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Hybrid Platform Operation Decision of Retail Enterprises

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Abstract: The development of e-commerce has formulated the hybrid platform mode for retail enterprises. We studied how the differences in product distribution cost, unit retail price, and competition conflict affect the business model decision making. The theoretical model shows the following results: (1) When the hybrid platform sells complementary products with third-party sellers, the profit of choosing the hybrid mode is always the best. (2) When the hybrid platform competes with third-party sellers, if the unit retail price is in a higher range, the merchant mode is the best choice; when the unit retail price is in the lower range, the hybrid platform mode is the best choice. (3) Competition between the hybrid platform and third-party sellers determines the profit level of the operating enterprise. The excessive price competition between the self-operated business and the third-party sellers is magnified by the existence of cross-network externalities, resulting in a strong anti-competitive effect, and affecting the profits of the hybrid platform's two businesses. These findings guide retail enterprises to design their business model as well as address competition conflict.

Keywords: business model; two-sided market; hybrid platform mode; price competition

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1. Introduction

The popularity of Internet technology has led to the rapid development of all kinds of markets, and produced a hybrid mode with both merchant mode and platform mode. In the retail market, Amazon, Alibaba, and JD.com are three represented companies using hybrid mode. In the mobile application market and video game market, Apple, Google, Microsoft, and Sony have also established their trading markets as well as self-operated business. Scholars think that an enterprise that developing not only two-sided user interaction markets, but also self-operated business, can be regarded as a hybrid platform mode (also known as mixed platforms, dual-role platforms, or dual-mode platforms) [1–5]. The emergence of the hybrid platform mode is driven by business practices. On the one hand, merchant enterprises provide high product quality and uniform service level [6]. They rely on scale economy to cover a large number of user needs, but the heavy asset characteristics make the product variety limited and the long-tail user coverage insufficient [7]. On the other hand, platform enterprises provide trading places to promote interaction between users, but it is difficult to unify product quality and service level.

The choice of merchant mode, platform mode, hybrid platform mode is one of the core issues perplexing enterprises and researchers. There are advantages and disadvantages of all three modes. Although the merchant mode attaches importance to asset operation, its product standards and service standards are easier to unify. The platform mode has light asset operation and less market risk [8], but difficulties in market governance. The hybrid mode has the advantages of both modes, and dual functions—on the one hand, the buyer and seller interacting in the market makes the operating enterprise undertake the function of connecting and matching buyers and sellers; on the other hand, the operating enterprise undertakes the function of selling products to consumers. Scholars pointed out that at least two different types of users interact through the platform enterprise, and their behaviors directly affect the utility or profit of other kinds of users [9,10]. Such a market is called a two-sided market, and this property is called cross-network externality. The hybrid mode

has obvious two-sided market characteristics. On the one hand, the income of the hybrid mode operation enterprise depends on the number of buyers. When the number of buyers is large, the sellers' sales volume can be higher. On the other hand, the buyers' income depends on the number of sellers. More sellers lead to more kinds of goods and higher buyer utility.

However, the "dual role" may lead to competitive conflicts between self-operated businesses and platform businesses, amplify the anti-competitive effect through cross-network externalities, and affect the overall profits of operating enterprises [11]. First, when the competition between third-party sellers and self-operated businesses is not fierce, the two businesses show a synergistic effect; that is, on the basis of running two-sided markets, they provide richer, higher-quality complementary goods and expand the diversity of goods. Second, when the competition between third-party sellers and self-operated businesses becomes fierce, the synergistic effect is less than the anti-competitive effect, and the competition for consumers between the two sides causes serious damage, reducing the market size and profits of the platform business. This also reduces the total profit of the hybrid platform. Therefore, according to the key characteristics of business practice, the question of how retail operating enterprises make decisions about their business model when faced with heterogenous product distribution costs, product unit prices, and competitive conflicts. Will the competitive conflict affect the business model decision? Finally, what is the impact of competition conflicts on the two major business profits of hybrid mode operators? The answer matters for the retail enterprise's choice, as well as for how to cope with the relationships between self-operated sellers and third-party sellers when adopting the hybrid platform mode. Moreover, the competition between self-operated sellers and third-party sellers also influences their profits as well as product diversity, which ultimately induces consumer welfare.

To answer the questions above, starting from the three factors of product distribution cost, product unit price, and competitive conflict, we constructed a theoretical model to compare the profit differences of retail enterprises choosing merchant mode, platform mode, and hybrid mode. We aimed to provide a theoretical basis for business model decision-making. Based on previous research on merchant mode and pure platform mode [12,13], our paper considers hybrid mode as a new business model. We also suggest that product unit price, unit distribution cost, and competitive conflict have an important impact on the business model decision-making process (see Figure 1). We define the applicable conditions of the three modes and offer specific strategies and find the conditions for deciding hybrid mode and pure platform. Furthermore, compared with [1], we highlight the impact of competition between self-operated sellers and third-party sellers, and suggest that hybrid mode enterprises should focus on the relationship with third-party sellers, and pay attention to the complementarity with third-party sellers, to maintain the balanced development of the two major businesses. Our research results have some contributions: First, we focus on the hybrid mode, and give the specific strategy of retail enterprise business model decision making. Second, our research makes clear the impact of competitive conflicts on the profits of hybrid mode operators. Third, our study's results also highlight the two major businesses, and expand the scope of research on two-sided market network externalities. we show that when the competition between the third-party sellers and the self-operated sellers is not fierce, the two businesses show a synergistic effect. Our research has some implications for retail enterprise model selection.

Our research gives the decision-making path of the operating enterprise, as follows: (1) If the hybrid platform and the third-party sellers sell complementary products, in the range of all distribution costs and unit retail prices, the profit of choosing the hybrid platform mode is always the best, compared with pure merchant and pure platform modes. In terms of the suboptimal choice, when the distribution cost is in a lower range, the merchant mode is the suboptimal choice; when the product distribution cost is in a higher range, the suboptimal choice depends on the unit retail price of the product. (2) If the hybrid platform competes with third-party sellers, when the product price is in a higher

range, the merchant mode is the best choice, and the suboptimal choice is the hybrid mode; when the unit retail price is in a lower range, the operating enterprise should first choose the hybrid mode, and the suboptimal choice depends on the product distribution cost. When the unit retail price is in the middle range, the operating enterprise should adopt the hybrid platform mode compared to the pure platform mode. (3) The excessive price competition between the self-operated business and the third-party sellers is magnified by the existence of cross-network externalities, resulting in a strong anti-competitive effect, affecting the profits of the hybrid platform.

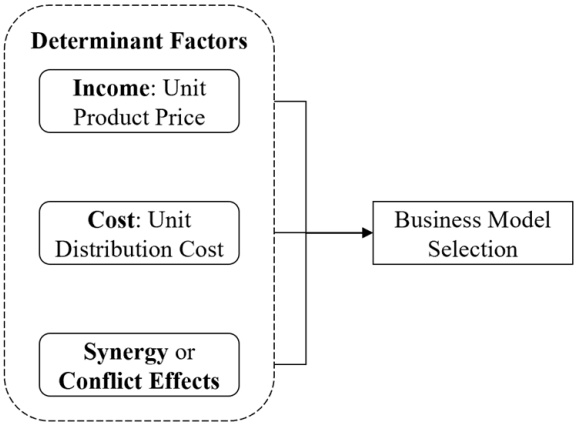

Figure 1. Factors determining the retailing enterprise business model selection.

The remainder of this paper is organized as follows: Section 1 describes the background of the question and related literature; Section 2 constructs a theoretical model based on reality; Section 3 discusses the mode selection; Section 4 discusses the impact of the competitive environment; Section 5 summarizes the main conclusions of this paper.

1.1. Related Literature

The development of e-commerce gradually changes the original inherent business model. Generally speaking, the business models of e-commerce operators can be summarized into two categories: One is the merchant mode, which uses Internet technology to engage in business activities, earns wholesale price differences, and provides high-quality, uniform goods or services to the demand side. This model is characterized by covering a large number of users needs with economies of scale [12,14]. The other is the platform mode, which provides trading venues and matching services to two groups of users by building two-sided markets. This model is characterized by covering long-tailed users and a large variety of goods and services [15–19]. In fact, with the promotion of the concept of the business model, it is more common for enterprises to incorporate business model changes into strategic considerations [20]. Many enterprises have proposed online platform strategies, through connecting multiside access, bringing more customer resources, mobilizing internal and external resources, and serving customers to create and obtain value [21]. With the progress of business practices, some e-commerce operators combine the merchant mode and the platform mode based on the needs of expanding share and managing the market. Many enterprises have begun to adopt the platform mode based on the merchant mode, forming the hybrid mode. The hybrid mode has the advantages of both the merchant mode and the platform mode. Therefore, according to previous research [1–5], we give the definition of the hybrid platform. The hybrid platform is a conciliatory model between pure merchant mode and pure platform mode; it can not only build the two groups' user interaction market, but also include self-operated businesses. The connotation of this definition has two aspects: on the one hand, the buyer and seller interact in the market in which the operating enterprise undertakes the functions of connecting and matching buyers and sellers; on the other hand, self-operated businesses include first-party businesses of wholesale from upstream suppliers and own-brand goods businesses.

The concept of hybrid platform mode has gradually evolved with the development of practice and theoretical research. Early business model decision making research considered the choice of a single business model: (1) The decision of vertical integration of traditional enterprises; When the complete contract is not feasible, vertical integration takes place out of the need to minimize the holding risk of some suppliers [19,22,23]. (2) The choice between two-sided platform and merchant modes; Hagiu [12] and Hagiu and Wright [18] discussed the importance and influencing factors of decision making in pure platform and merchant modes; Hagiu and Lee [24] discussed the difference between platform and merchant mode. Hagiu and Wright [25] compared the choice between the pure platform and pure merchant mode, where platform enterprises extract all consumer surplus by adopting an effective merchant mode. Luo and Fu [13] compared the conditions for retail enterprises to choose between pure platform mode and merchant mode. Belhadj et al. [26] considered the marketplace and reselling decision. (3) The choice of agency or wholesale; Johnson [27] studied the comparison and influence of agency mode and wholesale mode.

With a deep understanding of the research, many scholars have begun to regard the vertical integration in two-sided markets as a supplement to the platform mode, which is used to govern market competition or coordinate the number of participants: (1) The vertical integration of traditional enterprises is mainly to adjust the competition; for example, Farrell and Katz [28] studied the coordination between two complementary manufacturers. (2) The vertical integration in two-sided markets is to solve the problem of quantitative coordination. The platform can selectively enter some markets while using a micro-commitment mechanism to retain innovation incentives for developers [29]. The expected nature of buyers and sellers and the complement case between first-party content and third-party content is the key factors driving the platform to provide first-party content [30]. Carlton [31] believed that the first-party content products provided by the platform harm the sellers.

