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Strategic channel decisions for the supplier and specialized e-retailer in the presence of a third-party marketplace

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Abstract

With the advancement of e-commerce and the intensification of market competition, many suppliers have leveraged third-party online marketplaces to expand their sales channels and bolster competitiveness. This poses potential threats to e-retailers specializing in the core business of certain categories. This study examines a specialized e-retailer's selling mode choice (reselling, in-marketplace selling, or agency selling mode) and how this choice interacts with a supplier's channel strategy (marketplace, e-retailer, or both/dual channels) in the presence of a third-party marketplace. Our findings indicate that (1) the e-retailer's optimal selling mode is contingent on the supplier's sales service quality and efficiency, and the e-retailer's market occupation. Generally, when initially occupying a small market, the e-retailer prefers selling in a third-party marketplace, whereas when the initial market is relatively large, the e-retailer is more inclined to opt for the reselling (agency selling) mode if the supplier's sales efficiency is low (high). Additionally, if the supplier's sales service quality is low, the e-retailer will never choose the agency selling mode. (2) Exclusively introducing the marketplace channel is not the optimal choice for the supplier. Instead, adopting a dual channel is better when the direct selling cost is not too high. (3) Under certain scenarios, the supplier can manipulate the e-retailer's channel by introducing the marketplace channel and offering a reference price without actually selling any products.

Keywords: third-party marketplace; specialized e-retailer; selling mode choice; channel strategy

1. Introduction

Over the past three decades, the popularity of e-commerce has spawned the rapid development of third-party online marketplaces (3P marketplaces), which has bought new opportunities for supply

chain participants. On the one hand, 3P marketplaces directly connect suppliers and consumers, thereby streamlining intermediate links within supply chains (Shi et al., 2022). Compared to traditional distribution channels, suppliers can autonomously set their selling prices in marketplace channels, effectively circumventing the negative impact of the double-marginalization problem. However, owing to network effects, 3P marketplaces usually possess a broad and diverse consumer base, thereby offering retailers the opportunity to access a larger pool of potential consumers and expand their markets. According to a survey, after joining Taobao.com (one of the largest online shopping platforms in China), the online consumer groups for two major electronics and appliance suppliers, Suning and Gome, both increased by approximately 45%.

The emergence of 3P marketplaces has had a profound impact on the operations and transformation of specialized e-retailers. Specialized e-retailers are online retail firms that specialize in core businesses of certain categories. For example, Suning.com and Gome.com.cn specialize in selling electrical appliances, Dangdang.com in selling books, and Dazadi.com in sports equipment and game rooms (heavy and cumbersome items). Owing to e-retailers' expertise in selling specific product categories, consumers can expect to gain value added from purchases made through these channels. With the rise of 3P marketplaces, traditional e-retailers have undergone significant transformations seeking to adopt more suitable selling modes. For example, Gome.com.cn and Suning.com established flagship stores on Taobao.com (in-marketplace selling mode) to expand their consumer base. Dangdang.com employs diverse selling modes according to product type. In particular, for audio-visual products such as books, music, film, and television, Dangdang adheres to its traditional reselling mode, where it procures products from suppliers at wholesale prices and then sells them to platform customers at higher retail prices, thereby earning profits from price differences. For home appliances and digital products, Dangdang chooses to transform into a marketplace, leasing its online stores to suppliers and charging them sales referral fees (agency selling mode). However, Dangdang chooses to sell daily necessities by opening a flagship store on Taobao.com, a large 3P marketplace (in-marketplace selling mode). To avoid channel conflicts, some suppliers opt for a single channel, either Dangdang or Taobao.com (i.e., sell directly through Taobao.com), while others embrace both channels.

Driven by the potential for market expansion and the desire to overcome the double-marginalization issue, many suppliers are inclined to join 3P marketplaces. According to a survey conducted by China Computer News in 2013, nearly 100% of the interviewed enterprises expressed interest in embracing 3P marketplaces, but only 37.05% had introduced such channels for various reasons. On the one hand, if suppliers introduce a 3P marketplace channel and sell the same products, their retail partners (such as specialized e-retailers) may treat it as an encroachment (Tahirov and Glock, 2022), which could potentially lead to horizontal channel competition and reduced profit margins in retail channels. On the other hand, low sales efficiency is another hindrance preventing suppliers from joining marketplaces. A manager of AIDE, a small home appliance manufacturing enterprise in China, states, "Due to the limitation of business scope, we are not experts in market information collection, marketing planning, and after-sales management. This eliminates our motivation for direct selling." Instead, selling through reselling channels owned by specialized e-retailers is a viable option. Therefore, suppliers must decide which channel(s) to introduce (e-retailer, marketplace, or both; hereafter referred to as suppliers' channel strategy).

Considering the aforementioned discussion, in the presence of 3P marketplaces, exploring how specialized e-retailers should choose their selling modes and what channels suppliers should

introduce is essential. While considerable scholarly attention has been directed toward e-retailers' selling mode choices, research in this domain has predominantly focused on the trade-off between reselling and agency selling modes. With the recent diversification of channel strategies employed by e-retailers (e.g., Dangdang), a notable gap exists in understanding the relative effectiveness and constraints of these strategies. Drawing inspiration from these observations, this study addresses the following questions:

1. Which selling mode (reselling, agency selling, or in-marketplace selling) should a specialized e-retailer adopt to counteract the 3P marketplace? What are the advantages and disadvantages of the three modes?
2. Which channel should a supplier introduce (marketplace, e-retailer, or both/dual channels)? What is the interaction between the supplier's channel strategy and the e-retailer's selling mode choice?
3. How do consumers' channel choices vary under different channel structures?

To address these questions, we consider a supply chain comprising a supplier (she), *specialized* e-retailer (he), and an online marketplace. The e-retailer first chooses the selling mode (reselling, in-marketplace selling, or agency selling), and the supplier then determines her channel strategy (marketplace, e-retailer, or both/dual). Our study derives several important findings. First, the e-retailer's selling mode choice is closely related to the supplier's sales service quality, sales efficiency, and the e-retailer's market occupation. Generally, the e-retailer prefers to sell in the 3P marketplace when he initially occupies a small market. By contrast, when the initial market is relatively large, the e-retailer prefers the reselling (agency selling) mode if supplier sales efficiency is low (high). If the supplier's sales service quality is low, the e-retailer will never choose the agency selling mode. Second, exclusively introducing a marketplace channel is not a wise choice for the supplier. Instead, she could be better off by introducing the marketplace channel in addition to the e-retailer channel when the cost of direct selling is not excessively high. Third, in some cases, suppliers may opt to introduce a marketplace channel and provide a reference price without selling products through it. In this sense, the marketplace channel serves not only as a direct selling method but also as a vital counterbalance to manipulate the e-retailer channel.

This study contributes to the literature on multichannel competition in several ways. First, while a stream of literature has investigated channel competition between retailers and 3P marketplaces (Yan et al., 2018; Yan et al., 2019; Xu et al., 2021; Ha et al., 2022; Shen et al., 2022), few studies have examined the intricacies of channel competition among specialized e-retailers, 3P marketplaces, and suppliers. Our study contributes directly to the understanding of specialized e-retailers' selling mode choices to counteract supplier encroachment through the marketplace channel. In particular, both specialized e-retailer and supplier can choose to sell in the online 3P marketplace, thereby competing in the same channel. Second, existing studies on the e-retailer's selling mode strategy primarily focus on e-retailers' preferences for agency selling or reselling (Hagiu and Wright, 2015; Abhishek et al., 2016; Tian et al., 2018; Zhang and Zhang, 2020) or explore whether the e-retailer should introduce the in-marketplace selling mode to compensate for traditional reselling (Ryan et al., 2012; Shi et al., 2021; Liu et al., 2022; Zhen et al., 2022). Inspired by industrial practices, we allow the e-retailer to choose from the reselling, in-marketplace selling, or agency selling modes. To the best of our knowledge, we are among the first to comprehensively consider all three selling

modes for an e-retailer. Furthermore, we propose a novel strategic role of the marketplace channel by demonstrating that it not only enables the supplier to sell directly but also serves as a counterbalance for the supplier to manipulate the price in the e-retailer channel.

The remainder of this paper is organized as follows: The relevant literature is reviewed and summarized in Section 2. Section 3 describes the setup of our basic model and introduces the benchmark model. In Sections 4–6, we discuss the supplier's channel strategy and the two firms' optimal operational decisions when the retailer chooses reselling, in-marketplace, or agency selling mode, respectively. In Section 7, we explore the retailer's optimal selling mode choice and the supplier's optimal channel strategy for the whole game. Section 8 concludes the paper with a discussion of the managerial insights and directions for future research. All proofs are provided in the Appendix.

2. Literature review

Our study is closely related to the research on retailers'' selling channel selection/design and competition (Yaghin, 2020; Zhang et al., 2021; Zhang and Wu, 2022; Zhen et al., 2022; Li et al., 2023; Sigue and Gromova, 2023; Wang et al., 2024). In recent decades, substantial scholarly attention has been devoted to exploring e-retailers' selling mode choices between reselling and agency selling modes. Hagiu (2007) was one of the first to study this issue and established that e-retailers prefer the reselling mode with a large economic scale in distribution, whereas they lean toward agency selling when faced with asymmetric information concerning product quality. Motivated by Hagiu (2007), a few scholars study e-retailers' selling mode choice in various contexts. Abhishek et al. (2016) address this critical question by considering the cross-channel effect. They demonstrate that in the presence of a negative spillover between online and offline channels, the e-retailer favors agency selling; otherwise, the reselling mode is preferred. Based on Abhishek et al. (2016), Wang et al. (2021) consider sales efficiency and suggest that an e-retailer should choose a reselling strategy if the selling efficiencies in the two channels are either significantly different or sufficiently close; otherwise, a marketplace strategy is the choice. Zhang and Zhang (2020) extend the work of Abhishek et al. (2016) to incorporate asymmetric information and find that when the supplier's offline entry cost is very small or sufficiently large, the e-retailer shares information under the agency selling mode and keeps information private under the reselling mode. Chen et al. (2023) and Sigue and Gromova (2023) demonstrate the significant role of advertising in channel members' selling mode choice. As the landscape of 3P marketplaces continues to expand and medium-sized specialized e-retailers gain prominence, an emerging area of research explores the conditions under which such e-retailers choose to sell their products within 3P marketplaces, referred to as "in-marketplace selling." Recent findings suggest that several key factors influence the desirability of adopting this mode (or introducing a 3P marketplace channel), including a reduced referral fee rate (Shi et al., 2021), a higher fraction of market expansion (Liu et al., 2022), and the interplay between moderate channel competition and spillover effects (Zhen et al., 2022).

In light of this evolving landscape, the existing body of literature examining retailers' choices between reselling and agency selling options typically does not consider the 3P marketplace channel. Similarly, research on the decision to sell products within a 3P marketplace predominantly focuses on the choice between reselling and in-marketplace selling modes. In contrast to this prevailing research landscape, we draw inspiration from real-world industrial practices and adopt an innovative

approach by allowing the retailer to select their preferred selling mode from a comprehensive array of options encompassing reselling, agency selling, and in-marketplace selling modes. Our study affords specialized e-retailers and suppliers the flexibility to explore the online marketplace as a viable avenue for product distribution. To the best of our knowledge, our study represents a pioneering effort to holistically examine all three selling modes for e-retailers, namely, reselling, in-marketplace selling, and agency selling.

Another closely aligned stream of literature concerns supplier channel selection in supply chains. Considering the diverse channels available, the choice of channels has garnered considerable attention and is regarded as a pivotal marketing strategy for suppliers. A substantial body of literature has explored suppliers' channel designs (Chen et al., 2008). An important question is whether suppliers should venture into establishing their own direct selling channel and the ensuing consequences for supply chain participants. This topic has been investigated from various perspectives including quality control (Ha et al., 2015; Cui, 2019; Guan et al., 2019), advertising (Zhang et al., 2020), service investment (Yoon, 2016; Zhang et al., 2019), and asymmetric information (Li et al., 2014; Huang et al., 2018; Hu et al., 2021; Lin et al., 2024). Most of these studies suggest that the introduction of a direct channel benefits suppliers but has negative repercussions for retailers. Additionally, some studies argue that substantial channel construction investment can deter suppliers from opening online stores (Huang et al., 2018). Over the past two decades, 3P marketplaces have provided suppliers with new ways to sell directly, without investing in channel construction. Consequently, a series of emerging studies has investigated suppliers' channel strategy in terms of whether to introduce a 3P marketplace channel and its impact. Yan et al. (2018) are among the first to investigate how online spillover effects impact the supplier's strategy for introducing the marketplace channel. They find that a higher level of online spillover incentivizes the supplier to do so, which potentially reduces the e-retailer's profit when spillover is sufficiently high. Yan et al. (2019) further explore the impact of the supplier's sales efficiency and suggest that it should introduce the marketplace channel when direct selling efficiency is sufficiently high or low, thereby benefiting both supply chain members. Motivated by Yan et al. (2018, 2019), a few studies have explored suppliers' strategy for marketplace channel introduction in different contexts, including price competition (Shi et al., 2021), logistics service (Zhang and Ma, 2022), and closed-loop supply chain (Jia and Li, 2020). Rather than investigating the supplier's channel strategy, Ryan et al. (2012) and Liu et al. (2022) provide suggestions for e-retailers to introduce marketplace channels. Zhen and Xu (2021) further investigate who (e-retailer, supplier, or both) should introduce the marketplace channel.

Zhang and Zhang (2020) and Wang et al. (2021) investigate the supplier's channel choice between reselling and marketplace channels. By contrast, Yan et al. (2019), Jia and Li (2020), and Zhang and Ma (2022) focus on whether the supplier should introduce a marketplace channel as a complement to the reselling channel. Zhen and Xu (2021) take a further step by exploring who (e-retailer, supplier, or both) should introduce the marketplace channel. Note that in Zhen and Xu (2021), the retailer only provides a reseller channel for the supplier. Building upon Zhen and Xu (2021), we investigate a distinct scenario in which both the supplier and e-retailer have the option to participate and vend within the 3P marketplace. Furthermore, the e-retailer can function as a platform, thereby empowering the supplier with absolute control over prices (agency selling).

To clarify our contribution, the main connections and differences between our work and related literature are summarized in Table 1. First, in terms of the retailer's selling mode choice, some

Table 1
Comparison of related studies

	E-retailer's selling mode choice			Supplier's channel strategy		
	Reselling	Agency selling	In-marketplace selling	Introducing the e-retailer channel	Introducing the marketplace (direct) channel	Introducing both the e-retailer channel and the marketplace channel (dual channel)
Hagiu (2007)	√	√				
Abhishek et al. (2016)	√	√		√	√	√
Yan et al. (2019)				√	√	
Jia and Li (2020)				√		√
Zhang and Ma (2022)				√	√	√
Ryan et al. (2012)	√		√			
Liu et al. (2022)	√		√	√	√	√
Shi et al. (2021)	√		√	√	√	√
Zhen and Xu (2021)	√		√	√	√	√
Yan et al. (2018)	√	√		√	√	√
Zhang and Zhang (2020)	√	√		√	√	
Our work	√	√	√	√	√	√

studies examine the e-retailer's optimal strategy for choosing reselling mode or agency selling mode (Hagiu, 2007; Abhishek et al., 2016; Wang et al., 2021). Some research also explores the introduction of the in-marketplace selling mode to compensate for traditional reselling for the e-retailer (Ryan et al., 2012; Shi et al., 2021; Liu et al., 2022; Zhen et al., 2022). However, they overlook the possibility that the retailer could additionally function as an agency selling channel (e.g., Dangdang.com) alongside the existence of a 3P marketplace (e.g., Taobao.com). Rather than considering only one or two of the three selling modes (reselling, agency selling, and in-marketplace selling), we examine a complete strategy profile that includes all three modes for the retailer. We examine the e-retailer's coping strategy to counteract potential competition from the marketplace channel introduced by the supplier. Second, owing to the existence of the specialized e-retailer and the 3P online marketplace, the supplier usually has a broader choice of sales channels. Instead of focusing solely on whether a supplier should introduce a marketplace channel (Shi et al., 2021; Zhang and Ma, 2022), we examine which online channel (e-retailer, marketplace, or both channels) a supplier should opt for. Notably, we differentiate between the specialized e-retailer and the 3P online marketplace based on their potential consumer groups. Furthermore, we explore the interaction between the e-retailer's selling mode choice and the supplier's channel strategy. In particular, we delve into how the former's selling mode choice affects the latter's channel selection. Although a few recent works explore this issue (Yan et al., 2018; Zhang and Zhang, 2020), they do not consider the scenario in which e-retailers can enter and sell through the marketplaces, known as the in-marketplace selling mode.

