L is more subtle because unilateral adoption creates a first-mover differentiation advantage, whereas bilateral adoption restores symmetry and may intensify competition.

Proposition 6

Comparing the bilateral and unilateral live-streaming scenarios, and under the regularity condition $t \ge s(1-\theta)$, suppose $\alpha > \sqrt{2(s-m)(1-\theta)\theta}$. Then the following results hold.

1) **Price comparison:** If $\rho < 1 - \frac{2(s-m)(1-\theta)\theta}{\alpha^2}$, then $p_i^{L*} > p_1^{N*} > p_2^{N*}, i = 1,2$. Otherwise, $p_1^{N*} > p_i^{L*} > p_2^{N*}, i = 1,2$.

2) **Customization comparison:** If $\rho < 1 - \frac{2(s-m)(1-\theta)\theta}{\alpha^2}$, then $b_1^{N*} > b_i^{L*}, i = 1,2$. Otherwise, $b_1^{N*} < b_i^{L*}, i = 1,2$.



(a) $\alpha < \sqrt{2}\sqrt{(m-s)(-1+\theta)\theta}$ (b) $\alpha > \sqrt{2}\sqrt{(m-s)(-1+\theta)\theta}$

Figure 4. Comparison chart of optimal customization level size.

Proposition 6 compares firms' equilibrium decisions under unilateral and bilateral live-streaming adoption and shows that the relative rankings of prices and customization levels are governed by the same threshold condition. This threshold reflects the trade-off between the value created by live-streaming-based customization and the commission burden imposed by the platform.

For prices, the non-adopting manufacturer in the unilateral live-streaming scenario always charges the lowest price. This is because it does not provide live-streaming-enabled customization and therefore faces a weaker perceived-value position in competition with the adopting manufacturer. To retain demand, it must rely more heavily on price competition. The relative ranking between the bilateral-adoption price and the unilateral adopter's price, however, depends on the platform commission rate. When the commission rate is sufficiently low, bilateral live-streaming adoption allows both manufacturers to enhance consumers' perceived value, which raises the overall willingness to pay in the market. In this case, the bilateral-adoption price becomes the highest. By contrast, when the commission rate is relatively high, bilateral adoption becomes more costly because both manufacturers must bear the platform commission. As a result, the unilateral adopter, which still enjoys a differentiation advantage, may charge a higher price than the manufacturers in the bilateral-adoption scenario.

For customization, the same threshold effect applies. When the commission rate is low, the unilateral adopter has a stronger incentive to invest in customization in order to widen the gap with its traditional rival, so its optimal customization level exceeds that under bilateral adoption. However, when the commission rate is high, unilateral adoption becomes less attractive and the adopting manufacturer behaves more conservatively in customization. In contrast, under bilateral live-streaming competition, both manufacturers may still need to maintain a relatively high customization level in order to preserve their competitive positions. Therefore, the customization level under bilateral adoption may exceed that of the unilateral adopter when the commission burden is sufficiently high.

Overall, Figure 4 indicates that unilateral and bilateral live-streaming adoption differ not only in market structure but also in the strategic logic of pricing and customization. Low commission rates favor stronger market-wide pricing under bilateral adoption and stronger customization incentives for the unilateral adopter, whereas high commission rates weaken the bilateral pricing advantage and may reverse the ranking of customization levels.

Proposition 7

Under the admissible parameter region in which the unilateral adopter's differentiation advantage dominates the bilateral customization-competition effect, that is, $\pi_1^{N*} > \pi_2^{N*} > \pi_i^{L*}$, $i = 1, 2$, the unilateral live-streaming scenario yields the highest profit for the adopting manufacturer, while bilateral live-streaming adoption generates the lowest profit among the compared live-streaming scenarios. Since scenario L is symmetric, $\pi_1^{L*} = \pi_2^{L*} = \pi_i^{L*}$.

Proposition 7 indicates that, within this parameter region, the first manufacturer obtains the highest profit under unilateral live-streaming adoption. By introducing live-streaming-enabled customization ahead of its rival, manufacturer 1 enjoys a first-mover advantage: it attracts a larger market share, enhances consumers' perceived utility, and strengthens its pricing power. Manufacturer 2, although disadvantaged in scenario N, still earns more than under scenario L, where both firms simultaneously adopt live streaming and bear the associated customization and commission costs.