In recent years, many scholars have begun to put forward the possibility of the hybrid platform mode. They consider the development of the hybrid platform from two angles: The transformation from pure platform mode to hybrid platform mode, specifically focusing on Amazon's vertical integration behavior and competition with third-party vendor product categories [32,33]. The transformation from merchant mode to hybrid platform mode, which can reduce the expansion burden of merchant mode [34,35]; Tian et al. [36] considered that it can enable enterprises to choose appropriate performance cost and competition intensity. To sum up, previous studies on the hybrid platform all emphasize that the hybrid platform is both a market provider and a market participant.

Many scholars have conducted in-depth research on the driving factors of the development of the hybrid platform, which can be summarized as follows: to gain value, to enhance the platform ecosystem, to enhance the level of innovation, to reduce market competition, or to increase bargaining power and open control trade-offs. (1) To gain value; the motivation for the development of the hybrid platform is to obtain more consumer surplus [37,38]. Typically, Amazon is more likely to target successful product spaces [33], and many potential markets with long tails and niche products are traded in platform-based markets [39]. (2) To improve the system capability of the platform, including the technical level of platform ecology, the technical level of developers, and the level of information sharing. Gawer and Henderson [40] believed that the platform can selectively enter the platform market to enhance the innovation incentives for developers. Li et al. [34] showed that retailer development platforms can play an open role. Zhang and Zhang [41] showed that there are differences in the level of information sharing between the two models. Ning and Yang [42] studied the competition of hybrid platform enterprises to enter the application service market of developers, and found that developers with many users adopt more active strategies to enter the hybrid platform; the competition between hybrid platforms and developers improves the efficiency of the platform ecosystem. (3) To improve the level of innovation. Wen and Zhu [43], after studying Google's entry into the hybrid market, believed that Google entering the hybrid market caused developers to reduce

innovation and raise the price of applications. However, the motivation for innovation has not been completely suppressed, and innovation has been transferred to unaffected new applications. (4) To reduce market competition. Wen and Zhu [43] studied the impact of competition between Google and developers on the hybrid platform through empirical data, and found that the competition between Google and developers led the latter to reduce innovation and increase the price of application products; the competition between Google and developers reduces the intensity of competition between developers and reduces wasteful development efforts. Tian et al. [36] considered that the factors influencing the choice of a retailer's dominant mode include the cost of order performance and the intensity of product competition. Li and Agarwal [44] studied the vertical integration of social media, and found that social media platforms develop a hybrid mode that increases consumer use of the application and benefits third-party developers. (5) To increase the bargaining power with suppliers. Mantin et al. [38] believed that retailers adopting a dual model can enhance their bargaining position with manufacturers by creating "external choices". (6) Open control trade-offs; Parker and Van [45] believed that closed platforms increase the ability of platform sponsors to charge for access, while open platforms increase the ability of hybrid developers to develop on this basis.

Finally, our research is closely related to the literature on business model selection and channel competition. Firstly, some researchers studied the business model selection. Tian et al. [36] found that order fulfillment costs and upstream competition intensity affect business model decision. Zhang [6] found that when facing the same fixed fee, fixed user fee, and number of consumers, the hybrid platform mode is better than the platform mode and the merchant mode. Anderson and Bedre-Defolie [1] studied the influence of competitive advantages and fixed costs on the platform mode decision-making of e-commerce enterprises. Li et al. [34] pointed out that if the price influence coefficient between products is small, the fixed cost is low, and the potential demand difference coefficient is small, the retail enterprise should open the platform. Lai et al. [46] taking Amazon as an example, studied the impact of service-level competition on profit decision making of hybrid platform enterprises. Bisceglia et al. [47] pointed out that alleviating competition and filling the innovation gap can lead to vertical integration. Li et al. [48] considered that commission fee and service cost coefficient are the determinant that affect business model selection. Secondly, other scholars studied the retail and manufacturer's channel competition. Ryan et al. [49] studied the equilibrium between retailers using their own websites to sell products and those signing contracts with platform companies to sell products. Abhishek et al. [50] considered that online retail platforms can either sell products on behalf of manufacturers (agent sales) or resell products. They found that when the platform channel harms the traditional channel, the retail companies are more inclined to act as sales agents. Zhou et al. [51] studied the multichannel decision making of e-commerce enterprises, and noted that different consumer channel preferences and platform commissions affect the mode choice of e-commerce enterprises. Pu and Liu [52] studied the manufacturer's channel strategy considering physical store's fairness concern. Yang and Liu [53] studied the influence of e-commerce enterprise channel after-sale on mode choice. Dong et al. [54] pointed out that distribution channel competition affects the retailors' choice. Wang et al. [55] studied operation modes in which two suppliers supply substitute product to a e-retailer who owns online platform and sets platform service level. Wang et al. [56] considered the operating cost as important factor affect the channel mode.

Generally speaking, the research on the hybrid mode has just started, and previous studies have paid more attention to the model decision making under channel conflict and the welfare impact of platform enterprises selling products on the market, while the theoretical research on the decision-making mechanisms of retail enterprises is relatively scarce.

1.2. Contributions

Our research results have three contributions in theory: First, we focus on the hybrid mode, consider the business model decision-making problem, and give the specific path of retail enterprise business model decision making. Hagiu [12] compared the profit differences between traditional retailers and commission-earning platforms, and focused on the impact of the scale economy of product distribution or maintenance on the market performance of platform retailers. Luo and Fu (2014) [13] focused on different charging strategies in merchant and platform modes. Compared with previous studies, we put forward three major factors—product unit price, unit distribution cost, and competitive conflict—which have an important impact on the business model decision-making of retail enterprises.

Second, most studies on the hybrid mode focus on the trading platform, the channel conflict between third-party sellers, or emphasize the interest damage caused by the platform selling its products on the market [2,46,50]. Our research specifies the impact of competitive conflicts on the profits of enterprises operating in hybrid mode, expanding the relevant research on the hybrid mode. As far as we know, only Anderson and Bedre-Defolie [1] are concerned with pattern decisions for hybrid platforms. They proved the influence of hybrid platform product advantages and product quality on model selection. Zhou et al. [51] studied the sales model path of the platform supply chain system, and believe that the platform commission and consumers' channel preference affect the model decision making. The business model decision-making of retail enterprises not only faces the influence of unit distribution cost and unit retail price, but also faces the impact of competitive conflict between self-operated sellers and third-party sellers. Our research not only focuses on the decision-making paths of the three modes, but also makes clear the impact of competition conflicts on the total profits.

Third, our research also pay attention to the two major businesses of operating enterprises, and expands the scope of research on two-sided market network externalities. Our results show that when the competition between the third-party sellers and the operating enterprises is not fierce, the two businesses show a synergy effect. Based on running two-sided markets, hybrid platforms provide richer, higher-quality complementary goods, and expand the diversity of commodities. When the competition becomes fierce, the synergy effect is less than the anti-competitive effect, and the two sellers competing for consumers cause serious price competition through the magnifying effect of cross-network externalities, reducing the market size and the profits of the platform.

2. Model Settings and Equilibrium Analysis

The operating enterprise that adopts the merchant mode is called operating enterprise R (Retail), the operating enterprise that adopts the platform mode is called operating enterprise T (Two-sided), and the operating enterprise that adopts the hybrid platform mode is called operating enterprise H (Hybrid).

In the merchant mode, the operating enterprise R buys the product from the supplier (S) at the wholesale price w_R, and then sells the product to the consumer (B) at the market unit retail price p. At this time, the operating enterprise R incurs a unit product distribution cost c, as shown in Figure 2.

In the platform mode, the operating enterprise T does not directly participate in the transactions, but is responsible for connecting and matching consumers (B) and the supplier (S) (which we call third-party sellers in this situation), and for brokering transactions between the two sides. The operating enterprise T charges the retail product supply enterprise the merchandise transaction commission ratio t_S in proportion to the unit retail price p, as shown in Figure 2. Our definition of transaction commission is based on the work of Rochet and Tirole [16]. They give the net utility of users joining the platform $U^i = \left(b^i - a^i\right)N^j + B^i - A^i$, where b^i is the unit benefit from using the platform, a^i represents the charges for users on the i side, B^i is the membership fee income, and A^i is

the registration fee. Based on the above principles, we focus on the transaction commission ratio t_S; that is to say, $pt_S = a^S$.

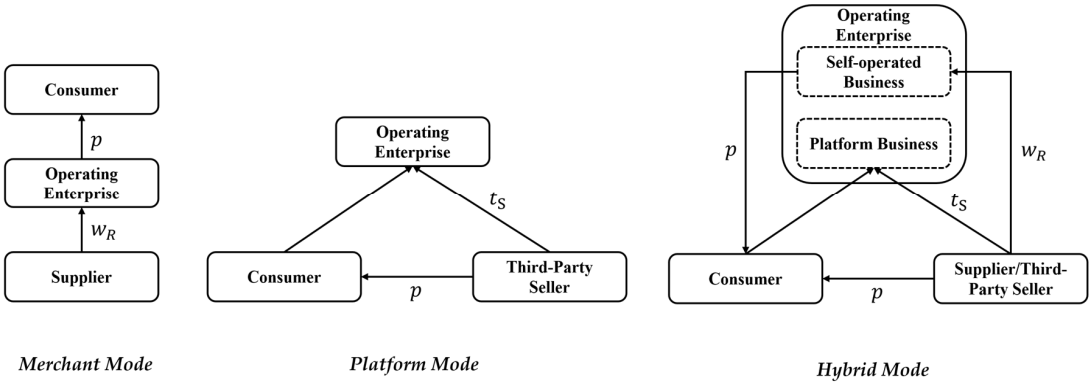

Figure 2. The capital flow of the merchant mode, platform mode, and hybrid mode.

In the hybrid platform mode, the operating enterprise H develops two parts of the business: First, in the platform business, operating enterprise H will not directly participate in the transaction, but will be responsible for connecting and matching consumers and suppliers (third-party sellers) who are willing to join the platform, and for brokering transactions between both parties, as shown in Figure 2. Similar to the pure platform mode, operating enterprise H will charge a commission t_S from third-party sellers who join the two-sided market in proportion to the market price p. Second, self-operated businesses will sell products directly to consumers at the price p. The operating enterprise H will purchase the product at the wholesale price w_R, bear the unit product distribution cost c, and sell it at the unit retail price p.

Considering the relationship between self-operated businesses and third-party sellers (collectively referred to as suppliers in the platform market), we called complementary case when self-operated sellers and third-party sellers sell different types of products. Also, we called competition case when self-operated sellers sell the same kinds of products as third-party sellers do.

2.1. Model Settings

2.1.1. Consumer

Suppose that consumers are evenly distributed on the line segment of $[0, 1]$ according to the order of reserved utility v. It is assumed that consumers have a unit demand for each variety of products. According to the hypothesis of the consumer distribution function [13,15,57], the number of consumers who choose to buy a product depends on the distribution function $F(\cdot)$, in which the product price p is not higher than the consumer reserve price v. The utility of consumer depends on the product pricing p. Therefore, consumers will choose to buy a certain product if and only $v \geq p$ under three modes.

