

The impact of the OEM's marketplace channel introduction on factory entry strategy in a platform-based supply chain

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ABSTRACT

Recently, a growing number of upstream factories are entering the territory of the national brand manufacturer (also called the original equipment manufacturer, denoted by OEM) by establishing their private labels (PLs) in a platform-based supply chain. Yet, existing literature rarely considers how the factory's entry strategy, non-entry, entry via the platform's marketplace channel, or entry via the platform's resale channel, interacts with the OEM's decision of whether (and how) to introduce a marketplace channel, although this phenomenon is common in reality. In a three-tier supply chain consisting of a factory, an OEM and a platform, we utilize game theory to discuss the relationship between the factory's entry strategy and the OEM's marketplace channel introduction strategy. Our results show that the factory's entry via the resale channel always benefits both the platform and himself. By contrast, the factory entering via the marketplace channel may hurt the platform or himself. Furthermore, we show that when the PL's perceived value is low, the OEM's marketplace channel introduction reduces the probability of the factory's entry through the marketplace channel; otherwise, such marketplace channel introduction raises the probability that the factory enters the market via the marketplace channel. Surprisingly, we find that the OEM's introduction of the marketplace channel may worsen her profit reduction caused by factory entry. Finally, we derive the equilibrium result and show that in response to factory entry, the OEM chooses not to introduce a marketplace channel to guide the factory to enter the market through the resale channel.

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1. Introduction

Recent years have witnessed the unprecedented growth of online retailing. In 2021, the worldwide transaction value of online retail hit 4.9 trillion U.S. dollars, which was nearly three times higher than that in 2014. It is projected to grow by 50% over the next four years, reaching 7.4 trillion U.S. dollars by 2025 (Tong et al., 2023). Beyond the traditional resale channel, numerous e-commerce platforms (e.g., Amazon) have opened up marketplace channels, achieving great success (Xu et al., 2021; Xi and Zhang, 2023). In this context, an increasing number of original equipment manufacturers (also called national brand manufacturers, denoted by OEMs) add marketplace channels to distribute their NB products besides the existing resale channel, a strategy defined as marketplace channel introduction (Wang et al., 2025). For example, in addition to the conventional resale channel, numerous OEMs such as Midea add the marketplace channel on JD.com.

Meanwhile, with the backing and advocacy of e-commerce platforms, a growing number of upstream factories that manufacture NB products for OEMs have launched their private labels (PLs) to compete against these NBs. For instance, Pinduoduo launched a new branding program¹. The program aims to help upstream factories create their PLs and support these factories in competing with OEMs. Similar programs have been rolled out by other platforms (e.g., JD.com² and

¹ <https://tech.huanqiu.com/article/40vOyIHkaBq>

² <https://baijiahao.baidu.com/s?id=1747647340568339622&wfr=spider&for=pc>

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Alibaba³). Furthermore, extant commercial practices show that the factories that have launched their PLs might sell these products on the platform via different selling channels⁴ (Liu et al., 2024). In other words, a factory may build a PL to enter the OEMs' market territory through marketplace or resale channels on these platforms.

Intuitively, such factory entry strategies (i.e., non-entry, entry via marketplace or resale channels) may be influenced by the OEM's marketplace channel introduction strategies. This is because different marketplace channel introduction strategies produce distinct competitive structures among supply chain members, which affects the factory's operational decisions, such as the entry decision and pricing. On the other hand, the factory's entry strategies generate brand competition, and further affect the OEM's marketplace channel introduction decision. However, how the OEM's marketplace channel introduction strategy interacts with the factory entry strategy remains unclear in the extant literature. On the basis of the foregoing considerations, we study the factory's entry strategies under different marketplace channel introduction strategies and their interactions. In particular, we strive to solve the problems outlined below. (i) Given the OEM's decision on whether to introduce a marketplace channel, should the factory enter the end market? If so, which selling channel (resale or marketplace) should he select? (ii) How does the OEM's introduction of the marketplace channel affect the factory's entry strategies? (iii) What is the interplay between the two strategies?

To address these scientific questions, we develop a model in which the OEM (*she*) that outsources her NB products' manufacturing services to the factory (*he*) distributes her NB goods through the traditional resale mode on the platform (*it*). The OEM faces the decision of whether to add a marketplace channel besides the existing resale mode. Meanwhile, to capture more profits, the factory may establish its PL products and sell them through the resale or marketplace channels on the platform. Depending on the above settings, we construct six strategy models and study the interactions of the factory's entry strategy and the OEM's marketplace channel introduction. In addition, the extension model examines the influence of the strategy decision sequence. The key conclusions are presented below. First, we demonstrate that regardless of whether the OEM adds a marketplace channel, the factory's entry via the resale channel always benefits himself. However, entering via the marketplace channel may hurt the factory if referral fees are large. Furthermore, the factory's entry always reduces the profit of the OEM but raises the platform's profit in most cases. Second, surprisingly, we find that the OEM's introduction of a marketplace channel may exacerbate her profit reduction caused by the factory's entry. Third, when the PL's perceived value is low, the OEM's introduction of a marketplace channel decreases the probability that the factory enters the market via the marketplace channel; when the PL's perceived value is high, the OEM's channel addition increases the probability of the factory's entry via the marketplace channel. Finally, we obtain the equilibrium results and show that when referral fees are small, the OEM will introduce a marketplace channel, and the factory will establish his PL products to enter the end market via the marketplace channel; when referral fees and the PL's perceived value are moderate, the OEM might choose not to add a marketplace channel, and the factory will adopt the entry through the resale channel; when referral fees are large, the OEM will introduce a marketplace channel, and the factory will establish his PL products to enter the market through the resale channel. In addition, we indicate that strategy decision sequences matter.

This paper makes several contributions. Firstly, most existing studies on the factory's entry strategy are conducted in the context of a single product (i.e., the NB product) (Ha et al., 2022; Gong et al., 2024); a few studies (Shi, 2019; Chen et al., 2019) focus on the factory's entry strategy involving the launch of PL products but ignore other chain members' strategic responses. In contrast, we investigate the factory's entry strategies under various OEMs' channel strategies and their interactions, which has been overlooked by existing literature. Furthermore, we identify the detailed conditions under which the factory conducts the entry and chooses an optimal entry channel in the context of different OEMs' channel strategies. This serves as a practical blueprint for factories' entry strategies in e-commerce supply chains. In addition, we derive several interesting findings. For example, the OEM's introduction of the marketplace channel might worsen her profit reduction caused by the factory's entry. To deal with the factory's entry, the OEM may choose not to add a marketplace channel to guide the factory to adopt the entry via the resale channel. These conclusions help provide useful guidelines for supply chain firms (i.e., OEMs and upstream factories) to formulate optimal strategic decisions.

The subsequent sections of this paper are arranged below. The second section reviews the literature related to factory entry and selling mode selection and further highlights the difference between our work and the existing literature. The third section describes our model settings, demand functions and the timing of events. In the fourth section, the equilibrium results under six scenarios are derived, and we further discuss the factory's entry strategy under different OEMs' selling channels. The fifth section investigates the influence of the OEMs' selling channels. Based on the above analysis, the sixth section obtains the final equilibrium strategies. The seventh section examines the robustness by analyzing an extended mode. The eighth section summarizes this paper.

2. Literature review

In this section, we review the literature related to selling mode selection and factory entry (also called factory encroachment),

³ <https://jg-static.eeo.com.cn/article/info?id=62c05e5303a6ab4fc240b52af8f6c128>

⁴ <https://www.jd.com>

and further clarify how our work differs from existing studies.