3. Model

3.1. Firms' strategies

Consider a supply chain comprising a supplier (she, denoted by the subscript, s), a *specialized* e-retailer (he, denoted by the subscript, r), and an online marketplace. The supplier and e-retailer are risk-neutral and profit-maximizing, and the marketplace earns profits through referral fees. As depicted in Fig. 1, the marketplace serves as a platform through which firms can sell their products, which we refer to as the *marketplace channel*. Encountering horizontal competition from this online marketplace, the specialized e-retailer has three common selling modes to choose: (1) adopting the traditional reselling mode and selling in his own webstore, which we refer to as the *reselling mode*, denoted as mode R; (2) joining the marketplace and acting as an intermediary by reselling the product purchased from the supplier to consumers, which we refer to as the *in-marketplace selling mode*, denoted as mode I. (In this *in-marketplace channel*, the marketplace charges a commission in proportion to the e-retailer's revenue at a rate of α.); (3) serving as a marketplace and allowing the supplier to sell directly through this agency channel by charging a proportion θ from the supplier's revenue, which we refer to as the *agency selling mode*, denoted as mode A. For exposition simplicity, we use the superscript $i \in \{R, I, A\}$ to capture different selling mode choices of the e-retailer and collectively refer to the above three channels as the *e-retailer channel*.

The supplier chooses the channel (marketplace, e-retailer, or both/dual) to introduce and sell through. For simplicity, we use the superscript $j \in \{M, E, D\}$ to denote the supplier's channel introduction strategy. Specifically, "M" represents the case where the supplier introduces the

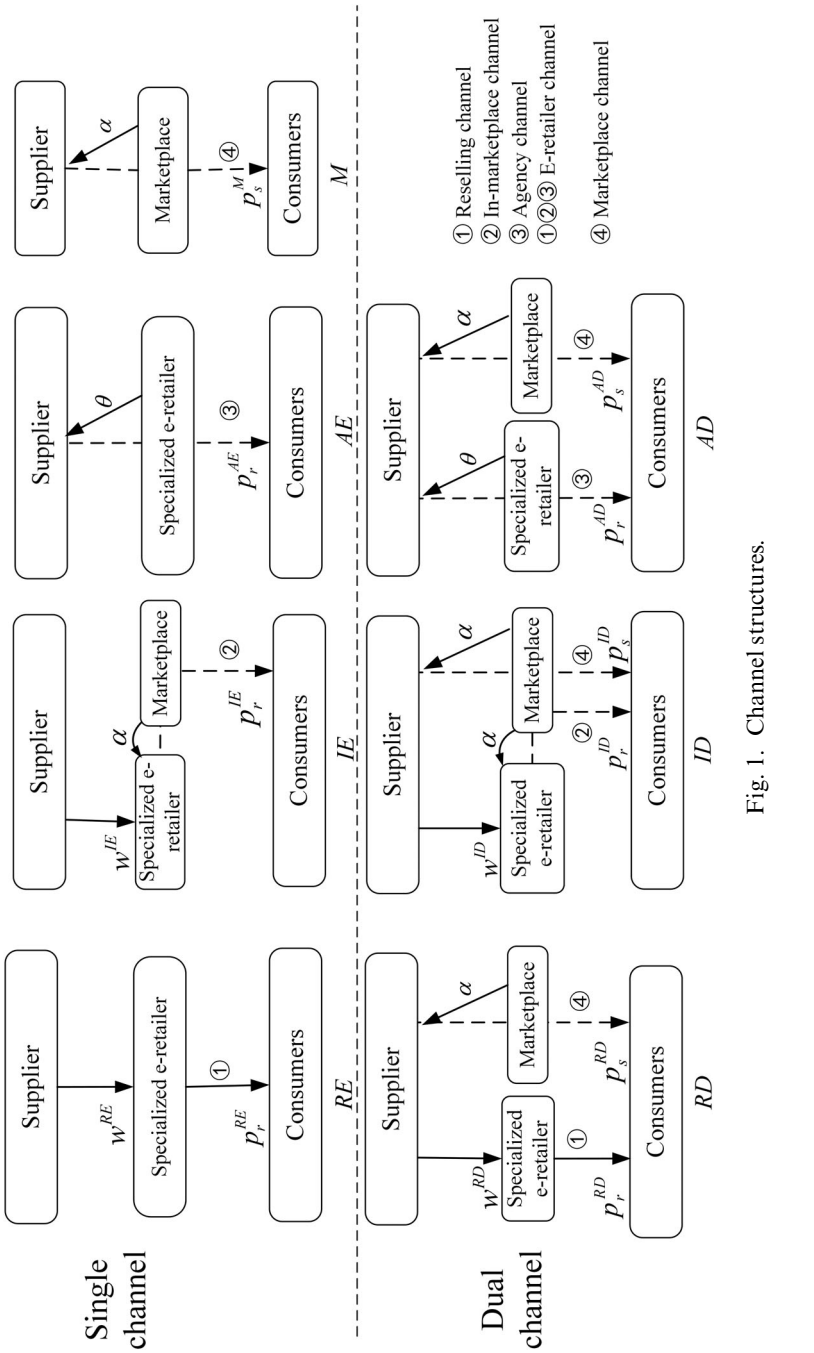

Fig. 1. Channel structures.

marketplace channel, "*E*" is the situation in which the supplier exclusively introduces the e-retailer channel, and "*D*" indicates the case where the supplier introduces dual channels.

Accordingly, seven possible outcomes arise from the different combinations of the e-retailer's selling mode choices (*R*, *I*, or *A*) and the supplier's channel strategies (*M*, *E*, or *D*), which we denote using a superscript combination. Specifically, case *M* means that the supplier only introduces and directly sells through a marketplace channel (single channel scenario). Cases *RE*, *IE*, and *AE* indicate that the supplier does not introduce the marketplace channel, while the e-retailer adopts the reselling, in-marketplace selling, and agency selling modes, respectively (single-channel scenario). Cases *RD*, *MD*, and *AD* imply that the supplier sells not only through the marketplace channel but also the e-retailer's reselling, agency, and in-marketplace channel, respectively (dual-channel scenario).

We consider that the supplier has a constant marginal production cost. Without loss of generality, we normalize this cost to zero (Cai, 2010; Zhou et al., 2019), which helps us better focus on firms' operational costs and channel strategies. When the supplier sells directly to consumers through the marketplace or e-retailer's agency channel, she acquires independent pricing power at the expense of bearing the selling cost. We use c to capture this cost for every unit the supplier sells directly to consumers. Considering the fact that the e-retailer is more efficient in retail operations than the supplier, we normalize the selling cost for the e-retailer to zero (Li et al., 2014). To guarantee that the supplier can obtain a non-negative profit, we assume that her unit selling cost is not too high, that is, $c \leq \bar{c} \triangleq (1-\alpha)\beta\rho$.

Note that under the agency selling mode, the e-retailer receives a referral fee in proportion to the supplier's revenue at rate θ, while the marketplace also charges a proportion α from the supplier's revenue in the marketplace channel. In practice, given the expertise they possess in selling specific product categories, specialized e-retailers typically apply lower referral fee rates, compared to online marketplaces. For instance, Suning.com, a specialized e-retailer focusing on electrical appliances, levies a referral fee of 3%–5% on the selling price for electrical appliance suppliers. By contrast, JD.com and Taobao.com, two of China's largest marketplaces, impose referral fees ranging from 5% to 10% and 8% to 10%, respectively. To model this, we apply the parameter constraints $0 \leq \theta \leq \alpha \leq 1$.

3.2. Market segment and consumer utility

We assume a unit mass of consumers exists in the whole market, each purchasing at most one unit of the product. Without loss of generality, we assume that all consumers are aware of the third-party marketplace (3P marketplace) because of its name recognition and high visibility (e.g., JD.com, Taobao.com, Amazon.com, etc.). However, not all consumers are familiar with the e-retailer channel (reselling or agency selling), and we use ϕ to represent the proportion of consumers who know both the e-retailer and marketplace (see Fig. 2). For simplicity, we refer to this proportion of consumers as the *overlapped market*. Similarly, $1-\phi$ represents the proportion of consumers aware only of the marketplace channel, which is referred to as the *exclusive market*. In the *overlapped market*, the market-clearing quantities of the e-retailer channel and supplier's marketplace channel are denoted by $Q^{ij}_{r(o)}$ and $Q^{ij}_{s(o)}$ at equilibrium, respectively. The market-clearing

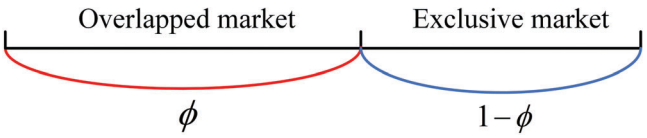

Fig. 2. Market segments.

quantity of the marketplace channel serving the *exclusive market* is denoted by $Q^{ij}_{s(e)}$. If the e-retailer chooses to join the 3P marketplace, his visibility will increase; consequently, all consumers will be familiar with the e-retailer's in-marketplace channel (Ryan et al., 2012). Under such circumstances, the demand in the e-retailer channel and the supplier's marketplace channel are denoted by $Q^{ij}_{r(o)}$ and $Q^{ij}_{s(o)}$ at equilibrium, respectively. Here, $i \in \{R, I, A\}$, $j \in \{E, D, M\}$, and the subscripts o and e represent the overlapping and exclusive markets, respectively. Note that the case where $i \in \{R, I, A\}$ and $j = M$ corresponds to the single channel scenario M in Fig. 1.

Given the market segments, consumers purchase from the selling channel that offers the highest positive utility. Their utility can be expressed as $U = V - p$ (Chiang et al., 2003; Bernstein et al., 2009), where p is the selling price, and V represents consumers' valuation of the product. As a benchmark, we assume that consumers' reserved valuation is $V = v$ for every unit, which is heterogeneous and uniformly distributed in the interval [0,1] (Chiang et al., 2003). If consumers purchase from the channel operated by the supplier, then their valuation of the product is accompanied by a discount coefficient $\rho \in (0, 1)$, which reflects the supplier's sales service quality. This setting is reasonable because the supplier is not an expert in the sales business (Yan et al., 2018), which can be attributed to the weakness in reception, logistics, and after-sales service for product maintenance or repair. Consequently, consumers may undervalue the products sold directly by the suppliers (Yan et al., 2018), and their valuation changes to $V = \rho v$ if they purchase from the marketplace channel operated by the supplier. Conversely, if consumers purchase from the specialized e-retailer, then they can expect a valuation premium owing to the specialized e-retailer's expertise and reputation in selling specific products. Here, we use the premium factor $\beta(\beta > 1)$ to capture the specialized e-retailer's service level. To avoid the e-retailer's arbitrage behavior that deviates from the wholesale purchase in Cases *RD* and *ID*, we assume that the premium factor could not be too high, that is, $\beta \leq 2\rho$, and c satisfies $(\beta - \rho)(1 - \alpha) = \bar{\bar{c}} \leq c \leq \bar{c} \triangleq (1 - \alpha)\beta\rho$. Consumers' valuation increases to $V = \beta v$ if they purchase from the e-retailer's own webstore or flagship store in the marketplace. Finally, because of the mutual effects of the valuation premium from the e-retailer channel and the valuation discount caused by the supplier's relatively low-quality sales service, the valuation gained from products sold through the e-retailer's agency channel is $\beta\rho v$. In summary, the factors influencing consumers' valuation in different channels are as follows:

v = consumers' reserved valuation for a certain product category;

ρv = consumers' valuation of the product sold in the 3P marketplace channel operated by the supplier, $0 < \rho < 1$;

βv = consumers' valuation of the product sold in the channel operated by the e-retailer, $\beta > 1$; and

$\beta\rho v$ = consumers' valuation of the product sold in the e-retailer's agency channel operated by the supplier.

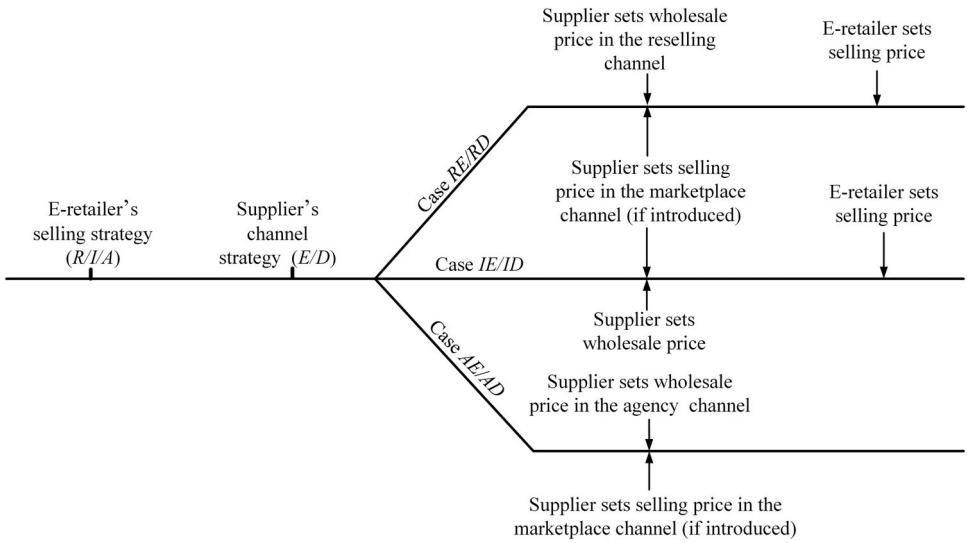

Fig. 3. Sequence of the game.

3.3. Sequence of events and decisions

As depicted in Fig. 3, the sequence of the game is as follows. Initially, the e-retailer makes the selling mode choice (reselling, in-marketplace selling, or agency selling) for a specific product. Subsequently, given the e-retailer's choice, the supplier decides whether to introduce the marketplace channel. This *ex-ante* setting of the choice is reasonable because, compared to the supplier's channel introduction decision, the e-retailer typically takes more time to determine the selling mode, which requires significant investments to establish the channel and adopt the proper retail practices. Then, the sequence of subsequent events is based on the e-retailer's selling mode choice and the supplier's introduction decision. Specifically,

- when the e-retailer serves as a reseller and sells through his own webstore (mode R), the supplier first sets wholesale price w. If the supplier joins the marketplace, she also determines the selling price p_s. Then, the e-retailer sets the selling price p_r in the reselling channel.
- When the e-retailer chooses to sell in the marketplace (mode *I*), the supplier first sets the wholesale price w, and if she joins the marketplace, she also determines the selling price p_s in the marketplace channel. The e-retailer follows by setting the selling price p_r.
- When the e-retailer decides to operate his own webstore under an agency mode (mode *A*), he yields his pricing power to the supplier. The supplier decides the selling price p_r in the agency channel, and if she joins the marketplace channel, she simultaneously sets the selling price p_s.

The key notation is summarized in Table 2.