This result highlights that bilateral live-streaming adoption may eliminate the strategic differentiation advantage created by unilateral adoption while retaining the cost burden of customization competition. Consequently, a late follower does not necessarily improve its profitability by imitating the pioneer. If effective differentiation cannot be achieved, maintaining the conventional channel may be more profitable than entering a symmetric live-streaming competition.

Proposition 8

Define the live-streaming competition-trap region as $\Omega_3 = \left\{(\alpha,\rho): \pi_1^{N*} > \pi_1^{B*}, \pi_2^{N*} > \pi_i^{L*}, \pi_i^{B*} > \pi_i^{L*}, i = 1,2\right\}$. In this region, unilateral live-streaming adoption is profitable for the adopting manufacturer, whereas bilateral live-streaming adoption reduces both manufacturers' profits below the benchmark level.

Proposition 8 shows that when the live-streaming effect is strong and the commission burden is light, live-streaming adoption can create substantial gains for a single adopter. However, once both manufacturers enter the live-streaming channel, intensified customization competition and commission payments erode these gains, causing bilateral adoption to perform worse than the benchmark scenario. In this sense, the market may fall into a **live-streaming competition trap**: although live streaming appears attractive as a unilateral strategy, mutual adoption results in lower profits for both firms. Therefore, the competition trap should be understood as a profit-eroding mutual imitation outcome: live streaming is attractive as a unilateral strategy, but once both firms adopt it, the differentiation advantage is dissipated by customization competition and commission payments.

3.5. Stage-1 Adoption Game

To further clarify the strategic implication of channel adoption, we summarize the first-stage adoption game. If neither manufacturer adopts live streaming, the payoff vector is $\left(\pi_i^{B*}, \pi_i^{B*}\right)$. If only manufacturer 1 adopts live streaming, the payoff vector is $\left(\pi_1^{N*}, \pi_2^{N*}\right)$; by symmetry, if only manufacturer 2 adopts live streaming, the payoff vector is $\left(\pi_2^{N*}, \pi_1^{N*}\right)$. If both manufacturers adopt live streaming, the payoff vector is $\left(\pi_i^{L*}, \pi_i^{L*}\right)$. Therefore, a manufacturer adopts live streaming when its rival does not adopt if $\pi_1^{N*} \ge \pi_i^{B*}$, and adopts live streaming when its rival has already adopted if $\pi_i^{L*} \ge \pi_2^{N*}$. These best-response conditions generate different adoption patterns, including non-adoption, asymmetric adoption, bilateral adoption, and the competition-trap region discussed below.

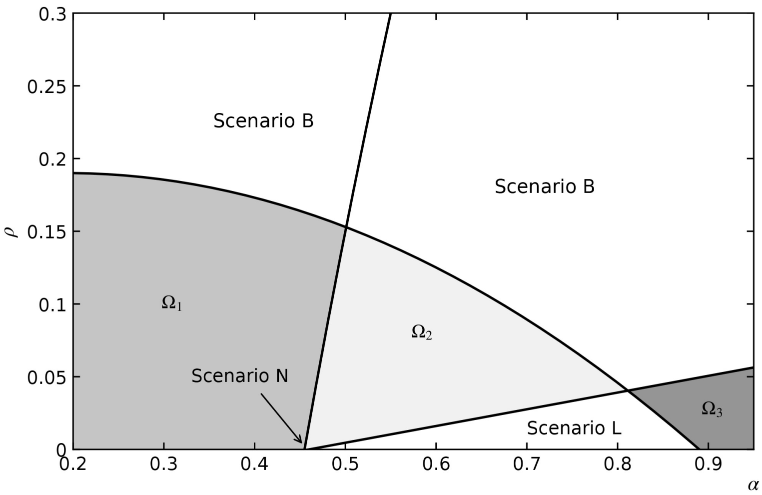


Figure 5. The equilibrium strategy of two manufacturers.

To further illustrate the strategic implications of the model, **Figure 5** partitions the (α,ρ)-space into several qualitatively different regions. The figure shows that manufacturers' live-streaming adoption decisions depend critically on the interaction between consumer sensitivity to live-streaming-based customization, captured by α, and the platform commission rate, captured by ρ.