If a consumer purchases a product from operators R. If and only if $v \geq p$, the consumer will choose to buy the product form the operator R. The consumer demand is N_B^R.

If a consumer purchases a product in operators T's market at the price p. If and only if $v \geq p$, the consumer will choose to join the market and buy the product. The consumer demand is N_B^T.

If consumer purchases product from operator H in complementary case. When the self-operated business sells products to the consumer, the utility gained by the unit consumer is $U_B^{H1} = (v - p)N_S^{H1}$. At the same time, when the platform business of the operator H connects the supplier and the consumer to trade, the utility obtained by the unit consumer and the third-party seller is $U_B^{H2} = (v - p)N_S^{H2}$. As a result, we get the number of consumers who choose to buy a certain product from the self-operated business of the operating enterprise H: $N_B^{H1} = Prob\{v \geq p\} = 1 - F(p) = 1 - p$. Similarly, the number of platform services that consumers join is $N_B^{H2} = Prob\{v \geq p\} = 1 - p$.

If a consumer purchase product from operator H in the competition case. As consumer only cares about the price of unit products, the suppliers and self-operated businesses will face Bertrand competition in some kinds of the product market, and the two sides will share the market equally at the same price. Same as complementary case, consumer demand in self-operated businesses is $N_B^{H1} = Prob\{v \geq p\} = 1 - p$. Similarly, consumer demand for platform services is $N_B^{H2} = Prob\{v \geq p\} = 1 - p$.

2.1.2. Supplier

The supplier S is evenly distributed on the line segment of $[0,\ 1]$ according to the order of unit production cost C_S. Assuming that the supplier provides independent products to the operating enterprise, the choice of selling goods to the operating enterprise or joining the platform market depends on the distribution function $\psi(\cdot)$, where the profit is greater than the unit production cost.

If suppliers S provide goods to operators R at the price w_R. If and only if $C_S \leq w_R$, the supplier will supply the product to the operator R and the number of suppliers is N_S^R.

If suppliers S choose to join the operator T, and each supplier bears the unit distribution cost of c. If and only if $C_S \leq \pi_S$, the supplier chooses to join the platform market and trade, providing the number of suppliers N_S^T.

In the complementary case of hybrid mode. At this time, to avoid direct competition with the self-operated business, the supplier prefers to join the platform business and become a third-party seller. The rest of the suppliers who do not join the platform supply the product to self-operated businesses at the price of w_R. The supplier who is willing to supply goods to the self-operated business is the suppliers who are willing to supply minus the quantity to join the platform market, which is given by Equation (1):

$$N_S^{H1} = Prob\{C_S \leq w_R\} - Prob\{C_S \leq \pi_S\} = \psi(w_R) - \psi(\pi_S) \tag{1}$$

The unit product income of each supplier is the purchase price w_R, and the profit function of each supplier who chooses to join operator H's platform business is $\pi_S = [(1 - t_S)p - c]N_B - C_s$. Suppliers will choose to join the platform market if and only if $C_S \leq \pi_S$. Equation (2) gives the number of suppliers who join the platform market:

$$N_S^{H2} = Prob\{C_S \leq \pi_S\} = \psi(\pi_S) = [(1 - t_S)p - c]N_B^{H2} \tag{2}$$

In the competition case of hybrid mode. Suppliers can choose to join the platform business. At the same time, they sell products to the self-operated business. In other words, supplier S treats downstream customers indiscriminately, and allows downstream enterprises to maintain competitive relations with themselves. The unit product income is the purchase price w_R, and the profit function of each supplier who chooses to join the platform business is π_S. If and only if $C_S \leq w_R$, the supplier is willing to supply goods to the self-operated business, so the actual willingness to supply the self-operated business is equal to the number of suppliers who supply the self-operated business minus the number of suppliers joining the platform market:

$$N_S^{H1} = Prob\{C_S \leq w_R\} - Prob\{C_S \leq \pi_S\} = \psi(w_R) - \psi(\pi_S) \tag{3}$$

The supplier will choose to join the platform market if and only if $C_S \leq \pi_S$. Equation (4) gives the number of suppliers who choose to join the platform:

$$N_S^{H2} = Prob\{C_S \leq \pi_S\} = \psi(\pi_S) = \frac{1}{2}[(1 - t_S)p - c]N_B^{H2} \tag{4}$$

2.1.3. Operating Enterprise

The merchant mode is consistent with the setting and symbol of Luo and Fu (2014) [13]. We take merchant mode as a comparison baseline. Previous studies [12] explored the two polar strategies for market intermediaries, and the conditions that affect the business model

selection. [13] focused on the different charging strategies of merchant and platform modes for the retail enterprise. Our research focuses on the advantages and disadvantages of the hybrid mode compared with the pure merchant mode and the pure platform mode, along with the influence of the competitive environment on hybrid mode decision making of retail enterprises. Under the merchant mode, the operating enterprise R bears the unit distribution cost c. Operators gain profits from the wholesale and retail price difference, the profit is $\pi^R = (p - c - w_R)N_B^R N_S^R$.

The platform mode is consistent with the setting and symbol of Luo and Fu (2014) [13]. We take platform mode as a comparison baseline. The utility of consumers joining the platform depends on the product pricing p. In the platform mode, the profit of the operator T comes from the transaction commission fee, and the profit of the operator T is $\pi^T = t_S p N_B^T N_S^T$.

In the hybrid mode, on the one hand, operator H acts as a dealer, directly facing consumers and selling goods. On the other hand, operator H acts as a platform business, connecting, matching, and making deals.

In the complementary case of hybrid mode. The profit consists of two parts: the first part comes from the profit of the self-operated business, and the second part comes from the connection and matching of the platform business. The profit function π^{HN} is expressed by Equation (5):

$$\pi^{HN} = (p - c - w_R)N_B^{H1} N_S^{H1} + t_S p N_B^{H2} N_S^{H2} \tag{5}$$

where N_B^{H1} represents the number of consumers attracted by the self-operated business in the hybrid platform mode, and N_S^{H1} represents the number of suppliers attracted by the wholesale products at w_R; N_B^{H2} represents the number of consumers who choose to join the platform in the hybrid platform mode, and N_S^{H2} represents the number of suppliers who choose to join the platform in the hybrid platform mode.

In the competition case, the profit function π^{HC} of the operating enterprise is:

$$\pi^{HC} = (p - c - w_R)N_B^{H1} N_S^{H1} + \frac{1}{2}(p - c - w_R)N_B^{H2} N_S^{H1} + t_S p N_B^{H2} N_S^{H2} \tag{6}$$

The first term on the right-hand side of Equation (6) is the profit of the self-operated business selling exclusive types of products, and the second term is the profit of the self-operated business selling competitive products. The third term is the trading commission income from the platform business.

2.2. Equilibrium Analysis

2.2.1. Merchant and Platform Mode

In the merchant mode, the equilibrium solution refers to the equilibrium results of Luo and Fu (2014) [13]; that is, when the operating enterprise maximizes profits, it needs to meet the first-order condition $\begin{cases} \frac{\partial \pi^R}{\partial p} = 0 \\ \frac{\partial \pi^R}{\partial w_R} = 0 \end{cases}$, and define the product pricing and wholesale pricing $\begin{cases} w_R^* \\ p_R^* \end{cases}$ of the operator R's profit maximization, as well as the extreme profit value π^{R*} of the operator R.

In the platform mode, the equilibrium solution also refers to the equilibrium results of Luo and Fu (2014) [13]; that is, when the operating enterprise maximizes profits, it needs to satisfy $\frac{\partial \pi^T}{\partial t_S} = 0$, and to define the optimal commission ratio t_S^* and the extreme profit value π^{T*}.

2.2.2. Complementary Case of Hybrid Mode

In the hybrid mode of the complementary case, assuming the selling price of the product of the operating enterprise H in the self-operated business market always satisfies the profit maximization pricing $\begin{cases} w_R^* = \frac{1-c}{3} \\ p_R^* = \frac{2+c}{3} \end{cases}$. Therefore, to maximize the profits of the

operating enterprise H, it is necessary to meet the first-order condition $\frac{\partial \pi^{HN}}{\partial t_S} = 0$, and to define the commission fee ratio:

$$t_S^* = \frac{1}{2} + \frac{(1-c)^2}{18(1-p)} - \frac{c}{1-p} \tag{7}$$

Substituting Equation (7) into Equation (3), we can obtain the local maximum profit:

$$\begin{aligned} \pi^{HN*} = \frac{1}{324}\big[13 + c^4 + c^3(2-18p) - 18p + 99p^2 - 162p^3 + 81p^4 + \\ 3c^2\big(29 - 48p + 33p^2\big) - 2c\big(11 + 72p - 144p^2 + 81p^3\big)\big] \end{aligned} \tag{8}$$

The second derivative $\frac{\partial^2 \pi^{HN}}{\partial t_S^2} = -2(-1+p)^2 p^2 < 0$ holds to ensure the global maximum profits of the operating enterprise H.

2.2.3. Competition Case of Hybrid Mode

In the hybrid mode of the competition case, suppose that the selling price always satisfies the profit maximization pricing $\begin{cases} w_R^* = \frac{1-c}{3} \\ p_R^* = \frac{2+c}{3} \end{cases}$ by enterprise H. When the operating enterprise maximizes its profit, it needs to meet the first-order condition $\frac{\partial \pi^{HC}}{\partial t^S} = 0$, and the profit maximization commission fee ratio is as follows:

$$t_S^* = \frac{1 - 2c + p}{4p} \tag{9}$$

In the conventional sense, the commission rate range is $0 \le t_S^* \le 1$. As a result, the product price range for a given distribution cost c is as follows: $0 \le p \le \frac{1}{6}\left(3 - \sqrt{5}\right)$ and $\frac{1}{6}\left(3 + \sqrt{5}\right) \le p \le 1$. This paper assumes that t_S^* can be changed arbitrarily; that is, the platform has transaction-based subsidy behavior or high platform tax behavior to balance its comprehensive profits, which will lead to positive or negative profits for each part of the business. This assumption is reasonable in reality, and there is a mutual subsidy between the business profits of all kinds of e-commerce platforms in reality. Substituting Equation (9) into Equation (6), the local maximum profit is given by Equation (10):

$$\pi^{HC*} = \frac{1}{288}(-1+p)\left(-41 + 28c - 68c^2 + 63p + 144cp + 36c^2 p - 135p^2 - 108cp^2 + 81p^3\right) \tag{10}$$

The second derivative $\frac{\partial^2 \pi^{HC}}{\partial t_S^2} = -(-1+p)^2 p^2 < 0$ holds to ensure the global maximum profits of the operating enterprise H.

