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INDISCRIMINATE OR MEMBERSHIP-BASED? THE LOGISTICS SERVICE STRATEGIES FOR E-COMMERCE PLATFORMS

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Abstract. This study focuses on e-commerce platforms that operate self-built logistics networks and extend these services to external channels. It examines two major logistics strategies used by such platforms: Indiscriminate Logistics Service (ILS) mode and Membership-Based Logistics Service (MLS) mode. ILS mode offers high-level logistics services to all consumers, while MLS mode restricts premium services to paying members. We examine which strategy yields better outcomes for both platforms and manufacturers, and how exogenous factors influence strategic choices. Results show that MLS mode does not always attract more members. When both the membership fee and logistics service level are low, ILS mode is more effective, as the price discounts in ILS mode are more attractive to members than the service upgrades offered in MLS mode. The optimal strategy for platforms and manufacturers depends on the membership fees and logistics service level. When the membership fee is high and logistics level is moderate, their interests may diverge. In other cases, a win–win outcome is achievable. Furthermore, in MLS, rising third-party logistics costs can increase members if membership fees remain moderate. In ILS, even low membership fees may fail to attract members if consumers strongly prefer purchasing through manufacturers' direct channels.

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1. Introduction

Over the past decade, e-commerce has grown rapidly, with global sales increasing from \$1.3 trillion in 2014 to \$5.2 trillion in 2021. This figure is expected to reach approximately \$8.1 trillion by 2026 [10]. Logistics services are critical to e-commerce, as they directly influence both consumer experience and firm performance [43]. To improve logistics efficiency, leading platforms such as Amazon and JD.com have established their own logistics networks. Compared to traditional third-party logistics (3PL), platform-operated logistics generally achieve higher delivery efficiency due to extensive warehouse coverage and shorter last-mile delivery. For example, JD.com has built approximately 1,400 warehouses across China, enabling next-day or even same-day delivery [42]. Likewise, Amazon operates 110 fulfillment centers in the U.S. and 185 worldwide, with more than 50% of Prime members in 60 major cities receiving same- or next-day delivery [33].

The high speed and reliability of these logistics services rely heavily on broad warehouse coverage. Platforms can pre-position inventory in regional warehouses to ensure rapid delivery to nearby consumers. With their

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logistical advantage, platforms serve not only their own users but also extend services to external channels. Platforms allow external sellers to pay for logistics services, enabling them to serve consumers using the platform logistics. For example, Amazon launched the "Buy with Prime" program in 2022. It extended Prime benefits, such as free fast delivery, to purchases made outside the Amazon platform, including on independent direct-to-consumer (DTC) websites [2]. JD Logistics adopted a similar approach. It now provides logistics services to external channels. Manufacturers like Midea and Volvo have integrated JD logistics into their own direct sales channels [20].

Platforms with self-built logistics typically adopt two main service modes when offering logistics both inside and outside the platform. The first is the Membership-Based Logistics Service (MLS) mode, where fast delivery is available exclusively to paying members. Nonmembers only receive standard delivery services. Amazon exemplifies this approach. It charges USD 139 annually for Prime membership, offering members access to faster shipping, both on and off the platform. These benefits are not available to nonmembers.

In contrast, JD.com employs an Indiscriminate Logistics Service (ILS) mode, under which all users – regardless of membership status – receive the same fast delivery service. Although JD Plus members (who pay RMB 99 per year) receive discounts and other perks, fast delivery is provided equally to both members and non-members, whether purchases are made on JD.com or via external channels.

The core distinction between the two modes is whether the platform differentiates between members and nonmembers when providing logistics services beyond its own marketplace. In the ILS mode, the only distinction between members and nonmembers is price discount, not logistics service. In contrast, the MLS mode treats premium logistics as an exclusive benefit for members. Intuitively, offering fast logistics as an exclusive benefit for members should create stronger incentives to subscribe. As a result, platform managers often assume that membership-based mode is more effective than indiscriminate mode in driving membership growth. However, whether membership-based logistics services can truly expand the member base remains an open question. Moreover, while MLS mode may boost membership revenue by encouraging more users to subscribe, it also limits logistics benefits to members only. Platforms therefore miss the opportunity to monetize logistics services from nonmembers, especially through off-platform channels. This raises a strategic question: should platforms provide fast logistics as a universal service to promote logistics development, or limit it to members as an exclusive benefit to enhance subscription appeal? Despite its importance, this issue remains largely underexplored in analytical research.

Therefore, our study aims to address the following research questions: (1) Does MLS mode effectively incentivize consumers to sign up for memberships? (2) Which logistics service mode – MLS or ILS – should the platform adopt? (3) How do external factors influence decisions for both platforms and manufacturers?

To address these questions, we consider a dual-channel supply chain consisting of a manufacturer and an e-commerce platform. Manufacturers sell products through two channels: platform reselling and direct selling. The platform operates a membership program, allowing consumers to pay a fee for membership. Additionally, it has established its own logistics systems and collaborates with manufacturers to provide logistics services in both the platform's and manufacturers' channels. The platform has two logistics choices: (1) ILS mode where all consumers receive services across all channels, and (2) MLS mode where services are exclusive to members. This study compares the two logistics models and examines their impacts on platform profit, manufacturer profit, and consumer demand.

Our study yields several major findings. First, an interesting finding challenges the common belief that membership-based mode always attracts more members. When both membership fees and logistics level are low, the logistics inclusiveness of the ILS mode encourages platforms to offset logistics costs by raising selling prices, which in turn provides members with larger discounts. Meanwhile, in MLS mode, as the service level gap between members and nonmembers shrinks, the appeal of membership diminishes. As a result, the ILS mode is able to attract more members. Second, the optimal choice for both the platform and the manufacturer depends on the membership fee and logistics service level. When both are high, ILS mode increases platform profit through greater sales volume and pricing flexibility, while also benefiting manufacturers. When logistics level is low, MLS mode is more effective by creating service differentiation and controlling costs. Third, in MLS mode, higher third-party logistics fees can drive membership growth when membership fees are moderate. In ILS mode, even low membership fees may fail to attract more members if consumers show a stronger preference for manufacturer direct channels.

The reminder of the paper is organized as follows. The related literature is reviewed in Section 2. The model description is presented in Section 3. In Section 4, we analyze the main model. Section 5 extends the model, and Section 6 concludes the paper.

2. Literature review

Our study is closely related to three streams of literature: logistics service, channel competition and membership mechanism.

2.1. Logistics service

Our study is related to the literature on logistics service. A large body of research has focused on logistics outsourcing and its impact on operational performance [13,15,18,44]. Zhu *et al.* [51] differentiate between basic and advanced outsourcing, highlighting how the outsourcing management process (OMP) interacts with service complexity to affect cost and delivery performance. Liu *et al.* [26] further introduce fairness concerns into the logistics outsourcing context and study how distributional and peer-induced fairness can influence order allocation decisions within the logistics service supply chain. Lou *et al.* [29] examine the logistics outsourcing strategies of retailers acting as supply chain leaders. Their findings show that under certain conditions, outsourcing logistics to third-party providers yields higher returns than managing logistics in-house.