Table 2
Summary of the key notations

Notation	Explanation
$i \in \{R, I, A\}$	Indicator for reselling (mode R), in-marketplace selling (mode I), and agency selling (mode A)
$j \in \{M, E, D\}$	Indicator for introducing the marketplace channel (M), introducing the e-retailer channel (E), and introducing both channels (D)
c	The cost for every unit the supplier sells directly to consumers
β	Premium factor of consumers' valuation due to purchasing in the e-retailer channel
ρ	Consumers' discount coefficient due to the supplier's sales inefficiency
ϕ	Proportion of all the consumers knowing both the e-retailer and the marketplace channels
α	Referral fee percentage
$w(w^{ij})$	Wholesale price (equilibrium wholesale price) charged by the supplier in case ij ($i = R,I,A; j = M,E,D$)
$p_s(p_s^{ij})$	Selling price (equilibrium selling price) in the supplier-owned marketplace channel in case ij ($i = R,I,A; j = M,E,D$)
$p_r(p_r^{ij})$	Selling price (equilibrium selling price) charged in the e-retailer channel in case ij ($i = R,I,A; j = M,E,D$)
$\pi_s; \pi_r(\pi_s^{ij}; \pi_s^{ij})$	The supplier's/e-retailer's profit (equilibrium profit) in case ij ($i = R,I,A; j = M,E,D$)

3.4. Benchmark: Case M

If the supplier chooses to exclusively introduce the marketplace channel, the equilibrium result falls into one case, that is, case M, regardless of which selling mode the e-retailer chooses. Under this scenario, the e-retailer always gains zero equilibrium profit; that is, $\pi_r^M = 0$. In the marketplace, only consumers with consumption values that satisfy $v \geq p_s/\rho$ make a purchase. Thus, the demand in the marketplace channel is $1 - p_s/\rho$. By maximizing $\pi_s = (1-\alpha)(1-p_s/\rho)p_s - c(1-p_s/\rho)$, we obtain the equilibrium selling price $p_s^M = (c/(1-\alpha)+\rho)/2$ and the supplier's equilibrium profit $\pi_s^M = ((1-\alpha)\rho - c)^2/(4(1-\alpha)\rho)$.

4. E-retailer choosing reselling mode

4.1. Supplier only introducing the e-retailer channel (RE)

In case RE, the e-retailer sells in the traditional manner, in which he purchases products from the supplier and sells them to end consumers at the retail price p_r. Here, only the consumers whose consumption value meets $v \geq p_r/\beta$ will purchase from the reselling channel. Hence, we can derive the demand for the e-retailer channel as $D_r = \phi(1 - p_r/\beta)$. The supplier's and e-retailer's profits are given by $\pi_s = w(1-p_r/\beta)\phi$ and $\pi_r = (p_r - w)(1-p_r/\beta)\phi$, respectively. By backward induction, we can verify that the equilibrium strategies of the supplier and e-retailer are $w^{RE} = \beta/2$ and $p_r^{RE} = 3\beta/4$, and their profits at equilibrium are $\pi_s^{RE} = \beta\phi/8$ and $\pi_r^{RE} = \beta\phi/16$, respectively.

4.2. Supplier introducing the dual channels (RD)

We use the superscript RD to represent the equilibrium outcomes when the supplier introduces both the marketplace and e-retailer channels. Specifically, consumers who are unaware of the e-retailer will purchase only through the marketplace if $v \geq p_s/\rho$. Those familiar with both channels will compare their utility in these two channels and choose the one that provides higher utility. Hence, if $\rho v - p_s \geq \beta v - p_r$ and $\rho v - p_s \geq 0$, consumers choose to purchase through the marketplace channel. If $\beta v - p_r \geq \rho v - p_s$ and $\beta v - p_r \geq 0$, they choose to purchase through the e-retailer channel. In addition, if $\beta v - p_r < 0$ and $\rho v - p_s < 0$, consumers make no purchase.

We can further derive the demand functions in the marketplace channel (D_s) and e-retailer channel (D_r) as follows:

$$(D_s, D_r) = \begin{cases} \left(1 - \frac{p_s}{\rho}, 0\right), & if\ \frac{p_r}{\beta} < 1 < \frac{p_r - p_s}{\beta - \rho} \\ \left(\phi\left(\frac{p_r - p_s}{\beta - \rho} - \frac{p_s}{\rho}\right) + (1-\phi)\left(1 - \frac{p_s}{\rho}\right), \phi\left(1 - \frac{p_r - p_s}{\beta - \rho}\right)\right), & if\ 0 < \frac{p_r}{\beta} \leq \frac{p_r - p_s}{\beta - \rho} < 1. \\ \left((1-\phi)\left(1 - \frac{p_s}{\rho}\right), \phi\left(1 - \frac{p_r}{\beta}\right)\right), & if\ \frac{p_r - p_s}{\beta - \rho} \leq \frac{p_r}{\beta} < 1 \end{cases}$$

The profit functions of the supplier and e-retailer are $\pi_s^{RD} = (1-\alpha)p_s D_s + wD_r$ and $\pi_r^{RD} = (p_r - w)D_r$ respectively. Solving the game through backward induction yields the equilibrium outcomes as demonstrated in Lemma 1.

Lemma 1. *For case RD,*

1. *when* $\bar{\bar{c}} \le c < \widehat{c}_1^{RD}$*, sales occur in the reselling channel to serve the overlapped market and in the marketplace channel to serve all consumers.*
2. *When* $\widehat{c}_1^{RD} \le c < \widehat{c}_3^{RD}$*, sales occur in the reselling channel to serve the overlapped market and in the marketplace channel to serve the exclusive market. Particularly,* $\hat{c}_2^{RD} \in (\hat{c}_1^{RD}, \hat{c}_3^{RD})$ *exists such that the e-retailer prevents the supplier from selling directly in the overlapped market when* $\hat{c}_1^{RD} \le c < \hat{c}_2^{RD}$.
3. *When* $\hat{c}_3^{RD} \le c < \bar{c}$*, sales only occur in the reselling channel to serve the overlapped market.*

The equilibrium results in case RD are reported in Table 3.

For case *RD*, the supplier introduces both reselling and marketplace channels. At equilibrium, four distinct patterns stemming from horizontal competition between these two channels exist. Intuitively, if the supplier's sales efficiency is relatively high (i.e., the selling cost is in a relatively low range, $\bar{\bar{c}} \le c < \widehat{c}_1^{RD}$), she has an incentive to sell directly to consumers through the marketplace channel and extract most of the profit from the reselling channel by tailoring her wholesale price. As a result, sales occur in both channels. By contrast, if the supplier is inefficient in direct selling, she gives up the selling business by charging a sufficiently high selling price in the marketplace channel. Under such a circumstance, the equilibrium profits of the supplier and e-retailer remain the same as those in case *RE*, which is independent of the selling cost.

If the selling cost falls within a moderate range ($\hat{c}_1^{RD} \le c < \hat{c}_3^{RD}$), the supplier tailors the direct selling price in the marketplace channel to only serve the consumers in the exclusive market. Specifically, two patterns within the range of $\hat{c}_1^{RD} \le c < \hat{c}_3^{RD}$ exist. On the one hand, when the selling cost is relatively small ($\hat{c}_1^{RD} \le c < \hat{c}_2^{RD}$), although the supplier does not sell directly in the overlapped market, the two firms' optimal decisions are changed. That is, the e-retailer strategically tailors the selling price and over-order products. If the e-retailer can carry more products in the reselling channel, this is also beneficial for the supplier. To induce over-procurement, the supplier would deliberately set her wholesale price at the boundary of $(c(2\beta - \rho)(1-\phi) + (1-\alpha)\rho^2(1-\phi) + 2\beta^2\phi - \beta\rho\phi)/B$, a value that increases with the selling cost c. Otherwise, if the supplier charges a higher wholesale price, the e-retailer would abandon deterrence and allow the supplier to sell directly in the overlapped market. Accordingly, we define this phenomenon as the *threateningly direct selling* in the overlapped market. This interesting result also indicates that for the supplier, the marketplace channel serves not only as a means of direct selling way but also as a vital counterbalance to manipulate the e-retailer channel. Especially when the selling cost is relatively small, the marketplace channel can be used for procurement inducement. However, if the selling cost is relatively high ($\hat{c}_2^{RD} \le c < \hat{c}_3^{RD}$), it is unwise for the supplier to horizontally compete with the e-retailer in the overlapped market, which can be expected by the e-retailer. In this sense, the supplier does not have incentives to induce over-procurement. Consequently, the supplier would use the marketplace channel as a direct selling way to serve the exclusive market only. These outcomes in case *RD* are illustrated in Fig. 4. We observe that if ϕ is relatively

Table 3
Equilibrium strategies and profits for the supplier and e-retailer in case *RD*

Supplier's channel strategy	① Direct selling in the whole market $\underline{\bar{c}} \le c < \widehat{c}_1^{RD}$	② Threateningly direct selling in the overlapped market $\widehat{c}_1^{RD} \le c < \widehat{c}_2^{RD}$	③No direct selling in the overlapped market $\widehat{c}_2^{RD} \le c < \widehat{c}_3^{RD}$	④ No direct selling in the whole market $\hat{c}_3^{RD} \le c \le \bar{c}$
w^{RD}	$\frac{c\alpha(2\beta-\rho(2-\phi))+(1-\alpha)(\beta-\rho)(4\beta-\alpha\rho(2-\phi))}{A}$	$\frac{c(2\beta-\rho)(1-\phi)+(1-\alpha)\rho^2(1-\phi)+2\beta^2\phi-\beta\rho\phi}{B}$	$\frac{\beta}{2}$	$\frac{\beta}{2}$
p_s^{RD}	$\frac{(\beta-\rho)\rho(4-\alpha(4-\phi))+c(4\beta-\rho(4-\alpha\phi))}{A}$	$\frac{c(1-\phi)+3\beta\phi+\rho(1-\alpha-3\phi+\alpha\phi)}{B}\beta$	$\frac{1}{2}(\frac{c}{1-\alpha}+\rho)$	ρ
p_r^{RD}	$\frac{(1-\alpha)(\beta-\rho)(6\beta-\rho(2+\alpha(1-\phi)))+c((2+\alpha)\beta-\rho(2+\alpha(1-\phi)))}{A}$	$\frac{c-c\phi+3\beta\phi+\rho(1-\alpha-3\phi+\alpha\phi)}{B}\beta$	$\frac{3\beta}{4}$	$\frac{3\beta}{4}$
$Q_{r(o)}^{RD}$	$\frac{(c(2-\alpha)+(1-\alpha)(2\beta-(2-\alpha)\rho))\phi}{A}$	$\frac{\rho(1-\alpha)(1-\phi)+\beta\phi+c(1-\phi)}{B}\phi$	$\frac{\phi}{4}$	$\frac{\phi}{4}$
$Q_{s(o)}^{RD}$	$\frac{-4c\beta+c\rho(2+\alpha(1-\phi))\phi(-(1-\alpha)\rho^2(2+\alpha(1-\phi))+\beta\rho(2-\alpha(2+\phi))}{A}$	0	0	0
$Q_{s(e)}^{RD}$	$(1-\phi)(1-\frac{(\beta-\rho)\rho(4-\alpha(4-\phi))+c(4\beta-\rho(4-\alpha\phi))}{A})$	$\frac{(1-\alpha)\rho(1-\phi)-c(1-\phi)+\beta\phi}{B}(1-\phi)$	$\frac{(1-\phi)((1-\alpha)\rho-c)}{2(1-\alpha)\rho}$	0
π_s^{RD}	$\frac{c^2(2\beta-\rho(2-\phi))-c\rho(\beta(4-\alpha(4-\phi)-2\phi)-2(1-\alpha)\rho(2-\phi))+(1-\alpha)(\beta-\rho)\rho((1-\alpha)\rho(2-\phi)+\beta\phi)}{A}$	$\frac{\rho(1-\alpha)(1-\phi)^2-c(1-\phi)+\beta\phi}{2B}$	$\frac{2c^2(1-\phi)}{(1-\alpha)\rho}-\frac{1}{8}(4c(1-\phi)+\beta\phi+)2(1-\alpha)\rho(1-\phi)$	$\frac{\beta\phi}{8}$
π_r^{RD}	$\frac{c(2-\alpha)+(1-\alpha)(2\beta-(2-\alpha)\rho)^2}{A^2}(\beta-\rho)\phi$	$\frac{\rho(1-\phi)(1-\alpha)^2-c(1-\phi)+\beta\phi}{B^2}(\beta-\rho)\phi$	$\frac{\beta\phi}{16}$	$\frac{\beta\phi}{16}$

Note: Here, $A = 8(1-\alpha)\beta-\rho(8-8\alpha+\alpha^2\phi)$, $B = 2(\rho-\alpha\rho(1-\phi)+2(\beta-\rho)\phi)$.

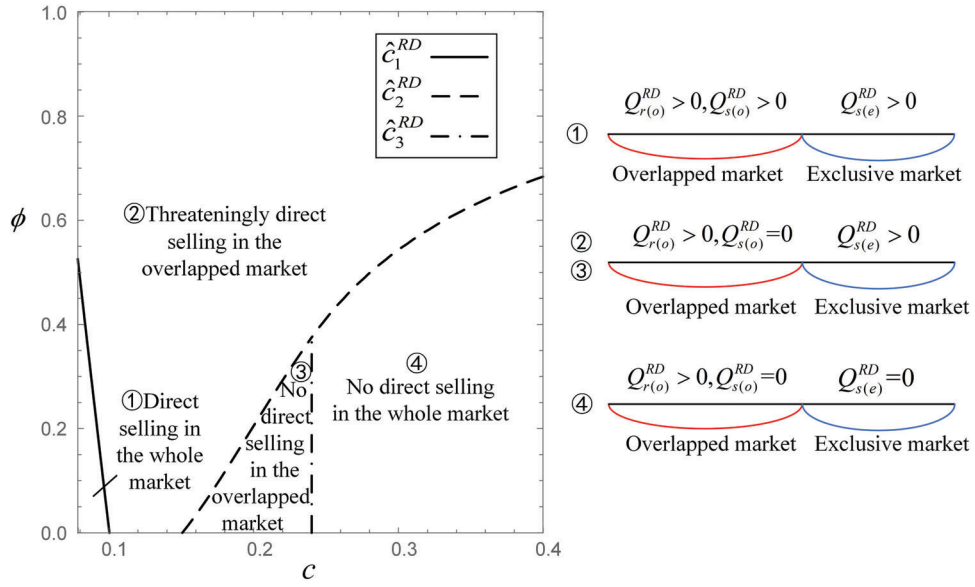

Fig. 4. The equilibrium results in case *RD* ($\alpha = 0.2, \beta = 1.1, \rho = 0.9$).

large, only two cases are present. That is, when c is relatively small, the supplier will conduct direct sales in the entire market, while when c is relatively large, she will conduct threateningly direct selling in overlapped markets. The underlying reason is that when ϕ is sufficiently high, the market disadvantage for the e-retailer relatively is weak. Therefore, the supplier, who is not adept at direct selling, has an incentive to employ threatening direct sales to weaken the retailer's control over the overlapped market. When ϕ is relatively small, if c falls within a medium range, there are no direct sales in the overlapped market; if c is sufficiently high, no direct sales occur in the whole market. This suggests that if the supplier is not highly skilled at direct selling, to reduce channel competition and obtain higher wholesale revenue, she should relinquish the overlapped market, where she would compete directly with the retailer. Conversely, if the supplier is exceptionally poor at direct selling, she should withdraw from the entire market and focus on wholesale selling. These findings lead to Proposition 1.

Proposition 1. *When more consumers are aware of the e-retailer,*

1. *the supplier has less incentive to sell directly in the overlapped market, that is,* $\frac{\partial \hat{c}_1^{RD}}{\partial \phi} < 0$.
2. *The supplier has more incentive to threateningly directly sell in the overlapped market, that is,* $\frac{\partial (\hat{c}_2^{RD} - \hat{c}_1^{RD})}{\partial \phi} < 0$.