The topic of selling mode selection has received considerable academic attention, and one could refer to Zhou et al. (2023) for a comprehensive review. Most of the literature investigates the factors that affect selling mode selection, such as information sharing, order fulfillment cost, logistics, private label introduction, and green technology improvement (Zhang and Hou, 2022; Cheng et al., 2022; Liu et al., 2022; Lu et al., 2023; Hao and Yang, 2023; Ha et al., 2022; Li et al., 2024; Tian et al., 2018, 2023; Gong et al., 2024). For instance, Wei et al. (2020) study the effect of leader-follower relationships on selling mode selection and find that when the manufacturer is the leader, he prefers to adopt a marketplace channel. Liu et al. (2022) investigate how the OEM's selling mode choice interacts with the e-commerce platform's PL outsourcing and show that she might adopt the resale mode to guide the outsourcing strategy of the platform. Among this category of literature, Li et al. (2024) is the most related paper to ours. They investigate the factory's entry strategy (no-entry, the entry via the self-built, marketplace and reselling channels) in a two-tier supply chain, and show that the factory always chooses to encroach from the economic standpoint. They examine factory entry model selection but neglect OEM's strategic response. Differing from Li et al. (2024), this paper not only considers the factory's entry strategy in a three-tier platform-based supply chain but also investigates the OEM's strategy response (i.e., whether to introduce a marketplace channel). Recently, an increasing number of scholars have been considering whether manufacturers would introduce marketplace channels besides the traditional resale channel, along with the impact that such a decision brings to the supply chain (Mantin et al., 2014; Geng et al., 2018; Xu et al., 2021). Xi and Zhang (2023) consider the interplay between marketplace channel introduction and pricing strategies, and find that regardless of pricing strategies, the manufacturer chooses to introduce the marketplace channel in addition to the resale channel. Unlike the above literature, we contribute to the channel introduction literature by investigating the influence of the factory entry strategy on the OEM's marketplace channel addition. We find that in response to the factory's entry, the OEM might choose not to introduce a marketplace channel.

Furthermore, literature related to factory entry could be broadly categorized into two types. The first one is the impact of factory entry (Park and Keh, 2003; Arya et al., 2007; Chen et al., 2012; Li et al., 2015; Chen et al., 2019; Yoon, 2016; Yang et al., 2023; Lin et al., 2024; Li et al., 2025). Among this category of literature, several scholars find that factory entry harms downstream retailers (Park and Keh, 2003), but others find that factory entry might benefit both retailers and factories (Arya et al., 2007; Dong et al., 2021). For instance, Sun et al. (2021), using a signaling game approach, demonstrate that factory entry is detrimental to downstream retailers. In contrast, Liu et al. (2021) consider factory entry strategies and reveal that the entry might benefit all supply chain members. The second category is about the interplay between factory entry and other supply chain members' operational strategies (Guan et al., 2020; Zhang et al., 2021a; Chang et al., 2023; Huang & Chen, 2023). Ha et al. (2022) investigate the interactions of demand information sharing and factory entry, and show that these two strategies complement each other. Zhang et al. (2021b) consider the interactions between factory entry and the retailer's PL introduction, and show that PL introduction may discourage the factory from entering the end market. Recently, encouraged by e-commerce platforms, an increasing number of factories manufacturing NB products for the OEM are establishing their PLs to compete with the NBs on the platform, which has been attracted by academics (Shi, 2019; Li et al., 2024; Zhang et al., 2023). Chen et al. (2019), the most related paper, investigates the factory's entry strategy under the reselling model within a supply chain involving one factory, one offline retailer and one OEM, and show that such entry might benefit all supply chain members. Differing from Chen et al. (2019), we examine the factory's entry model selection under different OEM channel strategies and their interplay. In practice, with the support of the platform, it is becoming more and more common for the factory to establish PLs and sell through the platform. However, to our knowledge, few have investigated factory entry strategies in the context of an OEM's decision to introduce a marketplace channel. Therefore, we strive to bridge this gap and contribute to factory entry literature by investigating the interplay between the OEM's marketplace channel introduction and factory entry. We obtain several interesting findings. For example, we show that when the PL's perceived value is high, introducing a marketplace channel by the OEM raises the probability of the factory entry via the marketplace channel; otherwise, the marketplace channel introduction reduces the probability that the factory encroaches through the marketplace channel.

3. Model formulation

Model structure. This paper constructs a three-level outsourced supply chain comprising one OEM (*she*), one factory (*he*), and one platform (*it*). The OEM that outsourced her NB's manufacturing services to the factory distributes these NB products via the traditional resale mode on the platform. With the emergence of marketplace channels, the platform also allows the OEM to add a marketplace channel to sell her NB products (Xi & Zhang, 2023; Xu et al., 2021). At this time, besides the existing resale mode, the OEM needs to decide whether to introduce a marketplace channel. For ease of exposition, we utilize subscripts I to stand for the marketplace channel introduction and N to denote non-introduction.

Meanwhile, with the e-commerce platform's encouragement and support, the factory may establish his PL to compete with the OEM's NB on the platform (i.e., the factory's entry) (Chen et al., 2019; Shi, 2019). Then, the factory has three entry model choices: entry via the marketplace channel (M), entry via the resale channel (R), and non-entry (N). When the factory selects the marketplace channel to enter the OEM's market, he sells his PL goods directly to consumers but needs to pay referral fees to the platform; when the factory selects the resale channel, he wholesales his PL goods to the platform that resells them to

consumers. Following Liu et al. (2025), the referral fee r ($0 < r < 1$) charged by the platform is assumed to be exogenous because generally, it charges a fixed referral fee for a large category of products.

Based on the OEM's marketplace channel introduction and the factory's entry models, we discuss the following six strategy scenarios (see Fig. 1). For convenience, we utilize (X, Y) to stand for the combination of the two firms' strategies, where $X = I$ or N represents introducing or non-introducing the marketplace channel for the OEM, respectively, and $Y = N, M$ or R stands for the factory's non-entry, entry with the marketplace or resale channels, respectively. Moreover, we use superscripts F, OEM and P to denote the factory, the OEM, and the platform, respectively.

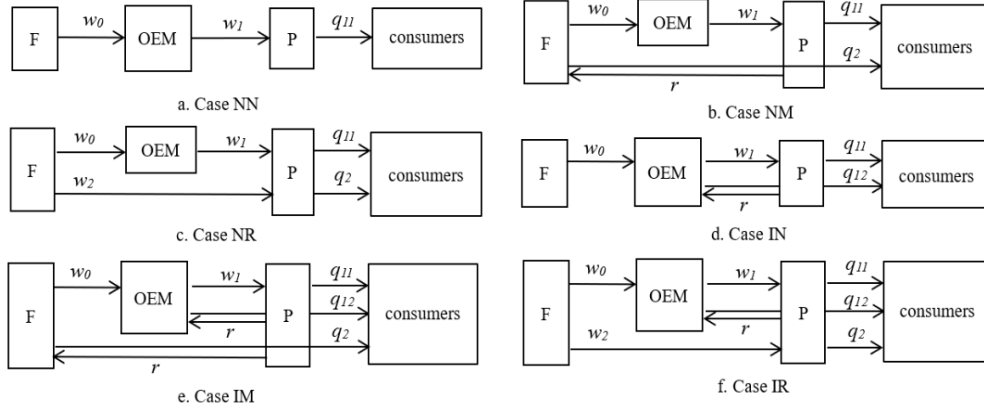


Fig. 1. Six strategy scenarios

Demand function. When the factory introduces PL products to compete with the OEM's NB products, there exist two brands in the market. Generally, the factory's PL is an inferior substitute for the OEM's NB (Chen et al., 2011). Thus, normalizing the NB's perceived value to one, we assume that the perceived value of the PL is θ ($0 < \theta < 1$), which captures the idea that the factory's PL product is a secondary substitute for the NB product. Consistent with Cheng et al. (2022) and Wu et al. (2022), we assume that a consumer's willingness to buy one NB product v follows a uniform distribution on $[0,1]$. Thus, when one consumer buys one unit of NB products, the consumer's utility is $v - p_1$; when one consumer buys one unit of PL products, the consumer's utility is $\theta v - p_2$. By comparing the consumer's utility in purchasing two brand products, we derive the two brands' demand functions, that is, $q_1 = 1 - \frac{p_1 - p_2}{1 - \theta}$ and $q_2 = \frac{p_1 - p_2}{1 - \theta} - \frac{p_2}{\theta}$, where q_1 and q_2 (p_1 and p_2) are the NB and PL products' selling quantities (retail prices), respectively. Then, their inverse demand functions are $p_1 = 1 - q_1 - q_2$ and $p_2 = \theta(1 - q_1 - q_2)$, respectively. Note that $q_1 = q_{11} + q_{12}$, where q_{11} and q_{12} are the NB product's selling quantities in the resale and marketplace channels, respectively. Thus, if the OEM does not introduce a marketplace channel, q_{12} equals zero (i.e., $q_1 = q_{11}$). In addition, similar to Zhang and Hou (2022), it is assumed that the two brands are the same production costs of zero.