Several studies have examined other mechanism and technology that affect logistics service quality and strategic choices. Li *et al.* [25] investigates how the choice of logistics mode influences the length of the price guarantee window (PGW) when PGW is treated as a signal of service cost. The results show that compared to third-party logistics, self-operated logistics tends to extend the PGW when service costs are low but shortens it when service costs are high. Tan *et al.* [37] examine how blockchain technology can improve logistics service performance among logistics service providers (LSPs). They proposed a blockchain model tailored for small and medium-sized logistics service supply chains. Similarly, Zhang and Liu [48] investigate blockchain adoption in serial logistics service chains and found that while blockchain can improve delivery quality and overall service chain profitability, it may reduce the profit margins of individual 3PL providers.

With the rise of platform logistics, many scholars examine the interaction between platforms that operate their own logistics and third-party sellers. Sun *et al.* [34] empirically analyze the effect of fulfillment by Amazon (FBA) on e-commerce platform sales and profits compared to fulfillment by seller (FBS). They develop a risk-adjusted fulfillment approach to improve the platform's rewards. Qin *et al.* [31] analyze the strategic dynamics of logistics service sharing between platforms and third-party sellers. Their results indicate that both parties benefit from logistics sharing when third-party logistics providers have moderate service quality and market potential. Lai *et al.* [22] further investigate the impact of FBA on Amazon, third-party sellers, and original equipment manufacturers (OEMs). Although FBA intensifies service competition between Amazon and sellers, it reduces price competition and allows all parties – including Amazon, sellers, and OEM suppliers – to potentially benefit. Zhou *et al.* [50] compare different delivery arrangements under various power structures. They find that, in a Stackelberg game, shifting delivery responsibilities to suppliers can create a win–win–win outcome across channel members, consumers, and society. While our study also considers the sharing of platform logistics with third-party sellers, it differs fundamentally from the works above. Existing literature focuses on logistics service sharing within the platform, that is, making platform logistics available only to sellers operating on the platform. In contrast, our study explores the economic implications of extending platform logistics services beyond the platform itself. Additionally, unlike earlier research that assumed a single logistics service provided by the platform, we consider the possibility of the platform offering both high and low-level logistics services. Finally, while previous studies concentrated on the decision to share logistics with third-party sellers, our study examines the platform's choice between different logistics modes (membership-based mode *vs.* indiscriminate mode) when sharing logistics with manufacturers.

In summary, prior literature has explored logistics outsourcing strategies and the sharing of platform logistics among internal users. However, it has neglected the logistics modes employed when platforms extend their services to external channels. This study fills that gap by examining scenarios in which a platform provides logistics services to manufacturers' direct channels. We identify the conditions under which the platform adopts different logistics modes and analyze how key factors influence the strategic choices of both the platform and the manufacturer.

2.2. Channel competition

Our study is also related to the prior literature on channel competition. Several studies focus on the impact of two or more shopping channels on consumer behavior and firm profit [5, 7, 24, 40, 41]. Cattani *et al.* [6] analyze the impact of equal pricing strategy on the manufacturer and retailer in the manufacturer's direct and retail channels, and explores the impact of the convenience of the Internet channel on manufacturer' decisions. Zhang and Hezarkhani [47] study manufacturers' channel strategies (*i.e.*, direct-channel strategy, retail-channel strategy, and dual-channel strategy consisting of both direct and retail channels) in a competitive setting. Chen *et al.* [9] study the impact of consumers' online channel acceptance and two types of spillover effects on manufacturer's selling strategies.

Another stream of research focuses on manufacturer encroachment and retailers' corresponding responses. For example, Li *et al.* [23] demonstrate that in the presence of information asymmetry, manufacturer encroachment results in the reduction of retailer's orders, potentially harming both parties. Ha *et al.* [16] conclude that encroachment may harm retailers if product quality is endogenous. Ha *et al.* [17] study manufacturer encroachment on platforms, and whether platforms should share information with manufacturers.

Several studies also explore competition among different selling modes on e-commerce platforms. Abhishek *et al.* [1] compare two selling modes, agency selling mode and reselling mode, and identified the conditions under which e-tailers use these modes. Tian *et al.* [39] compare three selling modes, that is, agency selling mode, reselling mode, and hybrid mode. Zhang and Zhang [46] study the agency selling and reselling by considering the demand information sharing strategies of e-tailer and supplier.

These studies focus on price competition and how channel design impacts consumer behavior and firm performance. Differently, this paper considers price competition and logistics service competition between platform and direct channels. This paper further explores product pricing and logistics service pricing in different channels under different logistics service modes and examines how logistics service modes affect inter-channel competition.

2.3. Membership mechanism

Finally, our study is related to previous research on membership mechanism. A stream of research examines membership-based pricing strategy. Kung and Zhong [21] study a platform that provides a delivery service to consumers by allocating orders to shoppers. They examine three pricing strategies for this service, *i.e.*, membership-based pricing, transaction-based pricing, and cross subsidization, finding that membership-based pricing dominates the other two strategies. Hung *et al.* [19] study multi-year membership pricing policy and traditional 1-year membership pricing policy. They find that the former can lead to more profit for the platform from a long-term perspective, but from a short-term perspective, the two policies are similar. Chen *et al.* [8] analyze two pricing strategies (*i.e.*, transaction-based pricing and membership-based pricing) for on-demand delivery service platform, showing that under some conditions, membership-based pricing can result in a win-win-win situation for the platform, consumers and the providers. Du *et al.* [12] study bundled collaboration strategies for paid membership programs between two firms. The results demonstrate that the optimal strategy is contingent on the firms' existing member base and their ability to monetize member value.

In recent years, scholars have gradually paid attention to the free shipping policy based on membership. Fang *et al.* [14] examine the three shipping strategies (*i.e.*, paid shipping, contingent free shipping, and membership-

TABLE 1. Summary of the relevant literature.

Research paper	Logistics service			Channel competition			Membership mechanism		
	Logistics outsourcing	Logistics sharing	Logistics mode	Channel strategy	Channel encroachment	Sales mode	Pricing strategy	Free shipping policy	Service upgrade
Zhu *et al.* [51]	✓								
Lou *et al.* [29]	✓								
Sun *et al.* [34]		✓	✓						
Qin *et al.* [31]		✓							
Lai *et al.* [22]		✓				✓			
Zhou *et al.* [50]			✓	✓					
Zhang and Liu [48]			✓						
Zhang and Hezarkhani [47]				✓	✓				
Chen *et al.* [9]				✓					
Ha *et al.* [17]					✓				
Zhang and Zhang [46]				✓		✓			
Kung and Zhong [21]			✓				✓		
Hung *et al.* [19]							✓		
Chen *et al.* [8]			✓				✓		
Sun *et al.* [35]						✓		✓	
Tang *et al.* [38]								✓	
Bhave *et al.* [3]								✓	
Our paper		✓	✓		✓			✓	✓

based free shipping) and the conditions under which they can be used, as well as how the membership-based free shipping introduction affects e-retailers. Sun *et al.* [35] study the value of the membership-based free shipping in the wholesale selling mode and the agency selling mode, respectively. They are surprised to find that membership-based free shipping may harm members in both modes, and this program always harms society in the wholesale mode. Tang *et al.* [38] compare the strategies of threshold free shipping (TFS) and membership free shipping (MFS) and explore two price discount policies (*i.e.*, limited-time discounts and threshold discounts) under MFS. Their analysis examines the impact of these different discount policies on both retailer profits and consumer welfare. Bhave *et al.* [3] investigate how membership-based free shipping programs affect retailer revenue and order volume throughout the subscription lifecycle. They find the revenue increase is driven by a rise in low-cost item purchases, an impact that peaks shortly after enrollment and then decays sharply.

