Introducing Own Brand Products on E-Commerce Platforms with Transaction Costs and Consumer Preferences

Kun Wang[1], Xin Yan[2]

[1]Lecture, School of Economics and Management, Jiangsu University of Science and Technology, Zhenjiang, 212100, China; School of Management, Fudan University, Shanghai, 200433, China.

[2]Lecture, School of Business Administration, Anhui University of Finance and Economics, Bengbu, 233030, China,

Correspondence Author:

Xin Yan, School of Business Administration, Anhui University of Finance and Economics, Bengbu, 233030, China.

Email ID: nkuyanxin@126.com

KEYWORDS	ABSTRACT
E-Commerce Platforms; Own Brand Product; Transaction Cost; Product Preference; Product Differentiation; Introduction Strategy.	The saturation of user growth on e-commerce platforms (EPs), coupled with the rise of new consumer segments and evolving purchasing preferences, has driven EPs to shift from pure intermediaries to brand owners by introducing their own brand (OB) products. However, the competition between OB and national brand (NB) products is complicated by differences in transaction costs and heterogeneous consumer preferences over product style. To investigate this complexity, we develop a game model that incorporates both horizontal and vertical product differentiation. We analyze three OB product introduction strategies—only horizontal difference, high-quality, and low-quality—and examine equilibrium outcomes under scenarios of symmetric and asymmetric transaction costs. Our results show that when competition is intense, any of the three strategies may be optimal depending on degree of horizontal difference and product preferences. In contrast, when competition is weak, the high- quality strategy becomes optimal. When competition is fierce, the dominant equilibrium strategy shifts from the only horizontal difference scenario to the low-quality one with horizontal differences increasing. However, the dominant equilibrium shifts in the opposite direction when product preference is high. Moreover, transaction cost differences do not consistently benefit EPs nor harm NB retailers; under certain conditions, both parties may experience profit losses. This study contributes to the literature by jointly considering transaction cost asymmetry and multidimensional consumer preferences in OB product strategies. It also identifies conditions under which OB and NB products can achieve win-win- win outcomes in terms of consumer surplus, total profit, and social welfare.

1. INTRODUCTION

In recent years, the business model of e-commerce platforms (EPs) has been undergoing a profound transformation. As user growth slows and the era of easy traffic gains fades, platforms are under growing pressure to evolve beyond their traditional role as passive intermediaries. This transformation is particularly evident in China, where the rise of a new middle class is reshaping the consumption landscape. According to the 2019 New Middle-Class White Paper, this demographic is expected to surpass 450 million by 2029, representing a powerful force of consumers who increasingly value quality, efficiency, and meaningful experiences over low prices. To meet these changing expectations, EPs are shifting from being mere sales channels to becoming strategic product curators and brand creators, aiming to actively shape demand rather than simply facilitate transactions.

This transformation is not purely speculative. Leading platforms such as JD.com, Amazon, and Target have launched a series of own brand (OB) products—such as J.Zao, Amazon Basics, and All in Motion—targeting consumers who demand quality assurance, design consistency, and reduced decision-making fatigue. In 2022 alone, J.Zao recorded a 60\% annual sales increase, while Amazon's OB revenue neared USD 1 billion. OB products appeal not only because of competitive pricing

but also because they mitigate the cognitive load of online shopping, which continues to grow with product proliferation and information overload(Kusi et al., 2022). According to iMedia Consulting, 46.9\% of surveyed users reported negative experiences related to inconsistent quality or misleading descriptions. OB products, often governed by stricter quality controls and standardized visuals, help address this "noise," offering a sense of reliability and simplicity.

The proliferation of OB products introduces a new competitive dynamic. Unlike traditional channel encroachment models—where upstream manufacturers bypass retailers (Tsay and Agrawal, 2004)—EPs do not merely compete as additional players in the supply chain. Rather, they redefine market structure by leveraging platform data, consumer access, and control over product visibility to compete horizontally with national brands (NBs). This creates a unique form of competition that is not purely based on price, but shaped by product differentiation and transaction cost asymmetry.

Product differentiation, as classic economic theory suggests, operates along two primary dimensions: vertical differentiation, which refers to quality levels, and horizontal differentiation, which reflects variations in design, style, or subjective appeal (Moorman et al., 2024). Similar horizontal and vertical differences between NB and OB products are frequently noted in Amazon listings, as illustrated in Figure 1. Consumers are generally consistent in their preference for higher quality (vertical), but their tastes for style and appearance (horizontal) are often heterogeneous (Lee et al., 2023; Gao and Souza, 2022). The dual existence of these preferences complicates the strategic landscape for OB product design and positioning.
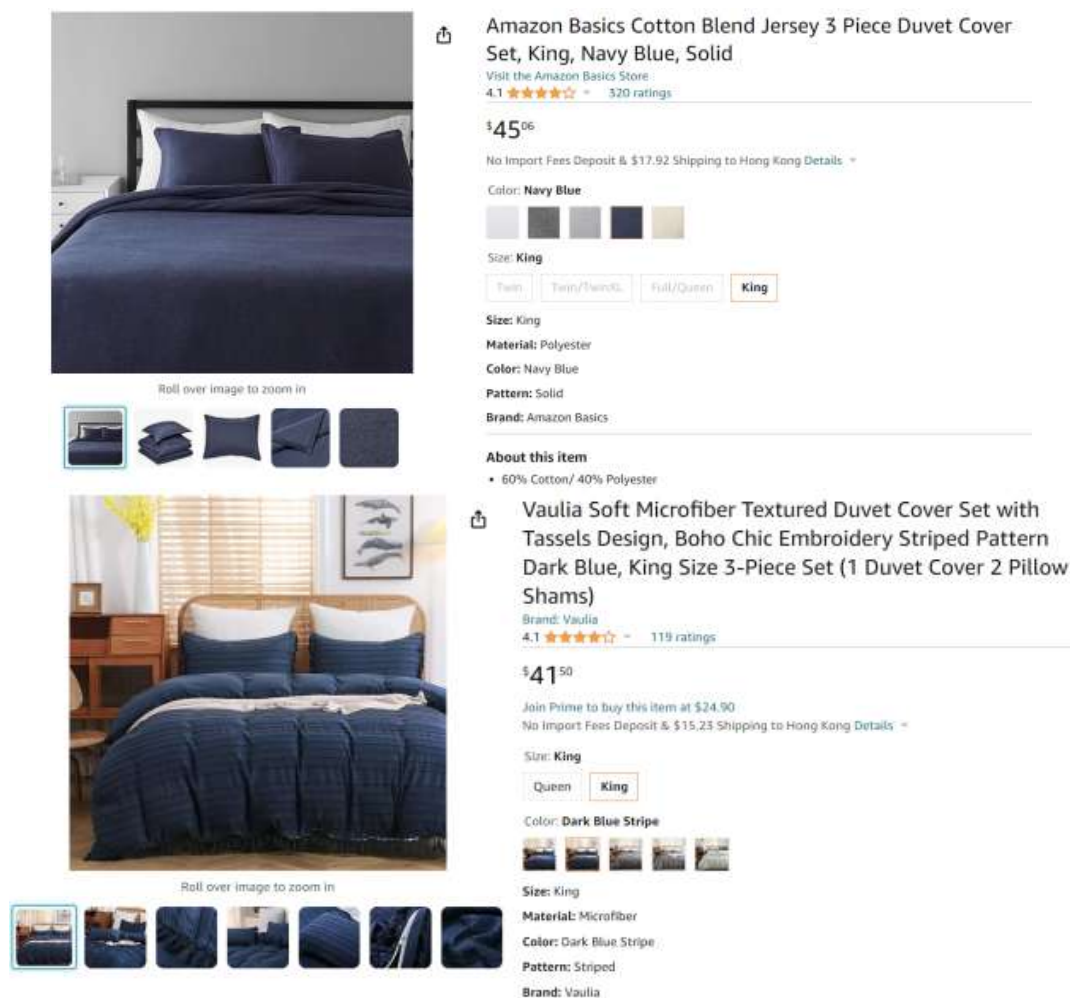

Figure 1. Horizontal and vertical differences between Amazon Basics and Vaulia

Furthermore, transaction cost theory adds another layer of complexity. Consumers incur not only monetary costs but also search costs, choice costs, and even trust costs when making online purchases (Teo et al., 2004; Hossain et al., 2022). Platforms can reduce these costs by offering OB products with clear positioning, while NB retailers may try to offset these disadvantages by bundling services or emphasizing brand heritage(Gielens et al., 2021). However, the asymmetry in transaction costs between OB and NB products often leads to uneven competition, which is further influenced by consumers' varying preferences across horizontal and vertical dimensions.

While these practical and theoretical insights highlight the growing importance of OB strategies, existing research leaves several important questions unanswered. For instance, although some studies have explored product line extension or store

brand encroachment (Zhang et al., 2021; Yu et al., 2024), they often assume homogenous preferences or ignore the role of transaction costs. Other work on product differentiation tends to isolate vertical or horizontal effects without jointly considering their interaction in strategic platform contexts.

Given this backdrop, our study aims to answer the following research questions:

(1) What are the optimal strategies for EPs when introducing OB products under varying consumer preferences and transaction costs?

(2) Does the introduction of OB products necessarily intensify competition with NB products?

(3) To what extent does OB introduction harm the profitability of NB retailers?

(4) Can asymmetric transaction costs generate win-win outcomes, or do they always tilt the competitive balance?

To address these questions, we construct a game-theoretic model of price and quality competition between an e-commerce platform (EP) and a national brand (NB) retailer, incorporating both horizontal and vertical product differentiation. The EP selects from three OB product strategies—horizontal only, horizontal with high quality, and horizontal with low quality—which are evaluated under symmetric and differential transaction cost (STC and DTC) scenarios. By integrating consumer preference heterogeneity and transaction cost asymmetry into the model, we analyze optimal strategy choices, identify dominant equilibrium outcomes, and assess their implications for firm profitability, consumer surplus, and social welfare.

We make the following contributions:First, we are the first to consider both horizontal and vertical differences in product introduction strategies for EPs, thereby differentiating our analysis from existing literature on channel encroachment and product line design. Second, we examine the impact of different transaction costs and inconsistent product preferences on product introduction strategies, which are closely related to practical business factors. Third, we identify the dominant equilibrium strategies between EPs and NB retailers, which is crucial for achieving a win-win outcome in the practical operations.Finally, we find that when competition is relatively weak and the consumer market is not entirely covered, the optimal product introduction strategy for EPs is a high-quality scenario. When competition is fierce and the consumer market is fully covered, any of the three scenarios may be optimal, depending on consumer preferences and horizontal product differences.

This study contributes to the literature in four key ways.Different transaction cost leads to competitive asymmetries between the NB and OB products in different consumer preference markets (with strong and relatively weak competition in consumer markets that prefer OB and NB products, respectively). Consequently, the high-quality scenario may not be the optimal product introduction strategy under certain conditions. When competition is fierce and horizontal differences increase, the dominant equilibrium strategy shifts from an only horizontal difference scenario to a low-quality one. However, under asymmetric competition, the dominant equilibrium strategy shifts from a low-quality scenario to an only horizontal difference one. This aligns with practice, as many OB products from J. Zao and Amazon Basics exhibit quality levels comparable to or inferior to those of NB products. Furthermore, different transaction costs do not necessarily benefit EPs, nor do they necessarily harm the NB retailer's profit. Under certain conditions, both the EPs and NB retailers will experience losses of profit.

The remainder of this study is organized as follows: Section 2 provides a literature review and Section 3 describes the research problem and model development. Section 4 analyzes the product introduction strategies. Finally, Section 5 summarizes the key results, management insights, and directions for future research.

2. LITERATURE REVIEW

Two streams are particularly relevant to this research: product encroachment and introduction, and product differentiation competition.

Studies on product encroachment have primarily focused on supplier and manufacturer encroachments. Supplier encroachment has always been considered the root cause of channel conflicts (Tsay and Agrawal, 2004). A large body of literature has examined supplier encroachment, leading to several key conclusions: additional channels can reduce retailers' sales efforts (Fein and Anderson, 1997), attract a portion of consumers (Alba et al., 1997), affect brand image (Frazier and Lassar, 1996), narrows the region of strategic inventory withholding (Yang et al., 2024), affect encroachment under information asymmetry (Tang et al., 2023; Chen et al., 2023; Tong et al., 2023), require retailers to pay more for quality improvement (Ha et al., 2016), and potentially harm retailers' profits. Traditionally, manufacturer's encroaching into retail market will increase the manufacturer's profit and decrease the retailer's profit due to channel competition. Manufacturer encroachment focuses on whether and when manufacturers strategically introduce online and offline channels (Zhang et al., 2022). Additionally, Nie et al. (2022) investigated the interaction of manufacturer encroachment and the retailer's store brand introduction. Their results reveal that bilateral encroachment may result in a prisoner's dilemma. Zhang et al. (2019) found that manufacturers always benefit from encroachment with an endogenous quality. Chang et al. (2024) found that adopting sales strategy and information strategy synthetically can effectively prevent manufacturer encroachment.