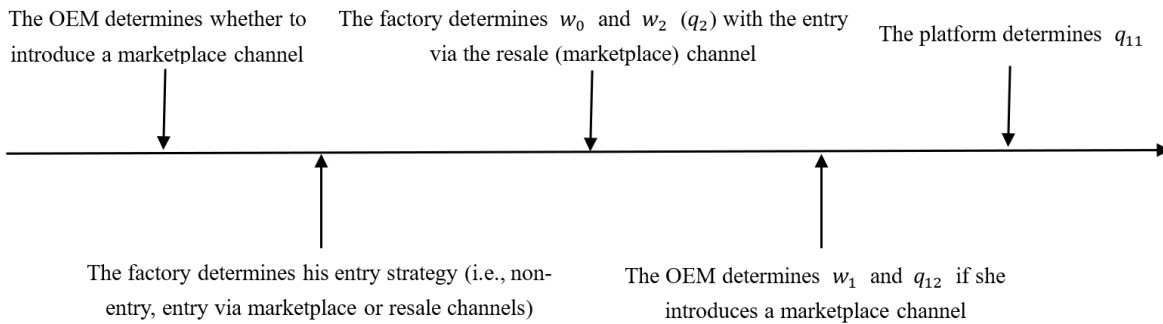


Fig. 2. The sequence of events.

Timing. In the strategic decision phase, the OEM first decides whether to add a marketplace channel alongside the traditional resale mode, and then the factory determines which entry model to adopt. Such a strategic decision sequence is prevalent in business practice. For example, on JD.com, numerous OEMs have adopted resale or dual-channel modes to sell their NB products. Currently, the factories manufacturing these OEMs' NB products start to establish their PLs and enter the OEMs' market territories with the support of JD.com⁵. In the extended section, to investigate the effect of the game sequence on the equilibrium outcome, we also examine another scenario wherein the factory first sets his entry strategy and the OEM then determines whether to add the marketplace channel. In the selling quantity decision phase, the factory first determines the

⁵ <https://baijiahao.baidu.com/s?id=1747647340568339622&wfr=spider&for=pc>

NB's wholesale price w_0 and the PL's wholesale price w_2 (the PL's sales quantity q_2) in the context of the entry via the resale (marketplace) model, and then the OEM decides the NB's wholesale price w_1 and the NB's sales quantity q_{12} in the marketplace channel if the OEM introduces a marketplace channel, and finally the platform sets the NB's sales quantity q_{11} in the traditional resale channel.

4. Equilibrium analysis

4.1. Cases without marketplace channel introduction

In Case NN, the factory manufactures NB products for the OEM, which sells them via the platform's resale channel. Therefore, the profit functions of these enterprises are $\pi_F^{NN} = w_0 q_{11}$, $\pi_{OEM}^{NN} = (w_1 - w_0) q_{11}$, and $\pi_P^{NN} = (p_1 - w_1) q_{11}$. Using backward induction, we derive the optimal results for Case NN as follows: $w_0^{NN*} = \frac{1}{2}$, $w_1^{NN*} = \frac{3}{4}$, and $p_1^{NN*} = \frac{7}{8}$.

In Case NM, the factory manufactures NB products for the OEM, which sells them via the platform's resale channel. Meanwhile, the factory establishes PL goods and distributes them directly to consumers via the platform's marketplace channel. Therefore, the enterprises' profit functions are $\pi_F^{NM} = w_0 q_{11} + p_2 q_2 (1 - r)$, $\pi_{OEM}^{NM} = (w_1 - w_0) q_{11}$, and $\pi_P^{NM} = (p_1 - w_1) q_{11} + p_2 q_2 r$. Then, we derive the optimal results for Case NM as follows: $w_0^{NM*} = \frac{\theta(3r+1)(\theta+\theta r-6)+16}{32-2\theta(3r+5)}$, $w_1^{NM*} = \frac{4\theta(5r+4)-3\theta^2(r+1)^2-24}{2\theta(3r+5)-32}$, $p_1^{NM*} = \frac{(2-\theta)(3\theta(r+1)-14)}{2\theta(3r+5)-32}$, and $p_2^{NM*} = \frac{\theta(3\theta(r+1)-14)}{2\theta(3r+5)-32}$.

In Case NR, the factory manufactures NB products for the OEM, which sells via the platform's resale channel. Meanwhile, the factory establishes PL products and sells them via the platform's resale channel. Therefore, the profit functions of these enterprises are $\pi_F^{NR} = w_0 q_{11} + w_2 q_2$, $\pi_{OEM}^{NR} = (w_1 - w_0) q_{11}$, and $\pi_P^{NR} = (p_1 - w_1) q_{11} + (p_2 - w_2) q_2$. Then, we derive the optimal results for Case NR as follows: $w_0^{NR*} = \frac{1}{2}$, $w_1^{NR*} = \frac{3-\theta}{4}$, $w_2^{NR*} = \frac{\theta}{2}$, $p_1^{NR*} = \frac{7-\theta}{8}$, and $p_2^{NR*} = \frac{3\theta}{4}$.

Lemma 1. *When the OEM chooses not to add a marketplace channel, we have: (i) $w_0^{NN*} = w_0^{NR*} > w_0^{NM*}$; (ii) $w_1^{NN*} > w_1^{NR*} > w_1^{NM*}$; (iii) $p_1^{NN*} > p_1^{NR*} > p_1^{NM*}$; (iv) $p_2^{NR*} > p_2^{NM*}$.*

Lemma 1 demonstrates that if the OEM refrains from introducing a marketplace channel, the factory's entry via the marketplace channel generates the lowest wholesale and retail prices for both brands, while non-entry leads to the highest prices for the NB. Intuitively, when the factory adopts the marketplace channel to enter the market, the PL's pricing power induces the factory to fix a lower price for PL goods to gain market share. This heightens competition with the NB, putting downward pressure on prices for both brands. However, when the factory chooses non-entry, there exists only the NB product. To squeeze more profits, the OEM will set the highest wholesale and retail prices of the NB product, as reflected in Lemma 1. These conclusions echo business practice (Liu et al., 2024). For instance, the NB product may have a lower retail price when the factory's PL product exists in the market.

Lemma 2. *Comparing Cases NM and NN, we have: (i) when $r < r_1$, $\pi_F^{NM*} > \pi_F^{NN*}$, when $r > r_1$, $\pi_F^{NM*} < \pi_F^{NN*}$; (ii) $\pi_{OEM}^{NM*} < \pi_{OEM}^{NN*}$; (iii) when $r < r_2$, $\pi_P^{NM*} < \pi_P^{NN*}$, when $r > r_2$, $\pi_P^{NM*} > \pi_P^{NN*}$.*

Lemma 2 shows how the factory's marketplace entry affects supply chain members' profits when the OEM has no marketplace channel. One might intuitively think that the factory could always benefit from his entry because this entry increases his income source (i.e., adding the income from selling PL products). However, Lemma 2(i) reveals that if referral fees are sufficiently large, such entry is detrimental to the factory. The intuition is that in this case, the factory needs to set a high price for PL goods to cover his high selling cost. This leads to more intense price competition between the two brands, under which the factory's profit from wholesaling the NB products greatly decreases. At this time, the factory will be hurt by the entry because his loss of reducing the NB product's revenue exceeds the benefit of adding the PL product's profit. Lemma 2(i) suggests that the factory should carefully evaluate the impact of referral fees when deciding whether to establish a PL and sell it via the marketplace channel.