While a few existing studies have focused on membership-based free shipping policies, they typically assume that the platform offers only a single logistics service, restricting these benefits exclusively to on-platform purchases. In contrast, our study considers a scenario where members enjoy superior logistics services compared to nonmembers, and these membership benefits extend to off-platform channels as well.

The differences between our paper and related works are summarized in Table 1.

2.4. Contributions

This study makes several contributions to the theoretical literature. Previous research has primarily focused on logistics management within platform channels [22, 31, 48]. To the best of our knowledge, this study is the first to examine the extension of platform logistics services to external channels. It explores the impact of different logistics service extensions to external channels on the channel pricing and profits of both platforms and manufacturers. In addition, while recent studies have explored free delivery policies related to membership programs [14, 35, 38], research on upgraded logistics services under membership schemes remains limited. We compare the Membership-Based Logistics Service (MLS) mode with the Indiscriminate Logistics Service (ILS) mode. Contrary to the common belief that membership services always lead to a larger member base, we reveal that, under certain conditions, the indiscriminate logistics service is more effective in attracting members than the membership logistics service.

Moreover, this study provides managerial insights for both platforms and manufacturers. Platforms should be aware that when membership fees are low and logistics capabilities are limited, the membership-based logistics mode is not effective in driving subscriptions. To expand the member base, platforms should adopt the indiscriminate logistics mode and focus on economic incentives, such as price discounts, as the core value of the membership program, rather than logistics upgrades. Furthermore, the choice between ILS mode and MLS mode should be guided by the combination of membership fee and logistics level. Specifically, platforms should avoid combining low membership fees with medium-level logistics services. This configuration may lead to conflicts between the platform and manufacturers over logistics preferences. In such cases, platforms should design appropriate contractual mechanisms to align incentives, while manufacturers need to adjust their cooperation strategies based on the platform's logistics maturity.

3. Model description

We consider a dual-channel supply chain consisting of a manufacturer and a retail platform. The manufacturer sells the same products through two channels: (1) Resell to the platform at wholesale price w, then the platform sells products to consumers at price p_p (*i.e.*, the platform channel); and (2) The manufacturer sells products directly (such as on their own official website) to the consumer at price p_d (*i.e.*, the direct channel). Without loss of generality, the marginal production costs are assumed to be zero [4,27,28,32]. We also consider the case with positive marginal production costs in Extension 5.1. The results remain qualitatively consistent with those of the main model. The platform operates its own logistics system. For consumers who buy from the platform channel, the platform offers higher level of logistics services s compared to the 3PLs (*i.e.*, third-party logistics services) [22,31]. At the same time, it covers unit logistics cost c. To assure the high-level logistics service is efficient, we assume $s > \max\{c,\ \hat{s}_1,\ \hat{s}_2\}$. For simplicity, we assume that the logistics level and cost of the 3PLs are 0. The platform also shares logistics for other sellers and charges a logistics fee f, which allows the manufacturer to use the platform's logistics in their direct channel. Moreover, the platform has a membership mechanism that consumers can register as members by paying membership fee m. This membership offers consumers high-level logistics services and product price discount $\rho \in [0, 1]$ on the platform. For example, JD.com PLUS provides members with exclusive shopping benefits including "PLUS 5% discount" [30]. When the platform provides logistics services to consumers, there are two logistics service strategies for the platform: Indiscriminate logistic service (ILS) and member-based logistic service (MLS). In ILS mode, the platform provides high-level logistics services to both members and nonmembers, whether on the platform channel or the direct channel. In MLS mode, the platform, regardless of channel, makes high-level logistics services available only to members. In this scenario, nonmembers are only allowed to get a lower level of logistics services. The key notations are summarized in Table 2.

3.1. Consumer utility and consumer demand

Considering whether consumers buy products in the platform channel or the direct channel, and whether they register as platform members or not, they have four choices: (1) buy products in the platform channel with membership; (2) buy products in the direct channel with membership; (3) buy products in the platform channel without membership; and (4) buy products in the direct channel without membership. Consumers' willingness to pay v for the product is heterogeneous, which is uniformly distributed on $[0, 1]$. In e-commerce platforms, the consumer base is large and diverse, and different consumers may have varying valuations of products. These differences may arise from factors such as personal background, market perception, and usage scenarios. For analytical tractability, consumers' valuations can reasonably be simplified as uniformly distributed over the $[0, 1]$ range. This assumption has been widely adopted in the literature [45,49]. Consumer preference for different channels is $\delta \in (0, 1)$. It can be interpreted as the consumers' preference for other factors in the channel, such

TABLE 2. Notation.

Parameters	
v	Valuation of the product
δ	Consumer preference for different channels
ρ	Product price discount
m	Membership fee
s_h	High-level logistics service
s_l	Low-level logistics service
c_h	Cost of high-level logistics service
c_l	Cost of low-level logistics service
g	Third-party logistics service fee
Decision variables	
f	Logistics service fee
w	Manufacturer's wholesale price
p_d	Selling price in the direct channel
p_p	Selling price in the platform channel
Variables of interest	
U	Consumer utility
D	Consumer demand
π_M	Manufacturer's profit
π_P	Platform's profit

as usage habits and purchasing experience, in addition to the nature of the product. Following Tan and Carrillo [36], we assume consumers prefer the direct channel.

For the convenience of description, we use the superscript i to denote logistics modes – ILS ($i = I$) or MLS ($i = M$), and the subscript xy to denote channels – the platform channel ($x = p$) or the direct channel ($x = d$), and with or without membership – with membership ($y = m$) or without membership ($y = n$), respectively. Consumer utility functions are given below.

$$U_{pm} = v - \rho p_p + s - m \tag{1}$$

$$U_{dm} = (1+\delta)v - p_d + s - m \tag{2}$$

$$U_{pn} = v - p_p + s \tag{3}$$

$$U_{dn} = (1+\delta)v - p_d + s \tag{4}$$

Consumer utility is negatively affected by the product price and positively affected by the logistics service level. If consumers enroll in membership, they need to pay a membership fee m in exchange for paying ρp_p for products on the platform and enjoying high-level logistics services s. Conversely, nonmembers will not enjoy a price discount, but enjoy different logistics services under different modes. As mentioned above, if the platform adopts ILS mode, nonmembers can enjoy the same logistics as members, that is, $U_{pn} = v - p_p + s$ and $U_{dn} = (1+\delta)v - p_d + s$. If the platform adopts MLS mode, nonmembers are only allowed to be provided with low-level logistics services, then $U_{pn} = v - p_p$ and $U_{dn} = (1+\delta)v - p_d$.

Based on the consumer utility, we derive the consumer demand under the two logistics service modes as shown in Appendix.

3.2. Sequence of events

In our study, we assume the platform has already cooperated with the manufacturer, *i.e.*, the platform has shared logistics with the manufacturer, and the manufacturer has determined to use the platform's logistics. This assumption is reasonable because 86% of sellers use Amazon FBA as their selling method in reality [11].