Retailers may introduce a competitive product to meet consumers' heterogeneous needs. Zhang et al. (2021) explored online manufacturers' strategic responses to retailers introducing competitive products, particularly in collaborative contexts with physical showrooms. When competition between introduced products and retailer products harms retailers but benefits online manufacturers, online manufacturers will encourage retailers to introduce competitive products. Otherwise, online manufacturers will prevent the introduction of competitive products. Yu et al. (2024) examined whether online retail platforms should pursue store brand (SB) encroachment and information sharing strategies. Their findings suggest that information sharing can facilitate SB encroachment in reselling but may deter it in agency selling. Ru et al. (2023) investigated how the relative bargaining power of members within a distribution channel affects a retailer's decision to introduce a store brand. Zheng et al. (2022) explore the impact of store brand introduction on multilateral contracting in a supply chain where two competing national brand manufacturers sell through a common retailer. In addition, studies have examined product introduction based on capacity constraints and product lifecycles (Hu et al., 2019), as well as defense and counterattack strategies for product introduction under duopoly competition (Piazzai and Wijnberg, 2019).

Generally, supply chain member encroachment refers to the encroachment of a party in a dominant role (supplier or manufacturer) or one that has a competitive advantageous (superior information). Member encroachment focuses more on channel conflicts. In this research, there is no dominant role between the EP and NB retailers, and the EP does not create channel conflicts. Previous studies on product introduction have mainly concentrated on the internal strategies of manufacturers or retailers regarding product line design, including various types of bundled sales, strategies for introducing different versions (or generations), and the launch of eco-friendly or innovative products. This study, however, examines how competition among different firms affects product introduction. Additionally, there has been limited research on product introduction strategies that take into account varying transaction costs and consumer preferences.

The literature related to product differentiation competition primarily examines both horizontal and vertical differences as well as differences in the two dimensions. Horizontal difference was first analyzed by Hotelling (1990), who characterized product differences in an industry based on factors such as location, quality, time, and consumer information. Amaldoss and He (2018) investigated how reference-dependent utility influences product competition in markets with diverse consumer preferences. In terms of vertical differentiation, Shaked and Sutton (1982) demonstrated that differentiation strategies can mitigate supply chain conflicts. Li and Chen (2018) found that exogenous quality differences intensify price competition in a retailer-led Stackelberg game, while endogenous quality differences can enhance the performance of supply chain members. Keskin and Birge (2019) examined how manufacturers can create a product line with uncertain quality and costs, concluding that a minimum quality standard can help achieve optimal pricing, even if consumers are shortsighted. In various service models, differences in product quality can influence pricing interaction between sales services and one-time rental services through marginal tenants and marginal buyer, as shown by Yu et al. (2018).

Regarding the two dimensions, Lacourbe et al. (2009) analyzed the optimal positioning of product portfolios for monopolistic firms facing vertical performance differences and horizontal characteristic differences among consumer groups. Their findings indicate that rising variable costs make vertical product differences more beneficial, while dominant fixed design costs favor horizontal differences. Horizontal differentiation serves as the primary profit driver, with vertical differentiation offering only marginal advantages. Qi et al. (2016) explored quality and pricing decisions in the context of varying consumer willingness to pay for quality and the booking utility of essential products. Their research revealed that a decline in consumer quality evaluation leads to lower product quality from companies, although optimal quality may rise with negative shifts in consumer booking utility. Lin (2022) investigated the potential for exclusive transactions that violate competition when downstream firms produce different products both vertically and horizontally. The study found that the smaller the horizontal difference or similarities between two products under a royalty license, the less likely an exclusive transaction is. Li and Liu (2019) analyzed how aesthetic design differences among brands affect consumer preferences. They found that consumers prefer high-end products to appear less appealing and low-end products to seem less harmful, creating a design dilemma for brands. This suggests that unified or diversified designs cannot enhance the appeal of both product categories simultaneously. Their findings led to a game theory model for assessing a brand's equilibrium design strategy. Interestingly, these contrasting preferences may lead brands to adopt asymmetric strategies, with one brand choosing a unified design and another opting for diversification, potentially resulting in mutually beneficial outcomes.

Current literature on product differentiation primarily focuses on mitigating competition between manufacturers and retailers. However, various studies indicate that differentiated competitive strategies do not effectively reduce competition. Unlike previous findings, the connection between EP and NB retailers lies only in the collection of commissions, which remains unchanged in the short term. Conversely, the connection between manufacturers and retailers is upstream and downstream, which may intensify the competitive environment and reinforce the idea that "the strong become stronger while the weak become weaker." Research on the introduction strategies of product differences aims to help EPs increase their competitive advantage while easing competitive with NB retailers to achieve symbiosis and mutually beneficial.

3. MODEL DEVELOPMENT

We consider EP and NB retailers. The NB retailer sells products through the EP, which charges a specific commission for each unit of the product sold. If the EP introduces an OB product for sale on its platform, it will compete with NB product.

Problem Description: When EPs introduce OB products on their platform, competition unfolds across two dimensions: horizontal and vertical differences between NB and OB products. Horizontal differences encompass design elements such as color, style, appearance, design, and overall product aesthetics. Vertical differences encompass variations in product quality and performance, influenced by factors like materials, manufacturing processes, and functional capabilities. The introduction of OB products prompts EPs to devise differential product strategies. Given consumers' inconsistent preferences for horizontal differences and the different transaction costs associated with NB and OB purchases, we will explore EPs' product introduction strategies in relation to consumer preferences and different transaction cost scenarios (STC and DTC).

Consumers: Consumer willingness to pay for product quality is heterogeneous, following a uniform distribution within a finite interval. We assume that the consumers utility from purchasing a unit of product is θq, where $\theta \sim U(0,1)$ and q represent product quality. For NB products, q denotes the quality parameter. The high-quality OB product parameter from EP is $(1 + \alpha)q$, while the low-quality OB product parameter is $(1 - \alpha)q$ (Alan et al., 2019). Here, α indicates the degree of product quality difference. Consumers exhibit diverse preferences regarding horizontal differences between NB and OB products, categorized into two groups: ρ and $1 - \rho$. ρ represents consumer preference for the style, design, and color of NB products, whereas $1 - \rho$ prefers those OB products. We use $\varphi(0 < \varphi < 1)$ to quantify the degree of horizontal difference. Higher φ signifies greater utility for consumers when purchasing products aligned with their preferred horizontal differences. Consumer preference for vertical differences is intuitive: all consumers prefer high-quality products. t represents the transaction cost. It varies, influencing the costs consumers incur when purchasing NB versus OB products.

Gaming: First, the EP determines the quality level of its OB product selection. Subsequently, a pricing game ensues between NB and OB products in the consumer market. EPs and NB retailers leverage horizontal and vertical product differences to compete in the consumer market and maximize their profits.

Assumption 1: For convenience in analysis and calculation, we assume $q = 1$.

Assumption 2: We do not account for production costs. Therefore, we assume the production costs for both types are zero (Alan et al., 2019).

We will examine scenarios with both same and different transaction costs using the Hotelling model to illustrated vertical quality differences and horizontal differences.

Subsequently, we will employ the Hotelling model to analyze optimal strategies for EPs and NB retailers under the STC and DTC scenarios. Under these scenarios, we primarily focus on three scenarios: only horizontal difference, high-quality and horizontal difference, and low-quality and horizontal difference. For convenience in analysis, we will denote these scenarios with superscripts n, h, l, dn, dh, and dl, representing the scenarios of only horizontal difference, high-quality and horizontal difference, and low-quality and horizontal difference under the STC and DTC scenarios. In the following sections, we will further simplify the high-quality and horizontal difference scenario and low-quality and horizontal difference scenario to high-quality scenario and low-quality scenario, respectively.

Table 1. The main notation list

Notation	Description
q	Product quality
α	The degree of product quality difference
ρ	Consumer preference for the product horizontal difference
φ	Utility for consumers when purchasing products aligned with their preferred horizontal differences
t	Transaction cost
π_s and π_r	The profits of NB retailers and EPs

3.1 STC Scenario

(1) Only Horizontal Difference

When there is only a horizontal difference between NB and OB products, the net utilities of type ρ consumers choosing NB and OB products are $u_s = 1 + \varphi - p_s - tx$ and $u_r = 1 - p_r - t(1 - x)$, respectively; the net utilities of type $1 - \rho$ consumers choosing NB and OB products are $u_s' = 1 - p_s - tx$ and $u_r' = 1 + \varphi - p_r - t(1 - x)$, respectively (He et al., 2023).

The demand for purchasing NB products consists of two parts: the demand of consumers who prefer the design of the NB product ($u_s > u_r$) and those who prefer the OB product ($u_s' > u_r'$). Similarly, the demand for OB products also has two components: from consumers who prefer the OB product ($u_s < u_r$) and those who prefer the NB product ($u_s' < u_r'$).

When the utility obtained by consumers purchasing NB or OB products is indifferentiable, the consumers' utility at the indifference point is $\frac{2+\varphi-p_r-t-p_s}{2}$. Therefore, the following regions can be defined: When $\frac{2+\varphi-p_r-t-p_s}{2} \geq 0$, the competition between EP and NB retailers is relatively fierce. Defining $\Omega_1^n = \{(p_s,p_r)|2+\varphi \geq p_r + t + p_s\}$, the demands for the NB and OB product are $d_s = \frac{\rho(p_r+t-p_s)}{t}$ and $d_r = (1-\rho)(2 - \frac{(p_r+t-p_s)}{t})$. When $\frac{2+\varphi-p_r-t-p_s}{2} < 0$, both EPs and NB retailers acquire some monopoly powers over the consumer market, indicating relatively weak competition. Defining $\Omega_2^n = \{(p_s,p_r)|2+\varphi < p_r + t + p_s\}$, demands for NB and OB products are $d_s = 2\rho(\frac{1-p_s}{t} + \frac{\varphi}{2t})$ and $d_r = 2(1-\rho)(\frac{1-p_r}{t} + \frac{\varphi}{2t})$.

When $(p_s,p_r) \in \Omega_1^n$ and Ω_2^n, the optimization of decision-making by NB retailers and EPs is as follows:

(2) High-Quality

An EP chooses to introduce a high-quality OB product (quality $1+\alpha$). There are vertical quality differences with the NB product and horizontal differences between the NB and OB products. The net utilities of type ρ consumers choosing NB and OB products are $u_s = 1 + \varphi - p_s - tx$ and $u_r = 1 + \alpha - p_r - t(1-x)$, respectively. The net utilities of type $1-\rho$ consumers choosing NB and OB products are $u'_s = 1 - p_s - tx$ and $u'_r = 1 + \alpha + \varphi - p_r - t(1-x)$, respectively. The demand analysis of the NB and OB products is similar to (1) and comprises two parts.

We can define the following regions based on the undifferentiated utility $\frac{2+\varphi+\alpha-p_r-t-p_s}{2}$ of consumers consuming the NB or OB product. When $\frac{2+\varphi+\alpha-p_r-t-p_s}{2} \geq 0$, the competition between EP and NB retailers is relatively fierce. Defining $\Omega_1^h = \{(p_s,p_r)|2+\varphi+\alpha \geq p_r + t + p_s\}$, the demand for NB and OB products is $d_s = \frac{\rho(p_r+t-p_s-\alpha)}{t}$ and $d_r = (1-\rho)(2 - \frac{p_r+t-p_s-\alpha}{t})$. When $\frac{2+\varphi+\alpha-p_r-t-p_s}{2} < 0$, EP and NB retailers have some monopoly powers over the consumer market, and the competition is relatively weak. Defining $\Omega_2^h = \{(p_s,p_r)|2+\varphi+\alpha < p_r + t + p_s\}$, the demand for the NB and OB products is $d_s = 2\rho(\frac{1-p_s}{t} + \frac{\varphi}{2t})$ and $d_r = 2(1-\rho)(\frac{1+\alpha-p_r}{t} + \frac{\varphi}{2t})$.

When $(p_s,p_r) \in \Omega_1^h$ and Ω_2^h, the optimization of decision-making and profit functions of EP and NB retailers are the same as in Equation (1).

(3) Low-Quality

An EP chooses to introduce a low-quality OB product (quality $1-\alpha$). There are vertical quality differences in the NB product and horizontal characteristic differences between the NB and OB products. The net utilities of type ρ consumers choosing NB and OB products are $u_s = 1 + \varphi - p_s - tx$ and $u_r = 1 - \alpha - p_r - t(1-x)$, respectively. The net utilities of type $1-\rho$ consumers choosing NB and OB products are $u'_s = 1 - p_s - tx$ and $u'_r = 1 - \alpha + \varphi - p_r - t(1-x)$, respectively. The demand analysis of the NB and OB products is similar to (1) and contains two parts.