Proposition 1 clarifies the supplier's motivation toward direct selling in the overlapped market. Intuitively, when more consumers are aware of the e-retailer, the supplier is more likely to abandon direct selling to avoid horizontal competition. Meanwhile, the supplier may have a greater incentive to adopt threateningly direct selling. This finding can be interpreted from two perspectives. On the one hand, as the e-retailer occupies a larger market, allocating more products to the e-retailer is in

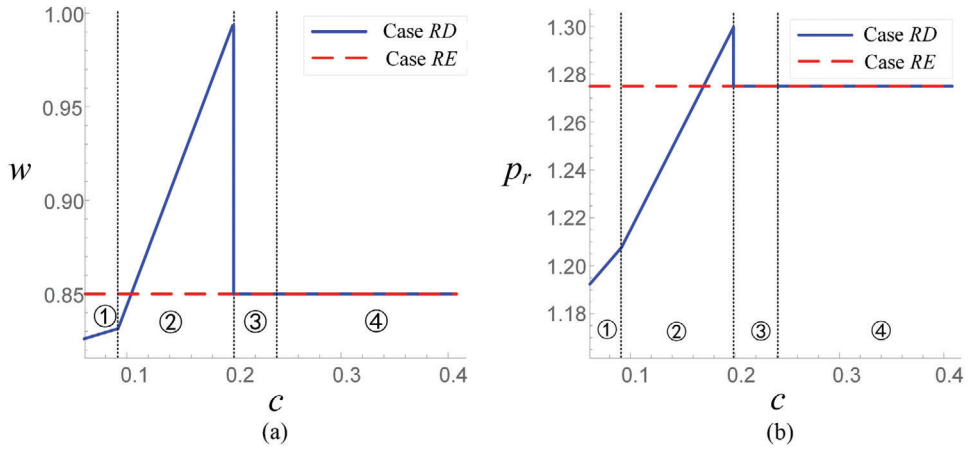

Fig. 5. Comparison of equilibrium prices between cases *RD* and *RE*. (a) Equilibrium wholesale price and (b) equilibrium selling price charged in the e-retailer channel

the supplier's interest. By adopting *threateningly direct selling* in the overlapped market, the supplier can induce excessive procurement and extract a higher profit from the reselling channel. Conversely, with a larger consumer base familiar with the e-retailer, they wield greater market influence. Consequently, the supplier's marketplace channel encounters intensified horizontal competition. To avoid competition while manipulating the e-retailer's pricing, it is in the supplier's interest to threateningly direct sell in the marketplace channel.

4.3. *Comparison of cases* RD *and* RE

Drawing on the equilibrium results obtained in Sections 4.1 and 4.2, we compare these results to gain insights into the supplier's channel strategy.

Proposition 2. *Comparing the equilibrium prices in cases RD and RE, we have,*

1. *the supplier charges a lower wholesale price in case RD than that in case RE when the unit selling cost is in a low range; otherwise, the wholesale price is not lower than that in case RE. That is, when* $\underline{\underline{c}} \le c < \frac{(1-\alpha)(\beta-\rho)\rho}{2\beta-\rho}$, $w^{RD} < w^{RE}$; *when* $c \ge \frac{(1-\alpha)(\beta-\rho)\rho}{2\beta-\rho}$, *and* $w^{RD} \ge w^{RE}$.
2. *The e-retailer charges a higher selling price in case RD when the unit selling cost is in a high range; otherwise, the selling price in RD is not higher than that in case RE. That is, when* $\underline{\underline{c}} \le c < \frac{\rho-\alpha\rho(1-\phi)}{2(1-\phi)}$, $p_r^{RD} < p_r^{RE}$; *when* $c \ge \frac{\rho-\alpha\rho(1-\phi)}{2(1-\phi)}$, $p_r^{RD} \ge p_r^{RE}$.

In Proposition 2 and Fig. 5, we compare the firms' equilibrium prices among different cases. Note that we set $\theta = 0.1$, $\phi = 0.2$, $\alpha = 0.2$, $\beta = 1.1$, $\rho = 0.9$ in Figs. 5–7. As compared to the case where the supplier exclusively sells through the reselling channel, the supplier who possesses dual channels (reselling and marketplace) would charge a lower wholesale price when the direct selling cost is low (as depicted in Fig. 5, it occurs in region (1) and part of region (2)). Under such a circumstance, the e-retailer would also reduce the reselling price in case *RD*. Consistent

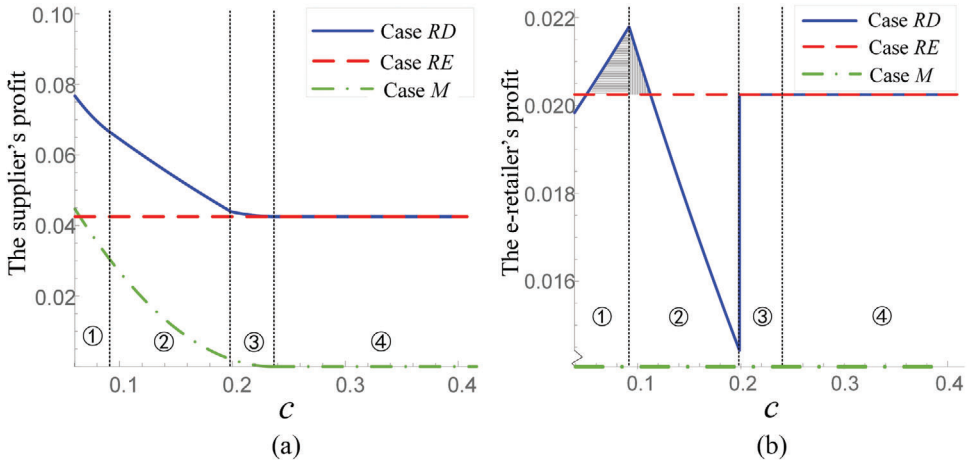

Fig. 6. The channel members' profits comparison among cases *M*, *RE*, and *RD*. (a) The supplier's profit and (b) the e-retailer's profit.

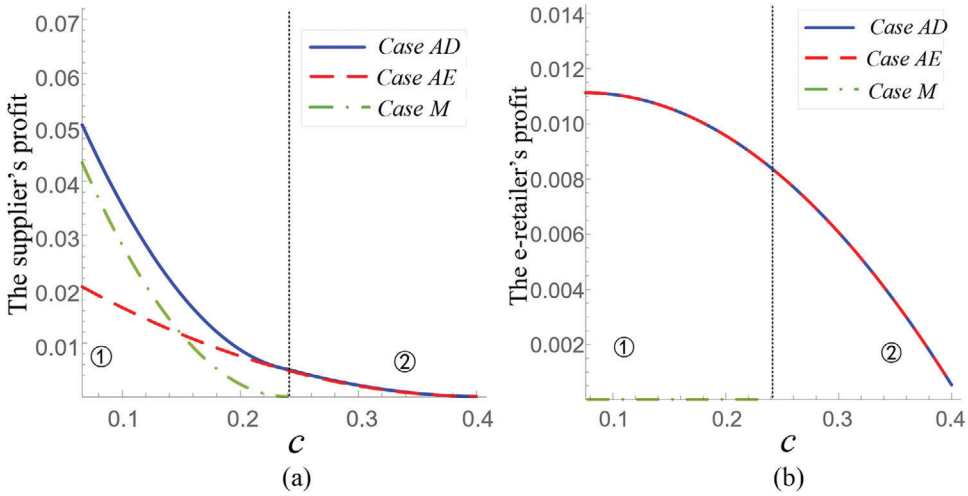

Fig. 7. The channel members' profits comparison among cases *M*, *AE*, and *AD*. (a) The supplier's profit and (b) the e-retailer's profit.

with findings in extensive literature, such as Chiang et al. (2003), Arya et al. (2007), and Li et al. (2014), this indicates that when the supplier is an efficient retail provider, introducing a direct selling channel may alleviate the issue of double-marginalization in the reselling channel. However, we posit that this benefit diminishes when the e-retailer's cost advantage in selling is significantly pronounced. This outcome arises from the interplay of two opposing effects. On the one hand, the supplier's encroachment into the marketplace channel inevitably causes the horizontal price competition with the reselling channel (*competition effect*). Consequently, the e-retailer has the incentive to lower the selling price. On the other hand, if the supplier introduces the costly marketplace channel, she has to charge a relatively high direct selling price. To avert a loss in the price competition,

the supplier has no choice but to enhance the wholesale price with the increase of the direct selling cost ($\partial w^{RD}/\partial c \geq 0$ can be easily verified), which compels the retailer to increase the reselling price (*wholesale price effect*). As a result, a threshold exists such that if the supplier's selling cost exceeds it ($c \geq (1-\alpha)(\beta-\rho)\rho/(2\beta-\rho)$), the e-retailer would charge a higher (or not lower) selling price in the reselling channel within case *RD*. We can readily verify that this threshold increases in the size of the overlapped market ϕ and if $\phi = 1$, $p_r^{RD} \leq p_r^{RE}$ always holds. This indicates that if horizontal competition occurs in the whole market, the competition effect conquers the wholesale price effect. Consequently, the e-retailer would consistently lower the selling price to compete with the marketplace channel.

Proposition 3. *When the e-retailer chooses the reselling mode,*

1. *the supplier can derive the highest profit in case RD when* $0 < c < \widetilde{c}_3^R$*; otherwise, she has no incentive to introduce the marketplace channel. That is, when* $c \in [\underline{\bar{c}}, \widetilde{c}_3^R]$, $\pi_s^{RD} > \max\{\pi_s^{RE}, \pi_s^M\}$*; when* $c \in [\widetilde{c}_3^R, \bar{c}]$, $\pi_s^{RE} = \pi_s^{RD} > \pi_r^M$.
2. *The e-retailer can obtain the highest profit in case RD when* $c \in [\widetilde{c}_1^R, \widetilde{c}_2^R]$*; otherwise, he prefers case RE. That is, when* $c \in [\tilde{c}_1^R, \tilde{c}_2^R]$, $\pi_r^{RD} > \pi_r^{RE} > \pi_r^M$*; when* $c \in [\underline{\bar{c}}, \tilde{c}_1^R) \cup (\tilde{c}_2^R, \bar{c}]$, $\pi_s^{RE} = \pi_s^{RD} > \pi_r^M$.

According to Proposition 3, when the e-retailer chooses the reselling mode, the supplier will always choose a dual-channel strategy as long as she is not particularly unskilled in direct selling, that is, c is not too high. In particular, if the direct selling cost for the supplier is sufficiently low or relatively high, the e-retailer will be better off when the supplier introduces the in-marketplace channel; otherwise, he is better off. The firms' equilibrium profits with regard to the direct selling cost are depicted in Fig. 6, which explicitly documents that exclusive introduction of the marketplace channel (case *M*) is not beneficial for both firms. Intuitively, case *M* is the worst case for the e-retailer since he earns zero profit in that case. From the supplier's perspective, Proposition 3 states that she can always derive a higher profit if she additionally introduces a reselling channel as a complement to the marketplace channel. The result indicates that the consumers' valuation premium induced by the specialized e-retailer overwhelms the drawbacks of horizontal competition. Conversely, if the supplier already operates the reselling channel, joining the 3P marketplace is unwise if he is not an expert in direct selling (i.e., $c \in [\tilde{c}_3^R, \bar{c}]$).

Figure 6 further reveals the bright side of the marketplace for the e-retailer, which arises in two shaded regions in Fig. 6b: (1) the region where direct sales occur in the overlapped market but the selling cost is high and (2) the region where the supplier threatens to directly sell in the marketplace channel. Note that in the first region, the supplier would always cut the wholesale price if she additionally introduces the marketplace channel. However, the e-retailer faces more pronounced horizontal price competition when the supplier excels in direct selling. Under the joint impact of these two conflicting effects, the e-retailer can benefit from the supplier's encroachment only if he has a significant advantage in selling (i.e., $c \in [\tilde{c}_1^R, \hat{c}_1^{RD}]$). In the second region, horizontal price competition is alleviated, and the e-retailer's profit is mainly influenced by the wholesale price. Recall the result in Proposition 2: in region ②, the supplier cuts the wholesale price only if she is relatively efficient in direct selling. Under such a circumstance, the e-retailer would gain a higher profit when the supplier encroaches (i.e., $c \in [\hat{c}_1^{RD}, \tilde{c}_2^R]$). In summary, the e-retailer benefits from the supplier's encroachment only when the selling cost falls within a moderate range as explicitly illustrated in the shaded regions of Fig. 6b.

5. E-retailer chooses in-marketplace selling mode

5.1. Supplier only introducing the e-retailer channel (IE)

In case *IE*, the e-retailer joins the marketplace and resells the product purchased from the supplier. Different from case *RE*, in this case, selling in the marketplace can help the e-retailer to expand his potential market. Consequently, all the consumers in the marketplace channel become aware of the e-retailer and the valuation for consumers purchasing from the in-marketplace e-retailer is βv. Hence, only the consumers whose valuation is $v \geq p_r/\beta$ will purchase in the marketplace channel. Hence, we derive the demand for the marketplace channel as $D_r = 1 - p_r/\beta$. The profits of the supplier and e-retailer are $\pi_s^{IE} = w(1 - p_r/\beta)$ and $\pi_r^{IE} = (1-\alpha)p_r(1 - p_r/\beta) - w(1 - p_r/\beta)$, respectively. Backward induction verifies that the equilibrium strategies of the supplier and the e-retailer are $w^{IE} = (1-\alpha)\beta/2$ and $p_r^{IE} = 3\beta/4$, respectively. The supplier's and e-retailer's profits are $\pi_s^{IE} = (1-\alpha)\beta/8$ and $\pi_r^{IE} = (1-\alpha)\beta/16$, respectively.

5.2. Supplier introducing the dual channels (ID)

We explore a scenario in which the e-retailer operates as the reseller in the marketplace and the supplier has the option of selling directly to the customers in the marketplace. Under this scenario, all the consumers are familiar with the e-retailer's in-marketplace channel, which leads to horizontal competition across the entire market. When consumers decide on their purchasing channel, they compare the utility they derive from different options. If $\rho v - p_s \geq \beta v - p_r$ and $\rho v - p_s \geq 0$, consumers opt to purchase through the marketplace channel. Otherwise, if $\beta v - p_r \geq \rho v - p_s$ and $\beta v - p_r \geq 0$, consumers choose to purchase from the e-retailer's in-marketplace channel. In cases where $\rho v - p_s < 0$ and $\beta v - p_r < 0$, consumers decide not to make any purchases. Accordingly, we can derive the following demand functions:

$$(D_s, D_r) = \begin{cases} \left(1 - \frac{p_s}{\rho}, 0\right), & if\ 0 \leq \frac{p_r}{\beta} \leq 1 \leq \frac{p_r - p_s}{\beta - \rho} \\ \left(\frac{p_r - p_s}{\beta - \rho} - \frac{p_s}{\rho}, 1 - \frac{p_r - p_s}{\beta - \rho}\right), & if\ 0 \leq \frac{p_s}{\beta} \leq \frac{p_r - p_s}{\beta - \rho} < 1. \\ \left(0, 1 - \frac{p_r}{\beta}\right), & if\ \frac{p_r - p_s}{\beta - \rho} \leq \frac{p_r}{\beta} \leq 1 \end{cases}$$

Therefore, the profit functions of the supplier and e-retailer are $\pi_s^{ID} = (1-\alpha)p_s D_s - cD_s + wD_r$ and $\pi_r^{ID} = (1-\alpha)p_r D_r - wD_r$, respectively.

Lemma 2. *A threshold* $\hat{c}_1^{ID} = \frac{(1-\alpha)(\beta-\rho)\rho}{2\beta-\rho}$ *exists such that*

1. *when* $\bar{\bar{c}} \leq c < \hat{c}_1^{ID}$, *sales occur in the e-retailer's in-marketplace channel to serve the overlapped market and the marketplace channel to serve the exclusive market.*
2. *When* $\bar{c}_1^{ID} \leq c < \bar{c}$, *sales only occur in the in-marketplace channel to serve the exclusive market and threateningly sell in the overlapped market.*

The equilibrium results in case ID are reported in Table 4.