Lemma 2(ii) shows that the factory's entry reduces the profit of his rival OEM, which can be intuitively explained by the brand competition, and thus we omit the details here. Furthermore, Lemma 2(iii) demonstrates that the platform's profit is influenced by referral fees. Specifically, when referral fees are small, the factory's entry through the marketplace channel hurts the platform; otherwise, such entry benefits the platform. In general, when the factory builds his PL to enter the end market via the marketplace channel, the platform's commission income increases, but its profit from selling NB products may decrease. When referral fees are small, the increased commission income cannot compensate for the profit loss from reselling NB products. This results in a reduced profit for the platform. Conversely, when referral fees are large, the platform's profit increases because of a higher commission income. This result implies that platforms need to weigh a trade-off: the benefit of gaining commission income against the loss in NB resale profit due to heightened competition. This trade-off is crucial when they support upstream factories in launching and selling PLs on their marketplace channels.

Lemma 2 emphasizes the importance of the referral fee in the factory’s entry via the marketplace channel if the OEM refrains from adding a marketplace channel, which could provide a theoretical basis for the factory’s entry model selection in practice.

Lemma 3. Comparing Cases NR and NN, we have: (i) $\pi_F^{NR*} > \pi_F^{NN*}$; (ii) $\pi_{OEM}^{NR*} < \pi_{OEM}^{NN*}$; (iii) $\pi_P^{NR*} > \pi_P^{NN*}$.

Lemma 3 demonstrates that if the OEM refrains from introducing a marketplace channel, the factory’s entry through the resale channel always benefits the factory and the platform but hurts the OEM. This is because when the factory enters the OEM’s territory via the resale channel, he transfers PL’s pricing power to the platform. To capture more profits, the platform gently reduces the NB product’s retail price to maintain its sales and sets suitable retail prices for the PL product. This is beneficial for the platform. Meanwhile, the income source addition (i.e., adding the profit from wholesaling PL products) caused by the entry pushes up the factory’s profit. However, similar to Lemma 2, such entry reduces the profit of its rival OEM due to the brand competition.

Differing from Lemma 2, which shows that the factory’s entry via the marketplace channel might hurt the factory or the platform, Lemma 3 implies that the factory can always choose the entry via the resale channel to increase his profit, and this behavior is always supported by the platform. Therefore, when the platform makes relevant policies to support the upstream factory to establish PL products and enter the market, it is also necessary to consider the impact of the factory’s entry model choice.

Proposition 1. Given that the OEM chooses not to add a marketplace channel, if $r < r_3$, the factory selects the entry via the marketplace channel (i.e., $\pi_F^{NM*} > \max\{\pi_F^{NR*}, \pi_F^{NN*}\}$); if $r > r_3$, the factory chooses the entry via the resale channel (i.e., $\pi_F^{NR*} > \max\{\pi_F^{NM*}, \pi_F^{NN*}\}$).

Proposition 1 illustrates the choice of the factory’s entry model when the OEM refrains from adding a marketplace channel. Proposition 1 implies that in this case, the factory always chooses to enter the OEM’s territory. Recall that the factory’s entry via the resale always raises the factory’s profit (see Lemma 3). Compared to the entry via the resale channel, adopting the marketplace channel to encroach may or may not make the factory more profitable. At this time, if it is more profitable for the factory to use the marketplace channel to enter the market, he could use the marketplace channel to encroach; otherwise, he could choose the resale channel. In other words, the entry can always benefit the factory by using an appropriate channel. Furthermore, Proposition 1 specifies the factory’s optimal entry strategy. More specifically, if referral fees are small, the factory will use the marketplace channel to enter the market; if referral fees are large, the factory will enter the OEM’s market via the resale channel. The reason behind this is that when referral fees are small, the factory will adopt the entry via a market channel due to its lower channel costs. In contrast, when referral fees are large, the platform squeezes most of the profit that the factory earns from selling his PL products under the revenue-sharing contract. At this time, if the factory chooses to enter the market via the marketplace channel, he will generate lower profits through this channel compared to the resale channel.

Proposition 1 is consistent with business practice. For example, with the support and encouragement of Suning.com, numerous factories manufacturing NB products for the OEM have established their PLs to compete with the OEM’s NBs⁶. In addition, Proposition 1 provides a blueprint of the entry for the factory, which could guide the factory to establish his PL product and choose an appropriate entry strategy.

4.2 Cases with marketplace channel introduction

In Case IN, the factory manufactures NB products for the OEM, which sells these NB products via the platform’s resale and marketplace channels. Thus, the enterprises’ profit functions are $\pi_F^{IN} = w_0(q_{11} + q_{12})$, $\pi_{OEM}^{IN} = (w_1 - w_0)q_{11} + (p_1 - rp_1 - w_0)q_{12}$ and $\pi_P^{IN} = (p_1 - w_1)q_{11} + r p_1 q_{12}$. Then, we derive the optimal results for Case IN below: $w_0^{IN*} = \frac{(r-5)(r-1)}{10-6r}$, $w_1^{IN*} = \frac{r(7r-18)+15}{20-12r}$, and $p_1^{IN*} = \frac{3}{4}$.

In Case IM, the factory manufactures NB products for the OEM, which sells them via the platform’s resale and marketplace channels. Meanwhile, the factory establishes PL goods and distributes them directly to consumers via the platform’s marketplace channel. Thus, the enterprises’ profit functions are $\pi_F^{IM} = w_0(q_{11} + q_{12}) + p_2 q_2(1 - r)$, $\pi_{OEM}^{IM} = (w_1 - w_0)q_{11} + (p_1 - rp_1 - w_0)q_{12}$ and $\pi_P^{IM} = (p_1 - w_1)q_{11} + p_1 q_{12}r + p_2 q_2 r$. Then, we derive the optimal results for Case IM as follows: $p_1^{IM*} = \frac{(2-\theta)(\theta^2-13\theta+\theta^2r-2\theta r-6r+30)}{2(3\theta^2-25\theta+2\theta^2r-\theta r-8r+40)}$, $p_2^{IM*} = \frac{\theta(\theta^2-13\theta+\theta^2r-2\theta r-6r+30)}{2(3\theta^2-25\theta+2\theta^2r-\theta r-8r+40)}$, $w_0^{IM*} = \frac{(r-1)(\theta^4-14\theta^3+75\theta^2-190\theta+\theta^4r^2-4\theta^3r^2-2\theta^2r^2+18\theta r^2+8r^2+2\theta^4r-21\theta^3r+69\theta^2r-52\theta r-80r+200)}{2(\theta+3r-5)(3\theta^2-25\theta+2\theta^2r-\theta r-8r+40)}$, and $w_1^{IM*} = \frac{\theta^4-22\theta^3+143\theta^2-350\theta+\theta^4r^3-4\theta^3r^3+4\theta^2r^3+6\theta r^3-28r^3+\theta^4r^2-9\theta^3r^2+45\theta^2r^2-146\theta r^2+212r^2+\theta^4r-\theta^3r-80\theta^2r+346\theta r-420r+300}{2(5-\theta-3r)(3\theta^2-25\theta+2\theta^2r-\theta r-8r+40)}$

⁶ <https://baijiahao.baidu.com/s?id=1655789002739035560&wfr=spider&for=pc>

In Case IR, the factory manufactures NB goods for the OEM, which distributes them via the platform's resale and marketplace channels. Meanwhile, the factory establishes PL goods and distributes them to consumers via the platform's resale channel. Thus, the enterprises' profit functions are $\pi_F^{IR} = w_0(q_{11} + q_{12}) + w_2q_2$, $\pi_{OEM}^{IR} = (w_1 - w_0)q_{11} + (p_1 - rp_1 - w_0)q_{12}$ and $\pi_P^{IR} = (p_1 - w_1)q_{11} + p_1q_{12}r + (p_2 - w_2)q_2$. Then, we can get the optimal results for Case IR as follows: $w_0^{IR*} = \frac{(r-1)^2(9\theta^2 - 55\theta + \theta^2r^4 - 7\theta^2r^3 - 4\theta r^3 + 10\theta^2r^2 + 31\theta r^2 + 4r^2 + 3\theta^2r - 44\theta r - 40r + 100)}{2(-5\theta^2 + 51\theta + 2\theta^2r^5 - 12\theta^2r^4 - 10\theta r^4 + 12\theta^2r^3 + 68\theta r^3 + 12r^3 + 7\theta^2r^2 - 95\theta r^2 - 92r^2 - 8\theta^2r - 10\theta r + 180r - 100)}$