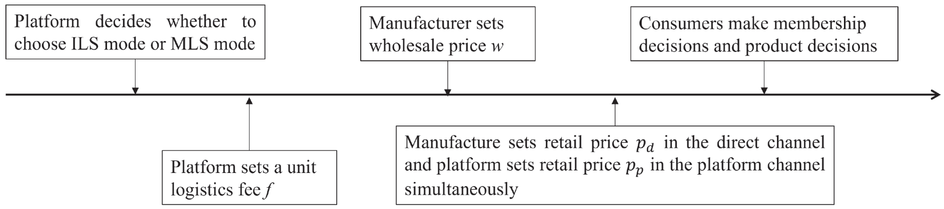

FIGURE 1. Sequence of events.

This assumption helps us focus on analyzing the platform's strategy of logistics service and the impacts of different logistics service modes on the platform, manufacturer, and consumers.

The sequence of events is shown in Figure 1. In stage 1, the platform decides whether to choose ILS mode or MLS mode. In stage 2, the platform sets a unit logistics fee f. In stage 3, the manufacturer sets wholesale price w. In stage 4, the manufacturer sets retail price p_d in the direct channel and platform sets retail price p_p in the platform channel simultaneously. In the final stage, consumers make membership decisions and product decisions.

4. Analysis

In this section, we first describe the equilibrium characterization in Subsection 4.1. We then provide the comparisons of equilibrium price and consumer demand (*i.e.*, member demand and total demand) in Subsection 4.2 and of the equilibrium profits in Subsection 4.3.

4.1. Equilibrium characterization

In this subsection, we first analyze the equilibrium for the indiscriminate logistic service (ILS) mode. We discuss the optimal decisions of the platform and the manufacturer when the platform chooses ILS mode. In this mode, the platform makes its logistics available to all consumers in the platform channel and direct channel. The platform decides on the logistics fee, then the manufacturer decides on the wholesale price, and finally the manufacturer and platform simultaneously decide on the selling price in their respective channels. The profits for the manufacturer and the platform are as follows:

$$\pi_M^I = \left(p_d^I - f^I\right)\left(D_{dm}^I + D_{dn}^I\right) + w^I\left(D_{pm}^I + D_{pn}^I\right) \tag{5}$$

$$\pi_P^I = \left(f^I - c\right)\left(D_{dm}^I + D_{dn}^I\right) + \left(\rho p_p^I - w^I - c\right)D_{pm}^I + \left(p_p^I - w^I - c\right)D_{pn} + m\left(D_{dm}^I + D_{pm}^I\right) \tag{6}$$

In equation (5), the first part denotes the manufacturer's profit from the direct channel, where f^I is the unit logistics fee charged by the platform to the manufacturer, regardless of whether the order is from a member or a nonmember, and the second part captures total wholesale profits from the platform channel. In equation (6), c is the cost of high-level logistics service, and the last part $m(D_{dm}^I + D_{pm}^I)$ denotes the total membership fee charged from the member consumers.

As shown in the appendix, we compute the equilibrium results. We use f^{I*} denote the equilibrium logistics fee, w^{I*} denote the wholesale price, (p_d^{I*}, p_p^{I*}) denote the selling price in the platform channel and the manufacturer direct channel. By using these equilibrium solutions, we derive the equilibrium member demand (D_m^{I*}), total demand (D^{I*}), platform profit (π_P^{I*}), and manufacturer profit (π_M^{I*}) can be found in Appendix.

Next, we examine the optimal decisions of the platform and the manufacturer when the platform chooses membership-based logistic service (MLS) mode. In this mode, consumers who register as members on the platform can be offered the high-level logistics in both the platform and direct channels, while those who do not register as members only be offered the low-level logistics services. The profits for the manufacturer and the platform are as follows:

$$\pi_M^M = \left(p_d^M - f^M\right)D_{dm}^M + \left(p_d^M - g\right)D_{dn}^M + w^M\left(D_{pm}^M + D_{pn}^M\right) \tag{7}$$

$$\pi_P^M = \left(f^M - c\right)D_{dm}^M + \left(\rho p_p^M - w^M - c\right)D_{pm}^M + \left(p_p^M - w^M\right)D_{pn}^M + m\left(D_{dm}^M + D_{pm}^M\right) \tag{8}$$

The platform only provides high-level logistics for members. For nonmember orders, the manufacturer uses low-level logistics services to deliver them, and we use g to denote the logistics fees that manufacturers pay for the low-level logistics services as shown in equation (7). Equation (8) denotes the platform profit in the MLS mode, where $m(D_{dm}^M + D_{pm}^M)$ refers to the total membership fees.

We derive the equilibrium results as shown in Appendix. We use f^{M*} to denote the equilibrium logistics fee and w^{M*} to denote the wholesale price. The equilibrium retail prices in the direct channel and the platform channel under the membership-based logistics mode are represented by (p_d^{M*}, p_p^{M*}). Likewise, the derived equilibrium member demand (D_m^{M*}), total demand (D^{M*}), platform profit (π_P^{M*}), and manufacturer profit (π_M^{M*}) are given in the Appendix.

Logistics cost plays a critical role in the platform's decision to develop its own logistics service. Based on the derived equilibrium solutions, Proposition 1 examines the influence of logistics cost (c) on the platform's strategic decisions.

Proposition 1. (1) *In ILS mode, we have* $\frac{dp_d^{I*}}{dc} > 0$ *and* $\frac{dp_p^{I*}}{dc} > 0$;

(2) *In MLS mode, we have* $\frac{dp_d^{M*}}{dc} > 0$ *and* $\frac{dp_p^{M*}}{dc} > 0$ *if* $0 < m < s$, $\frac{dp_d^{M*}}{dc} < 0$ *and* $\frac{dp_p^{M*}}{dc} > 0$ *if* $s < m < m_2$, *and otherwise* $\frac{dp_d^{M*}}{dc} = 0$ *and* $\frac{dp_p^{M*}}{dc} = 0$.

Proposition 1 shows how logistics cost affects channel prices under different logistics modes. According to Proposition 1(1), under the indiscriminate logistics mode, both channel prices increase as logistics cost rises. The reason is straightforward. Premium logistics enhances consumers' willingness to pay, but it also imposes a high logistics burden on the platform. To offset this burden, the platform raises the price in its own channel. At the same time, the platform charges the manufacturer a higher logistics fee, which induces the manufacturer to increase the direct-channel price as well. Proposition 1(2) presents a different pattern under the membership-based logistics mode. When the membership fee is low, the direct-channel price rises with logistics cost. A low membership fee attracts many consumers to join, which forces the manufacturer to undertake significant logistics expenses for member orders. As a result, the manufacturer raises the product price. When the membership fee is moderate, the direct-channel price decreases as logistics cost rises. Fewer consumers choose to join the membership program in this case, and the manufacturer's logistics burden declines, allowing it to lower the price to sustain demand. When the membership fee is sufficiently high, logistics cost has no influence on the direct-channel price. Consumers in the direct channel rarely join the membership program, and the manufacturer's logistics expenditure remains almost unchanged.

In practice, the extent of consumer preference reflects the consumer loyalty to a product channel, so it is an important factor influencing consumer demand. The third-party logistics competes with e-commerce platforms' self-logistics, and the third-party logistics fee also affects manufacturers' logistics choice, which in turn affects consumer demand. Therefore, we examine the effects of the consumer preference (δ) and the third-party logistics fee (g) on the equilibrium solutions in the ILS and MLS modes, concluding some interesting findings.