We can define the following regions based on the undifferentiated utility $\frac{2+\varphi-\alpha-p_r-t-p_s}{2}$ of consumers in consuming NB or OB products. When $\frac{2+\varphi-\alpha-p_r-t-p_s}{2} \geq 0$, the competition between EP and NB retailers is relatively fierce. Defining $\Omega_1^l = \{(p_s,p_r)|2+\varphi-\alpha \geq p_r + t + p_s\}$, the demand for NB and OB products is $d_s = \frac{\rho(p_r+t-p_s+\alpha)}{t}$ and $d_r = (1-\rho)(2 - \frac{(p_r+t-p_s+\alpha)}{t})$. When $\frac{2+\varphi-\alpha-p_r-t-p_s}{2} < 0$, EP and NB retailers have some monopoly powers over the consumer market, and the competition is relatively weak. Defining $\Omega_2^l = \{(p_s,p_r)|2+\varphi-\alpha < p_r + t + p_s\}$, the demand for NB and OB products is $d_s = \rho(\frac{\varphi}{t} + \frac{2(1-p_s)}{t})$ and $d_r = (1-\rho)(\frac{\varphi}{t} + \frac{2(1-\alpha-p_r)}{t})$.

When $(p_s,p_r) \in \Omega_1^l$ and Ω_2^l, the optimization of decision-making and profit functions of EP and NB retailers are the same as in Equation (1).

Lemma 1. Based on the only horizontal difference, high-quality, and low-quality scenarios, NB and OB products' optimal price, market demand, and EP's and NB retailers' equilibrium profits in the STC scenario can be observed (see, Appendix Table 9).

Corollary 1. By analyzing the sensitivity of consumer product preference to prices and demand, we can get

(i). $\frac{\partial p_s^{l1}}{\partial \rho} > \frac{\partial p_s^{n1}}{\partial \rho} > \frac{\partial p_s^{h1}}{\partial \rho} > 0$, $\frac{\partial p_r^{l1}}{\partial \rho} > \frac{\partial p_r^{n1}}{\partial \rho} > \frac{\partial p_r^{h1}}{\partial \rho} > 0$;

(ii). $\frac{\partial d_s^{l1}}{\partial \rho} > \frac{\partial d_s^{n1}}{\partial \rho} > \frac{\partial d_s^{h1}}{\partial \rho} > 0$, $0 > \frac{\partial d_r^{l1}}{\partial \rho} > \frac{\partial d_r^{n1}}{\partial \rho} > \frac{\partial d_r^{h1}}{\partial \rho}$;

(iii). $\frac{\partial d_s^{l2}}{\partial \rho} = \frac{\partial d_s^{h2}}{\partial \rho} > 0, \frac{\partial d_r^{l2}}{\partial \rho} > \frac{\partial d_r^{h2}}{\partial \rho} > 0.$

From Corollary 1, it is evident that in scenarios where competition between NB and OB products is relatively intense, consumer product preference (ρ) positively influences the prices of both products. The impact of consumer product preference on price competition varies across different scenarios. Specifically, an increase in consumer product preference enhances the price of both products, with the strongest effect observed in the low-quality scenario, followed by the only horizontal difference scenario, and the weakest effect in the high-quality scenario. Consumer product preference also has a positive and negative relationship with the demand for NB and OB products, respectively. It enhances demand for a brand's products, with the most strongest effect in the low-quality scenario, followed by only horizontal difference scenario, and the weakest effect in the high-quality scenario.

Contrastingly, consumer product preference has a demand cannibalization effect on OB products. For example, its effect is strongest in the high-quality scenario, followed by the only horizontal difference scenario, and the least in the low-quality scenario. When competition between the two products is relatively weak, consumer product preference does not impact product price and positively affects the demand for both products.

3.2 DTC Scenario

The previous section discussed how consumers face identical transaction costs when purchasing NB and OB products. The consumer shopping experience of OB products has a comparative advantage over the transaction cost of NB products. Therefore, this section assumes that consumers will face varied transaction costs when choosing between NB and OB products. The transaction cost for consumers to purchase the OB product is $t(0 < t < 1)$ and the transaction cost for consumers to purchase the NB product is 1.

(1) Only Horizontal Difference

When there are only horizontal differences between NB and OB products, the net utilities of type ρ consumers choosing NB and OB products are $u_s = 1 + \varphi - p_s - x$ and $u_r = 1 - p_r - t(1 - x)$, respectively. The net utilities of type $1 - \rho$ consumers choosing NB and OB products are $u'_s = 1 - p_s - x$ and $u'_r = 1 + \varphi - p_r - t(1 - x)$, respectively.

We can define the following region based on the undifferentiated utility $\frac{1+t\varphi-p_r-tp_s}{1+t}$ and $\frac{1+\varphi-p_r-tp_s}{1+t}$ of consumers consuming NB or OB products. When $1 + \varphi - p_r - tp_s > 1 + t\varphi - p_r - tp_s \geq 0$, the competition between EP and NB retailers is fierce. Defining $\Omega_1^{dn} = \{(p_s, p_r) | 1 + t\varphi > p_r + tp_s\}$, the demand for NB and OB products is $d_s = \frac{2\rho(p_r+t-p_s)}{1+t}$ and $d_r = 2(1-\rho)(1 - \frac{p_r+t-p_s}{1+t})$. When $1 + \varphi - p_r - tp_s > 0 > 1 + t\varphi - p_r - tp_s$, EP and NB retailers adopt different pricing competition strategies for consumer markets of the ρ and $1 - \rho$ type, resulting in consumer market competition of the $1 - \rho$ type being relatively fierce and consumer market competition of the ρ type being relatively weak. Defining $\Omega_2^{dn} = \{(p_s, p_r) | 1 + t\varphi < p_r + tp_s < 1 + \varphi\}$, the demand for NB and OB products is $d_s = \rho(1 + \varphi - p_s + \frac{p_r+t-\varphi-p_s}{1+t})$ and $d_r = (1-\rho)(\frac{1-p_r}{t} + 1 - \frac{p_r+t-\varphi-p_s}{1+t})$. When $0 > 1 + \varphi - p_r - tp_s > 1 + t\varphi - p_r - tp_s$, EP and NB retailers have some monopoly powers in the market, and the competition is relatively weak. Defining $\Omega_3^{dn} = \{(p_s, p_r) | 1 + \varphi < p_r + tp_s\}$, the demand for NB and OB products is $d_s = \rho(1 + \varphi - p_s + 1 - p_s)$ and $d_r = (1-\rho)(\frac{1-p_r}{t} + \frac{1-p_r+\varphi}{t})$.

When $(p_s, p_r) \in \Omega_1^{dn}, \Omega_2^{dn}$ and Ω_3^{dn}, the optimization of decision-making and profit functions of EP and NB retailers are the same as in Equation (1).

(2) High-Quality

An EP chooses to introduce a high-quality OB product (quality $1 + \alpha$). There are vertical quality differences in the NB product and horizontal characteristic differences in color, style, and design between the NB and OB products. The net utility of type ρ consumers choosing the NB and OB products is $u_s = 1 + \varphi - p_s - tx$ and $u_r = 1 + \alpha - p_r - t(1 - x)$, respectively. The net utility of type $1 - \rho$ consumers choosing NB and OB products is $u'_s = 1 - p_s - x$ and $u'_r = 1 + \alpha + \varphi - p_r - t(1 - x)$, respectively. The demand analysis of the NB and OB products is similar to the one in Section 3.1 (1) and contains two parts.

Based on the undifferentiated utility $\frac{1+\alpha+t\varphi-p_r-tp_s}{1+t}$ and $\frac{1+\alpha+\varphi-p_r-tp_s}{1+t}$ of consumers in consuming NB or OB products, we can define the following regions. When $1 + \alpha + \varphi - p_r - tp_s > 1 + \alpha + t\varphi - p_r - tp_s \geq 0$, the competition between EP and NB retailers is fierce. Defining $\Omega_1^{dh} = \{(p_s, p_r) | p_r + tp_s < 1 + \alpha + t\varphi\}$, the demand for NB and OB products is $d_s = \frac{2\rho(p_r+t-p_s-\alpha)}{1+t}$ and $d_r = 2(1-\rho)(1 - \frac{p_r+t-p_s-\alpha}{1+t})$. When $1 + \alpha + \varphi - p_r - tp_s > 0 > 1 + \alpha + t\varphi - p_r - tp_s$, EP and NB retailers adopt different pricing competition strategies for consumer markets of the ρ and $1 - \rho$ type, resulting in consumer market competition of the $1 - \rho$ type being relatively fierce and consumer market competition of the ρ type being relatively

weak. Defining $\Omega_2^{dh} = \{(p_s, p_r) | 1 + \alpha + t\varphi < p_r + tp_s < 1 + \alpha + \varphi\}$, the demand for NB and OB products is $d_s = \rho(1 + \varphi - p_s + \frac{p_r + t - \varphi - p_s - \alpha}{1+t})$ and $d_r = (1 - \rho)(2 - \frac{p_r + t - 1 - \alpha}{t} - \frac{p_r + t - \varphi - p_s - \alpha}{1+t})$. When $0 > 1 + \alpha + \varphi - p_r - tp_s > 1 + \alpha + t\varphi - p_r - tp_s$, EP and NB retailers have a certain degree of monopoly on the market; therefore, the competition is relatively weak. Defining $\Omega_3^{dh} = \{(p_s, p_r) | p_r + tp_s > 1 + \alpha + \varphi\}$, the demand for NB and OB products is $d_s = \rho(2 + \varphi - 2p_s)$ and $d_r = 2(1 - \rho)(1 - \frac{p_r + t - 1 - \alpha}{t} + \frac{\varphi}{2t})$.

When $(p_s, p_r) \in \Omega_1^{dh}$, Ω_2^{dh} and Ω_3^{dh}, the optimization of decision-making and profit functions of EP and NB retailers are the same as in Equation (1).

(3) Low-Quality

An EP chooses to introduce a low-quality OB product (quality $1 - \alpha$). There are vertical quality differences in the NB product and horizontal characteristic differences between the NB and OB products. The net utilities of type ρ consumers choosing NB and OB products are $u_s = 1 + \varphi - p_s - x$ and $u_r = 1 - \alpha - p_r - t(1 - x)$, respectively. The net utilities of type $1 - \rho$ consumers choosing NB and OB products are $u_s' = 1 - p_s - x$ and $u_r' = 1 - \alpha + \varphi - p_r - t(1 - x)$, respectively. The demand analysis for the NB and OB products is similar to Equation (1) and comprises two parts.

We can define the following regions based on the undifferentiated utility $\frac{1 - \alpha + t\varphi - p_r - tp_s}{1+t}$ and $\frac{1 - \alpha + \varphi - p_r - tp_s}{1+t}$ of consumers in consuming NB or OB products. When $1 - \alpha + \varphi - p_r - tp_s > 1 - \alpha + t\varphi - p_r - tp_s \geq 0$, the competition between EP and NB retailers is fierce. Defining $\Omega_1^{dl} = \{(p_s, p_r) | 1 - \alpha + t\varphi > p_r + tp_s\}$, the demand for the NB and OB products is $d_s = \frac{2\rho(p_r + t - p_s + \alpha)}{1+t}$ and $d_r = 2(1 - \rho)(1 - \frac{p_r + t - p_s + \alpha}{1+t})$. When $1 - \alpha + \varphi - p_r - tp_s > 0 > 1 - \alpha + t\varphi - p_r - tp_s$, EP and NB retailers adopt different pricing competition strategies for consumer markets of the ρ and $1 - \rho$ types, resulting in consumer market competition of the $1 - \rho$ type being relatively fierce and consumer market competition of the ρ type being relatively weak. Defining $\Omega_2^{dl} = \{(p_s, p_r) | 1 - \alpha + t\varphi < p_r + tp_s < 1 - \alpha + \varphi\}$, the demand for NB and OB products is $d_s = \rho(1 + \varphi - p_s + \frac{p_r + t - \varphi - p_s + \alpha}{1+t})$ and $d_r = (1 - \rho)(2 - \frac{p_r + t - 1 + \alpha}{t} - \frac{p_r + t - \varphi - p_s + \alpha}{1+t})$. When $0 > 1 - \alpha + \varphi - p_r - tp_s > 1 - \alpha + t\varphi - p_r - tp_s$, EP and NB retailers have some monopoly powers on the market; therefore, the competition is relatively weak. Defining $\Omega_3^{dl} = \{(p_s, p_r) | p_r + tp_s > 1 - \alpha + \varphi\}$, the demand for NB and OB products is $d_s = \rho(2 + \varphi - 2p_s)$ and $d_r = 2(1 - \rho)(1 - \frac{p_r + t - 1 + \alpha}{t} + \frac{\varphi}{2t})$.