When α is relatively high and ρ is low, live-streaming interaction substantially enhances consumers' perceived value, while the marginal cost of adopting the live-streaming channel remains limited. In this case, live-streaming adoption can improve firms' pricing power and generate profit gains. When both α and ρ are at moderate levels, live streaming still provides a positive demand effect, but the associated commission and customization costs become non-negligible. Under such conditions, unilateral adoption may outperform bilateral adoption, because the non-adopting manufacturer can avoid direct live-streaming competition and preserve its profitability. By contrast, when ρ is sufficiently high, the commission burden dominates the benefit of live-streaming interaction, so that neither manufacturer has a strong incentive to adopt the live-streaming channel, and the benchmark scenario becomes more attractive.

More specifically, three strategic regions can be identified in **Figure 5**.

Anti-coordination region Ω_1: When the attractiveness of live-streaming-based customization is limited and the platform commission rate is moderate, manufacturers exhibit an anti-coordination pattern in channel adoption. In this region, if only one manufacturer adopts live streaming, the adopter may incur excessive commission and customization costs without obtaining sufficient demand expansion, whereas the non-adopting rival benefits from avoiding these costs. If both manufacturers adopt live streaming, competition intensifies and the outcome remains suboptimal. Thus, firms have a strong incentive to wait and avoid being the first mover.

Pareto-improvement region Ω_2: When consumer sensitivity to live-streaming interaction is relatively strong and the commission rate remains moderate, simultaneous live-streaming adoption can improve the profitability of both manufacturers. In this region, live streaming creates sufficient additional consumer value to compensate for the associated costs, so bilateral adoption dominates the benchmark outcome. However, because this outcome relies on coordinated strategic choices, the market may still face a coordination problem if one manufacturer hesitates to adopt.

Live-streaming competition trap region Ω_3**:** When the live-streaming effect is strong and the commission rate is low, unilateral adoption is highly attractive because it creates a substantial differentiation advantage. However, once both manufacturers adopt live streaming, intensified customization competition dissipates this advantage and erodes profits. As a result, bilateral adoption may yield lower profits than the benchmark scenario, even though live streaming appears profitable from the perspective of an individual adopter. This region therefore reflects a live-streaming competition trap driven by excessive strategic investment in customization and channel rivalry. Overall, Fig. 5 demonstrates that manufacturers' channel choices and customization decisions exhibit a highly nonlinear strategic structure. Depending on the joint values of α and ρ, the market may display anti-coordination, Pareto-improving coordination, or a live-streaming competition trap. Therefore, the value of live-streaming adoption is inherently conditional rather than universal, and manufacturers should evaluate channel adoption jointly with customization incentives and platform governance conditions.

4. Conclusions

This study examines manufacturers' strategic decisions on live-streaming channel adoption and product customization in a competitive market. Based on a Hotelling framework, it analyzes how consumer responsiveness to live-streaming-based customization and the platform's commission policy jointly influence pricing, customization investment, market demand, and firm profitability under three scenarios: no live-streaming adoption, unilateral live-streaming adoption, and bilateral live-streaming adoption.

Several important findings emerge from the analysis. First, live-streaming adoption is not always beneficial. When only one manufacturer adopts a live-streaming channel, the adopting firm can enhance consumers' perceived value through customization-oriented live-streaming interaction, thereby improving its pricing power, expanding market demand, and increasing profit. This advantage is especially pronounced when consumers are highly responsive to live-streaming-based customization and the platform commission remains relatively low. In such a case, live streaming functions as an effective differentiation tool and creates a clear first-mover advantage. However, when the commission burden is high or the effectiveness of live-streaming interaction is weak, the benefits of adoption are significantly reduced and may even vanish.

Second, bilateral live-streaming adoption does not necessarily outperform the benchmark scenario. Although the presence of live streaming on both sides of the market enhances consumers' willingness to pay and supports higher prices, it also intensifies customization competition and increases channel-related costs. As a result, bilateral adoption may fail to improve profitability and can even leave both manufacturers worse off than in the traditional channel setting. This finding suggests that the strategic value of live streaming is conditional rather than universal. A digital channel that creates differentiation when adopted by one firm may generate excessive rivalry when adopted by all competing firms.