We focus on the effect of consumer preference on consumer enrollment in membership as shown in Proposition 2.

Proposition 2. (1) *In ILS mode, we have* $\frac{dD_m^{I*}}{d\delta} < 0$ *if* $0 < m < m_1$, *and otherwise* $\frac{dD_m^{I*}}{d\delta} = 0$;

(2) *In MLS mode, we have* $\frac{dD_m^{M*}}{d\delta} > 0$ *if* $0 < m < s$, $\frac{dD_m^{M*}}{d\delta} < 0$ *if* $s < m < m_2$, *and otherwise* $\frac{dD_m^{M*}}{d\delta} = 0$.

As shown in Proposition 2, in ILS mode, member demand decreases as consumer preference for the manufacturer's products increases, but only when the membership fee is low. This occurs because all consumers in ILS mode access high-level logistics services, making price discounts the primary influence on purchasing decisions. While a low membership fee may attract some consumers, a stronger preference for the manufacturer's products often leads them to buy directly rather than pay for membership. In contrast, in MLS mode, a low membership fee boosts member demand when consumer preference increases. The lower fee reduces barriers to entry, making the membership program more appealing. As a result, total membership revenue becomes a significant income source. When consumer preference for the direct channel grows, manufacturers often raise direct-channel prices, prompting consumers to shift their purchases to the platform channel for better pricing and logistics services, increasing their likelihood of becoming members.

The third-party logistics fee is another important factor that affects the member demand. Proposition 3 gives the impact of the third-party logistics fee in two modes.

Proposition 3. (1) *In ILS mode, we have* $\frac{dD_m^{I*}}{dg} = 0$*;*
(2) *In MLS mode, we have* $\frac{dD_m^{M*}}{dg} > 0$ *if* $s < m < m_2$*, and otherwise* $\frac{dD_m^{M*}}{dg} = 0$*.*

In ILS mode, variations in third-party logistics fees do not significantly affect member demand. In contrast, in MLS mode, an increase in these fees can boost member demand, provided the membership fee remains moderate. This occurs because higher logistics expenses for serving nonmembers lead manufacturers to raise product prices in the direct channel. As a result, consumers are motivated to switch to the platform channel. With a moderate membership fee, consumers tend to avoid the direct channel, which in turn increases their incentive to become platform members to access price discounts and superior logistics services.

4.2. Comparison of the prices across different channels

When providing logistics service under different modes, platforms and manufacturers consider selling prices setting. We compare selling prices in the platform and direct channels.

Proposition 4. *If (1)* $0 < m < s$*, or (2)* $s < m < m_2$ *and* $s > s_3$*, or (3)* $m > m_2$ *and* $s > s_4$*, the manufacturer's selling price in the direct channel is higher in ILS mode than MLS mode (i.e.,* $p_d^{I*} \geq p_d^{M*}$*); otherwise, it is lower in ILS mode than MLS mode (i.e.,* $p_d^{I*} < p_d^{M*}$*).*

Proposition 4 compares the direct-channel prices across different logistics modes. Referring to Figure 2, we find that when the membership fee (m) is sufficiently low, or when the membership fee is high while the level of logistics service (s) is also high, the direct-channel price under the indiscriminate logistics service (ILS) mode exceeds that under the membership-based logistics service (MLS) mode (*i.e.*, $p_d^{I*} \geq p_d^{M*}$). Otherwise, the price in the MLS mode becomes higher (*i.e.*, $p_d^{I*} < p_d^{M*}$). This result can be explained as follows. Although a low membership fee attracts many consumers to register, consumers do not receive a clear logistics advantage under the ILS mode, because premium logistics is provided to everyone. In contrast, in the MLS mode, premium logistics is offered exclusively to members. Under this arrangement, the manufacturer only bears logistics costs for member orders and can set a lower price in the direct channel. In the MLS mode, consumer demand is jointly driven by both price and logistics service. A high level of logistics service strengthens the distinction between members and nonmembers, which encourages more consumers to join the membership program. When the membership fee exceeds a threshold, some consumers choose to become members but no longer purchase through the direct channel. This outcome motivates the manufacturer to reduce the direct-channel price to retain demand. However, when the logistics service level in the MLS mode is low, the service gap between members and nonmembers narrows. The incentive to join the membership program weakens as a result. In this case, the manufacturer bears higher logistics costs for consumers in the direct channel – including both the logistics fee for members and the logistics cost for nonmembers – and therefore must charge a higher price.

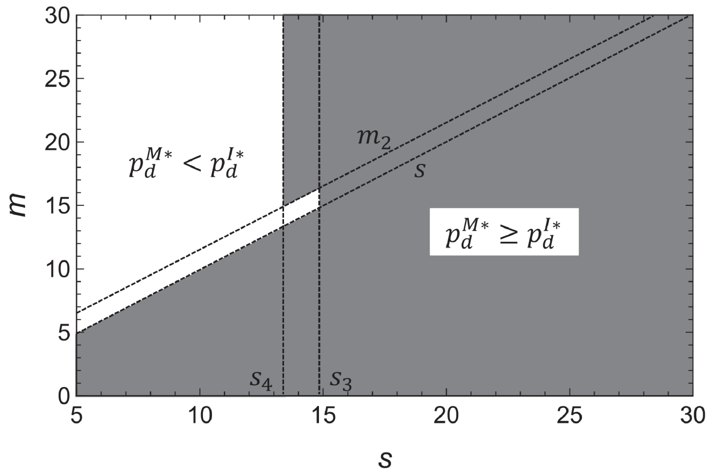

FIGURE 2. Comparison of manufacturers' direct-channel prices (p_d) under MLS and ILS modes, where the price ranking between the two modes depends on the membership fee (m) and logistics level (s) ($\delta = 0.1$, $g = 20$, $\rho = 0.8$, $c = 2$).

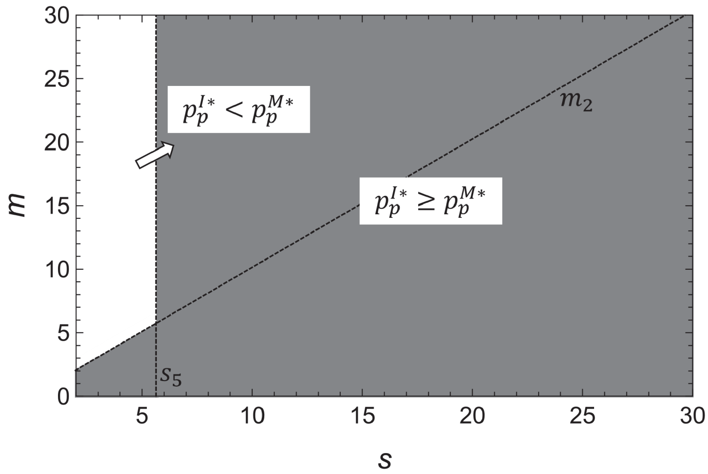

FIGURE 3. Comparison of platform-channel prices (p_p) under MLS and ILS modes, where the price ranking between the two modes depends on the membership fee (m) and logistics level (s) ($\delta = 0.1$, $g = 20$, $\rho = 0.8$, $c = 2$).