Table 4
Equilibrium strategies and profits for the supplier and e-retailer in case *ID*

Supplier's channel strategy	Direct selling to all consumers $\underline{\bar{c}} \le c < \hat{c}_1^{ID}$	② Threateningly direct selling in the overlapped market $\hat{c}_1^{ID} \le c < \bar{c}$
w^{ID}	$\frac{1}{2}\beta(1-\alpha)$	$\frac{1}{2}\beta(1-\alpha)$
p_s^{ID}	$\frac{c+\rho}{2}$	$\frac{(3\beta-2\rho)\rho}{4\beta-2\rho}$
p_r^{ID}	$\frac{1}{4}(\frac{c}{1-\alpha}+3\beta-\rho)$	$\frac{\beta(3\beta-2\rho)}{4\beta-2\rho}$
$Q_{r(o)}^{ID}$	$\frac{1}{4}+\frac{c}{4(1-\alpha)(\beta-\rho)}$	$\frac{\beta}{4\beta-2\rho}$
$Q_{s(o)}^{ID}$	$\frac{(1-\alpha)(\beta-\rho)\rho-c(2\beta-\rho)}{4(1-\alpha)\rho(\beta-\rho)}$	0
π_s^{ID}	$\frac{1}{8}(\frac{c^2(2\beta-\rho)}{(1-\alpha)(\beta-\rho)\rho}-2c+(1-\alpha)(\beta+\rho))$	$\frac{(1-\alpha)\beta^2}{8\beta-4\rho}$
π_r^{ID}	$\frac{(c+(1-\alpha)(\beta-\rho))^2}{16(1-\alpha)(\beta-\rho)}$	$\frac{(1-\alpha)\beta^2(\beta-\rho)}{4(2\beta-\rho)^2}$

Interestingly, from Lemma 2, in the case of *ID*, the supplier will always use "threat of direct selling" when c is relatively large ($\hat{c}_1^{ID} \le c < \bar{c}$), which is different from the case of *RD*. (Note that in the case of *RD*, when c is large, the supplier no longer uses this strategy, and the e-retailers no longer use price to prevent the supplier's channel encroachment.) This is because, in the case of *ID*, the e-retailer and the 3P marketplace compete for exactly the same customer base, and there is no need to take different customers of the exclusive and overlapped markets into account to set prices. In addition, in the case of *ID*, horizontal channel competition is more intense. Therefore, when c is large, the supplier always has the incentive to adopt the aforementioned pricing strategy in the direct selling channel, which restricts the pricing of e-retailers in the marketplace.

5.3. *Comparison of cases* ID *and* IE

Based on the equilibrium results obtained in Sections 5.1 and 5.2, we compare these results to derive insight into the supplier's channel strategy.

Proposition 4. *Comparing the equilibrium results in case ID and IE, we have,*

1. $w^{ID} = w^{IE}$.
2. $p_s^{ID} < p_s^M$, $p_r^{ID} < p_r^{IE}$.

From Proposition 4, we can conclude that the supplier will set the same wholesale price for the e-retailer, regardless of whether the marketplace channel is introduced. In addition, the price set by the supplier in case *ID* is lower than that in case *IE* and the benchmark case *M* even when there are no sales in the supplier's marketplace channel. The supplier can strategically use her marketplace pricing to suppress the e-retailer's pricing in the market, thereby increasing her own profit. The intensified market competition in case *ID* makes the retailer also lower his selling prices in case *IE*.

Proposition 5. *When the e-retailer chooses in-marketplace mode, we have,*

1. *the e-retailer obtains the highest profit in case IE. That is,* $\pi_r^{IE} > \max\{\pi_r^{ID}, \pi_r^M\}$.
2. *The supplier obtains the highest profit in case ID. That is,* $\pi_s^{ID} > \max\{\pi_s^{IE}, \pi_s^M\}$.

Different from the scenario in which the e-retailer chooses the reselling mode, Proposition 5 indicates that when the e-retailer chooses the in-marketplace mode, the supplier will always choose a dual-channel strategy. From Proposition 5, the e-retailer will always be harmed by the supplier's introduction of the marketplace channel, while the supplier will always benefit from the introduction of the marketplace channel in addition to the reselling channel. Note that the marketplace channel serves two purposes. On the one hand, in the traditional sense, it is the way of direct selling for the supplier. However, it can also serve as a channel to compete with the e-retailer, which can affect the e-retailer's pricing in the distribution channel. Therefore, the supplier can always suppress the retailer's pricing by introducing the marketplace channel to obtain greater profits, while harming the e-retailer.

6. E-retailer Choosing Agency Selling Mode

*6.1. Supplier only introducing the agency channel (*AE*)*

For case *AE*, the e-retailer serves as a marketplace and provides the sales business to the supplier. Owing to the supplier's retailing inefficiency, the consumer incurs a valuation discount when purchasing the product in the e-retailer's agency channel. In this way, the consumer purchases the product only if $\beta\rho v - p_r \geq 0$; that is, $v \geq p_r/(\beta\rho)$. The demand for the agency channel is $D_r = \phi(1 - p_r/(\beta\rho))$. The profits of the supplier and e-retailer are $\pi_s = (1-\theta)p_r D_r - cD_r$ and $\pi_r = \theta p_r D_r$, respectively. We can verify that the supplier's optimal selling price in the agency channel is $p_r^{AE} = \frac{1}{2}(\frac{c}{1-\theta} + \beta\rho)$. The supplier's and the e-retailer's profits are $\pi_s^{AE} = \frac{((1-\theta)\beta\rho - c)^2\phi}{4(1-\theta)\beta\rho}$ and $\pi_r^{AE} = \frac{1}{4}\theta\beta\rho\phi - \frac{c^2\theta\phi}{4(1-\theta)^2\beta\rho}$, respectively.

*6.2. Supplier introducing the dual channels (*AD*)*

We now consider the scenario in which the e-retailer provides a platform to the supplier and charges her a referral fee α. If the consumer who is not aware of the e-retailer purchases only through the marketplace channel, $v \geq p_s/\rho$. The consumer who is aware of both channels compares the utility obtained from different channels and purchases through the channel that provides the highest utility. Hence, if $\rho v - p_s \geq \beta\rho v - p_r$ and $\rho v - p_s \geq 0$, then the consumer chooses to purchase through the marketplace channel. However, if $\beta\rho v - p_r \geq \rho v - p_s$ and $\beta\rho v - p_r \geq 0$, then the consumer chooses to purchase from the agency channel. Finally, if $\rho v - p_s \leq 0$ and $\beta\rho v - p_r \leq 0$, then they choose not to purchase.

We derive the demands in the supplier-owned marketplace and agency channels D_s and D_r, respectively, as follows:

$$(D_s, D_r) = \begin{cases} \left(1 - \frac{p_s}{\rho}, 0\right) & if\ \frac{p_r}{\beta\rho} \leq 1 \leq \frac{p_r - p_s}{(\beta-1)\rho} \\ \left(\phi\left(\frac{p_r - p_s}{(\beta-1)\rho} - \frac{p_s}{\rho}\right) + (1-\phi)\left(1 - \frac{p_s}{\rho}\right), \phi\left(1 - \frac{p_r - p_s}{(\beta-1)\rho}\right)\right) & if\ 0 \leq \frac{p_r}{\beta\rho} \leq \frac{p_r - p_s}{(\beta-1)\rho} \leq 1. \\ \left((1-\phi)\left(1 - \frac{p_s}{\rho}\right), \phi\left(1 - \frac{p_r}{\beta\rho}\right)\right) & if\ \frac{p_r - p_s}{(\beta-1)\rho} \leq \frac{p_r}{\beta\rho} \leq 1 \end{cases}$$

Table 5
Equilibrium strategies and profits for the supplier and e-retailer in case *AD*

Supplier's channel strategy	① Direct selling to all consumers $\underline{\bar{c}} \le c < \hat{c}_1^{AD}$	② No direct selling in the whole market $\hat{c}_1^{AD} \le c < \bar{c}$
p_s^{AD}	$\frac{1}{2}(\frac{c}{1-\alpha}+\rho)$	ρ
p_r^{AD}	$\frac{1}{2}(\frac{c}{1-\theta}+\beta\rho)$	$\frac{1}{2}(\frac{c}{1-\theta}+\beta\rho)$
Q_r^{AD}	$\frac{1}{2}(1-\frac{c}{\beta(1-\theta)\rho})\phi$	$\frac{1}{2}\phi(1-\frac{c}{(1-\theta)\beta\rho})$
$Q_{s(o)}^{AD}$	0	0
$Q_{s(e)}^{AD}$	$\frac{((1-\alpha)\rho-c)(1-\phi)}{2(1-\alpha)\rho}$	0
π_s^{AD}	$\frac{1}{4}(\rho(1-\alpha(1-\phi)+(\beta-1-\beta\theta)\phi)$ $-2c+\frac{c^2(\beta(1-\theta)(1-\phi)+\phi-\alpha\phi)}{(1-\alpha)\beta(1-\theta)\rho})$	$\frac{(c-\beta(1-\theta)\rho)^2\phi}{4\beta(1-\theta)\rho}$
π_r^{AD}	$\frac{1}{4}\beta\theta\rho\phi-\frac{c^2\theta\phi}{4\beta(1-\theta)^2\rho}$	$\frac{1}{4}\theta\beta\rho\phi-\frac{c^2\theta\phi}{4(1-\theta)^2\beta\rho}$

The profit functions of the supplier and e-retailer are $\pi_s^{AD}=(1-\alpha)p_sD_s+(1-\theta)p_rD_r$ and $\pi_r^{AD}=\theta p_rD_r$, respectively.

Lemma 3. *A threshold $\hat{c}_1^{AD}=(1-\alpha)\rho$ exists such that*

1. *when $\underline{\bar{c}} \le c \le \hat{c}_1^{AD}$, sales occur in the agency channel to serve the consumers in the overlapped market and the marketplace channel to serve the consumers in the exclusive market.*
2. *When $\hat{c}_1^{AD} < c < \bar{c}$, sales occur only in the agency channel to serve consumers in the overlapped market.*

The equilibrium results in case AD are reported in Table 5.

Because the supplier determines prices in both channels simultaneously, she tries to avoid conflicts between different channels. If the selling cost is relatively low ($\underline{\bar{c}} \le c \le \hat{c}_1^{AD}$), the supplier will set prices over the two channels such that only those consumers in the exclusive market will make a purchase through the 3P marketplace channel. Given that the selling cost is relatively high ($\widehat{c}_1^{AD} < c < \bar{c}$), the supplier can obtain only a small profit if she sells directly in the 3P marketplace channel. Trading off the benefit brought by additional profits in the 3P marketplace and the loss caused by horizontal channel competition, the supplier chooses to abandon selling in the 3P marketplace and only provides products in the agency channel to serve consumers in the overlapped market. Note that even if ϕ is large, both channels will not simultaneously serve the overlapped market.

6.3. *Comparison of cases* AE *and* AD

Based on the equilibrium results obtained in Sections 6.1 and 6.2, we compare them to gain insights into the supplier's channel strategy.

Proposition 6. *For agency selling mode,*

1. *the e-retailer's profit is the same under modes AD and AE. That is,* $\pi_r^{AE} = \pi_r^{AD}$.
2. *The supplier can derive the highest profit in mode AD when* $\bar{\bar{c}} \le c < \hat{c}_1^{AD}$*; otherwise, she has no incentive to introduce the marketplace channel. That is, when* $\bar{\bar{c}} \le c < \hat{c}_1^{AD}$, $\pi_s^{AD} > \pi_s^{AE} > \pi_s^{M}$*; when* $\hat{c}_1^{AD} \le c < \bar{c}$, $\pi_s^{AE} = \pi_s^{AD} > \pi_s^{M}$.

Similar to the scenarios in which the e-retailer chooses the reselling mode, from Proposition 6, we can conclude that when the e-retailer chooses the agency selling mode, the supplier will always choose a dual-channel strategy as long as she is not particularly unskilled in direct selling; that is, c is not too high. In addition, Proposition 6 indicates that when the e-retailer chooses the agency selling mode and the supplier's selling cost c is relatively high ($\hat{c}_1^{AD} \le c \le \bar{c}$), the introduction of the marketplace channel cannot bring the supplier higher profits. This is because the selling prices in both channels are determined by the supplier, and the marketplace channel loses the function of "manipulating the e-retailer channel." In this case, the marketplace channel only has the role of expanding the market. When the supplier's selling cost c is relatively low, she can benefit from a larger market due to additional sales brought by the marketplace channel (as shown in region ① of Fig. 7a). However, when the selling cost is relatively high, if the supplier introduces the marketplace channel, she has to charge a relatively high price to avoid loss, which induces no sales in the exclusive market. As a consequence, the supplier's profit is the same under cases AD and AE (as shown in region ② of Fig. 7a).

7. Equilibrium for the whole game

By comparing the results in Sections 4–6, we can derive the e-retailer's optimal selling mode choice and supplier's optimal channel introduction decision under different conditions as shown in Proposition 7.

Proposition 7.

1. *If* $\rho > \bar{\rho}$,
   1) *The e-retailer prefers reselling and induces the supplier to introduce dual channels (case RD) when* $\phi > \phi_1^{RI}$ *and* $c \ge c_1^{AR}$ *and induces the supplier to exclusively introduce the e-retailer channel (case RE) when* $\phi_2^{RI} < \phi < \phi_3^{RI}$.
   2) *The e-retailer prefers agency selling when* $\phi > \phi_1^{AI}$ *and* $c < c_1^{AR}$*, in which the supplier introduces dual channels (case AD).*
   3) *Otherwise, the e-retailer prefers in-marketplace selling and the supplier introduces dual channels (case ID).*
2. *If* $\rho \le \bar{\rho}$*, the e-retailer will never choose agency selling mode.*

Please refer to the Appendix for the definitions of $\bar{\rho}$, ϕ_1^{RI}, ϕ_2^{RI}, ϕ_3^{RI}, *and* c_1^{AR}.

The equilibrium channel strategies for the two firms across varying parameters are illustrated in Proposition 7 and Fig. 8. We set $\theta = 0.1$, $\alpha = 0.2$, $\phi = 0.2$, $\beta = 1.1$, and $\rho = 0.6$ or 0.9 in Fig. 8. Under the majority of scenarios, the equilibrium channel strategy is the dual-channel strategy. This aligns seamlessly with the outcomes derived from Propositions 3, 5, and 6. That is, no matter which channel mode (reselling, in-marketplace, or agency selling) is chosen by the e-retailer,

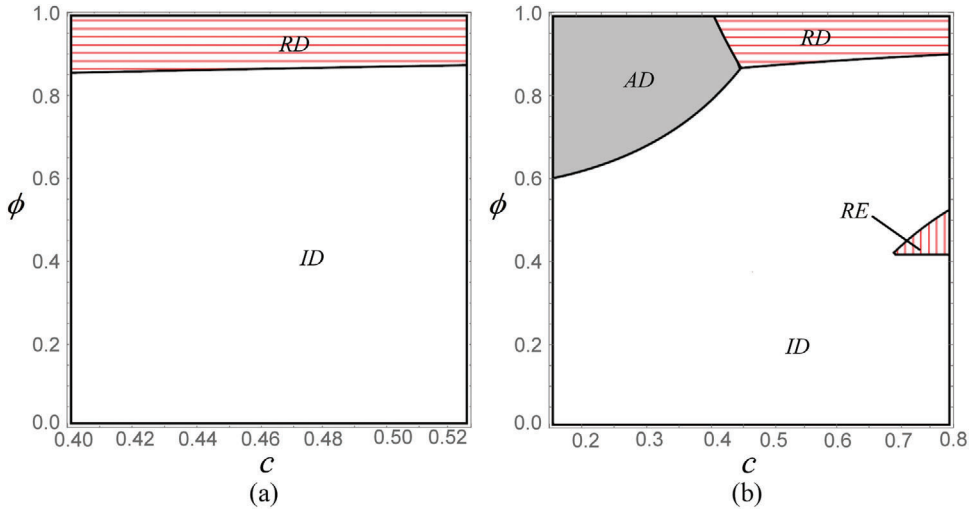

Fig. 8. Equilibrium strategies of channel members. (a) Low-quality sales service ($\rho = 0.6$) and (b) high-quality sales service ($\rho = 0.9$).

who acts as the leader in the channel decision-making process, in most cases, the supplier tends to opt to introduce the in-marketplace channel alongside the e-retailer channel. In addition, owing to the e-retailer's evident sales advantages, the supplier will invariably leverage the retailer channel. In instances where the supplier providing high-quality sales service is not proficient in direct selling (i.e., c is relatively large) and the proportion of all the consumers knowing both the e-retailer and marketplace channels (ϕ) falls within a mid-range, the equilibrium outcome may lean toward a single channel. In such cases, the supplier sells exclusively through the retailer channel, with the retailer adopting the reselling mode.