Third, the interaction between consumer responsiveness and platform commission gives rise to distinct strategic regions. When the attractiveness of live-streaming-based customization is limited and the commission rate is moderate, firms tend to avoid moving first, which leads to an anti-coordination pattern. When consumer responsiveness is relatively strong and the commission burden remains moderate, simultaneous adoption of live streaming can improve the profitability of both firms. By contrast, when consumer responsiveness is high and platform commissions are low, the market may fall into a live-streaming competition trap. In that case, unilateral adoption appears attractive from an individual firm's perspective, but mutual adoption intensifies competition and reduces the profits of both manufacturers.

These findings lead to several managerial implications. Manufacturers should not treat live streaming as a universally desirable digital strategy. Instead, live-streaming adoption should be evaluated together with customization investment, competitive conditions, and platform costs. Early adoption can be highly rewarding when the market strongly values live-streaming interaction and customization, but blind imitation may eliminate this advantage and compress industry profits. For platforms, commission policy plays a crucial role in shaping market outcomes. Excessively high commissions may discourage channel adoption, whereas very low commissions may stimulate excessive competition among manufacturers. Therefore, platform governance is central to the long-term sustainability of live-streaming commerce ecosystems.

This study can be extended in several directions. Future research may consider heterogeneous manufacturers, endogenous platform pricing, consumer learning, return policy design, or the role of influencers and third-party streamers. It may also be useful to incorporate supply chain contracts, uncertain demand, and dynamic competition in order to provide a more comprehensive understanding of live-streaming-based customization strategies in digital retail markets.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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Appendix A. Proofs of the Main Results

For notational convenience, define

$$A \equiv 3t + (1-\theta)(m-s), \Delta \equiv 6t\theta - \alpha^2(1-\rho).$$

Throughout the appendix, we focus on the interior equilibrium and assume

$$A > 0, \Delta > 0,$$

together with the mild regularity condition

$$t \geq s(1-\theta)$$

whenever a global price ordering is needed.

A.1. Proof of Lemma 1

In scenario B, the demand functions are

$$D_1^B = \frac{t+\theta\left(p_2^B - p_1^B\right)}{2t}, D_2^B = \frac{t+\theta\left(p_1^B - p_2^B\right)}{2t}.$$

Substituting these demands into the profit functions yields

$$\pi_1^B = \left[\theta p_1^B + (1-\theta)s\right]D_1^B, \pi_2^B = \left[\theta p_2^B + (1-\theta)s\right]D_2^B.$$

The second-order conditions are

$$\frac{\partial^2 \pi_1^B}{\partial\left(p_1^B\right)^2} = \frac{\partial^2 \pi_2^B}{\partial\left(p_2^B\right)^2} = -\frac{\theta^2}{t} < 0,$$

so both profit functions are concave in own prices. Solving the first-order conditions

$$\frac{\partial \pi_1^B}{\partial p_1^B} = 0, \frac{\partial \pi_2^B}{\partial p_2^B} = 0,$$

gives

$$p_1^{B*} = p_2^{B*} = s - \frac{s-t}{\theta}.$$

Substituting these prices back into the demand and profit functions, we obtain

$$D_1^{B*} = D_2^{B*} = \frac{1}{2}, \pi_1^{B*} = \pi_2^{B*} = \frac{t}{2}.$$

Hence, Lemma 1 is proved.

A.2. Proof of Lemma 2

In scenario N, the demand functions are

$$D_1^N = \frac{m+t+\alpha b_1^N - \theta\left(m + p_1^N - p_2^N\right)}{2t}, \; D_2^N = \frac{-m+t-\alpha b_1^N + \theta\left(m + p_1^N - p_2^N\right)}{2t}.$$

The corresponding profit functions are

$$\pi_1^N = (1-\rho)p_1^N D_1^N - \frac{\left(b_1^N\right)^2}{2}, \pi_2^N = \left[\theta p_2^N + (1-\theta)s\right]D_2^N.$$