Table 1 collates the definitions and descriptions of symbols used in this article.

Table 1. Definitions and descriptions of symbols.

Category	Symbol	Symbol Description
Utility/profit variable	U_B^R	The utility of consumers buying all products in the merchant mode.
	U_B^T	The utility of consumers trading products in the platform mode.
	U_B^{H1}	The utility of consumers buying self-operated products in the hybrid platform mode.
	U_B^{H2}	The utility of consumers trading products in the hybrid platform mode.
	π_S	The profit of the supplier under the corresponding mode.
	π^R	The profit of the operating enterprise under the merchant mode.
	π^T	The profit of the operating enterprise under the platform mode.
	π^{HN}	In the complementary case, the operating enterprise's profits.
	π^{HC}	In the competition case, the operating enterprise's profits.

Table 1. *Cont.*

Category	Symbol	Symbol Description
Price variable	v	Consumer reservation price—the total is 1, and evenly distributed online [0, 1].
	C_s	Supplier unit production cost—the total is 1, and evenly distributed online [0, 1].
	p	Unit retail price of a product sold to consumers, in the range of [0, 1]
	c	Unit distribution cost of each product, in the range of [0, 1]
	w_R	The wholesale price of the product, in the range of [0, 1]
	t_S	Transaction commission proportion from the supplier.
Quantity variable	N_B^R	Consumer demand for a single variety of products in the merchant mode.
	N_B^T	Consumer demand for choosing to join the platform.
	N_B^{H1}	Consumer demand for a single variety of products for self-operated businesses in the hybrid platform mode.
	N_B^{H2}	Consumer demand for a single variety of products for platform businesses in the hybrid platform mode.
	N_S^R	Supplier numbers for a single variety of products in the merchant mode.
	N_S^T	Supplier numbers for choosing to join the platform.
	N_S^{H1}	Supplier numbers for a single variety of products for self-operated businesses in the hybrid platform mode.
	N_S^{H2}	Supplier numbers for a single variety of products for platform businesses in the hybrid platform mode.

The time sequence of the game is as follows: (1) in the first stage, the operating enterprise chooses the operation mode—that is, one of the merchant mode, platform mode, or hybrid platform mode; (2) in the second stage, the operating enterprise chooses the operation mode according to the operation mode selected in the previous stage, making key price parameter decisions. If the operating enterprise chooses the merchant mode, it needs to decide w_R and p; if the operating enterprise chooses the platform mode, it needs to decide the transaction commission; if the operating enterprise chooses the hybrid platform mode, it needs to decide the transaction commission t_S; (3) in the third stage, consumers and suppliers decide the corresponding transaction behavior based on the decisions made by the operating enterprise, as shown in Figure 3.

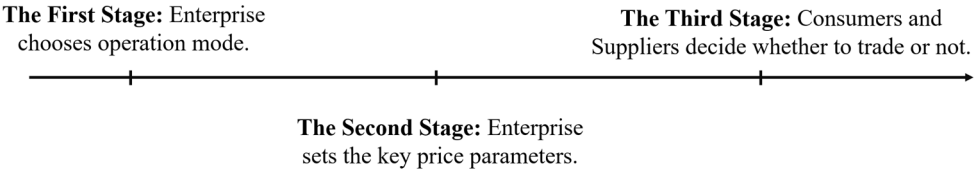

Figure 3. Game sequence diagram for the selection of operating enterprise mode.

3. Operation Decisions of Retail Enterprises

3.1. Complementary Case

According to the method of reverse induction, we analyzed the decision-making of consumers and suppliers in the third stage and the profit difference provided by optimal pricing in the second stage, and compared the profits of the retail, platform, and hybrid platform modes in the first stage. First of all, we compared the profits of the hybrid platform mode and the merchant mode, obtaining Lemma 1.

Lemma 1. *In the complementary case, based on the comparison of profits, the monopoly operation enterprise's choice is as follows: for any unit retail price* $p \in [0, 1]$ *and product distribution cost*

$c \in [0, 1]$, the monopoly operation enterprise should choose the hybrid platform mode over the merchant mode.

Proof. See Appendix A. □

Lemma 1 shows that when there is no competition between the hybrid platform and third-party sellers, the profit of the hybrid platform mode is always greater than that of the merchant mode. This is because operating enterprises adopt a hybrid mode, which has more platform modes than the merchant mode, and charging commission income according to transaction prices will expand the source of income for operating enterprises. This conclusion is consistent with [4], who found that the occupation of hybrid platforms leads to lower commission and lower equilibrium price, and attracts more consumers to participate. We explain that the strong complementary relationship between the two businesses of the hybrid-mode operation enterprises making profits from the two aspects produces greater profit than in merchant mode.

Figure 4 shows the numerical simulation results of the relationship between the profit difference between the hybrid platform mode and the merchant mode due to the product price p raise and when $c = 0.1$.

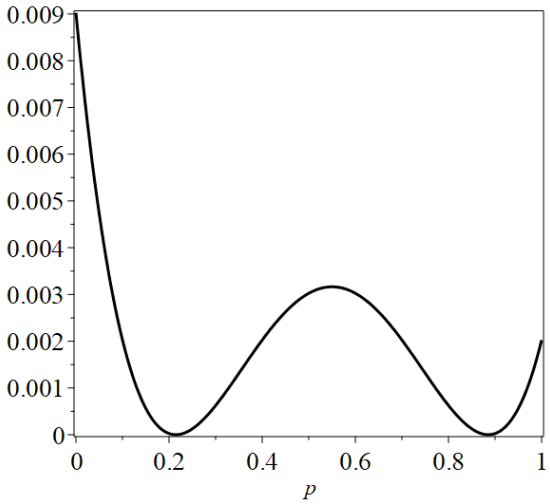

Figure 4. Numerical simulation of profit difference between the hybrid platform mode and merchant mode.

Next, comparing the profits of the hybrid mode and the platform mode, we can get Lemma 2.

Lemma 2. *In the complementary case, based on the comparison of profits, the monopoly operation enterprise's choice is as follows: for any unit retail price $p \in [0, 1]$ and product distribution cost $c \in [0, 1]$, the monopoly operating enterprise should choose the hybrid platform mode rather than the platform mode.*

Proof. See Appendix A. □

In complementary case, compared with the pure platform mode, the hybrid platform mode can expand the source of profit and earn the wholesale price difference. On the one hand, the hybrid platform mode charges transaction commission; on the other hand, the hybrid platform mode operates its own business, and the decline in the number of consumers caused by rising prices is relatively slow. Taken together, the hybrid mode generates more profits than the pure platform mode.

Figure 5 shows the numerical simulation results of the profit difference between the hybrid platform mode and the platform mode when $c = 0.5$. When the product price is in a low range, with the increase in the product price, the profit margin gradually narrows; when the product price is in a higher range, with the increase in the product price, the profit

margin gradually widens. This is because, on the one hand, when the product price is in a low range, the platform business of enterprises operating in the hybrid platform mode decreases rapidly with the increase in unit retail prices. The number of consumers shows a faster rate of decline (the number of consumers $(1-p)^2$); conversely, the self-operated business is relatively stable.

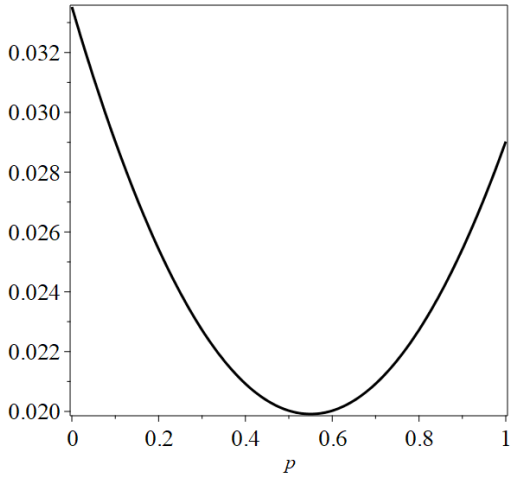

Figure 5. Numerical simulation of the profit difference between the hybrid platform mode and the platform mode.

Finally, according to Proposition 1 of the existing research [13], we give the relative profit range between the merchant mode and the platform mode. In the complementary case, based on the comparison of profits, the monopoly operation enterprise's choice is as follows: When given $c \in \left[0, \frac{1}{4}\right)$, for any $p \in [0, 1]$, the monopoly operation enterprise should choose merchant mode rather than platform mode. When given $c \in \left[\frac{1}{4}, 1\right]$, if there exists $\overline{P}_1 \in [0, 1]$, the monopoly operation enterprise should choose platform mode if and only if $p \in [0, \overline{P}_1)$, while the monopoly operation enterprise should choose merchant mode if and only if $[\overline{P}_1, 1]$ (see proof in Luo and Fu (2014) [13]).

First, when the product distribution cost c is low, the operating enterprise will give priority to the merchant mode, because when the product distribution cost is low, the profit space of the operating enterprise will not be squeezed by the distribution cost, so the profit of choosing the merchant mode will naturally be greater than that of the platform mode. Second, when the product distribution cost is in a high range, the unit retail price of the product determines the profit of the operating enterprise mode. First, when the unit retail price is low, the operating enterprise should give priority to the platform mode, because the product distribution cost is in the higher range, and the product price is in the lower range, so the operating enterprise is squeezed by the double profit of cost and price. At this time, the choice of platform mode to collect commission is a better choice. Second, when the unit retail price is high, operating enterprises make up for the problem of cost squeeze by raising prices, and giving priority to the merchant mode is a better choice.

Considering the conclusions of Lemma 1, Lemma 2, and the conclusion of profit comparison in Luo and Fu (2014) [13], Proposition 1 can be obtained.

Proposition 1. *In the complementary case, based on the comparison of profits, the monopoly operation enterprise's choice is as follows:*

(1) For any unit retail price $p \in [0, 1]$ and product distribution cost $c \in [0, 1]$, the hybrid platform mode is strictly better than platform mode or merchant mode;

(2) Among the suboptimal choices: Given $c \in \left[0, \frac{1}{4}\right)$ for any $p \in [0, 1]$, the monopoly operation enterprise should choose merchant mode rather than platform mode. Given $c \in \left[\frac{1}{4}, 1\right]$, if there exists $\overline{P}_1 \in [0, 1]$, the monopoly operation enterprise should choose platform mode if and only

if $p \in [0, \overline{P}_1)$, *and the monopoly operation enterprise should choose merchant mode if and only if* $[\overline{P}_1, 1]$.

The conclusion of Proposition 1 is briefly expressed in Figure 6: first, the profit of the operating enterprise choosing the hybrid platform mode is always optimal in the range of product distribution cost and product price; secondly, in the suboptimal choice, when the distribution cost is given in a lower range, the operating enterprise chooses the merchant mode as the suboptimal choice. Given that the product distribution cost is in a high range, the operating enterprise's choice of merchant mode or platform mode depends on the price of the product. When the operating enterprise can make up for the squeeze on the product distribution cost by raising the price, the operating enterprise should take the merchant mode as the suboptimal choice; when the operating enterprise is unable to raise the price—in other words, when the operating enterprise is faced with the squeeze on the product distribution cost—choosing the platform mode is the better suboptimal choice.