If the supplier provides high-quality sales service ($\rho > \bar{\rho}$), as depicted in Fig. 8b, reselling (R), in-marketplace (I), and agency selling (A) modes are all possible preferences for the specialized e-retailer. If the proportion of all the consumers knowing both the e-retailer and marketplace channels (ϕ) is small, the e-retailer has a strong incentive to choose in-marketplace mode to gain access to more consumers. If ϕ is large, the e-retailer has less incentive to choose in-marketplace mode, and if c is small, the e-retailer prefers agency selling. This is because, on the one hand, as c decreases, the e-retailer's profit under the agency selling mode increases (the advantage of agency selling is greater); on the other hand, if the e-retailer chooses the reselling mode, he will face strong horizontal competition from the supplier's marketplace channel, which is disadvantageous. However, if c is large, the reselling mode is more preferable for the e-retailer.

If the supplier is not able to provide high-quality sales service ($\rho \leq \bar{\rho}$), such as those suppliers in the small-commodities industry, the reselling (R) and in-marketplace (I) modes may be preferable, but agency selling mode (A) will never be chosen. If ϕ is small, the e-retailer has a strong incentive to choose in-marketplace mode to gain access to more consumers. However, if ϕ is large, the e-retailer prefers the reselling mode because he has the pricing power to compete with the supplier for more profit under this mode.

Table 6
Advantages and disadvantages of firms' different choices

Strategy		Analysis			
			Advantage		Disadvantage
Supplier's channel strategy	Introducing the marketplace channel	√	Obtain a large market (market expansion)	√	Incur a selling cost
		√	Horizontal channel competition is avoided		
	Introducing the e-retailer channel	√	Horizontal channel competition is avoided	√	E-retailer monopolizes the downstream market
	Introducing the e-retailer channel and the marketplace channel	√	Obtain a large market (market expansion)	√	Horizontal channel competition occurs (competition effect)
		√	Prevent the e-retailer from monopolizing the downstream market (price reference)	√	Incur a selling cost
E-retailer's selling mode choice	Reselling mode (R)	√	Can freely set market prices for profit (market power)	√	Horizontal competition with the marketplace channel when the selling cost is low
				√	Double marginalization
	In-marketplace selling mode (M)	√	Expand the market (market expansion)	√	Horizontal competition with the marketplace channel (Note that if the e-retailer chooses the In-marketplace selling mode, the supplier will definitely introduce the marketplace channel.)
				√	Double marginalization
	Agency selling mode (A)	√	The absence of double marginalization		
		√	The absence of horizontal competition (Note that under mode AD, the supplier uses different channel to serve different consumers to avoid horizontal competition.)	√	The supplier's selling inefficiency will cut into the e-retailer's profit

8. Conclusions and managerial insights

As e-commerce rapidly evolves and market competition intensifies, numerous suppliers and retailers opt for third-party platforms to broaden their sales channels and enhance market competitiveness. We consider a supply chain that comprises a supplier (she), a *specialized* e-retailer (he), and an online marketplace and examine the retailer's optimal selling mode choice and the supplier's optimal channel strategy. The e-retailer first chooses his selling mode from the reselling, in-marketplace selling, or agency selling modes, and then the supplier determines her channel strategy (marketplace, e-retailer, or both/dual channels). This study provides some valuable managerial implications for suppliers and *specialized* retailers when formulating strategies for third-party marketplace channel introduction and selling mode/channel choices. The primary results and insights are outlined below, and a comprehensive summary of the advantages and disadvantages associated with the various choices made by these two firms is provided in Table 6.

For the supplier, exclusively introducing the marketplace channel is not the optimal choice, and she can always obtain better by additionally introducing the specialized e-retailer's selling channel, primarily because the valuation premium induced by the specialized e-retailer overshadows the drawbacks of horizontal competition. In practice, the channel introduction and selection of the

supplier should be executed with caution. In general, for suppliers with less proficiency in selling, choosing dual channels is a smart choice, and the specific strategy should be determined according to the e-retailer's model selection. Particularly, (i) when the specialized e-retailer chooses the reselling mode, the supplier with a low unit selling cost should choose the dual channel (case *RD*) and charge a lower wholesale price; otherwise, she should not introduce the marketplace channel. If the unit selling cost falls within a middle range, the supplier should consider the strategy of threateningly direct sales to manipulate the e-retailer channel and gain higher profits, even if no sales occur in the overlapped market. This is because the introduction of a marketplace channel is not just a direct sales method for the supplier but also a means of competing with the e-retailer, thereby influencing the e-retailer's pricing in the distribution channel. However, if the unit selling cost is substantially high, the introduction of dual channels cannot make the supplier better. (ii) When the specialized e-retailer chooses the in-marketplace selling mode, the supplier should introduce the 3P marketplace channel and adopt the dual-channel strategy (case *ID*). If the unit selling cost is relatively low, sales take place in both the e-retailer's in-marketplace channel, serving the overlapped market, and the marketplace channel, serving the exclusive market. If the unit selling cost is sufficiently high, sales occur exclusively in the in-marketplace channel to serve the exclusive market, while threateningly direct sales occur in the overlapped market. (iii) When the specialized e-retailer chooses the agency selling mode, if the unit selling cost is relatively low, the supplier should introduce the additional 3P marketplace (case *AD*). In this case, sales occur in the agency channel to serve the consumers in the overlapped market and the marketplace channel to serve the consumers in the exclusive market. Otherwise, if the unit selling cost is sufficiently high, sales occur only in the agency channel to serve consumers in the overlapped market, and hence the supplier has no incentive to introduce the marketplace channel. For a high unit selling cost, both channels are priced by the supplier, and the marketplace channel loses the function of "manipulating the e-retailer channel," and hence the marketplace channel only has the role of expanding the market. Therefore, introducing a marketplace channel cannot bring the supplier with higher profits.

For the specialized e-retailer, we suggest that he choose the selling mode carefully according to the supplier's sales service quality. Specifically, (i) suppliers who offer high-quality sales service (such as the household appliance manufacturer Hair with its own logistics system and Midea with its perfect after-sales service department), reselling (*R*), in-marketplace (*I*), and agency selling (*A*) modes can all be preferred by the specialized e-retailer. Specific strategies depend on parameters such as the e-retailer's initial market share, the proportion of consumers aware of both the e-retailer and marketplace channels, and selling cost. For instance, the e-retailer should choose the reselling mode and induce the supplier to adopt dual channels (case *RD*) when their initial market share (i.e., the proportion of all consumers knowing both the e-retailer and marketplace channels) and selling cost are both relatively high and should induce the supplier to exclusively introduce the e-retailer channel (case *RE*) when the selling cost is in the medium range. Alternatively, when the e-retailer's initial market share is relatively high, but the selling cost is sufficiently low, the e-retailer should choose agency selling and induce the supplier to introduce dual channels (case *AD*); otherwise, the e-retailer should choose the in-marketplace selling mode to induce the supplier to introduce dual channels (case *ID*). (ii) For suppliers that provide low-quality sales service (such as suppliers in the small-commodities industry), the e-retailer should not choose the agency selling mode. If the e-retailer's initial market share is small, he should choose in-marketplace mode to get access to more consumers; otherwise, they should choose reselling mode.

There are several valuable directions for future research. First, we assume that the referral fee percentage of the 3P marketplace is fixed, and we can examine cases in which the marketplace strategically decides the referral fee percentage. Second, this study considers a case in which the supplier provides the same product through different channels. A good candidate for future exploration is to consider quality differentiation among channels, which is commonly adopted by suppliers to mitigate channel competition. Finally, channel competition is the key factor influencing suppliers' channel strategy. In addition, investigating an incentive contract to coordinate suppliers' dual channels under different selling modes, such as a bargaining contract, is also worthwhile.

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References

Abhishek, V., Jerath, K., Zhang, Z.J., 2016. Agency selling or reselling? Channel structures in electronic retailing. *Management Science* 62, 8, 2259–2280.

Arya, A., Mittendorf, B., Sappington, D.E.M., 2007. The bright side of supplier encroachment. *Marketing Science* 26, 5, 651–659.

Bernstein, F., Song, J., Zheng, X., 2009. Free riding in a multi-channel supply chain. *Naval Research Logistics* 56, 8, 745–765.

Cai, G.G., 2010. Channel selection and coordination in dual-channel supply chains. *Journal of Retailing* 86, 1, 22–36.

Chen, K., Kaya, M., Ozer, O., 2008. Dual sales channel management with service competition. *Manufacturing & Service Operations Management* 10, 4, 654–675.

Chen, X., Wang, X., Zhang, D., Yang, M., 2023. Selling models for platforms under service-sensitive demand. *Omega—International Journal of Management Science* 115, 102794.

Chiang, W.K., Chhajed, D., Hess, J.D., 2003. Direct marketing, indirect profits: a strategic analysis of dual-channel supply-chain design. *Management Science* 49, 1, 1–20.

Cui, Q., 2019. Quality investment, and the contract manufacturer's encroachment. *European Journal of Operational Research* 279, 2, 407–418.

Guan, X., Liu, B., Chen, Y.J., Wang, H., 2019. Inducing supply chain transparency through supplier encroachment. *Production and Operations Management* 29, 3, 725–749.

Ha, A., Long, X., Nasiry, J., 2015. Quality in supply chain encroachment. *Manufacturing & Service Operations Management* 18, 2, 280–298.

Ha, A.Y., Luo, H., Shang, W., 2022. Supplier encroachment, information sharing, and channel structure in online retail platforms. *Production and Operations Management* 31, 3, 1235–1251.

Hagiu, A., 2007. Merchant or two-sided platform? *The Review of Network Economics* 6, 2, 115–133.

Hagiu, A., Wright, J., 2015. Marketplace or reseller? *Management Science* 61, 1, 184–203.

Hu, H., Sun, S., Zheng, X., Chen, L., Huang, T., 2021. Committed or contingent? The retailer's information acquisition and sharing strategies when confronting manufacturer encroachment. *International Journal of Production Economics* 242, 108294.

Huang, S., Guan, X., Chen, Y., 2018. Retailer information sharing with supplier encroachment. *Production and Operations Management* 27, 6, 1133–1147.

Jia, D., Li, S., 2020. Optimal decisions and distribution channel choice of closed-loop supply chain when e-retailer offers online marketplace. *Journal of Cleaner Production* 265, 121767.
Li, K. K., Li, Y. Y., Gharehgozli, A., 2023. Selling exclusively or widely? Optimal strategic responses under online. platform power asymmetry and competition. *International Transactions in Operational Research*. https://doi.org/10.1111/itor.13350.
Li, Z., Gilbert, S.M., Lai, G., 2014. Supplier encroachment under asymmetric information. *Management Science* 60, 2, 449–462.
Lin, X., Lin, Q., Chen, Y.J., 2024. Reselling/agency selling and online intermediaries' information sharing with manufacturers and resellers. *Production and Operations Management* 33, 1, 264–281.
Liu, W., Liang, Y., Tang, O., Ma, X., 2022. Channel competition and collaboration in the presence of hybrid retailing. *Transportation Research Part E: Logistics and Transportation Review* 160, 102658.
Ryan, J.K., Sun, D., Zhao, X., 2012. Competition and coordination in online marketplaces. *Production and Operations Management* 21, 6, 997–1014.
Shen, J., Qian, J., Shao, X., 2022. Service channel choice for supply chain under online marketplace. *International Transactions in Operational Research* 29, 4, 2401–2422.
Shi, D., Wang, M., Li, X., 2021. Strategic introduction of marketplace platform and its impacts on supply chain. *International Journal of Production Economics* 242, 108300.
Shi, G., Jiang, L., Wang, Y., 2022. Interaction between the introduction strategy of the third-party online channel and the choice of online sales format. *International Transactions in Operational Research* 29, 4, 2448–2493.
Sigue, S., Gromova, E., 2023. The role of advertising in the choice between reselling and agency selling. *International Transactions in Operational Research*. https://doi.org/10.1111/itor.13351
Tahirov, N., Glock, C.H., 2022. Manufacturer encroachment and channel conflicts: a systematic review of the literature. *European Journal of Operational Research* 302, 2, 403–426.
Tian, L., Vakharia, A.J., Tan, Y.R., Xu, Y., 2018. Marketplace, reseller, or hybrid: strategic analysis of an emerging e-commerce model. *Production and Operations Management* 27, 8, 1595–1610.
Wang, F., Chen, J., Yang, H., Sun, F., 2024. Information and selling mode strategies in a supply chain with an outsourced private label product. *International Transactions in Operational Research* 31, 5, 3280–3317.
Wang, L., Chen, J., Song, H., 2021. Marketplace or reseller? Platform strategy in the presence of customer returns. *Transportation Research Part E: Logistics and Transportation Review* 153, 102452.
Xu, X., He, P., Zhang, S., 2021. Channel addition from marketplace or reselling under regional carbon cap-and-trade regulation. *International Journal of Production Economics* 236, 108130.
Yaghin, R.G., 2020. Enhancing supply chain production-marketing planning with geometric multivariate demand function (a case study of textile industry). *Computers & Industrial Engineering* 140, 106220.
Yan, Y., Zhao, R., Liu, Z., 2018. Strategic introduction of the marketplace channel under spillovers from online to offline sales. *European Journal of Operational Research* 267, 1, 65–77.
Yan, Y., Zhao, R., Xing, T., 2019. Strategic introduction of the marketplace channel under dual upstream disadvantages in sales efficiency and demand information. *European Journal of Operational Research* 273, 3, 968–982.
Yoon, D., 2016. Supplier encroachment and investment spillovers. *Production and Operations Management* 25, 11, 1839–1854.
Zhang, C., Li, Y., Ma, Y., 2021. Direct selling, agent selling, or dual-format selling: electronic channel configuration considering channel competition and platform service. *Computers & Industrial Engineering* 157, 107368.
Zhang, C., Ma, H., 2022. Introduction of the marketplace channel under logistics service sharing in an e-commerce platform. *Computers & Industrial Engineering* 163, 107724.
Zhang, J., Cao, Q., He, X., 2020. Manufacturer encroachment with advertising. *Omega—International Journal of Management Science* 91, 102013.
Zhang, J., Wu, D., 2022. How to design channel structures in the dual-channel supply chain with sequential entry of manufacturers? *Computers & Industrial Engineering* 169, 108234.
Zhang, S., Zhang, J., 2020. Agency selling or reselling: e-tailer information sharing with supplier offline entry. *European Journal of Operational Research* 280, 1, 134–151.
Zhang, S., Zhang, J., Zhu, G., 2019. Retail service investing: an anti-encroachment strategy in a retailer-led supply chain. *Omega—International Journal of Management Science* 84, 4, 212–231.

Zhen, X., Xu, S., 2021. Who should introduce the third-party platform channel under different pricing strategies? *European Journal of Operational Research* 299, 1, 168–182.
Zhen, X., Xu, S., Li, Y., Shi, D., 2022. When and how should a retailer use third-party platform channels? The impact of spillover effects. *European Journal of Operational Research* 301, 2, 624–637.
Zhou, J., Zhao, R., Wang, W., 2019. Pricing decision of a manufacturer in a dual-channel supply chain with asymmetric information. *European Journal of Operational Research* 278, 3, 809–820.

APPENDIX

Proofs of equilibrium results under modes M, RE, IE, and AE.