When $(p_s, p_r) \in \Omega_1^{dl}$, Ω_2^{dl} and Ω_3^{dl}, the optimization of decision-making and profit functions of EP and NB retailers are the same as in Equation (1).

Lemma 2. Based on the only horizontal difference, high-quality, and low-quality scenarios, we can observe NB and OB products' optimal price, market demand, and EP's and NB retailers' equilibrium profits in the DTC scenario (see, Appendix Table 10).

Corollary 2. By analyzing the sensitivity of consumer product preference to prices and demands, we can get

(i). $\frac{\partial p_s^{l1}}{\partial \rho} > \frac{\partial p_s^{n1}}{\partial \rho} > \frac{\partial p_s^{h1}}{\partial \rho} > 0$, $\frac{\partial p_{dr}^{l1}}{\partial \rho} > \frac{\partial p_{dr}^{n1}}{\partial \rho} > \frac{\partial p_{dr}^{h1}}{\partial \rho} > 0$; $\frac{\partial d_{ds}^{l1}}{\partial \rho} > \frac{\partial d_{ds}^{n1}}{\partial \rho} > \frac{\partial d_{ds}^{h1}}{\partial \rho} > 0$, $0 > \frac{\partial d_{dr}^{l1}}{\partial \rho} > \frac{\partial d_{dr}^{n1}}{\partial \rho} > \frac{\partial d_{dr}^{h1}}{\partial \rho}$.

(ii). $\frac{\partial p_s^{l2}}{\partial \rho} > \frac{\partial p_s^{n2}}{\partial \rho} > \frac{\partial p_s^{h2}}{\partial \rho} > 0$, $\frac{\partial p_{dr}^{l2}}{\partial \rho} > \frac{\partial p_{dr}^{n2}}{\partial \rho} > \frac{\partial p_{dr}^{h2}}{\partial \rho} > 0$; $\frac{\partial d_{ds}^{l2}}{\partial \rho} > \frac{\partial d_{ds}^{n2}}{\partial \rho} > \frac{\partial d_{ds}^{h2}}{\partial \rho} > 0$, $0 > \frac{\partial d_{dr}^{l2}}{\partial \rho} > \frac{\partial d_{dr}^{n2}}{\partial \rho} > \frac{\partial d_{dr}^{h2}}{\partial \rho}$.

*Corollary 2 s*hows that in situations where competition between NB and OB products is relatively fierce, there is a positive relationship between consumer product preference and both their prices. An increase in the proportion of consumers' preference for the NB product will have varying effects on price competition in different scenarios. For example, the positive effect on the low-quality scenario is the strongest, followed by the positive effect on the only horizontal difference scenario; the positive effect on the high-quality scenario is the weakest. The effect of product preference on the price competition of the OB product is consistent with that of the NB product. The proportion of consumers preferring the NB product has a positive and negative relationship with demand for the two products. The decrease in the proportion of product preference will weaken and strengthen the demand for the two products, and the effects will be different in different scenarios. For example, the weakening effect of demand for the NB product is weakest in the low-quality scenario, followed by the only horizontal difference scenario, and it is strongest in the high-quality scenario.

Conversely, the demand-strengthening effect for the OB product is strongest in the high-quality scenario, followed by the only horizontal difference scenario, and it is weakest in the low-quality scenario. When two products compete fiercely in the consumer market of the OB product and have a certain degree of monopoly in the consumer market of the NB product, the

impact of consumer product preference on the price and demand of both products is consistent with the impact of both products on the fierce competition of the consumer market.

4. PRODUCT INTRODUCTION STRATEGY ANALYSIS

First, we analyze the optimal product introduction strategies for EPs in STC and DTC scenarios. Then, based on the optimal product introduction strategies, we analyze the dominant equilibrium of the EPs and NB retailers. Finally, we explore social welfare.

4.1 Introduction Strategies under STC Conditions

In the STC scenario, Proposition 1 analyzes EP product introduction strategies under conditions of fierce competition between EPs and NB retailers. Currently, EPs and NB retailers have no monopoly over the consumer market, which is fully covered. Consumers choose products based on their horizontal preferences and vertical quality needs. In this case, all consumers can obtain a positive consumer surplus, except for undifferentiated consumers, who receive a zero surplus. Proposition 2 analyzes EPs' product introduction strategies in a relatively weak competition situation between EPs and NB retailers. EPs and NB retailers have some monopoly powers over the consumer market, which is not fully covered.

Under conditions of fierce competition between EPs and NB retailers, based on the constraints of three product introduction strategies, it can be concluded that when $\frac{9t(1-\rho)}{3-(3+r)\rho} > 2 + \varphi > \frac{(9t-3\alpha)(1-\rho)}{3-(3+r)\rho}$ occurs, product introduction strategy of high-quality exist. When $\frac{(9t+3\alpha)(1-\rho)}{3-(3+r)\rho} > 2 + \varphi > \frac{9t(1-\rho)}{3-(3+r)\rho}$, both product introduction strategies of high-quality and only horizontal difference exist simultaneously. When $2 + \varphi > \frac{(9t+3\alpha)(1-\rho)}{3-(3+r)\rho}$, only horizontal differences, high-quality and low-quality product introduction strategies all exist.

Proposition 1. Under conditions of fierce competition between EPs and NB retailers, the optimal product introduction strategies are shown in Table 2.

Table 2. The optimal product introduction strategies in the STC scenario

Conditions	Product introduction strategies
$\frac{(9t+3\alpha)(1-\rho)}{3-(3+r)\rho} > 2 + \varphi > \frac{9t(1-\rho)}{3-(3+r)\rho}, \frac{\alpha}{3} < t$ and $\frac{6t+5rt-\alpha-r\sqrt{13t^2+2t\alpha}}{6t+10rt+2r^2t-\alpha} \leq \rho < \frac{3}{3+r}$.	Introducing only horizontal difference OB product
(1) $\frac{9t(1-\rho)}{3-(3+r)\rho} > 2 + \varphi > \frac{(9t-3\alpha)(1-\rho)}{3-(3+r)\rho}$. (2) $\frac{(9t+3\alpha)(1-\rho)}{3-(3+r)\rho} > 2 + \varphi > \frac{9t(1-\rho)}{3-(3+r)\rho}, \frac{\alpha}{3} < t$ and $\rho < \frac{6t+5rt+\alpha-r\sqrt{13t^2-2t\alpha}}{6t+10rt+2r^2t-\alpha}$. (3) $2 + \varphi > \frac{(9t+3\alpha)(1-\rho)}{3-(3+r)\rho}, \frac{\alpha}{3} < t$ and $\rho < \frac{6+5r-r\sqrt{13}}{2(3+5r+r^2)}$.	Introducing high-quality OB product
$2 + \varphi > \frac{(9t+3\alpha)(1-\rho)}{3-(3+r)\rho}, \frac{\alpha}{3} < t$ and $\frac{6+5r-r\sqrt{13}}{2(3+5r+r^2)} \leq \rho < \frac{3}{3+2r}$.	Introducing low-quality OB product

When the horizontal difference between the two products is relatively small, a low-quality and only horizontal difference scenario will not appear. Therefore, the optimal product introduction strategy involves the selection of a high-quality scenario.

When the degree of horizontal difference between the two products is relatively moderate, the optimal product introduction strategy is to choose high-quality scenario or an only horizontal difference scenario, depending on consumer product preference. When consumers have a small product preference for the NB product, the optimal introduction strategy is to choose the high-quality scenario; otherwise, the only horizontal difference scenario should be selected.

Consumer product preference has a positive effect on price and a negative effect on demand ($\partial p_r^{n1}/\partial \rho > \partial p_r^{h1}/\partial \rho > 0$ and $0 > \partial d_r^{n1}/\partial \rho > \partial d_r^{h1}/\partial \rho$). As the proportion of consumers preferring the NB product increases, more consumers prefer the NB product. At this time, the only horizontal difference scenario will result in higher price and less demand reduction, resulting in a higher competitive advantage. When the proportion of consumer product preference decreases, more consumers prefer the OB product, and the advantage of the high-quality scenario gradually becomes prominent. Both horizontal and

vertical differences can slow price competition between the two products. When the proportion of consumer product preference is small, more consumers prefer the horizontal design of the OB product combined with high-quality vertical differences. This preference promotes the high-quality scenario more effectively than the scenario with only horizontal difference. Owing to the fierce competition between EPs and NB retailers, the consumer market is wholly covered. When the proportion of consumer product preference is high, more consumers prefer the horizontal design of the NB product. The competitive advantage of high-quality vertical differences cannot exceed that of the large consumer market of the NB product. EPs may opt for aggressive competition strategies by introducing OB products that differ only in horizontal aspects, effectively initiating a "price war" against NB products and escalating competition. In such scenarios, strategies that escalate competition are favored over those that mitigate it. Introducing a high-quality OB product is a price competition strategy that mitigates competition and focuses on increasing prices. Contrastingly, introducing an only horizontal difference OB product is a demand competitive strategy that intensifies competition and focuses on cannibalizing demand. EPs can choose different competitive strategies based on consumer preferences.

When the degree of the horizontal difference between the two products is relatively large, the EP needs to choose the optimal product introduction strategy from among the only horizontal difference scenario, high-quality scenario, and low-quality scenario. Compared to a case in which the horizontal differences are relatively moderate, the emergence of a low-quality scenario means that the only horizontal difference scenario will not be the optimal product introduction strategy. Both horizontal and vertical differences can alleviate price competition and demand cannibalization. However, the only horizontal difference scenario has no competitive advantage in vertical differences. As a result, when the three scenarios coexist, the EP will not choose the only horizontal difference scenario. When consumers have a small product preference for the NB product, the optimal product introduction strategy is a high-quality scenario.

In contrast, when consumers prefer the NB, the optimal product introduction strategy is a low-quality scenario. The consumer market for an OB product is larger when the product preference is small. EPs can increase product prices to mitigate the effects of price competition and expand its competitive advantage. If product prices are raised in low-quality scenarios, competition intensifies, weakening the significant advantages in the consumer market. When the product preference is large, the consumer market for the NB product is large, and the disadvantage of EPs is more prominent. In a low-quality scenario, EPs can ease competition by lowering product prices, whereas lowering product prices in a high-quality scenario will intensify competition and further exacerbate the competitive disadvantage of OB products.

Proposition 2. Under conditions of relatively weak competition between EPs and NB retailers, we can observe the optimal product introduction strategies as follows:

(i) When $\alpha < \varphi$ ($\alpha > \varphi$ and $2t < 2 + \varphi - \alpha$), EP needs to choose a product introduction strategy between the high-quality and low-quality scenarios, we can observe $p_s^{l2} = p_s^{h2}, p_r^{l2} < p_r^{h2}, d_s^{l2} = d_s^{h2}, d_r^{l2} < d_r^{h2}, \pi_s^{l2} = \pi_s^{h2}, \pi_r^{l2} < \pi_r^{h2}$.

(ii) When $\alpha > \varphi$ and $2 > 2t > 2 + \varphi - \alpha$, EPs need to choose a high-quality scenario.

When competition between EPs and NB retailers is relatively weak, the consumer market is not fully covered, and EPs and NB retailers have some monopoly powers. At this time, regardless of whether the OB product occupies a dominant position in the consumer market, the EP tends to choose high-quality scenario. Although a high-quality scenario may intensify competition when product preference is high, the EP can use its monopoly power to charge consumers better prices to ease competition. At the same time, we also found that, compared to the low-quality scenario, the high-quality scenario can not only allow EPs to set higher product prices but also achieve higher product demand. Since both EPs and NB retailers must take advantage of their monopoly powers, the low-quality scenario will increase product prices, leading to intensified competition and weakening the monopoly powers of EPs.

4.2 Introduction Strategies under DTC Conditions

In the DTC scenario, Propositions 3, 4, and 5, respectively, explore the product introduction strategies of the fierce competition scenario between EPs and NB retailers and the scenario involving fierce competition in the $1 - \rho$ type consumer market and relatively weak competition in the ρ type consumer market between EPs and NB retailers as well as the scenario in which there is a certain degree of monopoly ability between EPs and NB retailers. Depending on the level of product competition between EPs and NB retailers, the consumer market may be fully or partially covered.

Under conditions of fierce competition between EPs and NB retailers, based on the constraints of three product introduction strategies, it can be concluded that when $\varphi_2 > \varphi > \varphi_3$ occurs, product introduction strategy of high-quality exist. When $\varphi_1 > \varphi > \varphi_2$, both product introduction strategies of high-quality and only horizontal difference exist simultaneously. When $\varphi > \varphi_1$, only horizontal differences, high-quality and low-quality product introduction strategies all exist.(*denoting*

$$\varphi_1 = \frac{(2t^2 + 2\alpha - 1 + \alpha t + 2t)(1-\rho) + r\rho(1+t)}{3t - 3t\rho - rt\rho}, \varphi_2 = \frac{(2t^2 - 1 + 2t)(1-\rho) + r\rho(1+t)}{3t - 3t\rho - rt\rho}, and\ \varphi_3 = \frac{(2t^2 - 2\alpha - 1 - \alpha t + 2t)(1-\rho) + r\rho(1+t)}{3t - 3t\rho - rt\rho}.)$$

Proposition 3. Under conditions of fierce competition between EPs and NB retailers, the optimal product introduction strategies are shown in Table 3.