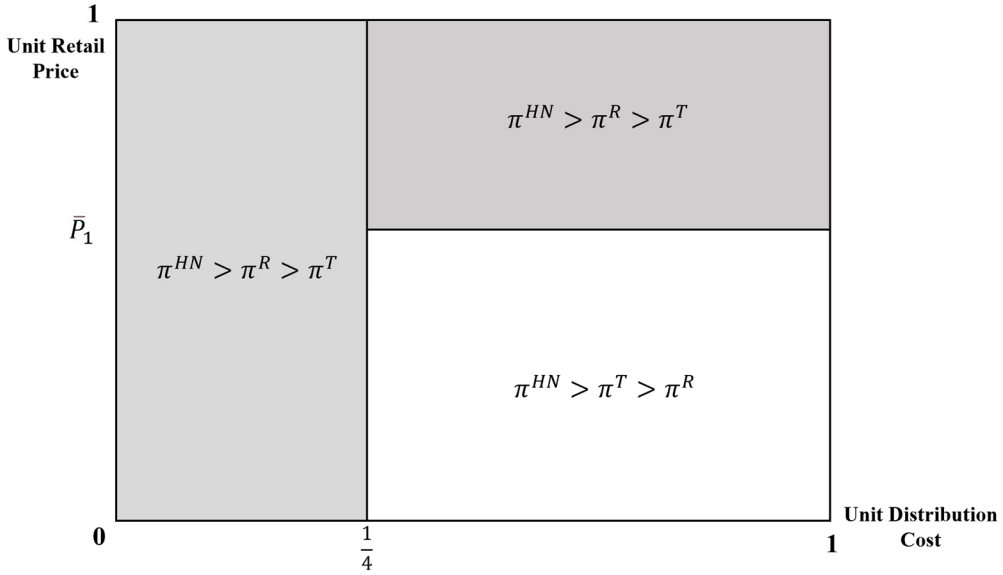

Figure 6. Operating enterprise business model selection path diagram in the complementary case.

Proposition 1 reveals the conditions and paths for the operating enterprise to choose the three modes. Fundamentally, the condition for the operating enterprise to choose the hybrid platform mode is that there is no competition between the hybrid platform mode and the supplier—that is, the products replace one another or are independent.

Analyzing the complementary case, we can get the synergy effects as Figure 7 shows.

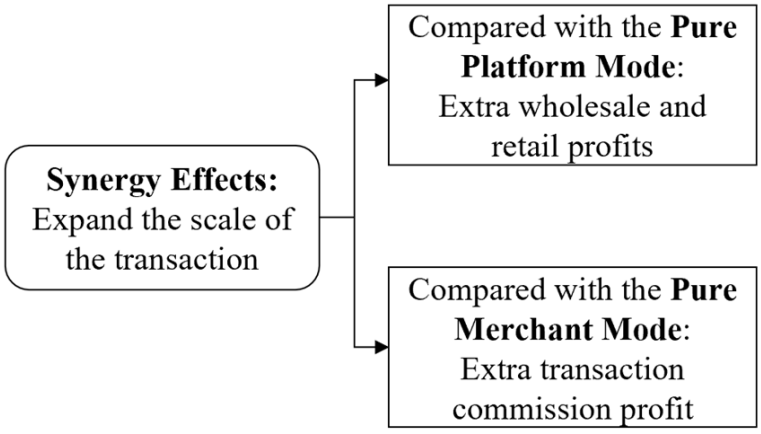

Figure 7. The synergy effects of hybrid mode in the complementary case.

In the complementary case, the advantages of the hybrid mode over the single mode come from two aspects: on the one hand, compared with the pure platform mode, the hybrid mode can supply goods to consumers in a flexible way and expand the types of goods that consumers can choose. By expanding the scale of consumer transactions, the operation enterprise earns additional wholesale and retail profits. On the other hand, compared with the merchant mode, the hybrid mode obtains a relatively stable transaction commission by increasing the platform business. It expands the types of goods that consumers can choose from and earns platform trading commissions by expanding the scale of consumer transactions. In sum, the hybrid mode generates more profits than the pure platform mode and the pure merchant mode.

3.2. Competition Case

In the previous discussion, we analyzed the profits of the operating enterprise H when the self-operated business mode did not compete directly with the suppliers who joined the platform business. In this section, we analyzed the mode selection of operating enterprises under competition cases.

Secondly, comparing the profits of the hybrid platform mode and the merchant mode, we get Lemma 3.

Lemma 3. *In the competition case, for any* $c \in [0,\ 1]$, *there exists* $\overline{P}_2$, *such that:*

(1) When $0 \leq p \leq \overline{P}_2$, *the operating enterprise should choose the hybrid platform mode rather than the merchant mode.*

(2) When $\overline{P}_2 \leq p \leq 1$, *the operating enterprise should choose the merchant mode rather than the hybrid platform mode.*

Proof. See Appendix A. □

Lemma 3 studies the trade-off between hybrid platform mode and merchant mode under the condition of competition. First, if and only if the price of the product is in the lower range, the operating enterprise should choose the hybrid platform mode. This is because operating enterprises need to face the trade-off between the commission and wholesale profit in competition cases. When the price of the product is in the lower range, the commission income of the operating enterprise is higher, so choosing to compete with suppliers and seize the market will inevitably lead to a decrease in the number of suppliers joining the platform business due to the decline in the number of consumers, generating less commission income. However, when the price is low, consumer demand is strong, and the profits brought by the market share can fully make up for the loss caused by the decline in commission fees. Based on this, the operating enterprise should choose the hybrid platform mode in the lower price range of the product. Second, if and only if the product price is in the higher range, the operating enterprise should choose the merchant mode. When the product price is higher, the consumer basis is less, and the competition between the operating enterprise and the supplier for the market causes the supplier to withdraw from the market, and the anti-competitive effect of vertical integration appears. By contrast, the profit of the merchant mode is stable. Based on this, the operating enterprise should choose the merchant mode in the range of high product prices.

We use Figure 8 to show the numerical simulation results of the relationship between the profit difference between the hybrid platform mode and the merchant mode, and the product price p when $c = 0.5$.

Next, we compare the profits of the hybrid mode and the platform mode, and we can get Lemma 4.

Lemma 4. *In the competition case, for any unit retail price* $p \in [0, 1]$ *and product distribution cost* $c \in [0,\ 1]$, *the monopoly operating enterprise should choose the hybrid platform mode rather than the platform mode.*

Lemma 4 reveals the conditions for operating enterprises to choose hybrid platform mode and platform mode under the condition of competition. Corresponding to Lemma 2, in competition cases, compared with the platform mode, even if there is a certain degree of competition, the profit of the hybrid mode is still less than that of the platform mode. This is because there are two parts of the business in the hybrid mode, charging transaction commissions on the one hand, and operating enterprises on the other. Thus, the hybrid mode has more sources of income than a single mode.

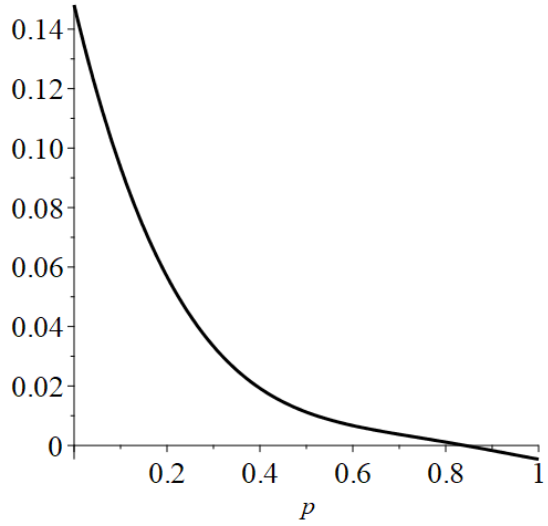

Figure 8. Simulation of the profit difference between the hybrid platform mode and the merchant mode.

Considering the conclusions of Lemmas 3 and 4, we get Proposition 2.

Proposition 2. *In the competition case, the choice of the operating enterprise is as follows:*

(1) Given $c \in \left[0, \frac{1}{4}\right)$, *there exist* $\overline{P}_1$ *and* $\overline{P}_2 \in [0,\ 1]$, *such that when* $p \in \left[max\left\{\overline{P}_1, \overline{P}_2\right\}, 1\right]$, *the profits of the merchant mode are always larger than those of the hybrid platform mode and the platform mode, in that order; when* $p \in \left[min\left\{\overline{P}_1, \overline{P}_2\right\}, max\left\{\overline{P}_1, \overline{P}_2\right\}\right]$, *the profit of the hybrid platform mode is always greater than that of the platform mode, and the profit of the merchant mode depends on the relative size of* $\overline{P}_1$ *and* $\overline{P}_2$*; when* $p \in \left[0, \min\left\{\overline{P}_1, \overline{P}_2\right\}\right]$, *the profit of the hybrid platform mode is greater than that of the merchant mode and the platform mode, in that order.*

(2) Given $c \in \left[\frac{1}{4}, 1\right]$, *there exist* $\overline{P}_1$ *and* $\overline{P}_2 \in [0,\ 1]$, *such that when* $p \in \left[max\left\{\overline{P}_1, \overline{P}_2\right\}, 1\right]$, *the profit of the merchant mode is always greater than that of the hybrid platform mode and the platform mode, in that order; when* $p \in \left[min\left\{\overline{P}_1, \overline{P}_2\right\}, max\left\{\overline{P}_1, \overline{P}_2\right\}\right]$, *the profit of the hybrid platform mode is always greater than that of the platform mode, and the profit of the merchant mode depends on the relative size of* $\overline{P}_1$ *and* $\overline{P}_2$*; when* $p \in \left[0, min\left\{\overline{P}_1, \overline{P}_2\right\}\right]$, *the profit of the hybrid platform mode is greater than that of the platform mode and the merchant mode, in that order.*

The conclusion of Proposition 2 is briefly expressed in Figure 9. Firstly, when $p \in \left[\max\left\{\overline{P}_1, \overline{P}_2\right\}, 1\right]$, the profit of the operating enterprise choosing the merchant mode is the greatest, and then when $p \in \left[\min\left\{\overline{P}_1, \overline{P}_2\right\}, \max\left\{\overline{P}_1, \overline{P}_2\right\}\right]$, the profit of the operating enterprise choosing the merchant mode and the hybrid platform mode is uncertain, but that of the hybrid platform mode is greater than that of the platform mode. Finally, when $p \in \left[0, \min\left\{\overline{P}_1, \overline{P}_2\right\}\right]$, if the unit distribution cost is low, then the suboptimal choice of the operating enterprise is the merchant mode rather than the platform mode, and if the unit distribution cost is higher, then the suboptimal choice of the operating enterprise is the platform mode rather than the merchant mode.