Proposition 5. *If (1) $0 < m < m_2$, or (2) $m > m_2$ and $s > s_5$, the platform's selling price in the platform channel is higher in ILS mode than MLS mode (i.e., $p_p^{I*} \geq p_p^{M*}$); otherwise, it is lower in ILS mode than MLS mode (i.e., $p_p^{I*} < p_p^{M*}$).*

Proposition 5 and Figure 3 compare the platform-channel prices under different logistics modes. In Figure 3, the white area indicates that the platform price is higher under the membership-based logistics service (MLS) mode, whereas the grey area indicates that the platform price is higher under the indiscriminate logistics service (ILS) mode. When the membership fee is low, or when both the membership fee and the logistics service level are high, the platform sets a higher price under the ILS mode than under the MLS mode. In contrast, when

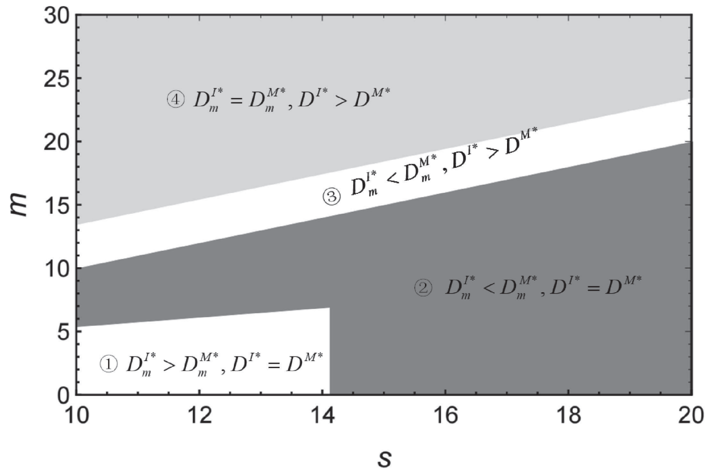

FIGURE 4. Comparison of platform membership demand (D_m) and total demand (D) under MLS and ILS modes, where the demand rankings depend on the membership fee (m) and logistics level (s) ($\delta = 0.3$, $g = 20$, $\rho = 0.8$, $c = 10$).

the membership fee is high and the logistics service level is low, the platform sets a higher price under the MLS mode. This result can be explained as follows. Under the ILS mode, the platform provides high-level logistics service to all consumers. As a result, the logistics cost is high. This cost burden is passed on to the manufacturer, which increases the wholesale price, and eventually leads to a higher retail price on the platform. Under the MLS mode, when the membership fee is high, consumers are unwilling to join the membership program. At the same time, the low logistics service level reduces the service advantage relative to non-members. In this situation, the platform raises the product price to emphasize the price-discount benefit of the membership program.

4.3. Comparison of consumer demand

Membership is an important measure for the platform to attract consumers, which increase user stickiness and stimulate consumption, thus comparing member demand and total demand under the two modes can help platforms deliberate whether to implement membership-based logistics services.

Next, we discuss member demand and total consumer demand, and explore the conditions under which mode can increase member demand.

Proposition 6. (1) *If $0 < m < m_1$ and $s < \frac{5}{2} + c + 4\delta + \frac{3}{6+4\delta}$, the member demand is higher in ILS mode than MLS mode (i.e., $D_m^{I*} > D_m^{M*}$), and the total consumer demand is the same in ILS mode as MLS mode (i.e., $D^{I*} = D^{M*}$);*

(2) *If (a) $0 < m < m_1$ and $s > \frac{5}{2} + c + 4\delta + \frac{3}{6+4\delta}$, or (b) $m_1 < m < s$, the member demand is lower in ILS mode than MLS mode (i.e., $D_m^{I*} < D_m^{M*}$), and the total consumer demand is the same in ILS mode as MLS mode (i.e., $D^{I*} = D^{M*}$);*

(3) *If $s < m < m_2$, the member demand is lower in ILS mode than MLS mode (i.e., $D_m^{I*} < D_m^{M*}$), and the total consumer demand is higher in ILS mode than MLS mode (i.e., $D^{I*} > D^{M*}$);*

(4) *If $m > m_2$, the member demand is the same in ILS mode as MLS mode (i.e., $D_m^{I*} = D_m^{M*}$), and the total consumer demand is higher in ILS mode than MLS mode (i.e., $D^{I*} > D^{M*}$).*

The parts (1)–(4) in Proposition 6 correspond to the regions 1–4 in Figure 4. As shown in Proposition 6, it is counterintuitive that membership-based logistics service (MLS) modes do not always stimulate consumers to join membership. When both the membership fee and logistics level are low, the indiscriminate logistics service

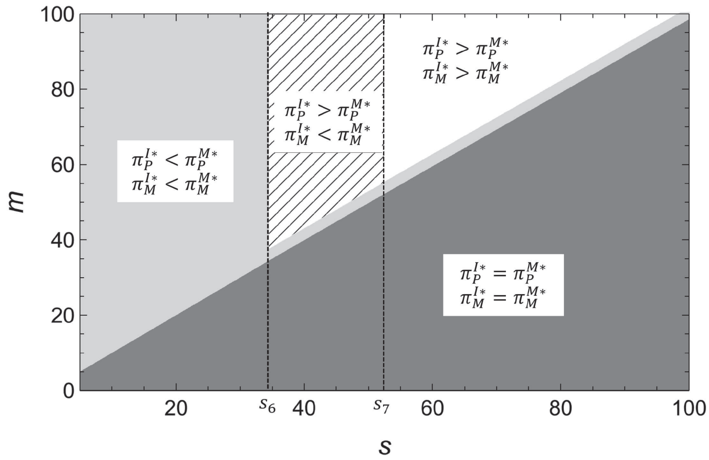

FIGURE 5. Comparison of manufacturer's profit (π_M) and platform's profit (π_P) under MLS and ILS modes, where the profit implications of the two modes depend jointly on the membership fee (m) and logistics level (s) ($\delta = 0.3$, $g = 20$, $\rho = 0.8$, $c = 5$).

(ILS) mode attracts more consumers. In ILS mode, the platform offers the same high-level logistics services to all consumers, and a low membership fee allows it to offset logistics costs by increasing product prices, resulting in greater discounts for members. With low logistics levels, the gap in service quality between members and non-members in MLS mode diminishes, making membership less appealing. In ILS mode, despite the lower service quality, consumers are attracted by higher price discounts, leading to increased membership. Conversely, as shown in Proposition 6(2), when logistics levels are high, the gap between members and non-members widens, making the logistics benefits of MLS mode more enticing. Under the conditions of Proposition 6(1) and (2), total consumer demand remains constant, as a low membership fee encourages consumers to join and make purchases regardless of the mode. When the membership fee is moderate, as indicated in Proposition 6(3), member demand is greater in MLS mode than in ILS mode due to the dominant benefits of membership. However, at high membership fees, consumers are unlikely to join in either mode. Proposition 6(3) and (4) demonstrate that when the membership fee exceeds a certain threshold, total consumer demand is higher in ILS mode than in MLS mode. Notably, in Proposition 6(3), total demand is greater in ILS mode despite higher member demand in MLS mode, suggesting that members constitute a larger share of consumers in MLS mode. This underscores the importance of member management in enhancing recognition and loyalty.