Table 3. The optimal product introduction strategies in the DTC scenario

Conditions	Product introduction strategies
$\varphi_1 > \varphi > \varphi_2$ and $\dfrac{8+2\alpha+4t+5r(1+t)-r\sqrt{1+t}\sqrt{9+17t-4\alpha}}{2(4+2t+\alpha+r(1+t)(5+r))} \le \rho < \dfrac{3}{3+r}$.	Introducing only horizontal difference OB product
(1) $\varphi_2 > \varphi > \varphi_3$. (2) $\varphi_1 > \varphi > \varphi_2$ and $\rho < \dfrac{8+2\alpha+4t+5r(1+t)-r\sqrt{1+t}\sqrt{9+17t-4\alpha}}{2(4+2t+\alpha+r(1+t)(5+r))}$. (3) $\varphi > \varphi_1$ and $\rho < \dfrac{8+5r+4t+5rt-r\sqrt{9+26t+17t^2}}{2(4+2t+r(1+t)(5+r))}$.	Introducing high-quality OB product
$\varphi > \varphi_1$ and $\dfrac{8+5r+4t+5rt-r\sqrt{9+26t+17t^2}}{2((5r+r^2)(1+t)+4+2t)} \le \rho < \dfrac{3}{3+2r}$.	Introducing low-quality OB product

When the horizontal difference between two products is small, the low-quality and only horizontal difference scenarios will not appear, and the high-quality scenario becomes the only product introduction strategy.

When the horizontal difference is relatively moderate, the EP needs to choose a product introduction strategy from between the only horizontal difference scenario and high-quality scenario. The optimal product introduction strategy depends on product preference. When the proportion of consumers who prefer the NB product is smaller, it means that more consumers prefer the design of the OB product. Thus, the optimal product introduction strategy for the EP is selecting a high-quality scenario. When the proportion of consumers who prefer the NB product is larger, more consumers prefer the design of the NB product. Thus, the optimal product introduction strategy for the EP is to choose the only horizontal difference scenario. When more consumers prefer the OB product, EPs can fully exploit the advantage of vertical differences to slow competition between NB and OB products and expand the advantage of the OB product. When more consumers prefer the NB product, the EP adopts a vertical differentiation competition strategy, which can slow competition with the NB product but cannot compensate for the competitive disadvantage of a smaller consumer market. EPs must give up on slowing competition and instead adopt the intensifying competition strategy, choosing the only horizontal difference scenario. In the horizontal difference scenario, because the consumer market is fully covered, the two products' price competition intensifies, and the demand cannibalization effect is strong.

When the horizontal difference is relatively large, the EP decides on the optimal product introduction strategy in the three scenarios based on consumer product preference. When consumers choose products with their preferred horizontal design styles, large horizontal differences bring greater utility to consumers, which also means that EPs and NB retailers must pay many costs to meet consumers' demands. At the same time, a larger horizontal difference will also greatly ease the two products' price competition. EPs will not choose the only horizontal difference scenario that intensifies competition but a vertical difference strategy that eases competition.

When the proportion of consumers preferring the NB product is small, the OB product gains more consumer markets that prefer it and gains a greater consumer market advantage. The EP tends to adopt strategies that slow competition and increase prices. For the low-quality scenario, raising the product price will narrow the two products' price gap and intensify price competition; however, raising the product price for the high-quality scenario will widen the two products' price gap and ease the price competition. High-quality products are expensive. Therefore, when the proportion of consumers preferring the NB product is small, the optimal product introduction strategy for EPs is to choose the high-quality scenario.

When a larger proportion of consumers prefer the NB, the NB product gains more consumer markets that prefer it, and the OB product loses its advantage in the consumer market. At this time, the EP also tends to adopt strategies to slow the competition. Lowering product prices for the low-quality scenario will widen the two products' price gap and ease the price competition, while lowering the product price for the high-quality scenario will narrow the two products' price gap and intensify the price competition. Lowering the product price has two disadvantages for the high-quality scenario: expanding the consumer market and intensifying competition. Therefore, the optimal product introduction strategy for the EP is to choose a low-quality scenario.

Proposition 4. With fierce competition in the $1 - \rho$ type consumer market and relatively weak competition in the ρ type consumer market between EPs and NB retailers, we can observe the optimal product introduction strategies as follows:

(A) When $\varphi < \varphi_4$, the EP must choose a product introduction strategy from among the horizontal difference, high-quality, and low-quality scenarios. We can observe that if $\rho \in (0, min\{\rho_0, \rho_1\}]$, then $\pi_r^{h2} \ge max\{\pi_r^{l2}, \pi_r^{n2}\}$; if $\rho \in [max\{\rho_0, \rho_2\}, \dfrac{8+19t+8t^2}{8+19t+rt+8t^2})$, then $\pi_r^{l2} \ge max\{\pi_r^{h2}, \pi_r^{n2}\}$.

(B) When $\varphi_4 < \varphi < \varphi_5$, the EP must choose a product introduction strategy from among the only horizontal difference and low-quality scenarios. We can observe that if $\rho \in (0, \rho_2)$, then $\pi_r^{n2} > \pi_r^{l2}$; if $\rho \in [\rho_2, \frac{8+19t+8t^2}{8+19t+rt+8t^2})$, then $\pi_r^{n2} \leq \pi_r^{l2}$.

(C) When $\varphi_5 < \varphi < \varphi_6$, the EP must choose the low-quality scenario.

(D) When $\varphi_6 < \varphi < 1$, the EP must choose a product introduction strategy from among the only horizontal difference and high-quality scenarios. We can observe that if $\rho \in (0, \rho_1)$, then $\pi_r^{n2} < \pi_r^{h2}$; if $\rho \in [\rho_1, \frac{8+19t+8t^2}{8+19t+rt+8t^2})$, then $\pi_r^{n2} \geq \pi_r^{h2}$.

It can be seen from *Proposition 4* that when the competition between EPs and NB retailers in the $1 - \rho$ type consumer market is relatively fierce and the competition in the ρ type consumer market is relatively weak, the optimal product introduction strategies of EPs depend on the degree of horizontal difference and consumer product preference (see Table 4).

Table 4. Fierce competition in the $1 - \rho$ type consumer market and relatively weak competition in the ρ type consumer market

Horizontal difference φ	The proportion of product preference ρ		
	Small	Large	
Small ($\varphi < \varphi_4$).	High-quality	Low-quality	
Below moderate ($\varphi_4 < \varphi < \varphi_5$).	Low-quality	Only horizontal difference	Optimal product introduction strategies
Above moderate ($\varphi_5 < \varphi < \varphi_6$).	Low-quality		
Larger ($\varphi_6 < \varphi < 1$).	High-quality	Only horizontal difference	

Note: we denote $\varphi_4 = \frac{(1-\rho)(8t^3-4+4\alpha+2t^2(4-3\alpha)-5t+11\alpha t)+2r\rho t(1+t)}{t(1-\rho)(4+4t^2+13t)-2t^2 r\rho}$,

$\varphi_5 = \frac{(1-\rho)(8t^3-4+8t^2-5t)+2r\rho t(1+t)}{t(1-\rho)(4+4t^2+13t)-2t^2 r\rho}$, and $\varphi_6 = \frac{(1-\rho)(8t^3-4+4\alpha+2t^2(4+3\alpha)-5t+11\alpha t)+2r\rho t(1+t)}{(1-\rho)(8-4t^3+2t^2+15t)-(t+1)tr\rho}$.

Propositions 4 (A) and (B) indicate that when the horizontal difference is small, the EP chooses the optimal product introduction strategy in three scenarios: (1). The only horizontal difference scenario is not among the optimal product introduction strategies. (2). When the proportion of consumers preferring the NB product is small, the high-quality scenario is the optimal product introduction strategy, whereas the low-quality scenario is the optimal product introduction strategy when it is large. A smaller horizontal difference gives consumers who prefer horizontal differences in products less utility. Furthermore, it makes it relatively easy for consumers to switch between two products, leaving much flexibility for EPs and NB retailers in formulating pricing strategies. In the ρ type consumer market, both parties have some monopoly powers on the market. When consumers prefer the OB product, EPs can increase prices in the high-quality scenario, slow competition, and use monopoly power to gain a competitive advantage. When consumers prefer the NB product, the market is not fully covered, and the only horizontal difference scenario leads to intensified competition in the ρ type consumer market, which significantly weakens the monopolistic power of both parties. Therefore, the low-quality scenario can widen the price gap between the two products by lowering the price and easing the price competition. However, the low-quality scenario will cannibalize the demand for the NB product to a certain extent by lowering the price and weakening the monopoly power of both parties. However, easing price competition and increasing the demand cannibalization produced by lowering prices can increase the competitiveness of EPs more than in the high-quality and only horizontal difference scenarios.

When the horizontal difference is large, the EP chooses the optimal product introduction strategy from among the high-quality and only horizontal difference scenarios. Larger horizontal differences mean that consumers gain more utility and pay greater opportunity costs when switching between two products. A smaller product preference coefficient is conducive to EPs using high-quality OB products to expand their competitive advantage further and reduce competition intensity. Larger product preference is not conducive to EP implementation strategies that ease competition. Instead, the EP tends not to introduce an OB product with differentiated quality but to introduce an OB product with only horizontal differences to compete with the NB product for the consumer market. Therefore, an aggressive competitive strategy is beneficial.

Propositions 4 (B) and (C) differ from the more intense competition between NB and OB products in the STC and DTC scenarios. The horizontal difference is relatively moderate at this time, and high-quality scenario will not become an optimal product introduction strategy. The optimal product introduction strategy for EPs is a low-quality or only horizontal difference scenario. Proposition 4 (B) indicates that when the horizontal difference is below moderate and the proportion of consumers preferring the OB product is relatively large, the EP chooses to provide an OB product with only horizontal differences rather than using quality differences to further consolidate its competitive advantage. On the contrary, when consumers prefer

horizontal differences in NB products, the EP does not choose more aggressive competitive strategies but instead avoids intensifying competition and chooses the low-quality scenario. The below moderate horizontal difference makes it difficult for consumers to switch between two products. When consumers prefer the OB product, it has a competitive advantage in the ρ type consumer market, and consumers are fully covered in the $1 - \rho$ type consumer market. At this time, the EP should not choose the low-quality scenario to mitigate competition in the ρ type consumer market but should choose the scenario with only horizontal differences in a high-quality rather than a low-quality scenario. Although the two products' price competition has intensified and monopolies have weakened, the EP can set higher product prices to avoid significant losses in the $1 - \rho$ type consumer market due to lower product prices. When the horizontal difference is above moderate, the only horizontal difference scenario is no longer the equilibrium strategy for introducing an OB product on an EP. Thus, only the low-quality scenario is the optimal product introduction strategy for the EP.

Proposition 5. Under conditions of relatively weak competition between EPs and NB retailers, we can observe the optimal product introduction strategies as follows:

(i) When $\frac{2t+2\alpha-2}{3-t} > \varphi$, the EP must choose a product introduction strategy from among the high-quality and low-quality scenarios. We can observe $p_{ds}^{l3} = p_{ds}^{h3}, p_{dr}^{l3} < p_{dr}^{h3}, d_{ds}^{l3} = d_{ds}^{h3}, d_{dr}^{l3} < d_{dr}^{h3}, \pi_{ds}^{l3} = \pi_{ds}^{h3}, \pi_{dr}^{l3} < \pi_{dr}^{h3}$.

(ii) When $\frac{2t+2\alpha-2}{3-t} < \varphi$, the EP must choose the high-quality scenario.

When both EPs and NB retailers have some monopoly powers, the low-quality scenario cannot be the optimal product introduction strategy. The consumer market is not fully covered, and EPs and NB retailers will choose to use their monopoly powers to obtain more consumer surplus. For the EP, the high-quality scenario makes it more convenient than the low-quality scenario to set higher product prices, exercise monopoly powers, and weaken competition between the two products.