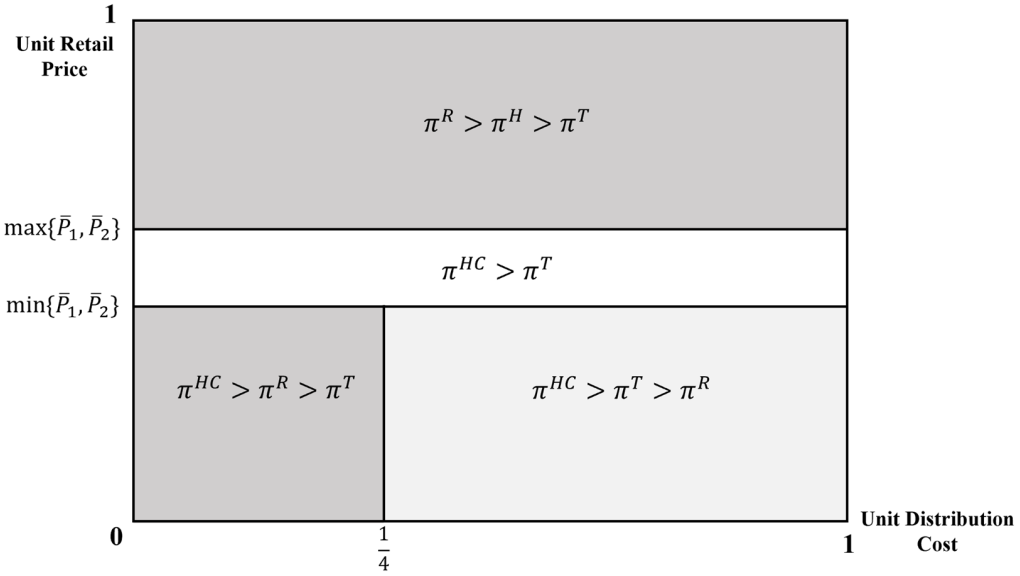

Figure 9. Operating enterprise business model selection path diagram in competition cases.

Proposition 2 reveals the path of business model choice under competition cases. First, if and only if the price of the product is in a higher range (that is, the price of the product exceeds the critical value $\max\{\overline{P}_1, \overline{P}_2\}$), the operating enterprise adopts the merchant mode as the best choice, and the suboptimal choice is the hybrid platform mode. This is because when the unit retail price of the product is high, the consumer basis is small—whether it is the hybrid platform mode or the pure platform, the commission income is at a low level—and because of the anti-competitive effect, enterprise H faces the dual problems of platform business and self-operated business. In this case, the operating enterprise should choose the merchant mode first. Second, when the price is in the lower range (that is, the price of the product is lower than the critical value $\min\{\overline{P}_1, \overline{P}_2\}$), the operating enterprise should first choose the hybrid platform mode, and the suboptimal choice depends on the product distribution cost. When the product distribution cost is low, the profit of the merchant mode is higher than that of the platform mode, and the merchant mode is the suboptimal choice; when the product distribution cost is high, the operating enterprise faces the pressure of distribution cost when choosing the merchant mode, and the product price is limited to below the critical value, which makes it unprofitable for the operating enterprise to choose the merchant mode, and the suboptimal choice is the platform mode. Finally, when the product price is in the middle range, the operating enterprise should first adopt the hybrid platform mode, while the comparison between the merchant mode and the hybrid platform mode is relatively complex.

Analyzing the competition case, we can get the conflict effects as Figure 10 shows.

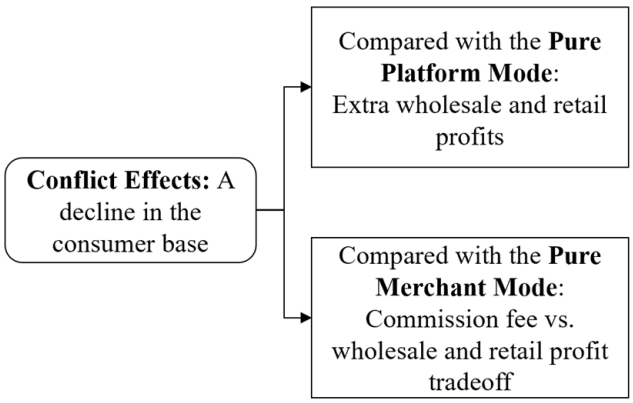

Figure 10. The conflict effects of hybrid mode in the competition case.

In the competition case, the hybrid mode's advantages are affected by the competition effects: on the one hand, compared with the pure platform mode, the hybrid mode can expand the types of goods, and raise its profits higher than the pure platform mode by setting the optimal transaction commission fee. On the other hand, the profit of hybrid mode and pure merchant mode depends on the trade-off between transaction commission and wholesale profits. If the market share competition profits can fully make up for the loss in commission fees, then the profit of the hybrid mode will be higher than that of the pure merchant mode, on the contrary, the profit of the hybrid mode will be lower than that of the pure merchant mode. Generally speaking, the competition effect does not affect the choice between the hybrid mode and the pure platform mode, but affects the mode choice between the hybrid mode and the pure merchant mode.

3.3. Difference between Complementary and Competition Case

We further analyze the profit difference of the hybrid platform mode by comparing the competition case and the complementary case. First of all, in the competition case, the profit comparison is given by Lemma 5.

Lemma 5. *Comparing the competition case with the complementary case, given the distribution cost c, there exists* $\overline{P}_3$:

(1) When $0 \leq p \leq \overline{P}_3$, *the competition increases the profit of the operating enterprise H.*

(2) When $\overline{P}_3 \leq p \leq 1$, *the competition reduces the profit of the operating enterprise H.*

Proof. See Appendix A. □

Lemma 5 highlights that competition conditions make operating enterprises' profits change compared with complementary ones. First, when the price of the product is in a low range, the competition cases increase the profit of the operating enterprise. This is because, when the product price is in a low range, there are large numbers of consumers in the platform business, whether buying products from self-operated businesses or third-party sellers, so that even if the operating enterprises compete directly with suppliers—reducing the number of suppliers and, thus, reducing the commission business income—there are still considerable numbers of consumers who can buy from the self-operated business. This part of the profit even exceeds the commission business income. Based on this, the competition conditions increase the profits of the operating enterprises. Second, when the product prices are in a high range, the competition cases reduce the profits of the operating enterprises. This is because, when the product price is in a high range, the platform business income declines faster due to the decline in the number of consumers, and the self-operated business faces lower consumer demand. This part of the profit cannot make up for the loss caused by the decline in commission income. In other words, the platform business income is more sensitive to the marginal change in the number of consumers in the higher price range, and the growth rate of self-operated business income is linear with the price. Based on this, the competition cases reduce the profits of the operating enterprises.

Synthesizing Lemma 5 and Proposition 1 and Proposition 2, the conclusion in Figure 11 is obtained by comparing important intervals. First, when the unit retail price is lower than the key value $\min\{\overline{P}_1, \overline{P}_2, \overline{P}_3\}$, the profit of the hybrid mode is higher than that of the other three modes in the competition environment. This is because the hybrid mode in the competition case (denoted by π^{HC}) squeezes the market share of third-party sellers, which increases the self-operated business profits and reduces the platform business profits. The overall profits increase. Second, when the unit retail price is higher than the key value $\max\{\overline{P}_1, \overline{P}_2, \overline{P}_3\}$, the profit of the hybrid mode in the complementary case (denoted by π^{HN}) is higher than that of the merchant mode, and the profit of the merchant mode is higher than that of the hybrid mode in the competition case. This is because when the unit retail price is higher, the consumer demand of the self-operated business is lower, even if the profit increase caused by squeezing the market share of third-party sellers is not enough to make up for the loss caused by the decline in commission in competition case.

At this time, operators should carefully consider the relationship with third-party sellers and avoid direct competitive conflicts with third-party sellers to maintain the stability of profits.

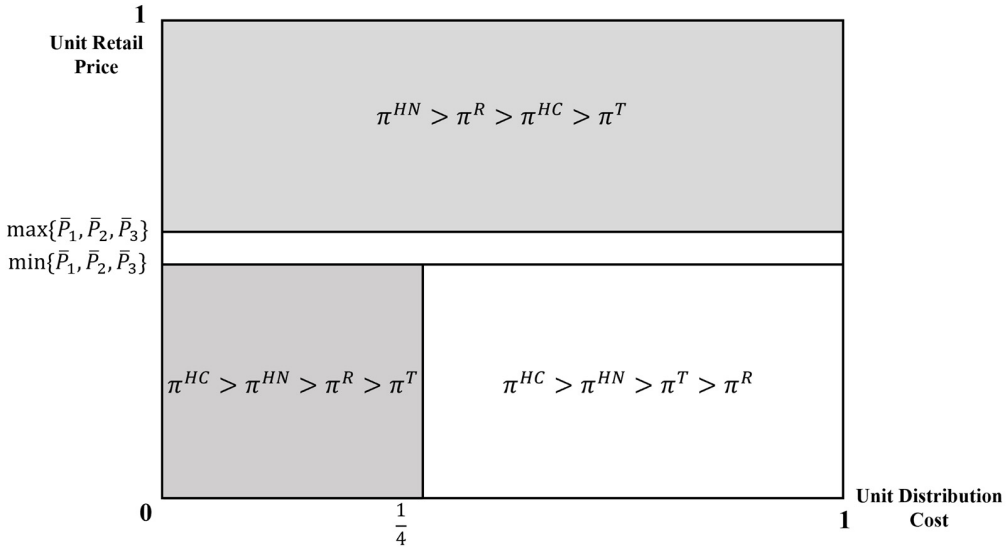

Figure 11. Overall business model selection in the complementary and competition case.

Compared with the previous literature, our conclusion has new expansions. First, compared with [12,13] which discussed the business model selection of retail enterprises, our study points out the emergence of the hybrid mode as a combination of merchant mode and platform mode; second, our study expands the comparative base [1]. The effects of complementary and the competition case on the profits of the hybrid mode should be carefully considered, and we give an operational decision-making path.

4. The Influence of Competition between Self-Operated and Third-Party Sellers

We further analyze the comparison of H profit sources of operating enterprises under the hybrid platform mode. In the complement case, we define π^{HN-R} as representing the self-operated business profit of operating enterprise H, and π^{HN-T} represents the platform business profit of operating enterprise H:

$$\begin{cases} \pi^{HN-R*} = \dfrac{1}{162}(-1+c)^2\left(7+c+c^2-9p-9cp+9p^2\right) \\ \pi^{HN-T*} = \dfrac{1}{324}[13+c^4+c^3(2-18p)-18p+99p^2 \\ -162p^3+81p^4+3c^2\left(29-48p+33p^2\right)-2c\left(11+72p-144p^2+81p^3\right)] \end{cases} \tag{11}$$

Define $\Delta = \pi^{HN-T} - \pi^{HN-R}$, which means that the platform business profit exceeds the profit of the self-operated business, yielding Proposition 3:

Proposition 3. *In the complementary case, there exists $\bar{c}_1 \in [0,\ 1]$, such that:*

(1) When $c \in [0, \bar{c}_1]$, for any $p \in [0,\ 1]$, the profit of platform businesses is less than that of self-operated businesses.