To match the equilibrium expressions reported in the main text, we solve the first-order conditions jointly. For manufacturer 1, the Hessian with respect to $\left(p_1^N, b_1^N\right)$ is

$$H_1 = \begin{pmatrix} -\frac{\theta(1-\rho)}{t} & \frac{\alpha(1-\rho)}{2t} \\ \frac{\alpha(1-\rho)}{2t} & -1 \end{pmatrix},$$

whose leading principal minors satisfy

$$-\frac{\theta(1-\rho)}{t} < 0, \det(H_1) = \frac{(1-\rho)\left(4t\theta - \alpha^2(1-\rho)\right)}{4t^2} > 0,$$

under the regularity condition $4t\theta > \alpha^2(1-\rho)$. Hence, π_1^N is jointly concave in $\left(p_1^N, b_1^N\right)$. For manufacturer 2,

$$\frac{\partial^2 \pi_2^N}{\partial\left(p_2^N\right)^2} = -\frac{\theta^2}{t} < 0,$$

so π_2^N is concave in p_2^N.

Solving the system

$$\frac{\partial \pi_1^N}{\partial p_1^N} = 0, \frac{\partial \pi_1^N}{\partial b_1^N} = 0, \frac{\partial \pi_2^N}{\partial p_2^N} = 0,$$

yields

$$b_1^{N*} = \frac{\alpha(1-\rho)A}{\Delta},$$

$$p_1^{N*} = \frac{2tA}{\Delta},$$

$$p_2^{N*} = s - \frac{s-2t}{\theta} - \frac{2tA}{\Delta}.$$

Substituting these equilibrium decisions back into the demand functions gives

$$D_1^{N*} = \frac{\theta A}{\Delta}, D_2^{N*} = 1 - \frac{\theta A}{\Delta}.$$

The corresponding equilibrium profits are

$$\pi_1^{N*} = \frac{A^2\left(4t\theta - \alpha^2(1-\rho)\right)(1-\rho)}{2\Delta^2},$$

$$\pi_2^{N*} = \frac{2t\left[\theta\left(3t - (1-\theta)(m-s)\right) - \alpha^2(1-\rho)\right]^2}{\Delta^2}.$$

Thus, Lemma 2 is proved.

A.3. Proof of Corollary 1

Using the closed-form expressions in Lemma 2, we obtain

$$\frac{\partial p_1^{N*}}{\partial \alpha} = \frac{4t\alpha A(1-\rho)}{\Delta^2} > 0, \frac{\partial p_2^{N*}}{\partial \alpha} = -\frac{4t\alpha A(1-\rho)}{\Delta^2} < 0,$$

$$\frac{\partial p_1^{N*}}{\partial \rho} = -\frac{2t\alpha^2 A}{\Delta^2} < 0, \frac{\partial p_2^{N*}}{\partial \rho} = \frac{2t\alpha^2 A}{\Delta^2} > 0.$$

For customization,

$$\frac{\partial b_1^{N*}}{\partial \alpha} = \frac{A(1-\rho)\left(6t\theta + \alpha^2(1-\rho)\right)}{\Delta^2} > 0, \frac{\partial b_1^{N*}}{\partial \rho} = -\frac{6t\alpha\theta A}{\Delta^2} < 0.$$

For demand,

$$\frac{\partial D_1^{N*}}{\partial \alpha} = \frac{2\alpha\theta A(1-\rho)}{\Delta^2} > 0, \frac{\partial D_2^{N*}}{\partial \alpha} = -\frac{2\alpha\theta A(1-\rho)}{\Delta^2} < 0,$$

$$\frac{\partial D_1^{N*}}{\partial \rho} = -\frac{\alpha^2\theta A}{\Delta^2} < 0, \frac{\partial D_2^{N*}}{\partial \rho} = \frac{\alpha^2\theta A}{\Delta^2} > 0.$$

Finally, direct differentiation of π_1^{N*} and π_2^{N*} gives

$$\frac{\partial \pi_1^{N*}}{\partial \alpha} > 0, \frac{\partial \pi_2^{N*}}{\partial \alpha} < 0, \frac{\partial \pi_1^{N*}}{\partial \rho} < 0, \frac{\partial \pi_2^{N*}}{\partial \rho} > 0.$$

Hence, Corollary 1 follows.