Table 5. Fierce competition between EPs and NB retailers in the STC and DTC scenarios

Horizontal difference φ	The proportion of product preference ρ		
	Small	Larger	Optimal product introduction strategies
Small	High-quality		
Moderate	High-quality	Only horizontal difference	
Larger	High-quality	Low-quality	

Combining Propositions 1 and 3, we compare situations in which there is fierce competition between the NB and OB products in the the STC and DTC scenarios (see Table 5). We find that when the horizontal difference is moderate in the the STC and DTC scenarios, the only horizontal difference scenario will become the optimal choice for the EP. When the horizontal difference is relatively large, the combined effect of the horizontal and vertical differences leads to a more significant competitive mitigation effect. Thus, the EP tends to adopt strategies that mitigate competition and avoid price wars. However, when the horizontal difference is moderate, even though the consumer market is fully covered and competition between EPs and NB retailers is fierce, horizontal differences can also alleviate competition. However, this alleviation effect is more apparent when OB products have an advantage in the consumer market. When there is a large horizontal difference, the opportunity cost for consumers to choose products that they do not prefer is high, putting great pressure on EPs and NB retailers to set product prices. As a result, EPs may not adopt competitive strategies that cannibalize demand and may not adopt more fierce price competition strategies. When OB products have fewer preference groups in the consumer market, the only horizontal difference scenario intensifies competition, and choosing a price war strategy to compete in the consumer market is the optimal product introduction strategy for EPs. Therefore, while EPs adopt the introduction of vertically differentiated products to alleviate competition when the competition level is relatively low, they adopt a strategy of intensifying competition in this scenario.

4.3 Dominant Equilibrium Analysis

This section explores the dominant equilibrium between EPs and NB retailers. Although EPs and NB retailers compete in the consumer market, the optimal product introduction strategies of EPs may not necessarily harm NB retailers' profit but may benefit the NB retailer; that is, there may be a dominant equilibrium between the EP and NB retailers under certain conditions.

Lemma 3. *Based on the profit comparison of NB retailers, we can observe* $\pi_s^{l1} > \pi_s^{n1} > \pi_s^{h1}, \pi_s^{l2} = \pi_s^{h2}$ *in the STC scenario;* $\pi_{ds}^{l1} > \pi_{ds}^{n1} > \pi_{ds}^{h1}, \pi_{ds}^{l2} > \pi_{ds}^{n2} > \pi_{ds}^{h2}, \pi_{ds}^{l3} = \pi_{ds}^{h3}$ *in the DTC scenario.*

In the STC scenario, when the two products compete fiercely, the NB retailer can achieve the highest profit in the low-quality scenario, less in only horizontal difference scenario, and the least in high-quality scenario. In the DTC scenario, the profit situations of the NB retailer are consistent with the STC scenario, except in a situation where the two products' price competition is relatively weak. In the STC and DTC scenarios, the profit of the NB retailer is the same in the different product introduction scenarios when the price competition between the two products is relatively weak.

If a high-quality scenario coexists with other scenarios, choosing the high-quality scenario will harm the NB retailer. In contrast, the only horizontal difference scenario can enable the NB retailer to achieve higher profit when coexisting with the high-quality scenario. A high-quality scenario is the optimal product introduction strategy, which always occurs when there is fierce competition between EPs and NB retailers and OB products have an advantage in the consumer market. This leads to EPs fully utilizing the advantage of consumer product preferences and quality differences to gain more profit. The low-quality scenario and only horizontal difference scenario cannot be utilized simultaneously and EPs cannot utilize competitive strategies based on consumer product preference advantage and quality difference advantage to gain more competitive advantage.

Propositions 6 and 7 demonstrate dominant equilibrium strategies in the STC and DTC scenarios. The dominant equilibrium strategies are the low-quality and only horizontal difference scenarios, which often occur when consumers have a larger proportion of preference for the NB product. Owing to a larger proportion of product preference, NB products can gain more of the consumer market, give NB products a greater competitive advantage, and ultimately facilitate the formation of dominant equilibrium strategies.

Proposition 6. *In the STC scenario, the dominant equilibriums between EPs and NB retailers are as follows:*

(A) With fierce competition between EPs and NB retailers,

(i) if $\frac{(9t+3\alpha)(1-\rho)}{3-(3+r)\rho} > 2 + \varphi > \frac{9t(1-\rho)}{3-(3+r)\rho}, \frac{\alpha}{3} < t < 1,$ *and* $\frac{6t+5rt-\alpha-r\sqrt{13t^2+2t\alpha}}{6t+10rt+2r^2t-\alpha} < \rho < \frac{3}{3+r},$ *then* $\pi_r^{n1} > \pi_r^{h1}$ *and* $\pi_s^{n1} > \pi_s^{h1}$

(ii) if $2 + \varphi > \frac{(9t+3\alpha)(1-\rho)}{3-(3+r)\rho}, \frac{\alpha}{3} < t < 1,$ *and* $\frac{6+5r-r\sqrt{13}}{2(3+5r+r^2)} < \rho < \frac{3}{3+2r},$ *then* $\pi_r^{l1} > max\{\pi_r^{h1}, \pi_r^{n1}\}$ *and* $\pi_s^{l1} > \pi_s^{n1} > \pi_s^{h1}.$

(B) With relatively weak competition between EPs and NB retailers, when $\frac{2-\alpha}{2} < t < \frac{3-\alpha}{2}$ *and* $2t - 2 + \alpha < \varphi,$ *we can observe* $p_s^{l2} = p_s^{h2}, p_r^{l2} < p_r^{h2}, d_s^{l2} = d_s^{h2}, d_r^{l2} < d_r^{h2}, \pi_s^{l2} = \pi_s^{h2}, \pi_r^{l2} < \pi_r^{h2}.$

Proposition 6 (A) indicates that, in the STC scenario, when competition is fierce, the low-quality and only horizontal difference scenarios are the dominant equilibrium strategies between EPs and NB retailers. When the horizontal difference is moderate and consumers prefer the NB product, the only horizontal difference scenario can become the dominant equilibrium strategy compared to the high-quality scenario. Owing to the moderate horizontal difference, the opportunity cost faced by consumers when switching between two products is not significant. NB products have an advantage in the consumer market, and the EP has abandoned quality competition strategies and instead opted for the only horizontal difference scenario. Although competition is relatively fierce in the horizontal difference scenario, the competition is only reflected in the horizontal difference, and the lack of quality competition benefits NB retailers.

When a larger horizontal difference exists, and consumers prefer NB products, the low-quality scenario is the only dominant equilibrium strategy among the three. A larger horizontal difference enables consumers to achieve higher utility in choosing NB products, while also causing them to face greater opportunity costs in switching between products, which can lead to greater costs for the EP when competing for this group of consumers. The high-quality scenario can bring higher utility. The EP adopts the high-quality scenario to compete in consumer markets that prefer NB products, which requires a high opportunity cost. Therefore, competing for these consumers is not an optimal strategy for EPs. Compared with the low-quality scenario, the only horizontal difference scenario can only rely on horizontal competition for consumers while EPs also face intense product competition. In contrast, low-quality scenarios can use quality differences to ease competition while attracting consumers with low quality and prices. Therefore, a low-quality scenario that cannibalizes demand while slowing price competition will not cannibalize the profit of NB retailers, becoming a dominant equilibrium strategy.

Proposition 6 (A) indicates that when the two products' price competition is relatively weak, the high-quality scenario can become the dominant equilibrium strategy compared to the low-quality scenario. Proposition 6 (B) and Proposition 6 (A) have opposite dominant equilibrium strategies, mainly because of the monopoly powers of EPs and NB retailers in the consumer market. For NB retailers, any strategy that weakens the competitive pressure of the OB product on NB products is beneficial. The only horizontal difference scenario will intensify competition, whereas the high-quality scenario can weaken products' competition more than the low-quality scenario.

Proposition 7. *In the DTC scenario, we can observe that the dominant equilibriums between EPs and NB retailers are as follows:*

(A) With fierce competition between EPs and NB retailers,

(i) if $\varphi_1 > \varphi > \varphi_2$ and $\frac{8+2\alpha+4t+5r(1+t)-r\sqrt{1+t}\sqrt{9+17t-4\alpha}}{2(4+5r+r^2+2t+5rt+r^2t+\alpha)} < \rho < \frac{3}{3+r}$, then $\pi_{dr}^{n1} > \pi_{dr}^{h1}$ and $\pi_{ds}^{n1} > \pi_{ds}^{h1}$.

(ii) if $\varphi > \varphi_1$ and $\frac{8+5r+4t+5rt-r\sqrt{9+26t+17t^2}}{2((5r+r^2)(1+t)+4+2t)} < \rho < \frac{3}{3+r}$, then $\pi_{dr}^{l1} > max\{\pi_{dr}^{h1},\pi_{dr}^{n1}\}$ and $\pi_{ds}^{l1} > \pi_{ds}^{n1} > \pi_{ds}^{h1}$.

(B) With fierce competition in the $1-\rho$ type consumer market and relatively weak competition in the ρ type consumer market between EPs and NB retailers,

(i) if $\varphi < \varphi_4$ and $\rho \in [max\{\rho_0,\rho_2\}, \frac{8+19t+8t^2}{8+19t+rt+8t^2})$, then $\pi_r^{l2} > max\{\pi_r^{h2},\pi_r^{n2}\}$ and $\pi_{ds}^{l2} > \pi_{ds}^{n2} > \pi_{ds}^{h2}$.

(ii) if $\varphi_4 < \varphi < \varphi_5$ and $\rho \in [\rho_2, \frac{8+19t+8t^2}{8+19t+rt+8t^2})$, then $\pi_r^{n2} < \pi_r^{l2}$ and $\pi_{ds}^{l2} > \pi_{ds}^{n2}$.

(iii) if $\varphi_6 < \varphi < 1$ and $\rho \in [\rho_1, \frac{8+19t+8t^2}{8+19t+rt+8t^2})$, then $\pi_r^{n2} > \pi_r^{h2}$ and $\pi_{ds}^{n2} > \pi_{ds}^{h2}$.

(C) With relatively weak competition between EPs and NB retailers, when $\frac{2t+2\alpha-2}{3-t} > \varphi$, then $p_{ds}^{l3} = p_{ds}^{h3}$, $p_{dr}^{l3} < p_{dr}^{h3}$, $d_{ds}^{l3} = d_{ds}^{h3}$, $d_{dr}^{l3} < d_{dr}^{h3}$, $\pi_{ds}^{l3} = \pi_{ds}^{h3}$, $\pi_{dr}^{l3} < \pi_{dr}^{h3}$.

The dominant equilibrium strategies in Propositions 7 (A) and (C) are similar to those in Propositions 6 (A) and (B), with the main difference being the constraints on the dominant equilibrium strategies.

Proposition 7 (B) indicates that when an EP competes fiercely in the $1-\rho$ type consumer market and weakly in the ρ type consumer market, the low-quality scenario becomes the dominant equilibrium strategy when the horizontal difference is small or moderate compared to the other two scenarios. When the horizontal difference is large, the only horizontal difference scenario becomes the dominant equilibrium strategy relative to the high-quality scenario. When the horizontal difference is small or moderate, it is not very difficult for consumers to switch between two products. Considering that NB products have a large consumer market, the only horizontal difference scenario can intensify competition, leading to greater numbers of consumers switching between the two products. Compared with the high-quality scenario, low-quality scenarios can achieve a better balance between weakening competition and cannibalizing demand, allowing the OB product to gain more profit while avoiding losses for the NB product. When there is a large horizontal difference, consumers cannot easily switch between the two products. The only horizontal difference scenario can cannibalize more demand than the high-quality scenario, allowing the OB product to gain more consumer markets.

Based on Propositions 6 and 7, we analyze the impact of different transaction costs on the profits of EPs and NB retailers within the existing dominant equilibrium area, as shown in Proposition 8.

Proposition 8. *The impacts of different transaction costs on the profit of EPs and NB retailers are as follows.*

(A) With fierce competition between EPs and NB retailers, we can obtain Table 6.

Table 6. Comparison of optimal introduction strategies under different cost scenarios

Conditions	Comparisons
$\frac{3}{7} < \alpha, \frac{\alpha}{3} < t \le \sqrt{1-2\alpha+2\alpha^2} - 1 + \alpha$ and $\frac{8t+7t^2-2t\alpha-\alpha^2}{t+t(2r+7)(1+t)-2t\alpha-\alpha^2} < \rho$.	$\pi_r^{l1} > \pi_{dr}^{l1}$
(1) $\alpha \le \frac{3}{7}, \frac{\alpha}{3} < t$ and $\rho \le \frac{3}{3+r}$. (2) $\frac{3}{7} < \alpha, \frac{\alpha}{3} < t < \sqrt{1-2\alpha+2\alpha^2} - 1 + \alpha$ and $\rho < \frac{8t+7t^2-2t\alpha-\alpha^2}{t+t(2r+7)(1+t)-2t\alpha-\alpha^2}$. (3) $\frac{3}{7} < \alpha, \sqrt{1-2\alpha+2\alpha^2} - 1 + \alpha < t < 1$ and $\rho \le \frac{3}{3+r}$.	$\pi_r^{l1} \le \pi_{dr}^{l1}$
$\frac{3}{7} < \alpha, \frac{\alpha}{3} < t \le \sqrt{1-2\alpha+2\alpha^2} - 1 + \alpha$ and $\rho \le \frac{3}{3+r}$.	$\pi_s^{l1} \ge \pi_{ds}^{l1}$
(1) $\alpha \le \frac{3}{7}, \frac{\alpha}{3} < t < 1$ and $\rho \le \frac{3}{3+r}$. (2) $\frac{3}{7} < \alpha, \sqrt{1-2\alpha+2\alpha^2} - 1 + \alpha < t < 1$ and $\rho \le \frac{3}{3+r}$.	$\pi_s^{l1} < \pi_{ds}^{l1}$

(B) With relatively weak competition between EPs and NB retailers, we can observe $\pi_r^{h2} > \pi_{dr}^{h2}$, $\pi_s^{h2} > \pi_{ds}^{h2}$.