(2) When $c \in [\bar{c}_1, 1]$, there exists $\overline{P}_4 \in [0,\ 1]$, such that when $p \in \left[0, \overline{P}_4\right]$, the profit of platform businesses is greater than that of self-operated businesses, and when $p \in \left[\overline{P}_4, 1\right]$, the profit of platform businesses is less than that of self-operated businesses.

Proof. See Appendix A. □

Proposition 3 reveals the relationship between self-operated businesses and platform businesses in terms of the profits of operating enterprises in hybrid platform mode in the

complementary case. Overall, the relative profit depends on the unit distribution cost. First, when the unit distribution cost is low, the platform business profit is always less than the self-operated business profit. Consistent with the previous explanation, when the unit distribution cost is low, self-operated businesses are free to adjust the price, while the cost-end unit distribution cost is lower, and the profit level of self-operated businesses is higher. Second, when the unit distribution cost is higher, the unit retail price is in a lower range, and the profit of platform businesses is greater than that of self-operated businesses in a lower unit retail price range. This is because, when the unit retail price is low, there is a high level of consumer participation in the two businesses, and the profit margin of the self-operated businesses is relatively low due to the higher distribution cost. Third, when the unit distribution cost is higher and the unit retail price is in a higher range, the profit of self-operated businesses is greater than that of platform businesses. This is because the unit retail price is higher, and the level of consumer participation in the two businesses has decreased to varying degrees, but the decline rate of the platform business is faster; based on this, under this condition, the profit of the platform business is less than that of the self-operated business.

Figure 12 depicts the relationship between the product selling price p and the profits of each part of the business when the unit distribution cost of the product is at $c \in [\bar{c}_1, 1]$ (when $c = 0.5$). At this time, the profits of the platform business and self-operated business depend on the impact of unit retail price on the number of consumer participants.

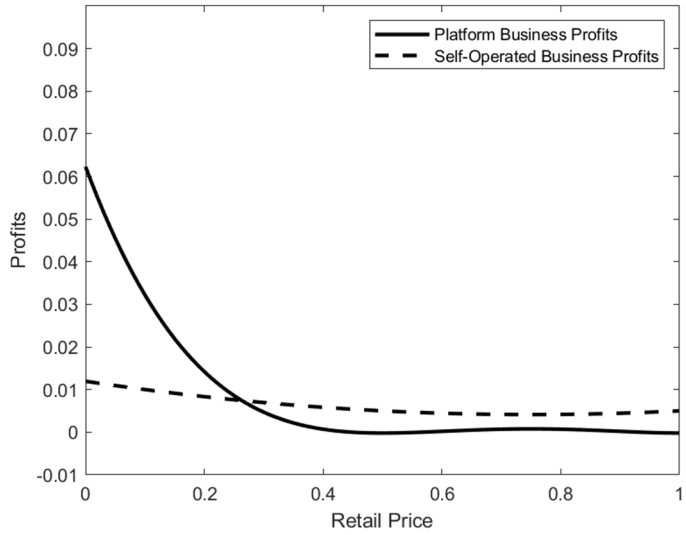

Figure 12. Self-operated business profits and platform business profits in the complementary case.

In the competition case, π^{HC-R} is defined to represent the self-operated business profit of operating enterprise H, and π^{HC-T} represents the platform business profit of operating enterprise H:

$$\begin{cases} \pi^{HC-R*} = -\frac{1}{216}(-1+c)^2(-11+2c+12p+6cp-9p^2) \\ \pi^{HC-T*} = \frac{1}{32}(-1+p)^2(-1+4c^2+2p-8cp+3p^2) \end{cases} \tag{12}$$

Define $\Delta = \pi^{HN-T} - \pi^{HN-R}$, which means that the platform business exceeds the profit of the self-operated business, yielding Proposition 4.

Proposition 4. *In the competition case, for any $c \in [0, 1]$, $p \in [0, 1]$, the profit of platform businesses is always less than that of self-operated businesses.*

Proof. See Appendix A. □

Proposition 4 reveals the relative size of the profits of the two businesses under the condition of competition. In this situation, the profit of the platform business is always less

than that of the self-operated business. This is because, on the one hand, when operating enterprises adopt a hybrid mode and compete with suppliers, they compete for half of the consumers who join the suppliers of the platform. Due to the existence of cross-network externalities, this part of the consumer loss leads to a certain proportion of suppliers being unwilling to join the platform business, and through the amplification effect, the participation equilibrium of the two-sided market converges to a smaller equilibrium than the original equilibrium. On the other hand, because the self-operated business competes for half of the consumers in the market, it increases its consumer base and gains greater profits. As a result, the profit of the self-operated business is always at a high level.

Figure 13 shows the relationship between the profit of each part of the business and the product price p when the unit distribution cost $c = 0.5$. The changing relationship in Figure 13 confirms the explanation of Proposition 4. Price competition between third-party sellers and self-operated businesses induces a low unit retail price p, and the profit of the platform business decreases or even becomes negative. At this time, the self-operated business subsidizes the platform business, but the two-sided market participation equilibrium is still at a low level. Therefore, enterprises operating in hybrid platform mode are very likely to face "coordination failure" [58].

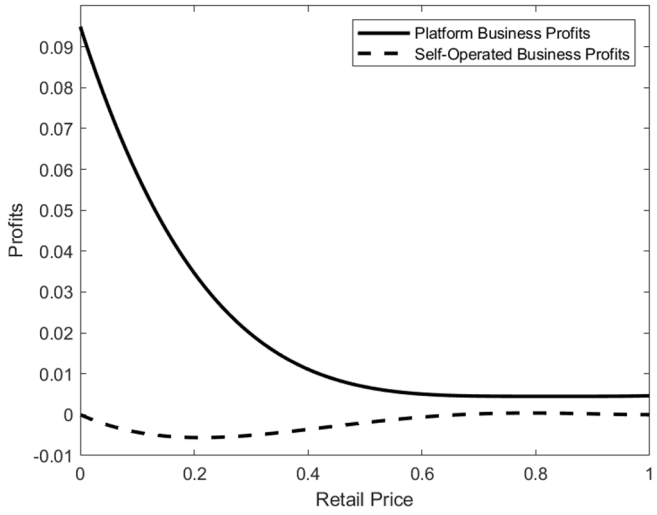

Figure 13. Self-operated business profits and platform business profits in the competition case.

5. Conclusions and Limitations

5.1. Discussion and Conclusions

The development of e-commerce gradually changes the original inherent business model. With the progress of business practice, some e-commerce operators combine the merchant mode and the platform mode based on the needs of expanding their share and managing the market. Many enterprises begin to adopt the platform mode based on the merchant mode, establishing the hybrid platform mode. The hybrid mode has the advantages of both the merchant mode and the platform mode, being able to provide consumers with a large variety of goods and services while ensuring the quality of goods and services. However, the "dual role" may lead to competitive conflicts between self-operated businesses and platform businesses, amplify the anti-competitive effect through cross-network externalities, and affect the overall profits of operating enterprises.

Therefore, according to the key characteristics of business practice, the question of how retail operating enterprises make decisions when faced with product distribution costs, product unit prices, and competitive conflicts should be considered. Specifically, will the competition conflict affect the business model selection? Finally, what is the impact of competition conflicts on the two major business profits of hybrid mode operators? The answer affects the retail enterprise's business model choice, as well as how to cope with the competition between self-operated sellers and third-party sellers when adopting the hybrid

platform mode. Moreover, the competition between self-operated sellers and third-party sellers also influences the third-party sellers' profits as well as product diversity, which ultimately induces consumer welfare.

Combined with the characteristics of the hybrid mode platform, we constructed a theoretical model to compare the profit differences of retail enterprises when choosing merchant mode, platform mode, or hybrid mode. Based on previous research [12,13], our paper considers hybrid mode businesses, and suggests that product unit price, unit distribution cost, and competitive conflict have an important impact on the operation mode decision making of retail enterprises. This paper defines the applicable conditions of the three modes, and gives the specific strategies for retail enterprises. Furthermore, this paper highlights the impact of competition between self-operated sellers and third-party sellers on two major businesses, and suggests that operating enterprises in hybrid mode should focus on their competitive relationship with third-party sellers to maintain the balanced development of the two major businesses, which is the core research conclusion of this paper.

We analyzed the retail enterprises' operational decisions, and found that the e-commerce operating enterprises should be encouraged to adopt the hybrid mode. The main conclusions are as follows: (1) When there is a complementary case between the hybrid-mode operating enterprise and the third-party seller, as well as the arbitrary unit retail price and product unit distribution cost, the optimal choice is the hybrid platform mode for operating enterprises. (2) When there is a competition case between the hybrid-mode operating enterprise and the supplier, there is a certain unit retail price threshold, and when it is greater than this threshold, the operating enterprise should give priority to the hybrid platform mode, while when it is less than the threshold, the operating enterprise should give priority to the merchant mode. (3) Competition between self-operated sellers and third-party sellers determines the profit level of the hybrid operating enterprise; when the product price is in a lower range, due to the profit gain of the hybrid-mode operating enterprise being greater than the commission loss, the profit of the operating enterprise is greater than that in the complementary case. When the product price is in a high range, the platform business income is more sensitive to the marginal change in the number of consumers, and the self-operated business is relatively insensitive to the consumer change. The competition case reduces the profit of the operating enterprise. (4) When the competition conflict between the self-operated business and the third-party sellers is weak, when the unit distribution cost is low, the profit of the self-operated business is always greater than that of the platform business. When the unit distribution cost is high, there is a certain unit retail price threshold; when the unit retail price is low, the platform business profit is always greater than the self-operated business profit; when the unit retail price is high, the platform task profit is always less than the self-operated business profit. (5) When the competition conflict between self-operated businesses and third-party sellers is strong, the profit of platform businesses is always less than that of self-operated businesses for any product distribution cost; at this time, due to the existence of lower participation equilibrium, there are price competition and coordination problems in the hybrid platform mode.

5.2. Theoretical Contributions

Our research results have three contributions in theory: First, our research focuses on the hybrid mode, and gives the specific strategy of retail enterprise business model decision making. Compared with previous studies, we put forward three major factors: product unit price, unit distribution cost, and competitive conflict. We think that all of these factors have an important impact on the business model decision-making of retail enterprises.