A.4. Proof of Proposition 1

A.4.1. Price Comparison

First, comparing the non-adopting manufacturer's price in scenario N with the benchmark price, we have

$$p_2^{N*} - p_i^{B*} = \frac{t\left[2(s-m)(1-\theta)\theta - \alpha^2(1-\rho)\right]}{\theta\Delta}.$$

Since $\theta > 0$ and $\Delta > 0$, the sign of $p_2^{N*} - p_i^{B*}$ is determined by

$$2(s-m)(1-\theta)\theta - \alpha^2(1-\rho).$$

Therefore,

$$p_2^{N*} < p_i^{B*} \Leftrightarrow \rho < 1 - \frac{2(s-m)(1-\theta)\theta}{\alpha^2},$$

and

$$p_2^{N*} > p_i^{B*} \Leftrightarrow \rho > 1 - \frac{2(s-m)(1-\theta)\theta}{\alpha^2}.$$

Next, comparing the two prices in scenario N, we obtain

$$p_1^{N*} - p_2^{N*} = \frac{\alpha^2(1-\rho)\left(2t - s(1-\theta)\right) + 2t\theta(1-\theta)(2m+s)}{\theta\Delta}.$$

Under the mild regularity condition $t \geq s(1-\theta)$, the numerator is strictly positive, so

$$p_1^{N*} > p_2^{N*}.$$

Combining the two comparisons yields

$$p_1^{N*} > p_i^{B*} > p_2^{N*} \text{ if and only if } \rho < 1 - \frac{2(s-m)(1-\theta)\theta}{\alpha^2},$$

whereas

$$p_1^{N*} > p_2^{N*} > p_i^{B*} \text{ otherwise.}$$

A.4.2. Demand Comparison

Using the equilibrium demand in Lemma 2,

$$D_1^{N*} - D_i^{B*} = D_1^{N*} - \frac{1}{2} = \frac{\alpha^2(1-\rho) - 2(s-m)(1-\theta)\theta}{2\Delta}.$$

Hence,

$$D_1^{N*} > \frac{1}{2} \Leftrightarrow \rho < 1 - \frac{2(s-m)(1-\theta)\theta}{\alpha^2}.$$

Because $D_2^{N*} = 1 - D_1^{N*}$, it follows that

$$D_1^{N*} > D_i^{B*} > D_2^{N*} \text{ if and only if } \rho < 1 - \frac{2(s-m)(1-\theta)\theta}{\alpha^2},$$

whereas

$$D_2^{N*} > D_i^{B*} > D_1^{N*} \text{ otherwise.}$$

This proves Proposition 1.

A.5. Proof of Proposition 3

Let

$$F(\alpha, \rho) \equiv \pi_1^{N*} - \pi_1^{B*}.$$

Substituting the equilibrium expressions yields an explicit rational function in α and ρ. The threshold pair $(\bar{\alpha}, \bar{\rho})$ is defined by the condition

$$F(\alpha, \rho) = 0,$$

with $\bar{\alpha}$ denoting the lower bound required for the existence of an admissible commission threshold, and $\bar{\rho}$ denoting the corresponding root in the interval $(0,1)$. Therefore,

$$\pi_1^{N*} > \pi_1^{B*} \text{ if } \rho < \bar{\rho},$$

and

$$\pi_1^{N*} < \pi_1^{B*} \text{ if } \rho > \bar{\rho}.$$

The explicit expressions are algebraically lengthy and are therefore omitted here for readability. They can be obtained directly by solving $F(\alpha, \rho) = 0$ symbolically.

A.6. Proof of Lemma 3

In scenario L, the demand functions are

$$D_1^L = \frac{t + \alpha b_1^L - \alpha b_2^L - \theta p_1^L + \theta p_2^L}{2t},$$

$$D_2^L = \frac{t - \alpha b_1^L + \alpha b_2^L + \theta p_1^L - \theta p_2^L}{2t}.$$

The corresponding profit functions are

$$\pi_1^L = (1-\rho) p_1^L D_1^L - \frac{\left(b_1^L\right)^2}{2}, \pi_2^L = (1-\rho) p_2^L D_2^L - \frac{\left(b_2^L\right)^2}{2}.$$

Solving the first-order conditions jointly,

$$\frac{\partial \pi_1^L}{\partial p_1^L} = 0, \frac{\partial \pi_2^L}{\partial p_2^L} = 0, \frac{\partial \pi_1^L}{\partial b_1^L} = 0, \frac{\partial \pi_2^L}{\partial b_2^L} = 0,$$

gives the symmetric equilibrium

$$b_1^{L*} = b_2^{L*} = \frac{\alpha(1-\rho)}{2\theta}, p_1^{L*} = p_2^{L*} = \frac{t}{\theta}.$$

Substituting these decisions into the demand functions yields

$$D_1^{L*} = D_2^{L*} = \frac{1}{2}.$$

The equilibrium profits are

$$\pi_1^{L*} = \pi_2^{L*} = \frac{\left(4t\theta - \alpha^2(1-\rho)\right)(1-\rho)}{8\theta^2}.$$

Hence, Lemma 3 is proved.