1. Under mode M, the supplier sells exclusively t*hrou*gh the marketplace channel, in which only the consumer with valuation $v > p_s/\rho$ will purchase the goods. Hence, the demand in the marketplace channel is $D_s = 1 - p_s/\rho$. The supplier's payoff function can be written as $\pi_s^M = (1-\alpha)p_s(1-p_s/\rho) - c(1-p_s/\rho)$. Solving the first order condition, we have $p_s^M = \frac{1}{2}(\frac{c}{1-\alpha} + \rho)$ for $0 < c < (1-\alpha)\rho$.
2. Under mode RE, the consumers whose valuation satisfies $v \geq p_r/\beta$ will purchase from the reselling channel. Hence, the demand in the retailer channel is $D_r = \phi(1 - p_r/\beta)$. The supplier's and the retailer's profit function are $\pi_s^{RE} = wD_r$ and $\pi_r^{RE} = (p_r - w)D_r$. Substituting $D_r = \phi(1 - p_r/\beta)$ into π_r^{RE}, we have $\pi_r^{RE} = (p_r - w)\phi(1 - p_r/\beta)$, which is concave on p_r if $p_r > w$ and $p_r < \beta$. Differentiating π_r^{RN} with respect to p_r, we have $\partial\pi_r^{RN}/\partial p_r = \phi(\beta + w - 2p_r)$. The first-order condition to the maximization of π_r^{RE} is $p_r^* = \frac{\beta+w}{2}$. Substituting p_r^* into π_s^{RE}, we have $\pi_s^{RE} = \frac{1}{2}(\beta - w)w\phi$, which is concave on w if $w < \beta$. Solving the first order condition, we have $w^{RE} = \frac{\beta}{2}$ and $p_r^{RE} = \frac{3\beta}{4}$.
3. Under mode IE, the consumers whose valuation satisfies $v \geq p_r/\beta$ will purchase from the retailer channel. Hence, the demand in the retailer channel is $D_r = 1 - p_r/\beta$. The supplier's and the retailer's profit function are $\pi_s^{IE} = wD_r$ and $\pi_r^{IE} = (1-\alpha)p_rD_r - wD_r$. Substituting $D_r = 1 - p_r/\beta$ into π_r^{IE}, we have $\pi_r^{IE} = ((1-\alpha)p_r - w)(1 - \frac{p_r}{\beta})$, which is concave on p_r if $p_r > \frac{w}{1-\alpha}$ and $p_r < \beta$. Differentiating π_r^{ME} with respect to p_r, we have $\partial\pi_r^{IE}/\partial p_r = \frac{w+\beta+2p_r(-1+\alpha)-\beta\alpha}{\beta}$. The first-order condition to the maximization of π_r^{IE} is $p_r^* = \frac{w+\beta}{2}$. Substituting p_r^* into π_s^{IE}, we have $\pi_s^{IE} = \frac{w(\beta(1-\alpha)-w)}{2\beta(1-\alpha)}$, which is concave on w if $w < \beta(1-\alpha)$. Solving the first order condition, we have $w^{IE} = \frac{\beta}{2}(1-\alpha)$ and $p_r^{IE} = \frac{3}{4}\beta$. Then the channel members' equilibrium profits can be easily obtained.
4. Under mode AE, the supplier directly sells to the end consumers through the agency selling channel. Note that the utility of the consumers purchasing in this channel can be expressed as $U = \rho v - p_r$. Hence, only the consumer whose reserved utility $v \geq p_r/(\beta\rho)$ will purchase from this channel. The demand function is $D_r = \phi(1 - p_r/(\beta\rho))$. The supplier's profit function can be written as $\pi_s^{AE} = \phi(1-\theta)(1 - p_r/(\beta\rho))p_r - c\phi(1 - p_r/(\beta\rho))$. The first-order condition to the maximization of π_s^{AE} is $p_r^* = \frac{1}{2}(\frac{c}{1-\theta} + \beta\rho)$. The profits of the supplier and the e-retailer are $\pi_s^{AE} = \frac{((1-\theta)\beta\rho - c)^2\phi}{4(1-\theta)\beta\rho}$ and $\pi_r^{AE} = \frac{1}{4}\theta\beta\rho\phi - \frac{c^2\theta\phi}{4(1-\theta)^2\beta\rho}$, respectively.

Proof of Lemma 1. We first define four mutually-exclusive regions A_1^{RD}, A_2^{RD}, A_3^{RD} and A_4^{RD}, and let $A_1^{RD} = \{\frac{w\rho+\beta\rho}{2\beta} \le p_s \le \rho\}$, $A_2^{RD} = \{w-\beta+\rho \le p_s \le \frac{-w\rho-\beta\rho+\rho^2}{-2\beta+\rho}\}$, $A_3^{RD} = \{w-\beta+\rho \le p_s \le \frac{-w\rho-\beta\rho+\rho^2}{-2\beta+\rho}\}$, $A_4^{RD} = \{0 \le p_s \le w-\beta+\rho\}$.

With backward induction, to characterize the equilibrium for the system, we first investigate the retialer's best resoponse to the supplier's whosale price w and sales price p_s, which is summarized as Lemma A1 as follows.

Lemma A1. *Given a wholesale price w and a direct price p_s, the optimal price p_r is given by*:

$$p_r = \begin{cases} \frac{w+\beta}{2}, & (p_s, w) \in A_1^{RD} \\ \frac{\beta p_s}{\rho}, & (p_s, w) \in A_2^{RD} \\ \frac{1}{2}(w+\beta-\rho+p_s), & (p_s, w) \in A_3^{RD} \\ \beta-\rho+p_s, & (p_s, w) \in A_4^{RD} \end{cases}$$

Anticipating the retailer's best response, the supplier's equilibrium price can be obtained by comparing her payoffs among regions $A_i^{RD}, i = 1, 2, 3, 4$.

In region A_1^{RD}, the supplier's decision problem is

$$\max_{p_s,w} \pi_s^{RD} = \frac{w(\beta-w)\phi}{2\beta} + \frac{c(1-\phi)(\rho-p_s)}{\rho} + \frac{(1-\alpha)(1-\phi)(\rho-p_s)p_s}{\rho}, \text{ s.t. } (p_s, w) \in A_1^{RD}.$$

By solving the first order condition, we have $w^* = \frac{\beta}{2}$ and $p_s = \frac{1}{2}(\frac{c}{1-\alpha}+\rho)$. In order to satisfy the condition that $(p_s, w) \in A_1^{RD}$, it should be guaranteed that $\frac{1}{2}(\rho-\alpha\rho) \le c \le \rho-\alpha\rho$. The profits of the supplier and the retailer in this case are $\pi_s^{A_{11}^{RD}} = \frac{1}{8}(4c(-1+\phi) + \frac{2c^2(-1+\phi)}{(-1+\alpha)\rho} + 2(-1+\alpha)\rho(-1+\phi) + \beta\phi)$ and $\pi_r^{A_{11}^{RD}} = \frac{\beta\phi}{16}$, respectively.

If $c < \frac{1}{2}(\rho-\alpha\rho)$, without loss of generality, we set the price in marketplace channel $p_s{}^* = \frac{(w+\beta)\rho}{2\beta}$ to satisfy the condition $(p_s, w) \in A_1^{RD}$. Then, the wholesale price can be derived with the first order condition that $w = \frac{\beta(c-c\phi+\beta\phi)}{(1-\alpha)\rho(1-\phi)+2\beta\phi}$. The profits of the supplier and the retailer in this case are $\pi_s^{A_{12}^{RD}} = \frac{(c(-1+\phi)+(-1+\alpha)\rho(-1+\phi)+\beta\phi)^2}{4(-1+\alpha)\rho(-1+\phi)+8\beta\phi}$ and $\pi_r^{A_{12}^{RD}} = \frac{1}{4}\beta\phi(1-\frac{c-c\phi+\beta\phi}{(1-\alpha)\rho(1-\phi)+2\beta\phi})^2$, respectively.

If $c > \rho-\alpha\rho$, without loss of generality, we set the price in marketplace channel $p_s{}^* = \rho$ to satisfy the condition $(p_s, w) \in A_1^{RD}$. Then, the wholesale price can be derived with the first order condition that $w = \frac{\beta}{2}$. The profits of the supplier and the retailer in this case are $\pi_s^{A_{13}^{RD}} = \frac{\beta\phi}{8}$ and $\pi_r^{A_{13}^{RD}} = \frac{\beta\phi}{16}$, respectively.

In region A_1^{RD}, the e-retailer's profit can be summarized as

$$\pi_r^{A_1^{RD}} = \begin{cases} \frac{1}{4}\beta\phi\left(-1+\frac{c-c\phi+\beta\phi}{(-1+\alpha)\rho(-1+\phi)+2\beta\phi}\right)^2 & if\ c < \frac{1}{2}(\rho-\alpha\rho) \\ \frac{\beta\phi}{16} & if\ \frac{1}{2}(\rho-\alpha\rho) \le c \le \rho-\alpha\rho \\ \frac{\beta\phi}{16} & if\ c > \rho-\alpha\rho \end{cases}.$$

The supplier's decision in region A_2^{RD}, A_3^{RD}, and A_4^{RD} can be also given with the similar proof, and thus is omitted here.

Comparing the supplier's profits under different regions, we can finally get the payoffs of the suppliers and e-retailer at equilibrium.

Proof of Lemma A1. According to the consumers' purchasing decision discussed in the main text, the retailer has three pricing strategies, depending on how his selling price compares with that in the marketplace channel: (i) $\frac{p_r-p_s}{\beta-\rho} \le \frac{p_r}{\beta} < 1$, (ii) $0 < \frac{p_r}{\beta} \le \frac{p_r-p_s}{\beta-\rho} < 1$, and (iii) $0 < \frac{p_r}{\beta} < 1 < \frac{p_r-p_s}{\beta-\rho}$.

In case (i), the retailer earns zero profit due to no sales in the reselling channel. Hence, it is a dominated strategy for the retailer. Without loss of generality, let $p_r = \frac{\beta p_s}{\rho}$, which can be derived from $\frac{p_r-p_s}{\beta-\rho} = \frac{p_r}{\beta}$.

In case (ii), we first investigate the inner solution, in which the retailer's profit function is $\pi_r^{RD} = \phi(-w+p_r)(1-\frac{p_r-p_s}{\beta-\rho})$. From the first order condition, we have $p_r{}^* = \frac{1}{2}(w+\beta-\rho+p_s)$. Note that the condition $0 < \frac{p_r}{\beta} \le \frac{p_r-p_s}{\beta-\rho} < 1$ holds if and only if $w-\beta+\rho \le p_s \le \frac{-w\rho-\beta\rho+\rho^2}{-2\beta+\rho}$. Under this circumstance, the retailer's profit is $\pi_r^{RD} = \frac{\phi(w-\beta+\rho-p_s)^2}{4(\beta-\rho)}$, and the supplier's profit is

$$\pi_s^{RD} = \frac{\begin{pmatrix}-\rho\left(w\left(w-\beta+\rho\right)\phi + c\left(-\beta\left(-2+\phi\right)+\rho\left(-2+\phi\right)+w\phi\right)\right)+\left(-1+\alpha\right)\left(2\beta+\rho\left(-2+\phi\right)\right)p_s^2\\ +\left(c\left(2\beta+\rho\left(-2+\phi\right)\right)+\rho\left(\left(-1+\alpha\right)\beta\left(-2+\phi\right)-\left(-1+\alpha\right)\rho\left(-2+\phi\right)-w\left(-2+\alpha\right)\phi\right)\right)p_s\end{pmatrix}}{2\left(\beta-\rho\right)\rho}.$$

Then we investigate the corner solution under the condition that $0 < \frac{p_r}{\beta} \le \frac{p_r-p_s}{\beta-\rho} = 1$, in which there is no demand in the reselling channel. Hence, it is also a dominated strategy for the retailer. Another corner solution is $0 < \frac{p_r}{\beta} = \frac{p_r-p_s}{\beta-\rho} < 1$. Without loss of generality, we set $p_r{}^* = \frac{\beta p_s}{\rho}$. We then derive the supplier's and retailer's profit follows $\pi_s^{RD} = \frac{(\rho-p_s)(c(-1+\phi)+w\phi+(-1+\alpha)(-1+\phi)p_s)}{\rho}$, $\pi_r^{RD} = \frac{\phi(\rho-p_s)(\beta p_s-w\rho)}{\rho^2}$.

In case (iii), we first investigate the inner solution with the condition that $0 < p_r < 1 < \frac{p_r-p_s}{\beta-\rho}$. Solving the first order condition, the optimal selling price in the reseller channel is $p_r{}^* = \frac{w+\beta}{2}$. To satisfy the condition $0 < p_r < 1 < \frac{p_s-p_r}{\beta\rho-1}$, we need $\frac{w\rho+\beta\rho}{2\beta} < p_s < \rho$. The supplier's and the retailer's profits are $\pi_m^{RD} = \frac{w(\beta-w)\phi}{2\beta} + \frac{c(-1+\phi)(\rho-p_s)}{\rho} + \frac{(-1+\alpha)(-1+\phi)(\rho-p_s)p_s}{\rho}$, $\pi_r^{RD} = \frac{(w-\beta)^2\phi}{4\beta}$. Then we investigate the corner solution with the condition that $0 < p_r < 1 = \frac{p_r-p_s}{\beta-\rho}$. Without loss of generality, we set $p_r{}^* = p_s+\beta-\rho$. And then we will come to the same equilibrium as that in case (ii).

By comparing the retailer's payoffs among different scenarios discussed above, we can easily get the retailer's best response, summarized as Lemma 1.

Proof of Proposition 1.

1. $\frac{\partial \hat{c}_1^{RD}}{\partial \phi} = -\frac{\alpha\beta\rho(4\beta+(4-\alpha)\rho)}{(4\beta-\rho(2+\alpha(1-\phi)))^2}$. We can see that $(4\beta-\rho(2+\alpha(1-\phi)))^2 > 0$ and $\alpha\beta\rho(4\beta+(4-\alpha)\rho) > 0$ for $\beta > 1,\ 0 < \rho < 1,\ 0 < \alpha < 2\sqrt{2}\sqrt{\frac{2\beta^2-4\beta\rho+2\rho^2+\beta\rho\phi-\rho^2\phi}{\rho^2\phi^2}} - \frac{4(\beta-\rho)}{\rho\phi}$ and $0 < \phi < 1$.

$$2.\ \hat{c}_2^{RD} - \hat{c}_1^{RD} = \begin{cases} -\frac{(-1+\alpha)(\beta-\rho)\rho}{2\beta-\rho} + \frac{\sqrt{\frac{(-1+\alpha)\beta\rho^2(\rho+\alpha\rho(-1+\phi)+2\beta\phi-2\rho\phi)}{(-2\beta+\rho)^2(-1+\phi)}}}{\sqrt{2}} \\ \quad + \frac{\rho((-1+\alpha)\rho(-2+\alpha(-1+\phi))+\beta(-2+\alpha(2+\phi)))}{4\beta+\rho(-2+\alpha(-1+\phi))} \qquad if\ 0 < \phi < \frac{1-\alpha}{2-\alpha} \\ -\frac{\sqrt{\frac{\beta\phi(\rho+\alpha\rho(-1+\phi)+2\beta\phi-2\rho\phi)}{(-1+\phi)^2}}}{\sqrt{2}} + \frac{-\beta\phi+\rho(-1+\alpha+\phi-\alpha\phi)}{-1+\phi} \\ \quad + \frac{\rho((-1+\alpha)\rho(-2+\alpha(-1+\phi))+\beta(-2+\alpha(2+\phi)))}{4\beta+\rho(-2+\alpha(-1+\phi))} \qquad if\ \frac{1-\alpha}{2-\alpha} \le \phi < 1 \end{cases}$$

It can be verified that $\frac{\partial \hat{c}_2^{RD} - \hat{c}_1^{RD}}{\partial \phi} < 0$.

Proof of Proposition 2.