The low-quality scenario is the dominant equilibrium strategy in the two products' fierce competition. When the transaction cost is relatively small and the proportion of consumers preferring the NB product is high, the profit of the EP in the STC scenario is higher than in the DTC scenario. By contrast, the profit of the EP in the STC scenario is lower than in the DTC scenario. When the transaction cost is relatively low, the profit of NB retailers in the STC scenario is higher than in the DTC scenario. By contrast, the profit of NB retailers in the STC scenario was lower than in the DTC scenario.

Compared to the STC scenario, a smaller transaction cost gives the OB product a greater competitive advantage, enabling the EP to set higher prices. Owing to the two products' fierce competition, the EP with an OB product uses the advantage of transaction costs to increase prices, leading to the retailer of the NB product also taking advantage of the larger consumer market preference for their products to increase prices ($p_{ds}^{l1} > p_s^{l1}, p_{dr}^{l1} > p_r^{l1}$). A smaller transaction cost can weaken the demand for OB products that is caused by price increases, but price increases directly lead to the demand for NB products being cannibalized. Considering the complete coverage of the consumer market, the increase in prices for both products results in a significant decrease in demand for the NB product and an increase in demand for the OB version. The NB retailer suffers significant profit losses, leading to significant profit losses for the EP.

The high-quality scenario is the dominant equilibrium strategy in a situation involving relatively weak competition between the two products. Currently, the profits of the EPs and NB retailers in the STC scenario are higher than in the DTC scenario. A smaller transaction cost gives EPs a greater competitive advantage. When competition is weak, both the EPs and NB retailers have monopoly powers in the consumer market. Compared to the STC scenario, smaller transaction costs encourage EPs to fully utilize their monopoly powers and set higher product prices ($p_{dr}^{h1} > p_r^{h1}$). The NB retailer also chooses to increase product prices along with the EP ($p_{ds}^{h1} > p_s^{h1}$), and, ultimately, both parties can obtain relatively greater profit.

4.4 Social Welfare Analysis

This section examines the changes in the consumer surplus (CS), total profit (TP), and social welfare (SW) of the EPs and NB retailers under dominant equilibrium introduction strategies. SW is the sum of CS and TP.

In the STC scenario, the consumer surplus and social welfare functions in the horizontal difference scenario are as follows:

$$CS^{n1} = \rho(\int_0^{x_0}(1 + \varphi - p_s - tx)dx + \int_0^{x_0'}(1 - p_s - tx)dx) + (1 - \rho)(\int_{x_0}^1(1 - p_r - t + tx)dx + \int_{x_0'}^1(1 + \varphi - p_r - t + tx)dx) \quad \text{.............................(2)}$$

$$SW^{n1} = CS^{n1} + TP^{n1} = CS^{n1} + \pi_s^{n1} + \pi_r^{n1} \quad \text{.............................(3)}$$

Similar to the horizontal difference scenario, we can obtain consumer surplus and social welfare functions for low-quality and high-quality scenarios in the STC scenario, as well as consumer surplus and social welfare functions for the only horizontal difference, low-quality, and high-quality scenarios in the DTC scenario, which are CS^{h1} and SW^{h1}, CS^{h2} and SW^{h2}, CS^{l1} and SW^{l1}, CS^{l2} and SW^{l2}, CS_d^{n1} and SW_d^{n1}, CS_d^{n2} and SW_d^{n2}, CS_d^{h1} and SW_d^{h1}, CS_d^{h2} and SW_d^{h2}, CS_d^{h3} and SW_d^{h3}, CS_d^{l1} and SW_d^{l1}, CS_d^{l2} and SW_d^{l2}, CS_d^{l3} and SW_d^{l3}, respectively (See Appendix).

Lemma 4. *In the STC scenario, the comparison results of consumer surplus, total profit, and social welfare are as follows:*

(A) With fierce competition, the comparison results are shown in Table 7 and Figure 2.

*(B) With relatively weak competition, we can observe $CS^{l2} < CS^{h2}, TP^{l2} < TP^{h2}, SW^{l2} < SW^{h2}$.*

Table 7. Dominant equilibrium strategies in the STC scenario

Horizontal difference φ	The proportion of product preference ρ	
	Large	
Moderate	Only horizontal difference (Fig 2. A-1)	Dominant equilibrium strategies
Large	Low-quality (Fig 2. A-2)	

From $p_s^{n1} > p_s^{h1}, d_s^{n1} > d_s^{h1}$, and $d_r^{n1} < d_r^{h1}$, it can be seen that the NB and OB products have achieved high product demand in the only horizontal difference and high-quality scenarios. The EP may use quality differences to set higher prices for OB products in high-quality scenarios. At this time, the NB retailer reduces the price of the NB, and the price gap between the two products widens, easing competition between the products. By contrast, with an only horizontal difference scenario, the EP may lower the prices of their OB products. At this time, the NB retailer increases the price of the NB product, narrowing the price gap between the two products and intensifying competition between them, and consumers gain more consumer surplus from the intensified competition.

Similarly, from $p_s^{n1} < p_s^{l1}$, $d_s^{n1} < d_s^{l1}$, and $d_r^{n1} > d_r^{l1}$, it can be seen that the NB and OB products have achieved higher product demand in low-quality and only horizontal difference scenarios, respectively. In the only horizontal difference scenario, the price gap between the OB and NB products widens. By contrast, in low-quality scenarios, the price gap between the two products narrows, competition between the products intensifies, and consumers gain more consumer surplus from intensified competition.
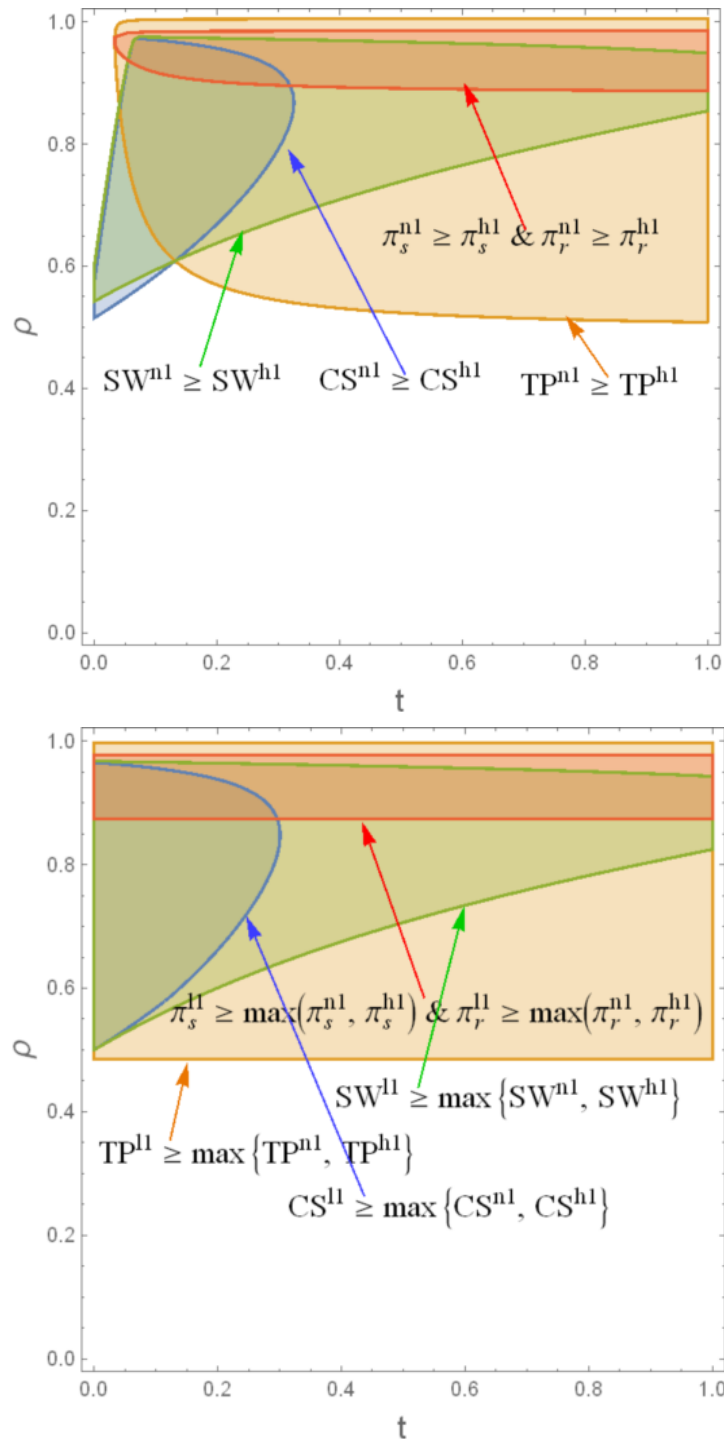
(A-1) Only horizontal difference dominant   **(A-2) Low-quality dominant**

Figure 2. Comparisons of consumer surplus, total profit, and social welfare in the STC scenario

Lemma 5. *In the DTC scenario, the comparison results of consumer surplus, total profit, and social welfare are as follows:*

(A) With fierce competition, the comparison results are shown in Table 8 and Figure 3.

(B) With fierce competition in the $1-\rho$ type consumer market and relatively weak competition in the ρ type consumer market, the comparison results are shown in Table 8 and Figure 3.

(C) With relatively weak competition between EPs and NB retailers, we can observe $CS_d^{L3} < CS_d^{h3}$, $TP_d^{L3} < TP_d^{h3}$, $SW_d^{L3} < SW_d^{h3}$.

**Table 8. Dominant equilibrium strategies in the DTC scenario**

Horizontal difference φ	Fierce competition	Fierce competition in the $1-\rho$ type consumer market and relatively weak competition in the ρ type consumer market	
		The proportion of product preference ρ is larger	
Small	—	Low-quality (Fig 3. B-1)	Dominant equilibrium scenarios
Moderate/Above moderate	Only horizontal difference (Fig 3. A-1)	Low-quality (Fig 3. B-2)	
Large	Low-quality (Fig 3. A-2)	Only horizontal difference (Fig 3. B-3)	

From $p_{ds}^{n1} > p_{ds}^{h1}$, $d_{ds}^{n1} > d_{ds}^{h1}$, and $d_{dr}^{n1} < d_{dr}^{h1}$, it can be seen that NB products face horizontal and vertical differences in competition in the high-quality scenario. Simultaneously, OB products have the advantages of lower transaction costs and complete consumer coverage, which forces retailers of NB products to set lower product prices in high-quality scenarios to gain more of the consumer market. Therefore, the two products' price competition in the high-quality scenario is fiercer than in the only horizontal difference scenario, resulting in consumers obtaining more consumer surplus. Similarly, from $p_{ds}^{n1} < p_{ds}^{l1}$, $d_{ds}^{n1} < d_{ds}^{l1}$, and $d_{dr}^{n1} > d_{dr}^{l1}$, it can be seen that the two products' competition in the only horizontal difference scenario is fiercer than in the low-quality scenario, leading to consumers obtaining more consumer surplus.

From $p_{ds}^{n2} < p_{ds}^{l2}$, $p_{dr}^{n2} > p_{dr}^{l2}$, $d_{ds}^{n2} < d_{ds}^{l2}$, and $d_{dr}^{n2} > d_{dr}^{l2}$, it can be seen that the relatively weak competition in the ρ type consumer market has leads EPs to use monopoly power and vertical quality differences to set lower prices for OB products in the low-quality scenario, further alleviating competition between the two products. In contrast, in the only horizontal difference scenario, the OB product is set at a higher price, whereas the NB retailer sets lower prices for the NB product. The two products' price gap further narrows, leading to intensified competition between the two products in the only horizontal difference scenario. Competition between the two products in the low-quality scenario is weaker than in the only horizontal difference scenario, resulting in consumers being able to obtain consumer surplus from the latter.