Second, our research makes clear the impact of competitive conflicts on the profits of hybrid-mode operators. Previous studies on the hybrid mode focus on the trading platform and the channel competition between third-party sellers, or emphasize the interest damage caused by the platform selling its products on the market [2,46,50]. Our research not only

focuses on the decision-making paths of the three modes, but also makes clear the impact of competitive conflicts on the total profits of operating enterprises.

Third, our study's results also highlight the two major businesses of operating enterprises, and expand the scope of research on two-sided market network externalities. Our results show that when the competition between the third-party sellers and the self-operated sellers is not fierce, the two businesses show a synergistic effect; that is, on the basis of running two-sided markets, hybrid operators provide richer, higher-quality complementary goods, and expand the diversity of commodities. When the competition between third-party sellers and self-operated sellers becomes fierce, the synergistic effect is less than the anti-competitive effect. The two sellers competing for consumers will reduce the market size and profits of the operators, through the magnifying effect of cross-network externalities.

5.3. Managerial Implications

Our research has four strategic implications for retail enterprise model decision making: First, on the basis of pure platform mode and pure merchant mode, retail enterprises can consider introducing a hybrid mode appropriately to provide consumers with high-quality goods and expand commodity diversity, to increase market trading scale and profits.

Second, when retail enterprises introduce the hybrid mode, it will produce synergy and competitive conflicts at the same time. Synergy effects will expand the source of income, selling complementary products and improving the overall profit level. The competition conflict will reduce the platform business profit and increase the self-operated business profit, but the overall business profit will approach the pure merchant mode.

Third, retail enterprises should pay special attention to the competition with third-party sellers. When the competition becomes fierce, the synergy effect is less than the anti-competitive effects, and will cause serious price competition. Through the magnifying effect of network externalities, the market scale and profit of the retail enterprise are reduced.

Fourth, we suggest that retail enterprises should provide different kinds of goods from third-party sellers according to their advantages, reducing the direct competitive conflicts with third-party sellers, and maintaining the balanced and stable development of self-operated businesses and platform businesses. In business practice, many hybrid mode retail enterprises have followed this advice.

5.4. Limitations and Further Research

There are several limitations to this research. For the theoretical study, the relevant assumptions were too strict, such as exogenous setting—if we take the endogenous pricing decision, the theoretical model analysis could be more applicable; however, it would be much more difficult to analyze. Furthermore, our assumption of monopoly operation enterprises is limited; if we could study the several hybrid platforms' competition, the conclusion would be more general.

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Appendix A. Proof of Lemmas and Propositions

Proof of Lemma 1. Define the difference in profits between the hybrid platform mode and the merchant mode $\Delta = \pi^{HN*} - \pi^{R*}$. Find all the extreme points with respect to the first-order condition of p, and substitute them into the function Δ. We can find that for any $c \in [0,\ 1]$, $\Delta\left(p = \frac{1+c}{2}\right) = \frac{25(-1+c)^4}{5184} \geq 0$; $\Delta\left(p = \frac{1}{6}\left(3+3c-\sqrt{5}\sqrt{1-2c+c^2}\right)\right) = 0$; $\Delta\left(p = \frac{1}{6}\left(3+3c+\sqrt{5}\sqrt{1-2c+c^2}\right)\right) = 0$. The upper and lower bounds of the function interval $\Delta(p=0) = \frac{1}{324}\left(1+7c+c^2\right)^2 > 0$; $\Delta(p=1) = \frac{1}{324}(-1+c)^4 \geq 0$. By considering the monotonicity, for any $p \in [0,1]$ and $c \in [0,\ 1]$, the function $\Delta \geq 0$ holds. □

Proof of Lemma 2. Define the difference in profits between the hybrid platform mode and the platform mode $\Delta = \pi^{HN*} - \pi^{T*}$. Find all the extreme points $p^{\Delta HT*} = \frac{1+c}{2}$ for the first-order condition of p. It can be determined that the function has a minimum value according to the second-order condition of the function $\frac{\partial^2\Delta}{\partial p^2} = \frac{1}{9}(-1+c)^2 \geq 0$. Substitute the extreme value into the function and get $\Delta\left(p = p^{\Delta HT*}\right) = -\frac{1}{648}(-1+c)^3(17+7c) \geq 0$. The upper and lower bounds of the function interval $\Delta(p=0) = \frac{1}{324}(-1+c)^2\left(13+4c+c^2\right) \geq 0$, $\Delta(p=0) = \frac{1}{324}(-13+c)(-1+c)^3 \geq 0$. Therefore, for any $c \in [0,\ 1]$, the profit difference $\Delta \geq 0$ holds. □

Proof of Lemma 3. Define the difference in profits between the hybrid platform mode and the merchant mode $\Delta = \pi^{HC*} - \pi^{R*}$; we found that for any product unit distribution cost $c \in [0,\ 1]$, the turning point (p_{H1}, p_{H2}) matches the condition: $\Delta'(p = p_{H1}) = \frac{1}{108}\left(-12+\sqrt{3}\sqrt{(-1+c)^2}+24c-2\sqrt{3}\sqrt{(-1+c)^2}c-12c^2+\sqrt{3}\sqrt{(-1+c)^2}c^2\right) \leq 0$. $\Delta'(p = p_{H2}) = \frac{1}{108}\left(-12-\sqrt{3}\sqrt{(-1+c)^2}+24c+2\sqrt{3}\sqrt{(-1+c)^2}c-12c^2-\sqrt{3}\sqrt{(-1+c)^2}c^2\right) \leq 0$. $\Delta'(p=0) = \frac{1}{72}\left(-26-29c-26c^2\right) < 0$, $\Delta'(p=1) = \frac{1}{9}\left(-1+2c-c^2\right) \leq 0$. We can thus conclude that $\frac{\partial\Delta}{\partial p} \leq 0$ is true.

Because the function $\Delta(p=0) = \frac{1}{288}\left(41-28c-4c^2\right) \geq 0$, $\Delta(p=1) = \frac{1}{27}(-1+c)^3 < 0$, and there exists a real root $\overline{P}_2$. Therefore, for any $c \in [0,\ 1]$, there exists $\overline{P}_2$; when $0 \leq p \leq \overline{P}_2$, the monopoly operating enterprise should choose the hybrid platform mode, and when $\overline{P}_2 \leq p \leq 1$, the monopoly operating enterprise should choose the merchant mode. □

Proof of Lemma 4. Define $\Delta = \pi^{HN*} - \pi^{R*}$, which represents the profit difference between the hybrid platform mode and the platform mode. We can find the monotonicity of the first derivative by judging the second derivative's turning point (p_{d1}, p_{d2}). For any $c \in [0,\ 1]$, $\Delta'(p = p_{d1}) \leq 0$, $\Delta'(p = p_{d2}) \leq 0$, $\Delta'(p=0) < 0$, $\Delta'(p=1) \leq 0$ holds, and $\frac{\partial\Delta}{\partial p} \leq 0$, which tha means the function Δ decreases monotonously. The monotone decreasing function has a real root p_6, and for any $c \in [0,\ 1]$, $\Delta(p=0) = \frac{1}{288}\left(41-28c-4c^2\right) \geq 0$, $\Delta(p=1) = 0$, $\Delta(p=p_6) = 0$. Therefore, for any $c \in [0,\ 1]$, $\Delta \geq 0$ is true. □

Proof of Lemma 5. Define the difference in profits between the complementary case and the competition case $\Delta = \pi^{HN} - \pi^{HC}$. We can derive the existence of a real solution $\overline{P}_3$ with respect to $\Delta = 0$. The upper and lower bounds of the function interval $\Delta(p=0) = \frac{-265+76c+84c^2+16c^3+8c^4}{2592} < 0$, $\Delta(p=1) = \frac{1}{324}(-13+c)(-1+c)^3 \geq 0$. Therefore, the function Δ is monotonously increasing with p. So, if $0 \leq p \leq \overline{P}_3$, the function $\Delta = \pi^{HN} - \pi^{HC} \leq 0$ holds, and when $\overline{P}_3 \leq p \leq 1$, the function $\Delta = \pi^{HN} - \pi^{HC} \geq 0$ holds. □

Proof of Proposition 3. Define $\Delta = \pi^{HN-R} - \pi^{HN-T}$, which means that the self-operated business of a hybrid retail enterprise exceeds the profit of the platform business. We can see that there are four roots of p when $\Delta = 0$:

$$\begin{cases} p_1^{HN} = \frac{1}{2}\left(1 + c - \frac{1}{3}\sqrt{13 - 26c + 13c^2 - 8\sqrt{4 - 13c + 15c^2 - 7c^3 + c^4}}\right) \\ p_2^{HN} = \frac{1}{2}\left(1 + c + \frac{1}{3}\sqrt{13 - 26c + 13c^2 - 8\sqrt{4 - 13c + 15c^2 - 7c^3 + c^4}}\right) \\ p_3^{HN} = \frac{1}{2}\left(1 + c - \frac{1}{3}\sqrt{13 - 26c + 13c^2 + 8\sqrt{4 - 13c + 15c^2 - 7c^3 + c^4}}\right) \\ p_4^{HN} = \frac{1}{2}\left(1 + c + \frac{1}{3}\sqrt{13 - 26c + 13c^2 + 8\sqrt{4 - 13c + 15c^2 - 7c^3 + c^4}}\right) \end{cases}$$

It can be seen that there are only p_3^{HN} and p_4^{HN} in the root that satisfies the interval range, where $p_3^{HN} \in [0,\ 1]$, and we can conclude that $\frac{1}{2}\left(-3 + \sqrt{13}\right) < c \leq 1$—that is, $\bar{c}_1 = \frac{1}{2}\left(-3 + \sqrt{13}\right)$. When $p_4^{HN} \in [0,\ 1]$, we can determine that $c = 1$, which is in the upper bound of the interval.

Therefore, when $c \in [0, \bar{c}_1]$, $\Delta \geq 0$ is always true, and when $c \in [\bar{c}_1, 1]$, there exists the root $\overline{P}_4 = p_3^{HN} = \frac{1}{2}\left(1 + c - \frac{1}{3}\sqrt{13 - 26c + 13c^2 + 8\sqrt{4 - 13c + 15c^2 - 7c^3 + c^4}}\right)$, such that when $p \in \left[0, \overline{P}_4\right]$, $\Delta < 0$ holds. If $p \in \left[\overline{P}_4, 1\right]$, $\Delta \geq 0$ is true. □

Proof of Proposition 4. Define $\Delta = \pi^{HN-R} - \pi^{HN-T}$, which means that the profits of the self-operated business exceed those of the platform business; $\Delta = \frac{1}{864}\{89 - 24c(1 + 3p) + 24c^2(1 + 3p) - 8c^3(1 + 3p) + 3p[-100 + 27p(6 + (-4 + p)p)]\} \geq 0$ is always true in $p \in [0,\ 1]$ and $c \in [0,\ 1]$. □

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