1. When $c \le \hat{c}_1^{RD}$, we have $w^{RE} > w^{RD}$; when $\hat{c}_1^{RD} \le c \le \hat{c}_2^{RD}$, $w^{RE} - w^{RD} = \frac{(c(2\beta-\rho)+(-1+\alpha)(\beta-\rho)\rho)(-1+\phi)}{2(\rho+\alpha\rho(-1+\phi)+2\beta\phi-2\rho\phi)} > 0$ is equivalent to $c < \frac{(1-\alpha)(\beta-\rho)\rho}{2\beta-\rho}$; when $\hat{c}_2^{RD} \le c \le \bar{c}$, we have $w^{RE} - w^{RD} = 0$. Hence, if and only if $c < \frac{(1-\alpha)(\beta-\rho)\rho}{2\beta-\rho}$, $w^{RE} > w^{RD}$.
2. When $c \le \hat{c}_1^{RD}$, we have $p_s^{RD} > p_s^M$; when $\hat{c}_1^{RD} \le c \le \hat{c}_2^{RD}$, $p_s^{RD} - p_s^M = \frac{(c(2\beta-\rho)+(-1+\alpha)(\beta-\rho)\rho)\phi}{2(-1+\alpha)(\rho+\alpha\rho(-1+\phi)+2\beta\phi-2\rho\phi)} > 0$ is equivalent to $c < \frac{(1-\alpha)(\beta-\rho)\rho}{2\beta-\rho}$; when $\hat{c}_2^{RD} \le c \le \bar{c}$, we have $p_s^M - p_s^{RD} \ge 0$. Hence, if and only if $c < \frac{(1-\alpha)(\beta-\rho)\rho}{2\beta-\rho}$, $p_s^{RD} > p_s^M$.

Proof of Proposition 3.

1. Note that $\pi_r^M = 0$, $\pi_r^{RE} > 0$, and $\pi_r^{RD} > 0$. Hence, $\pi_r^M < \min\{\pi_r^{RD}, \pi_r^{RE}\}$. Next, we compare π_r^{RD} and π_r^{RE} in the feasible regions. (a) When $c \le \hat{c}_1^{RD}$, $\pi_r^{RD} - \pi_r^{RE} = \frac{(1-\alpha)^2(\beta-\rho)(2\beta-(2-\alpha)\rho)^2\phi}{(8(-1+\alpha)\beta+\rho(8-8\alpha+\alpha^2\phi))^2} - \frac{\beta\phi}{16} > 0$ is equivalent to $c > \tilde{c}_1^R$. (b) When $\hat{c}_1^{RD} \le c \le \hat{c}_2^{RD}$, $\pi_r^{RD} - \pi_r^{RE} = \frac{1}{16}\phi(-\beta + \frac{4(\beta-\rho)((-1+\alpha)\rho(-1+\phi)+\beta\phi)^2}{(\rho+\alpha\rho(-1+\phi)+2\beta\phi-2\rho\phi)^2}) > 0$ is equivalent to $c < \tilde{c}_2^{RD}$. (c) When $c > \hat{c}_2^{RD}$, $\pi_r^{RE} = \pi_r^{RD}$.
2. As for the supplier, it is easy to proof that $\pi_s^M < \pi_s^{RD}$, that is, the supplier will not choose mode M. Next, we compare π_s^{RD} and π_s^{RE} in the feasible regions. (a) When $c \le \hat{c}_1^{RD}$, $\pi_s^{RD} - \pi_s^{RE} = \frac{(-1+\alpha)(\beta-\rho)((-1+\alpha)\rho(-2+\phi)+\beta\phi)}{8(-1+\alpha)\beta+\rho(8-8\alpha+\alpha^2\phi)} - \frac{\beta\phi}{8} > 0$. (b) When $\hat{c}_1^{RD} \le c \le \hat{c}_2^{RD}$, $\pi_r^{RD} - \pi_r^{RE} = \frac{((1-\alpha)\rho(1-\phi)+\beta\phi)^2}{4(\rho-\alpha\rho(1-\phi)+2\beta\phi-2\rho\phi)} - \frac{\beta\phi}{8} > 0$. (c) When $\hat{c}_2^{RD} < c < \hat{c}_3^{RD}$, $\pi_s^{RD} - \pi_s^{RE} = \frac{(c+(-1+\alpha)\rho)^2(1-\phi)}{4(1-\alpha)\rho} > 0$. 4) When $\hat{c}_3^{RD} \le c \le \bar{c}$, $\pi_s^{RD} - \pi_s^{RE} = 0$. Hence, we can see that when $c \in [\underline{\bar{c}},\ \tilde{c}_2^R]$, $\pi_s^{RD} > \pi_s^{RE} > \pi_s^M$; when $c \in [\tilde{c}_3^R,\ \bar{c}]$, $\pi_s^{RE} = \pi_s^{RD} > \pi_r^M$.

Proof of Lemma 2. The proof is similar with the proof of Lemma 1, and thus is omitted here.
Proof of Proposition 4.

1. The proof is straightforward, and thus is omitted here.
2. According to the result derived in Section 5.1 and Lemma 2, we have $p_s^{ID} = \begin{cases} \frac{c+\rho-\alpha\rho}{2-2\alpha} & if\ \underline{\bar{c}} \le c < \frac{(1-\alpha)(\beta-\rho)\rho}{2\beta-\rho} \\ \frac{\beta(3\beta-2\rho)}{4\beta-2\rho} & if\ c \ge \frac{(1-\alpha)(\beta-\rho)\rho}{2\beta-\rho} \end{cases}$ and $p_s^M = \frac{1}{2}(\frac{c}{1-\alpha} + \rho)$.

Hence, $p_s^M - p_s^{ID} = \begin{cases} \frac{c\alpha}{2(1-a)} & if\, \bar{c} \le c < \frac{(1-\alpha)(\beta-\rho)\rho}{2\beta-\rho} \\ \frac{1}{2}\left(\frac{c-\frac{(1-\alpha)\rho(\beta-\rho)}{2\beta-\rho}}{1-\alpha}\right) & if\ c \ge \frac{(1-\alpha)(\beta-\rho)\rho}{2\beta-\rho} \end{cases}$. Note that $1-\alpha > 0$. Hence, $p_s^M - p_s^{ID} > 0 \to p_s^M > p_s^{ID}$. Similarly, we can proof that $p_r^{ID} < p_r^{IE}$.

Proof of Proposition 5. Note that $\pi_r^M = 0$, $\pi_r^{IE} > 0$ and $\pi_r^{ID} > 0$. Hence, $\pi_r^M < \min\{\pi_r^{ID}, \pi_r^{IE}\}$. Next, we compare π_r^{ID} and π_r^{IE} in the feasible regions. (a) When $c \le \hat{c}_1^{IE}$, $\pi_r^{IE} - \pi_r^{ID} = \frac{1}{16}(1-\alpha)(\rho - c(2+\frac{c}{\beta-\rho})) > 0$; (b) when $\hat{c}_1^{ID} \le c \le \bar{c}$, $\pi_r^{IE} - \pi_r^{ID} = \frac{(1-\alpha)\beta\rho^2}{16(2\beta-\rho)^2} > 0$.

As for the supplier, it can be easily proof that $\pi_s^M < \pi_s^{ID}$, that is, the supplier will not choose mode M. Next, we compare π_s^{ID} and π_s^{IE} in the feasible regions. (1) When $c \le \hat{c}_1^{ID}$, $\pi_s^{IE} - \pi_s^{ID} = \frac{(c-(-1+\alpha)(\beta-\rho))^2}{8(1-\alpha)(\beta-\rho)} > 0$; (2) when $\hat{c}_1^{ID} \le c \le \bar{c}$, $\pi_r^{IE} - \pi_r^{ID} = \frac{(1-\alpha)\beta^2}{8\beta-4\rho} - \frac{(c-(1-\alpha)\rho)^2}{4(1-\alpha)\rho} > 0$.

Proof of Lemma 3. According to the consumers' purchasing decision discussed in the main text, the supplier has three pricing strategies, depending on how his selling price compares with that in the marketplace channel: (i) $\frac{p_r-p_s}{(\beta-1)\rho} \le \frac{p_r}{\beta\rho} < 1$, (ii) $0 < \frac{p_r}{\beta\rho} \le \frac{p_r-p_s}{(\beta-1)\rho} < 1$, and (iii) $\frac{p_r}{\beta\rho} < 1 < \frac{p_r-p_s}{(\beta-1)\rho}$.

In case (i), the supplier earns zero profit in the e-retailer channel. Without loss of generality, let $p_s = \frac{p_r}{\beta}$, which can be derived from $\frac{p_r-p_s}{(\beta-1)\rho} = \frac{p_r}{\beta\rho}$.

In case (ii), we first investigate the inner solution. Solving the first order condition, we have $p_s^* = \frac{(-1+\beta)(-1+\theta)(-2c+\rho(-2-\alpha(-2+\phi)+\theta\phi))}{4(-1+\alpha)(-1+\beta)(-1+\theta)-(\alpha-\theta)^2\phi}$, $p_r{}^* = \frac{(-1+\beta)(-c(-2+\alpha+\theta)-(-1+\alpha)\rho(2\beta+\theta-2\beta\theta+\alpha(-1+\phi)-\theta\phi))}{4(-1+\alpha)(-1+\beta)(-1+\theta)-(\alpha-\theta)^2\phi}$. Given p_s^* and p_r^*, it can be verified that the condition $\frac{p_r{}^*}{\beta\rho} < \frac{p_r{}^*-p_s{}^*}{(\beta-1)\rho}$ cannot hold. To satisfy the condition, we set $p_s = \frac{p_r}{\beta}$, which is derive from the equation $\frac{p_r}{\beta\rho} = \frac{p_r-p_s}{(\beta-1)\rho}$. Substituting $p_s = \frac{p_r}{\beta}$ into the supplier's profit function, we have $\pi_s^{AD} = \frac{(\beta\rho-p_r)(-c\beta+(1-\alpha-\phi+\alpha\phi+\beta\phi-\beta\theta\phi)p_r)}{\beta^2\rho}$. Solving the first order condition, we have $p_r^* = \frac{c+\rho+\alpha\rho(-1+\phi)+(-1+\beta-\beta\theta)\rho\phi}{2(1+\alpha(-1+\phi)+(-1+\beta-\beta\theta)\phi)}$. Solving $p_s = \frac{p_r{}^*}{\beta}$, we have $p_s^* = (\rho + c/(1-\alpha)(1+(-1+\beta)\phi))/2$. The payoff of the supplier and the e-retailer are $\pi_s^{AD} = (c+\rho(-1+\alpha+\phi-\alpha\phi-\beta\phi+\beta\theta\phi))^2/(4\rho(1+\alpha(-1+\phi)+(-1+\beta-\beta\theta)\phi))$ and $\pi_r^{AD} = \beta\theta\phi(\rho^2(-1+\alpha+\phi-\alpha\phi-\beta\phi+\beta\theta\phi)^2 - c^2)/(4\rho(\alpha-1+\phi-\alpha\phi-\beta\phi+\beta\theta\phi)^2)$, respectively.

In case (iii), we first investigate the inner solution with the condition that $0 < p_r < 1 < \frac{p_r-p_s}{\beta-\rho}$. Solving the first order condition, the optimal selling price in the reseller channel is $p_r{}^* = \frac{1}{2}(\frac{c}{1-\theta} + \beta\rho)$ and $p_s{}^* = \frac{1}{2}(\frac{c}{1-\theta} + \rho)$. To satisfy the condition $0 < p_r < 1 < \frac{p_r-p_s}{\beta-\rho}$, we need $0 < c < \hat{c}_1 \triangleq \rho - \alpha\rho$. The supplier's and the retailer's profits are $\pi_s^{AD} = \frac{1}{4}\begin{pmatrix} \rho(1-\alpha(1-\phi)+(\beta-1-\beta\theta)\phi) \\ -2c + \frac{c^2(\beta(1-\theta)(1-\phi)+\phi-\alpha\phi)}{(1-\alpha)\beta(1-\theta)\rho} \end{pmatrix}$, $\pi_r^{AD} = \frac{1}{4}\beta\theta\rho\phi - \frac{c^2\theta\phi}{4\beta(1-\theta)^2\rho}$.

When $\rho - \alpha\rho \le c \le \bar{c}$, Then we investigate the corner solution with the condition that $\frac{p_r}{\beta\rho} < 1 = \frac{p_r-p_s}{(\beta-1)\rho}$. At equilibrium, the supplier's and the e-retailer's profit are, respectively, $\pi_s^{AD} = \frac{(\beta(1-\theta)\rho-c)^2\phi}{4\beta(1-\theta)\rho}$ and $\pi_r^{AD} = \frac{1}{4}\beta\theta\rho\phi - \frac{c^2\theta\phi}{4\beta(1-\theta)^2\rho}$.

By comparing the supplier's payoff among different scenarios above, we can easily get the equilibrium results, summarized as Lemma 3.

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Proof of Proposition 6.

1. It is straightforward to see that $\pi_r^{AE} = \pi_r^{AD} = \theta\beta\rho\phi/4 - c^2\alpha\phi/(4(1-\theta)^2\beta\rho)$.
2. As for the supplier, it is easy to prove that $\pi_s^M < \pi_s^{AD}$, that is, the supplier will not choose mode M. Next, we compare π_s^{AD} and π_s^{AE} in the feasible regions. (1) When $c \le \hat{c}_1^{AD}$, $\pi_s^{AD} - \pi_s^{AE} > 0$; (2) when $\hat{c}_1^{AD} \le c \le \bar{c}$, $\pi_s^{AD} - \pi_s^{AE} = 0$.

Proof of Proposition 7. In order to obtain the e-retailer's equilibrium selling mode choice, we compare his profits pairwise.

1. We first compare the e-retailer's profits under mode R and mode I. According to the equilibrium payoff obtained in Lemma 1, we can easily get the following properties by comparing the retailer's profit under different modes:

a) When $0 < c < \hat{c}_3^{RD}$, if the e-retailer chooses the reselling mode, the supplier will introduce the e-retailer channel and the marketplace channel. On the other hand, the supplier will always sell through these two channels under mode I. Hence, we compare the e-retailer's payoff under mode RD and mode ID in the range of $0 < c < \hat{c}_3^{RD}$. There exists a threshold ϕ_1^{RI} such that, when $\phi < \phi_1^{RI}$, we have $\pi_r^{ID} > \pi_r^{RD}$; when $\phi > \phi_1^{RI}$, $\pi_r^{ID} < \pi_r^{RD}$.

b) When $\hat{c}_3^{RD} < c < \bar{c}$, if the e-retailer chooses the reselling mode, the supplier will only sell through the e-retailer channel. On the other hand, the supplier will always sell through both the marketplace channel and the e-retailer channel under mode I. Hence, we compare the e-retailer's payoff under mode RE and mode ID in the range of $\hat{c}_3^{RD} < c < \bar{c}$. We find that there exists a threshold ϕ_2^{RI} such that, when $\phi < \phi_2^{RI}$, we have $\pi_r^{ID} > \pi_r^{RE}$; when $\phi > \phi_2^{RI}$, $\pi_r^{ID} < \pi_r^{RE}$. The range $\hat{c}_3^{RD} < c < \bar{c}$ can also be rewritten as $\phi < \phi_3^{RI}$. To summarize, when $\phi_2^{RI} < \phi < \phi_3^{RI}$, $\pi_r^{ID} < \pi_r^{RE}$; when $\phi < \phi_2^{RI}$, $\pi_r^{ID} > \pi_r^{RE}$.

2. We then compare the e-retailer's profits under mode A and mode I. When $c < \hat{c}_1^{AI}$, the supplier chooses to sell in the marketplace and the e-retailer's webstore under mode A and mode I. Thus, we compare the e-retailer's profit between mode AD and ID. $\pi_r^{AD} - \pi_r^{ID} > 0$ is equivalent to $\phi > \phi_1^{AI}$.

3. We finally compare the e-retailer's profits under mode R and mode A. In order to avoid tedious discussions, we only focus on the region $\phi \in [\min\{\phi_1^{AI}, \phi_1^{RI}\}, 1] \cup [\phi_2^{RI}, \phi_3^{RI}]$ because in other regions, both mode A and mode R are dominated by mode I. Comparing the e-retailer's profits under mode R and A, we find that there exists a c_1^{AR} such that when $c < c_1^{AR}$, the e-retailer prefers the agency selling mode, and he prefers the reselling mode when $c \ge c_1^{AR}$. Furthermore, when $\rho \le \overline{\rho}$, we have $c_1^{AR} < 0$, the reselling mode is a dominant strategy.