$$w_1^{IR*} = \frac{(1-r)(-23\theta^2 + 119\theta + \theta^2r^5 - 4\theta^2r^4 - 8\theta r^4 - 6\theta^2r^3 + 48\theta r^3 + 14r^3 + 17\theta^2r^2 - 37\theta r^2 - 106r^2 - 5\theta^2r - 70\theta r + 210r - 150)}{2(-5\theta^2 + 51\theta + 2\theta^2r^5 - 12\theta^2r^4 - 10\theta r^4 + 12\theta^2r^3 + 68\theta r^3 + 12r^3 + 7\theta^2r^2 - 95\theta r^2 - 92r^2 - 8\theta^2r - 10\theta r + 180r - 100)}$$

$$w_2^{IR*} = \frac{\theta(1-r)(-7\theta^2 + 63\theta + \theta^2r^5 - 6\theta^2r^4 - 6\theta r^4 + 5\theta^2r^3 + 43\theta r^3 + 8r^3 + 9\theta^2r^2 - 69\theta r^2 - 66r^2 - 10\theta^2r - 7\theta r + 152r - 110)}{2(-5\theta^2 + 51\theta + 2\theta^2r^5 - 12\theta^2r^4 - 10\theta r^4 + 12\theta^2r^3 + 68\theta r^3 + 12r^3 + 7\theta^2r^2 - 95\theta r^2 - 92r^2 - 8\theta^2r - 10\theta r + 180r - 100)}$$

$$p_1^{IR*} = \frac{-14\theta^2 + 92\theta + 2\theta^2r^5 - 12\theta^2r^4 - 12\theta r^4 + 11\theta^2r^3 + 79\theta r^3 + 18r^3 + 8\theta^2r^2 - 94\theta r^2 - 138r^2 + \theta^2r - 61\theta r + 270r - 150}{2(-5\theta^2 + 51\theta + 2\theta^2r^5 - 12\theta^2r^4 - 10\theta r^4 + 12\theta^2r^3 + 68\theta r^3 + 12r^3 + 7\theta^2r^2 - 95\theta r^2 - 92r^2 - 8\theta^2r - 10\theta r + 180r - 100)}$$

, and $p_2^{IR*} = \frac{\theta(-12\theta^2 + 128\theta + 6\theta^2r^5 - 2\theta r^5 - 37\theta^2r^4 - 17\theta r^4 + 6r^4 + 41\theta^2r^3 + 185\theta r^3 - 10r^3 + 13\theta^2r^2 - 283\theta r^2 - 178r^2 - 19\theta^2r - 3\theta r + 442r - 260)}{4(-5\theta^2 + 51\theta + 2\theta^2r^5 - 12\theta^2r^4 - 10\theta r^4 + 12\theta^2r^3 + 68\theta r^3 + 12r^3 + 7\theta^2r^2 - 95\theta r^2 - 92r^2 - 8\theta^2r - 10\theta r + 180r - 100)}$.

Lemma 4. When the OEM adds a marketplace channel, we have: (i) if $r < r_4$, $w_0^{IN*} > w_0^{IR*} > w_0^{IM*}$, if $r > r_4$, $w_0^{IR*} > w_0^{IN*} > w_0^{IM*}$; (ii) if $r < r_5$, $w_1^{IN*} > w_1^{IR*} > w_1^{IM*}$, if $r > r_5$, $w_1^{IR*} > w_1^{IN*} > w_1^{IM*}$; (iii) if $r < r_6$, $p_1^{IN*} > p_1^{IR*} > p_1^{IM*}$, if $r > r_6$, $p_1^{IR*} > p_1^{IN*} > p_1^{IM*}$; (iv) $p_2^{IR*} > p_2^{IM*}$.

Lemma 4 shows that if the OEM adds a marketplace channel, the factory's entry via the marketplace channel generates the lowest retail and wholesale prices of both brands, and non-entry might lead to the highest prices, which is similar to Lemma 1. However, Lemma 4 also reveals that when referral fees are large, the factory's entry via the resale channel could generate the highest retail and wholesale prices for both brands. This is because when referral fees are large, the OEM increases the retail price of the NB to cover the substantial marketplace channel usage fees. At this time, both the factory and the platform raise the PL's wholesale and retail price because of the brand competition.

Lemma 5. (1) Comparing Cases IM and IN, we have: (i) when $r < r_7$, $\pi_F^{IM*} > \pi_F^{IN*}$, when $r > r_7$, $\pi_F^{IM*} < \pi_F^{IN*}$; (ii) $\pi_{OEM}^{IM*} < \pi_{OEM}^{IN*}$; (iii) when $\theta < \theta_1$, $\pi_P^{IM*} < \pi_P^{IN*}$, when $\theta > \theta_1$, $\pi_P^{IM*} > \pi_P^{IN*}$.

(2) Comparing Cases IR and IN, we have: (i) $\pi_F^{IR*} > \pi_F^{IN*}$; (ii) $\pi_{OEM}^{IR*} < \pi_{OEM}^{IN*}$; (iii) $\pi_P^{IR*} > \pi_P^{IN*}$.

Similar to Lemma 2, Lemma 5(1) indicates that when the OEM adds a marketplace channel, the factory's entry via the marketplace channel might hurt the factory or the platform, and such entry always harms the profit of the OEM. The logic behind this is identical to Lemma 2, and hence we omit the details for brevity. Furthermore, Lemma 5(2) indicates that when the OEM adds a marketplace channel, the factory's entry via the resale channel always benefits the factory and the platform, but hurts the OEM. The reason behind this is identical to that of Lemma 3, and hence we omit it.

Proposition 2. When the OEM introduces a marketplace channel, if $r < r_8$, the factory chooses entry through the marketplace channel (i.e., $\pi_F^{IM*} > \max\{\pi_F^{IR*}, \pi_F^{IN*}\}$); if $r > r_8$, the factory chooses entry through the resale channel (i.e., $\pi_F^{IR*} > \max\{\pi_F^{IM*}, \pi_F^{IN*}\}$).

Proposition 2 illustrates the choice of the factory's entry strategy when the OEM adds a marketplace channel. Specifically, if referral fees are small, the factory will adopt the marketplace channel to enter the market; otherwise, the factory will enter the end market via the resale channel. The reason behind this is intuitive and identical to that of Proposition 1, and hence we omit the details.

Note that compared with the scenario of the absence of the OEM's marketplace channel, the values of the thresholds change when the OEM introduces a marketplace channel, implying that the OEM's marketplace channel introduction matters. Then, we analyze the role of marketplace channel introduction in Section 4.3.

4.3 Impact of the OEM's marketplace channel introduction

Based on the above lemmas and propositions, this subsection investigates the impact of the OEM's marketplace channel introduction on the firms' payoff and the factory's entry strategy.

Proposition 3. The OEM's marketplace channel introduction may worsen her profit reduction caused by factory entry, i.e., $\Delta\pi_{OEM}^{IM} < \Delta\pi_{OEM}^{NM}$ if $\theta < \theta_3$; $\Delta\pi_{OEM}^{IR} < \Delta\pi_{OEM}^{NR}$ if $\theta < \theta_4$.

As shown in Lemmas 2 and 5, the OEM's profit decreases after introducing the factory's PL products regardless of the OEM's channel strategies. On such a basis, conventional wisdom suggests that the OEM's marketplace channel addition could alleviate her profit reduction brought by factory entry because of the increase in the OEM's selling channels for NB products.

However, surprisingly, our results suggest that the marketplace channel introduction might worsen the OEM's profit reduction caused by factory entry. The reason behind this is as follows. Regardless of the factory's entry modes, when the PL's perceived value is not high (i.e., the brand competition is weak), if the OEM adds a marketplace channel, the OEM's profit increase of adding a marketplace channel is small; however, the factory's entry might greatly reduce the NB product's sales in the traditional resale channel because of the fierce channel competition caused by the OEM's marketplace channel introduction. This leads to the expansion of the OEM's profit loss. That is, due to the OEM's marketplace channel addition, the OEM's profit loss caused by factory entry outweighs her profit increase brought by the entry, as reflected in Proposition 3.