From $p_{ds}^{n2} > p_{ds}^{h2}$, $p_{dr}^{n2} < p_{dr}^{h2}$, $d_{ds}^{n2} > d_{ds}^{h2}$, and $d_{dr}^{n2} < d_{dr}^{h2}$, it can be seen that compared to the only horizontal difference scenario, EPs use their monopoly power and vertical quality differences in the ρ type consumer market to set higher product prices for OB products in a high-quality scenario, further easing the competitive situation between the two products. By contrast, in the only horizontal difference scenario, the EP sets lower prices for the OB product, while the NB retailer sets higher prices for the NB product, resulting in intensified competition between the two products, and consumers gain more consumer surplus from the intensified competition.
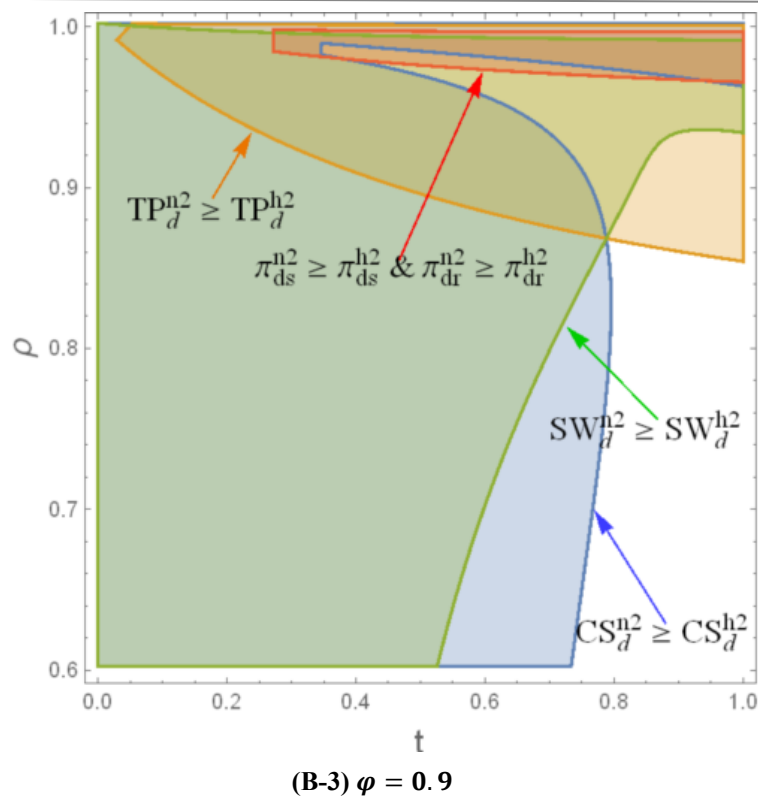
(A-1) $\varphi = 0.2$

(A-2) $\varphi = 0.4$

(B-1) $\varphi = 0.3$

(B-2) $\varphi = 0.7$

(B-3) $\varphi = 0.9$
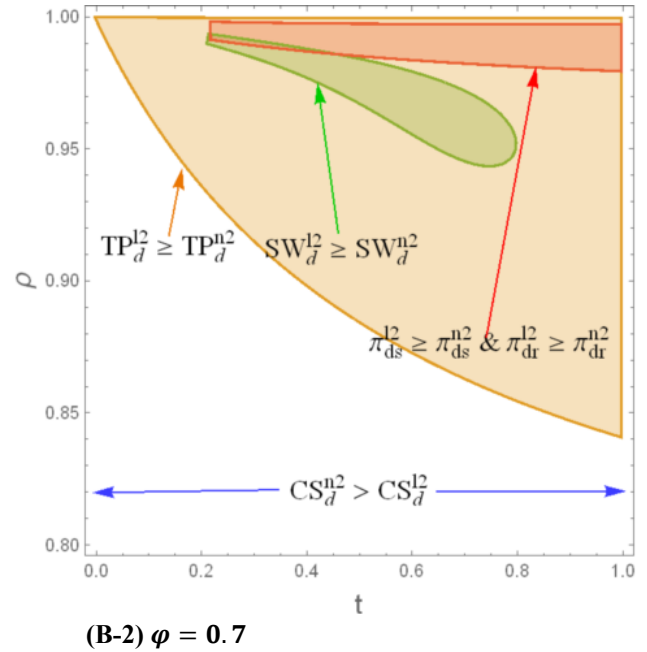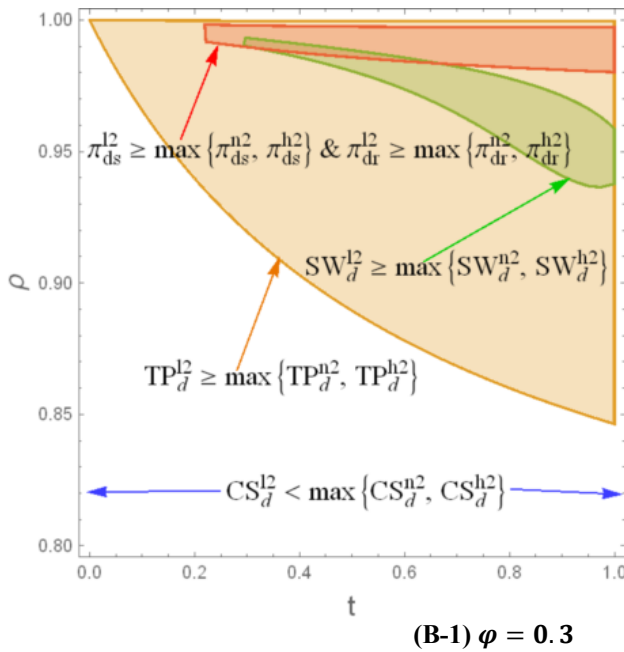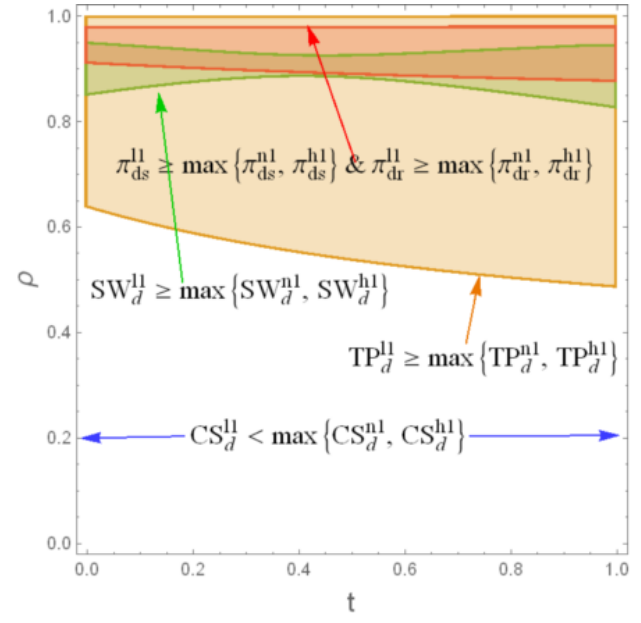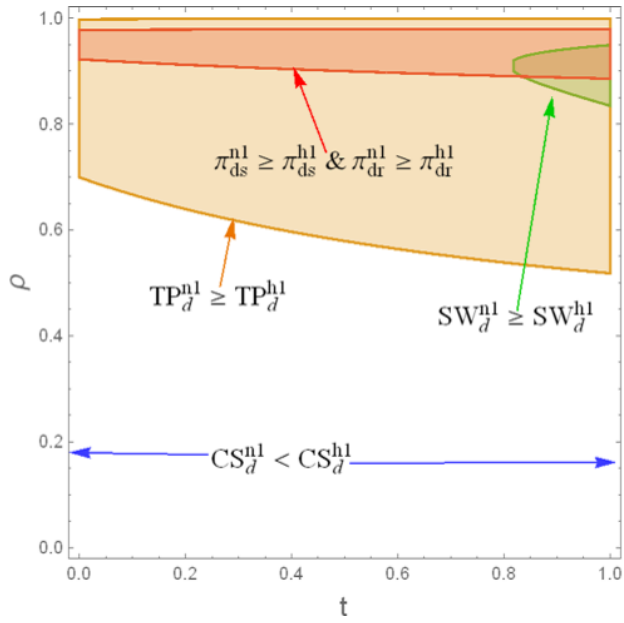
Figure 3. Comparisons of consumer surplus, total profit, and social welfare in the DTC scenario

5. CONCLUSION

EPs such as JD.com and Amazon are gradually expanding their OB product lines. The introduction of an OB product inevitably creates a competitive relationship with the NB version. Considering that consumers have inconsistent preferences for horizontal differences in styles, designs, and color combinations between NB and OB products, and consistent preferences for vertical differences, the transaction costs incurred by consumers when choos- ing to consume NB or OB products are different. OB products might help consumers save more time in selecting a product. We constructed a price game and a quality selection model based on these scenarios between EPs and NB retailers. We studied how EPs should choose the optimal product introduction strategy for the STC and DTC scenarios. Then, from the perspective of symbiosis and win-win for EPs and NB retailers, we analyzed the issue of dominant equilibrium strategies between EPs and NB retailers. Finally, we explored the impact of different transaction costs on dominant equilibrium strategies. We obtained theoretical results and management insights.

5.1 Theoretical results

(1) When competition is fierce between NBs and OB products, the optimal product introduction strategies under the STC and DTC scenarios are similar, depending on the degree of horizontal difference and the product preference coefficient. When the horizontal difference is small, the EP chooses the high-quality scenario. When the horizontal difference is moderate and the preference coefficient of the NB is small, the EP chooses only the horizontal difference scenario, whereas the EP chooses a high-quality scenario when the preference coefficient is high. When the horizontal difference is large and the preference coefficient is small, the EP chooses a high-quality scenario, and when the preference coefficient is high, the EP chooses a low-quality scenario.

(2) When competition is fierce, the optimal product introduction strategies in the STC and DTC scenarios are similar. When the EPs and NB retailers have a certain degree of market monopoly power, the EP chooses a high-quality scenario. High-quality scenarios allow EPs to utilize monopoly powers effectively to set higher product prices and obtain higher product demand.

(3) In contrast with the STC scenario, in the DTC scenario, where EPs and NB retailers are competing fiercely in the $1-\rho$ type consumer market and relatively weakly in the ρ type consumer market, the horizontal difference is relatively moderate, and a high-quality scenario will not be an optimal introduction strategy. Owing to the relatively weak competition in the ρ type consumer market and the competitive disadvantage of the OB product in the ρ type consumer market, if an EP chooses the high-quality scenario with strong mitigation of competition, the monopoly power of both parties will be further strengthened, exacerbating the competitive disadvantage of the OB product. However, choosing low-quality and horizontal-difference scenarios can better balance price competition and demand cannibalization.

(4) When competition is fierce or relatively weak, the dominant equilibrium strategies of the EPs and NB retailers are similar. When competition is fierce, as the horizontal difference increases, the dominant equilibrium strategy shifts from the only horizontal difference scenario to the low-quality scenario. When competition is relatively weak, the dominant equilibrium strategy is the high-quality scenario. However, in the $1-\rho$ type consumer market with relatively weak competition in the ρ type consumer market, the dominant equilibrium strategy shifts from the low-quality scenario to the only horizontal difference one.

(5) Compared to the STC scenario, when competition is fierce, different transaction costs may not necessarily be beneficial to EPs, nor may they necessarily harm the NB retailer's profit. Interestingly, under certain conditions, both the EPs and NB retailers experience profit losses. When competition is relatively weak, the different transaction costs do not improve the profits of the EPs or NB retailers.

(6) Under the STC scenario, there are areas where dominant equilibrium strategies can improve consumer surplus, total profit, and social welfare. Contrastingly, only when the competition in the ρ type consumer market is relatively weak and the horizontal difference is larger, or when the competition is relatively weak, do the dominant equilibrium strategies exist in areas that can improve consumer surplus, total profit, and social welfare under STC scenario.

5.2 Management Insights

Product quality and horizontal difference are crucial for competitive strategies. EPs should carefully consider product design and various competitive strategies to gain a competitive advantage, which may involve improving product quality, innovating in terms of design, or adjusting product characteristics to meet the needs of different consumers.

In fiercely competitive markets, EPs and NB retailers may need to focus on product quality and pricing strategies. Contrastingly, they need to pay more attention to product characteristics and market segmentation in relatively weaker markets.

EPs and NB retailers should invest in understanding consumer needs and preferences to develop more precise product introduction strategies, which may include market research, consumer feedback, and data analysis.

When EPs and NB retailers have a certain degree of market monopoly power, a high-quality scenario may be the most profitable choice. Managers should wisely use their monopoly power and develop appropriate pricing strategies to maximize product demand and profit.

EPs should pursue profit and consider the overall interests of society, simultaneously. When formulating strategies, it is necessary to balance economic benefits with social welfare to ensure symbiosis and win-win for EPs and NB retailers.

5.3 Limitations and Future Research

When analyzing the strategy of introducing product differences on EPs, we did not consider the competition between various EPs; rather, we considered oligopoly competition. There are several similar NB retailers in the EP space. When considering the competition between numerous NB retailers and external competition, differences in introduction strategies will inevitably be affected significantly, which will be the direction of future research in this field.

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