4.4. Comparison of the stakeholder profit

Now, we compare the profits of ILS mode and MLS mode. We examine when the platform and manufacturer can achieve a win-win situation. Our analysis shows that membership fee (m) and logistics level (s) play a key role in the decisions made by different stakeholders.

Corollary 1. *If $0 < m < s$, the profit of platform (manufacturer) is the same in ILS mode as in MLS mode, i.e., $\pi_P^{I*} = \pi_P^{M*}$ ($\pi_M^{I*} = \pi_M^{M*}$); If $m \geq m_2$ and $s \geq s_6$ ($s \geq s_7$), it is higher in ILS mode than MLS mode, i.e., $\pi_P^{I*} \geq \pi_P^{M*}$ ($\pi_M^{I*} \geq \pi_M^{M*}$); otherwise, the opposite results hold.*

Corollary 1 and Figure 5 compare the profits of the platform and the manufacturer under the indiscriminate logistics service (ILS) mode and the membership-based logistics service (MLS) mode. When the membership fee (m) is sufficiently low, the platform's profits under the two modes are identical, as shown by the grey region in Figure 5. The same holds for the manufacturer. In this case, the high logistics cost under the ILS mode is offset by the higher product revenue compared with the MLS mode. As the membership fee increases, consumers become less willing to join the membership program. Under the ILS mode, the platform mainly benefits from the logistics fees charged to the manufacturer, and this source of income exceeds the membership-fee revenue under the MLS mode. When both the membership fee (m) and the logistics service level (s) are high, it becomes more profitable for the platform to adopt the ILS mode because offering high-level logistics to all consumers generates greater demand and higher logistics revenue. From the manufacturer's perspective, a high membership fee reduces the demand for membership. When the logistics service level is high, consumers exhibit stronger willingness to pay under the ILS mode, allowing the manufacturer to set higher retail and wholesale prices and ultimately earn greater profit in the ILS mode. In contrast, when the membership fee is high but the logistics service level is low, consumers are strongly discouraged from joining the membership program. Even though the platform charges a high logistics fee in the ILS mode, the overall cost borne by nonmembers exceeds the benefit it brings, which makes the MLS mode more advantageous.

Figure 5 also shows when both parties can achieve a win–win outcome. As shown in the grey region, when the membership fee is low, the ILS and MLS modes make no difference to the profits of either party. When both the membership fee and logistics service level are high, the ILS mode is mutually beneficial, as indicated by the white region. When the membership fee is at a moderate level, or when it is high but the logistics service level is low, the MLS mode becomes a win–win mode, as shown in the light-grey region. However, when the membership fee is high and the logistics service level is moderate, the shaded region in Figure 5 reveals that the preferences of the manufacturer and the platform always diverge. The reason is as follows. With a high membership fee, most consumers do not join the membership. If the logistics service level is moderate, the manufacturer earns more by selling products and collecting wholesale revenue while paying lower logistics expenses under the MLS mode than under the ILS mode. Meanwhile, the platform mainly profits from logistics revenue, which is higher under the ILS mode than under the MLS mode.

5. Extensions

In this section, we extend the model by relaxing certain baseline assumptions and examine two scenarios. First, we relax the assumption of zero production cost in the main model. Second, we consider the case in which the platform determines the membership fee endogenously.

5.1. Impact of the production costs

In the main model, the production cost is normalized to zero. In this extension, we introduce a positive production cost for the manufacturer and further examine how production cost affects the platform's choice of logistics mode. Let the manufacturer's unit production cost be e. Under the indiscriminate logistics service mode, the manufacturer's profit function is $\pi_M^I = \left(p_d^I - f^I - e\right)\left(D_{dm}^I + D_{dn}^I\right) + \left(w^I - e\right)\left(D_{pm}^I + D_{pn}^I\right)$, while under the membership-based logistics service mode, it is $\pi_M^M = \left(p_d^M - f^M - e\right)D_{dm}^M + \left(p_d^M - g - e\right)D_{dn}^M + \left(w^M - e\right)\left(D_{pm}^M + D_{pn}^M\right)$. Other functions in the main model remain unchanged. The games are solved by backward induction, and the derived equilibrium outcomes are presented in the Appendix. Our analysis focuses on the impact of production cost on the logistics strategy of both the platform and the manufacturer.

Figure 6 presents a comparison of the manufacturer's and the platform's profits under different logistics modes when the manufacturer's production cost is considered. Figure 6 shows that when the membership fee is high and the logistics service level is low, the membership-based logistics mode leads to a win–win outcome for both parties. This finding is consistent with Corollary 1 in the main model, further supporting the robustness of our results. When the logistics service level is sufficiently high, a win–win outcome is realized under the indiscriminate logistics service mode. However, at a moderate logistics service level, the manufacturer prefers the membership-based mode, while the platform favors the indiscriminate mode. We also investigate how the production cost affects the equilibrium regions. As illustrated in Figure 7, the two strategy thresholds (s_{A1} and s_{A2}) in Figure 6 both increase with the production cost (e), with s_{A2} rising more sharply (corresponding to the rightward shift of the black arrow in Fig. 6). This implies that as production costs rise, the likelihood of a win–win outcome under the indiscriminate mode decreases, while the probability of profit misalignment between

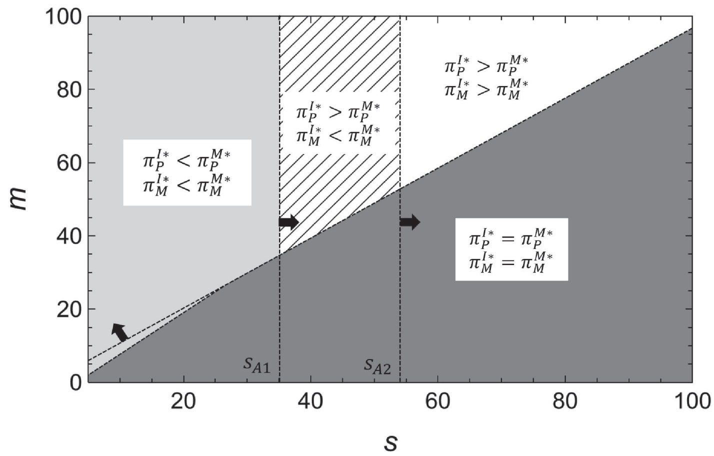

FIGURE 6. Profit comparison under MLS and ILS modes with production cost e, where the profit implications of the two modes depend on the membership fee (m) and logistics level (s) ($\delta = 0.3$, $g = 20$, $\rho = 0.8$, $c = 5$, $e = 1$).

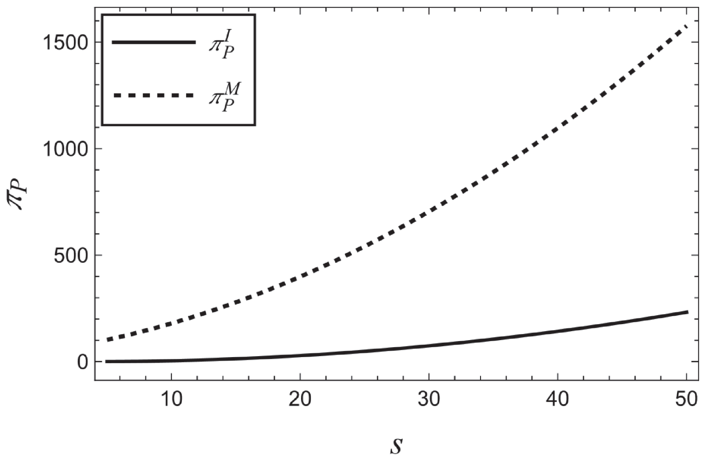

FIGURE 7. Impact of production cost (e) on the logistics service threshold (s_A), where the threshold increases with e ($\delta = 0.3$, $g = 20$, $\rho = 0.8$, $c = 5$).

the platform and the manufacturer increases. The reason is that higher production costs make it more difficult for the manufacturer to sustain profitability under the indiscriminate mode solely through price adjustments. As a result, the manufacturer is more likely to switch to a logistics mode that helps reduce cost burdens. Overall, incorporating this extension into our model provides additional insights into the platform's logistics mode choice, while the core results derived from the main model remain largely unchanged.