Next, we investigate the impact of the OEM's marketplace channel introduction on the factory's profits. When the factory adopts the entry via the resale channel, the OEM's marketplace channel introduction does not change the factory's strategy choice by comparing Lemmas 3 and 5. However, when the factory adopts the entry via the marketplace channel, the OEM's marketplace channel introduction has an important impact on the profits of the factory, which can be seen in Proposition 4.

Proposition 4. *Given the factory adopts the entry via a marketplace channel, when $\theta < \widehat{\theta}_1$, the OEM's marketplace channel introduction reduces the probability of factory entry; when $\theta > \widehat{\theta}_1$, this introduction increases the probability of factory entry.*

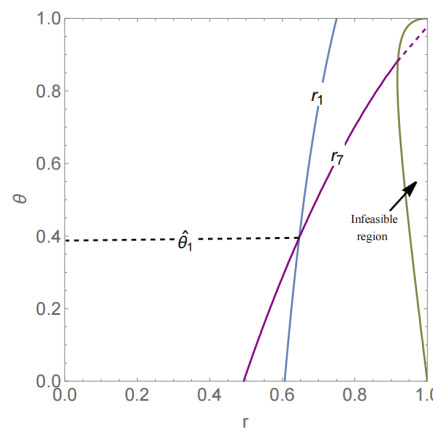


Fig. 3. r_1 and r_7 as functions of θ

Proposition 4 analyzes how the OEM's introduction of a marketplace channel affects the attractiveness of marketplace entry for the factory. Specifically, when the PL's perceived value is low, the OEM's marketplace channel introduction reduces the probability of the factory's entry via the marketplace channel; otherwise, it increases the probability of the factory's entry. Recalling Lemmas 2 and 5, we know that if the OEM does not introduce a marketplace channel, when $r < r_1$, the factory chooses the entry via the marketplace channel; when $r > r_1$, he chooses non-entry. If the OEM introduces a marketplace channel, when $r < r_7$, the factory adopts the entry through the marketplace channel; when $r > r_7$, he chooses non-entry. By comparison, it is shown that when $\theta < \widehat{\theta}_1$, $r_1 > r_7$ (see Fig. 3), which implies that the OEM's marketplace channel addition reduces the probability that the factory's entry via the marketplace channel. Conversely, when $\theta > \widehat{\theta}_1$, $r_1 < r_7$, implying that the OEM's marketplace channel addition raises the probability of the factory's entry. Proposition 4 suggests that whether the factory builds his PL product might be affected by the OEM's marketplace channel introduction decision. In particular, if the PL's perceived value is high, the factory prefers to choose the entry. This result could provide guidance for the factory when deciding on the PL introduction.

Proposition 5. *When $\theta < \widehat{\theta}_2$, the OEM's marketplace channel introduction reduces the probability that the factory's entry via the marketplace channel; when $\theta > \widehat{\theta}_2$, it raises the probability that the factory's entry via the marketplace channel.*

Proposition 5 reveals that when the PL's perceived value is low (i.e., $\theta < \widehat{\theta}_2$, and we can see the threshold $\widehat{\theta}_2$ in Fig. 4), the OEM's marketplace channel addition reduces the possibility of the factory's entry through the marketplace channel. However, when the PL's perceived value is high, the OEM's marketplace channel introduction increases the probability that the factory enters the end market through the marketplace channel. The logic behind this is similar to Proposition 4, and hence, we omit the analysis process for brevity.

Propositions 4 and 5 contribute to the factory entry literature by considering the role of the marketplace channel introduction in the factory's entry strategy and further showing that such marketplace channel introduction matters. Therefore, factory managers need to carefully consider the impacts of the OEM's channel modes when deciding their PL introduction and entry channel selection.

5. Equilibrium strategies

This section investigates the final equilibrium strategy (i.e., the marketplace channel introduction decision for the OEM).

Before we proceed, we first discuss the OEM's marketplace channel introduction under different factory entry strategies.

Lemma 6. *Regardless of the factory's entry strategies, the OEM always chooses to introduce a marketplace channel, i.e., $\pi_{OEM}^{IN*} > \pi_{OEM}^{NN*}$, $\pi_{OEM}^{IM*} > \pi_{OEM}^{NM*}$ and $\pi_{OEM}^{IR*} > \pi_{OEM}^{NR*}$.*

Lemma 6 shows that the OEM always introduces a marketplace channel regardless of factory entry strategies. This is because no matter which strategy the factory uses to encroach on the OEM's territory, the addition of the marketplace channel could induce the OEM to raise the whole sales volume of her NB products, which is always beneficial to the OEM. This finding echoes Zhang et al. (2022) and could help explain why a growing number of OEMs choose to add a marketplace channel besides the traditional resale channel in reality.

Proposition 6. *When $r > r_3$, the equilibrium outcome is Case IR; when $r_8 < r < r_3$ and $\theta > \theta_2$, the equilibrium outcome is Case NR; otherwise, the equilibrium outcome is Case IM.*

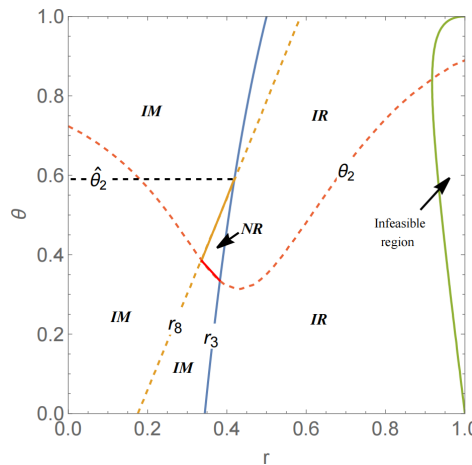


Fig. 4. The final equilibrium outcomes.

Fig. 4 further shows the final equilibrium outcomes. Specifically, if referral fees are small, the OEM will introduce a marketplace channel, and the factory will establish a PL to enter the market through the marketplace channel. If referral fees are large, the OEM will add a marketplace channel, but the factory will establish a PL to enter the market through the resale channel. If referral fees and the PL's perceived value are moderate, the OEM will not introduce a marketplace channel, and the factory will establish a PL to encroach via the resale channel. Note that the factory always chooses to enter the OEM's market territory, and the reason is that entering the end market is the dominant strategy for the factory (see Propositions 1 and 2). Interestingly, the OEM might give up introducing a marketplace channel to guide the factory to adopt the entry via the resale channel. Recall that no matter which strategy the factory uses to encroach, the addition of the marketplace channel could induce the OEM to raise her NB's sales volume, which is always beneficial to the OEM (see Lemma 6). However, when the referral fee and the PL's perceived value are moderate, if the OEM introduces a marketplace channel, the factory will adopt entry via the marketplace channel; if the OEM does not add a marketplace channel, the factory will choose the entry through the resale channel (see Proposition 5). In this case, the factory's entry via the resale channel could help weaken the brand competition, thus benefiting the OEM. Therefore, when the referral fee and the PL's perceived value are moderate, the OEM will first choose not to introduce a marketplace channel to induce the factory to use the entry via the resale channel (i.e., first-mover advantage). In other words, to deal with factory entry, the OEM might utilize her first-mover advantage to induce the factory's entry strategy choice.

Proposition 6 illustrates the interplay of the OEM's marketplace channel introduction and the factory's entry model choice and further suggests that firm managers need to assess the impacts of factory entry (the OEM's marketplace channel introduction) when considering the OEM's marketplace channel introduction (the factory's entry strategy).

6. Extended model—another game sequence

In the baseline model, we assume that the OEM's marketplace channel introduction precedes the factory's entry strategy. In practice, however, the factory's entry strategy may precede the OEM's marketplace channel introduction. With this in mind, we investigate this scenario to study the impact of the strategy decision sequence. By using the subgame results in Section 4, we derive the equilibrium outcome of the whole game when the factory first sets the entry strategy.