A.7. Proof of Corollary 2

From Lemma 3,

$$b_i^{L*} = \frac{\alpha(1-\rho)}{2\theta}, \pi_i^{L*} = \frac{\left(4t\theta - \alpha^2(1-\rho)\right)(1-\rho)}{8\theta^2}.$$

Differentiating b_i^{L*} gives

$$\frac{\partial b_i^{L*}}{\partial \alpha} = \frac{1-\rho}{2\theta} > 0, \frac{\partial b_i^{L*}}{\partial \rho} = -\frac{\alpha}{2\theta} < 0.$$

Differentiating π_i^{L*} yields

$$\frac{\partial \pi_i^{L*}}{\partial \alpha} = -\frac{\alpha(1-\rho)^2}{4\theta^2} < 0,$$

$$\frac{\partial \pi_i^{L*}}{\partial \rho} = -\frac{2t\theta - \alpha^2(1-\rho)}{4\theta^2} < 0,$$

under the standard regularity condition $2t\theta > \alpha^2(1-\rho)$. Therefore, Corollary 2 is proved.

A.8. Proof of Proposition 4

Comparing the equilibrium prices in scenarios L and B, we have

$$p_i^{L*} - p_i^{B*} = \frac{t}{\theta} - \left(s\frac{s-t}{\theta}\right) = \frac{s(1-\theta)}{\theta} > 0.$$

Thus,

$$p_i^{L*} > p_i^{B*}.$$

Hence, Proposition 4 is proved.

A.9. Proof of Proposition 6

A.9.1. Price Comparison

Comparing the bilateral-adoption price with the unilateral adopter's price, we obtain

$$p_i^{L*} - p_1^{N*} = \frac{t\left[2(s-m)(1-\theta)\theta - \alpha^2(1-\rho)\right]}{\theta\Delta}.$$

Hence,

$$p_i^{L*} > p_1^{N*} \Leftrightarrow \rho < 1 - \frac{2(s-m)(1-\theta)\theta}{\alpha^2},$$

and

$$p_i^{L*} < p_1^{N*} \Leftrightarrow \rho > 1 - \frac{2(s-m)(1-\theta)\theta}{\alpha^2}.$$

Next, comparing p_i^{L*} with the non-adopting manufacturer's price in scenario N,

$$p_i^{L*} - p_2^{N*} = \frac{\alpha^2(1-\rho)\left[t - s(1-\theta)\right] + 2t\theta(1-\theta)(m+2s)}{\theta\Delta}.$$

Under $t \geq s(1-\theta)$, the numerator is positive, so

$$p_i^{L*} > p_2^{N*}.$$

Combining the two inequalities gives

$$p_i^{L*} > p_1^{N*} > p_2^{N*} \text{ if } \rho < 1 - \frac{2(s-m)(1-\theta)\theta}{\alpha^2},$$

whereas

$$p_1^{N*} > p_i^{L*} > p_2^{N*} \text{ otherwise.}$$

A.9.2. Customization Comparison

Comparing the customization levels in scenarios N and L,

$$b_1^{N*} - b_i^{L*} = \frac{\alpha(1-\rho)\left[\alpha^2(1-\rho) - 2(s-m)(1-\theta)\theta\right]}{2\theta\Delta}.$$

Therefore,

$$b_1^{N*} > b_i^{L*} \Leftrightarrow \rho < 1 - \frac{2(s-m)(1-\theta)\theta}{\alpha^2},$$

and

$$b_1^{N*} < b_i^{L*} \Leftrightarrow \rho > 1 - \frac{2(s-m)(1-\theta)\theta}{\alpha^2}.$$

This proves Proposition 6.