Proposition 7. *When $r < r_8$, the equilibrium outcome is Case IM; when $r > r_8$, the equilibrium outcome is Case IR.*

Proposition 7 shows the equilibrium outcome of the whole game when the factory first sets the entry strategy. Specifically,

when referral fees are small, the factory uses the entry via the marketplace channel, and then the OEM introduces a marketplace channel. When referral fees are large, the factory adopts the entry via the resale channel, and then the OEM adds a marketplace channel. Note that compared with the baseline model, we show that when the factory first chooses the entry strategy, the OEM always introduces a marketplace channel. This is because regardless of factory entry strategies, introducing a marketplace channel is always the dominant strategy for the OEM (see Lemma 6). Furthermore, we show that as the PL's perceived value increases, the factory is willing to choose the entry through the marketplace channel (i.e., $\frac{\partial r_g}{\partial \theta} > 0$). The intuition is that with the increase of the PL's perceived value, the factory favors mastering the PL product's pricing power to better compete with the NB product.

Furthermore, there exists a first-mover advantage for the factory and the OEM. Specifically, when the PL's perceived value is moderate, if the OEM moves first, Case NR is the equilibrium outcome; if the factory first sets his entry strategy, Case IR is the equilibrium outcome. In this case, the OEM's first move (i.e., introducing a marketplace channel) induces the factory to enter the market via the resale channel, which makes the OEM better off (i.e., the OEM's first-mover advantage). However, the factory's first move (i.e., setting his entry strategy) makes the OEM add the marketplace channel, which benefits the factory (i.e., the factory's first-mover advantage). Therefore, when firm managers make strategy decisions, they need to seriously assess the impacts of the strategy decision sequence.

7. Conclusion

This paper investigates the interplay between factory entry and the OEM's marketplace channel addition, which has been ignored by the existing literature. In a three-tier supply chain, an OEM outsources her NB's manufacturing services to a factory and sells these NB products through the platform's resale channel. To squeeze more profits, the OEM may add a marketplace channel on the platform, while the factory decides whether to establish a PL and sell PL goods through the marketplace or resale channels on the platform. Our study builds on and importantly extends the dialogue started by Chen et al. (2019) and Xi and Zhang (2023) by considering how the factory's entry strategy interacts with the OEM's marketplace channel introduction. This perspective yields novel insights with significant managerial implications.

First, our results show that regardless of the OEM's channel strategies, the factory's entry through the marketplace channel not only decreases the OEM's profit, but also may hurt the platform or the factory; while the entry through the resale channel always benefits the platform and the factory, but harms the OEM. Furthermore, given the OEM's channel introduction strategy, the factory always chooses a suitable channel to establish his PL and enter the end market, which makes the factory better off.

Second, consistent with the conventional wisdom, we show that when the referral fee is not high, the introduction of the OEM's marketplace channel could effectively reduce her profit loss caused by factory entry. However, we also find that the OEM's channel introduction may aggravate her profit loss brought by factory entry when the referral fee is high. Moreover, we show that when the perceived value of the PL's product is low, the OEM's marketplace channel introduction reduces the possibility of the factory's entry through the marketplace channel; when the perceived value of the PL's product is high, this channel introduction raises the possibility of the factory's entry via the marketplace channel.

Third, we obtain the final equilibrium results and reveal that when the referral fee is low, the OEM introduces a marketplace channel, and then the factory enters the market via the marketplace channel. When the referral fee is high, the OEM introduces a marketplace channel, and then the factory adopts the entry via the resale channel. Surprisingly, when the referral fee and the PL's perceived value are moderate, to cope with factory entry, the OEM chooses not to introduce a marketplace channel to induce the factory to adopt the resale channel, which makes the OEM better off. In addition, the extended model examines another scenario in which the entry strategy of the factory precedes the OEM's channel introduction, and shows that the timing of strategy decision is important and there may exist a first-mover advantage for both the factory and the OEM.

Our results carry several important managerial insights for the factory, the OEM and the platform. First, we suggest that the factory should seize the convenience provided by the platform and actively establish his PL products. This finding is consistent with reality. Under the support of the e-commerce platform, numerous factories have built their PL products to compete with the OEM's NB products. Furthermore, our results present a road map for the factory to choose the entry model. When the referral fee is low, the factory should select the entry through the marketplace channel; otherwise, the factory should adopt the resale channel to enter the market. Meanwhile, the factory should consider the impact of the PL's perceived value and strategy decision timing when deciding his entry strategy. Second, our results offer a theoretical basis for the introduction of the OEM's marketplace channel. For example, although the marketplace channel introduction may increase the sales of the OEM's NB products, the OEM may choose not to add a marketplace channel to guide the factory to use the resale channel, which benefits the OEM. These conclusions contribute to the channel introduction literature by showing the interactions of the factory entry strategy and the marketplace channel introduction. Third, our findings suggest that in most cases, it is profitable for the platform to actively encourage upstream factories to establish their PLs and sell them through the platform. In reality, a growing number of platforms (e.g., Pinduoduo and Suning.com) support and encourage upstream factories to establish their PL products to sell them on the platforms. However, we also find that when the referral fee is low, the factory's entry via the marketplace may harm the platform. Therefore, when the platform encourages the factory to establish his PL

products, it should carefully pay attention to the impacts of the entry model and the referral fee.

There exist some possible directions for future research. First, the firms may have different leader-follower relationships, and one can study the impact of the leader-follower relationship on the equilibrium outcome in the future. Second, we assume that the information among the firms is symmetrical. Future research can examine factory entry and the OEM's marketplace channel addition in the situation of information asymmetry. Third, this paper utilizes game theory to derive several theoretical findings. In the future, empirical research on factory entry could be carried out to supplement and extend these findings.

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Appendix

Proof of Lemma 1.

By comparative analysis, we show that $w_0^{NN^*} - w_0^{NR^*} = 0$, $w_0^{NR^*} - w_0^{NM^*} = \frac{\theta(\theta+30r^2+40r-15r-1)}{2(50+30r-16)} > 0$, $w_1^{NN^*} - w_1^{NR^*} = \frac{\theta}{4} > 0$, $w_1^{NR^*} - w_1^{NM^*} = \frac{\theta(6+60r^2+90r-31r-1)}{4(50+30r-16)} > 0$, $p_1^{NN^*} - p_1^{NR^*} = \frac{\theta}{8} > 0$, $p_1^{NR^*} - p_1^{NM^*} = \frac{\theta(70+90r-3r-29)}{8(50+30r-16)} > 0$, and $p_2^{NR^*} - p_2^{NM^*} = \frac{\theta(90+30r-20)}{4(50+30r-16)} > 0$. Thus, we can obtain Lemma 1.

Proof of Lemmas 2-6.

Similar to Lemma 1, we can prove Lemmas 2-6. It is noted that $r_1 = -\frac{80+\sqrt{640(40-43)+3721}-61}{240}$. Furthermore, r_2, r_4, r_5, r_6, r_7 and θ_1 are the only meaningful root of the equations $2310 + 1440^2r^3 + 4800^2r^2 - 15450r^2 + 3360^2r - 24620r + 4128r - 352 = 0$, $200 + \theta r^6 - 70r^5 - 2r^5 + 190r^4 + 7r^4 - 530r^3 + 35r^3 + 960r^2 - 123r^2 - 920r + 119r - 20 = 0$, $1550 + 80r^7 - 800r^6 - 22r^6 + 2920r^5 + 240r^5 - 5050r^4 - 969r^4 + 3600r^3 + 2008r^3 + 1020r^2 - 2352r^2 - 3480r + 1536r - 425 = 0$, $130 + 20r^5 - 120r^4 - 6r^4 + 140r^3 + 46r^3 + 50r^2 - 97r^2 - 260r + 92r - 31 = 0$, $-100^3 + 650^2 + 100 + 60^3r^3 - 240^2r^3 + 60r^3 + 117r^3 + 20^3r^2 - 660^2r^2 + 3640r^2 - 815r^2 - 140^3r + 1250^2r - 5760r + 1235r - 425 = 0$ and $-4000^5 + 48000^4 - 184000^3 + 240000^2 - 100000 + 360^7r^7 - 2880^6r^7 + 1080^5r^7 + 28440^4r^7 - 14760^3r^7 - 104760^2r^7 - 1170r^7 + 8928r^7 - 120^7r^6 - 8400^6r^6 + 93960^5r^6 - 199440^4r^6 - 492360^3r^6 + 1285080^2r^6 + 924900r^6 - 154272r^6 - 1520^7r^5 + 26440^6r^5 - 67000^5r^5 - 813840^4r^5 + 4179940^3r^5 - 2288600^2r^5 - 11637310r^5 + 1018752r^5 - 240^7r^4 + 25840^6r^4 - 456200^5r^4 + 2804840^4r^4 - 4177680^3r^4 - 16504240^2r^4 + 51785240r^4 - 3191360r^4 + 1800^7r^3 - 38720^6r^3 + 270030^5r^3 + 275960^4r^3 - 12448800^3r^3 + 57663160^2r^3 - 96656750r^3 + 4773600r^3 + 1000^7r^2 - 29600^6r^2 + 429100^5r^2 -$

$$3735720^4 r^2 + 19349560^3 r^2 - 54925800^2 r^2 + 72134500 r^2 - 2996000 r^2 + 3000^6 r - 72450^5 r + 740400^4 r - 4008700^3 r + 11263000^2 r - 13621250 r + 440000 r = 0, \text{ respectively.}$$

Proof of Proposition 1.

By comparative analysis, we show that when $r < r_3$, $\pi_F^{NM^*} > \text{Max}\{\pi_F^{NR^*}, \pi_F^{NN^*}\}$; when $r > r_3$, $\pi_F^{NR^*} > \text{Max}\{\pi_F^{NM^*}, \pi_F^{NN^*}\}$, where $r_3 = -\frac{110-61+\sqrt{\theta(730-2350)+3721}}{240}$.

Proof of Proposition 2.

Similar to Proposition 1, we can derive Proposition 2. Note that r_8 is the only meaningful root of the equation $-50^5 + 1030^4 - 7330^3 + 20790^2 - 15900 + 20^5 r^7 - 80^4 r^7 + 60^3 r^7 + 370^2 r^7 - 160 r^7 - 80^5 r^6 + 40^4 r^6 + 1280^3 r^6 - 5050^2 r^6 + 120 r^6 + 56 r^6 - 100^5 r^5 + 1890^4 r^5 - 8020^3 r^5 + 14460^2 r^5 + 16460 r^5 - 550 r^5 + 190^5 r^4 - 1160^4 r^4 + 640^3 r^4 + 15720^2 r^4 - 87420 r^4 + 978 r^4 + 180^5 r^3 - 2830^4 r^3 + 13320^3 r^3 - 48190^2 r^3 + 113960 r^3 + 3788 r^3 - 140^5 r^2 + 290^4 r^2 + 2790^3 r^2 + 3840^2 r^2 - 11680 r^2 - 11276 r^2 - 180^5 r + 2180^4 r - 7340^3 r + 5940^2 r - 22420 r + 8410 r - 1150 = 0$.

Proof of Proposition 3.

We assume that $\Delta \pi_{OEM}^{IM} = \pi_{OEM}^{IN^*} - \pi_{OEM}^{IM^*}$, $\Delta \pi_{OEM}^{NM} = \pi_{OEM}^{NN^*} - \pi_{OEM}^{NM^*}$, $\Delta \pi_{OEM}^{IR} = \pi_{OEM}^{IN^*} - \pi_{OEM}^{IR^*}$ and $\Delta \pi_{OEM}^{NR} = \pi_{OEM}^{NN^*} - \pi_{OEM}^{NR^*}$. By comparative analysis, we have $\Delta \pi_{OEM}^{IM} < \Delta \pi_{OEM}^{NM}$ if $\theta < \theta_3$; $\Delta \pi_{OEM}^{IR} < \Delta \pi_{OEM}^{NR}$ if $\theta < \theta_4$. Note that θ_3 and θ_4 are the only meaningful roots of the equations $144000^8 - 3760250^7 + 39236000^6 - 203499500^5 + 495600000^4 - 143236250^3 - 1935300000^2 + 3834000000 + 6480^9 r^9 - 51840^8 r^9 - 19440^7 r^9 + 686880^6 r^9 - 226800^5 r^9 - 3246480^4 r^9 + 513540^3 r^9 + 4639680^2 r^9 + 19440^9 r^8 - 406080^8 r^8 + 2334960^7 r^8 - 743040^6 r^8 - 22897080^5 r^8 + 28625400^4 r^8 + 67607190^3 r^8 - 67560480^2 r^8 - 49023360 r^8 - 16560^9 r^7 - 296640^8 r^7 + 8085600^7 r^7 - 49808160^6 r^7 + 70233840^5 r^7 + 253335240^4 r^7 - 657340920^3 r^7 - 174568320^2 r^7 + 747279360 r^7 + 13031424 r^7 - 101520^9 r^6 + 2020800^8 r^6 - 9534600^7 r^6 - 46629480^6 r^6 + 537886380^5 r^6 - 1441067400^4 r^6 - 68162520^3 r^6 + 4754330880^2 r^6 - 2985223680 r^6 - 215992320 r^6 - 58000^9 r^5 + 2917440^8 r^5 - 44492900^7 r^5 + 281437720^6 r^5 - 579921240^5 r^5 - 1704992280^4 r^5 + 10419012640^3 r^5 - 14415292160^2 r^5 - 4026936320 r^5 + 1379973120 r^5 + 114000^9 r^4 - 1845440^8 r^4 - 3508090^7 r^4 + 264508080^6 r^4 - 2301910300^5 r^4 + 8936062120^4 r^4 - 14170859180^3 r^4 - 7859320640^2 r^4 + 52068965120 r^4 - 4308101120 r^4 + 150000^9 r^3 - 4834240^8 r^3 + 64898280^7 r^3 - 439723920^6 r^3 + 1345541280^5 r^3 + 938474520^4 r^3 - 22704639080^3 r^3 + 79211120000^2 r^3 - 121436185600 r^3 + 6929254400 r^3 + 50000^9 r^2 - 1815360^8 r^2 + 33784460^7 r^2 - 381588840^6 r^2 + 2787758100^5 r^2 - 13687080600^4 r^2 + 45198757000^3 r^2 - 95312512000^2 r^2 + 113037632000 r^2 - 5543680000 r^2 + 363200^8 r - 9139700^7 r + 107175800^6 r - 800637000^5 r + 4166477000^4 r - 14727234500^3 r + 32547400000^2 r - 39301760000 r + 1921280000 r - 224000000 = 0$ and $6250^4 - 118000^3 + 739250^2 - 1608500 + 1600^3 r^{13} + 360^4 r^{12} - 26560^3 r^{12} - 11680^2 r^{12} - 5520^4 r^{11} + 177040^3 r^{11} + 200640^2 r^{11} + 28240 r^{11} + 32680^4 r^{10} - 608920^3 r^{10} - 1393280^2 r^{10} - 501040 r^{10} - 2256 r^{10} - 93000^4 r^9 + 1142120^3 r^9 + 5098000^2 r^9 + 3599680 r^9 + 41344 r^9 + 120960^4 r^8 - 1077960^3 r^8 - 10759440^2 r^8 - 13679680 r^8 - 308304 r^8 - 17600^4 r^7 + 347620^3 r^7 + 13348600^2 r^7 + 30239940 r^7 + 1224672 r^7 - 118070^4 r^6 - 192800^3 r^6 - 9615150^2 r^6 - 39905340 r^6 - 2855360 r^6 + 71020^4 r^5 + 804380^3 r^5 + 5083060^2 r^5 + 30873380 r^5 + 3999584 r^5 + 63310^4 r^4 - 538680^3 r^4 - 4501890^2 r^4 - 15106300 r^4 - 3171520 r^4 - 49000^4 r^3 - 471060^3 r^3 + 3209840^2 r^3 + 10353180 r^3 + 1012640 r^3 - 23250^4 r^2 + 511720^3 r^2 + 562030^2 r^2 - 11039780 r^2 + 349200 r^2 + 12500^4 r + 43100^3 r - 1949100^2 r + 6741100 r - 380000 r + 90000 = 0$, respectively.

Proof of Propositions 4-7.

By using backward induction, we can prove Propositions 4-7, which is omitted due to similarity.



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