5.2. Endogenous membership fee

In the main model, we assume that the membership fee is exogenous. However, in practice, the membership fee is often an endogenous variable and constitutes a key strategic decision for the platform. This extension discusses the results when the platform endogenously determines the membership fee. Specifically, we assume the platform sets both the membership fee and logistics fee in the first stage, while the subsequent decision

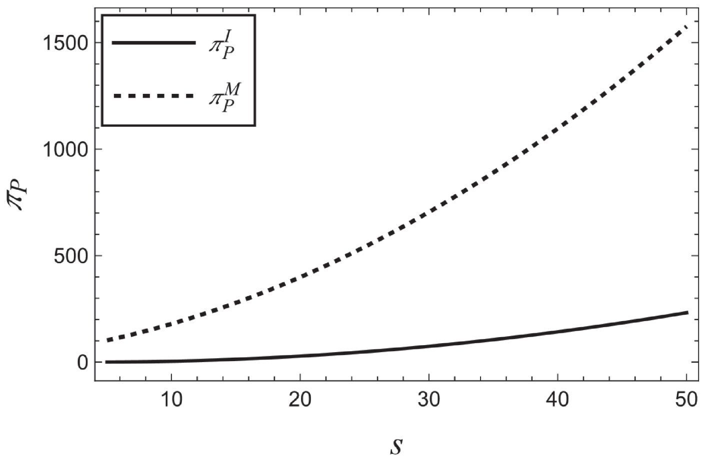

FIGURE 8. Impact of logistics service (s) on platform profit (π_P) under different modes, where π_P increases with s ($\delta = 0.3$, $g = 20$, $\rho = 0.8$, $c = 5$).

sequence remains unchanged. Using backward induction, the equilibrium outcomes are derived and presented in the Appendix.

Our analysis reveals that under the indiscriminate logistics service mode, the platform can choose any positive membership fee, as it always adjusts the retail price accordingly. Specifically, an increase in the membership fee (m) leads to a corresponding decrease in the platform's retail price ($\frac{\partial p_P^{I*}}{\partial m}$), while other decision variables remain unaffected. As a result, the platform's profit remains stable regardless of the membership fee. In contrast, under the membership-based logistics service mode, the platform can choose any membership fee within a moderate range ($s < m < m_2$) to maximize its profit. Within this range, the platform is able to generate revenue directly from membership fees while also achieving substantial net profit from product sales.

Figure 8 illustrates the impact of logistics service level (s) on platform profit under MLS mode (π_P^M) and ILS mode (π_P^I). Recalling the main model with an exogenous membership fee, platform profit increases with the logistics service level regardless of the logistics mode adopted (see Cor. 1 for details). We find that this result continues to hold when the membership fee is endogenous. However, unlike Corollary 1, the membership-based logistics mode consistently outperforms the indiscriminate mode across all logistics service levels. This is because the membership-based mode enables the platform to generate more direct revenue through membership fees while reducing the logistics cost burden associated with nonmember transactions.

6. Conclusions

We compare and analyze the two modes – Membership-Based Logistics Service (MLS) mode and Indiscriminate Logistics Service (ILS) mode – from the perspectives of both the platform and the manufacturer. We also examine how exogenous factors influence consumer demand in these different modes. The findings of this study offer practical insights for platform management.

Our analysis has revealed three key findings. First, we find that the membership-based logistics mode does not always provide an effective incentive for consumers to join the membership program. When both the membership fee and the logistics service level are low, the indiscriminate logistics service mode attracts more members. This because the logistics inclusiveness of indiscriminate logistics service encourages platforms to offset logistics costs by raising selling prices, which in turn provides larger discounts to members. In this situation, consumers' decisions to join are driven more by price discounts than by improvements in logistics service. At the same time, the manufacturer increases the retail price in the direct channel. Second, from the perspective of the platform and the manufacturer, the optimal logistics mode depends on the membership fee and the logistics service level. When both are high, the ILS mode is more effective. In contrast, when the membership fee is high but the logistics service level is low, the membership-based logistics service mode becomes superior. We also find that the platform and the manufacturer can achieve a win–win outcome in most cases. However, when the membership fee is high and the logistics service level is moderate, their preferences diverge and conflict becomes inevitable. Third, under the indiscriminate logistics service mode, changes in third-party logistics costs have no significant influence on membership demand. Under the membership-based logistics service mode, however, member demand increases when third-party logistics costs rise, provided that the membership fee remains at a moderate level. Our analysis also reveals distinct effects of consumer preference for the direct channel on member demand across the two modes. Under the indiscriminate logistics service mode, stronger preference for the direct channel decreases member demand, even when the membership fee is low. Under the membership-based logistics service mode, the opposite effect occurs.

This study provides three meaningful managerial implications for platforms and manufacturers. First, platforms should recognize that when both the membership fee and the logistics service level are low, adopting a membership-based logistics mode does not effectively motivate consumers to join the membership program. In this case, if the platform aims to expand its membership base, the strategic focus should shift toward price incentives rather than logistics enhancement. The platform can instead adopt the indiscriminate logistics mode and attract members primarily through price discounts. Second, platforms and manufacturers should select the logistics mode based on the combination of the membership fee and logistics service capability. In most cases, both parties benefit when their decisions are aligned. However, our results indicate that when the membership fee is high and the logistics service level lies in the moderate range, the two parties may develop conflicting preferences. Within this "conflict region," the platform must coordinate incentives by using contractual mechanisms, logistics subsidies, or revenue-sharing arrangements to avoid profit losses caused by divergent mode choices. Manufacturers should also adjust their cooperation stance in accordance with the platform's logistics maturity and remain flexible when the logistics mode is subject to change. Third, platforms can optimize their logistics strategy by monitoring third-party logistics pricing and shifts in consumer purchasing behavior. Under the indiscriminate logistics mode, the platform does not need to pay particular attention to third-party logistics costs. Under the membership-based logistics mode, however, an increase in third-party logistics costs can stimulate membership registration, whereas a decrease can hinder it. Thus, the platform may collaborate with third-party logistics providers to regulate the logistics cost borne by manufacturers for nonmembers and thereby influence member demand. Moreover, when the goal is to accelerate membership growth under the membership-based logistics mode, the platform can invest more resources in supporting manufacturers' official direct channels. This can encourage consumers to shop across channels while enjoying membership benefits. In contrast, under the indiscriminate logistics service mode, the platform should highlight exclusive member discounts and superior service experiences to reduce consumers' reliance on the direct channel.

This study has certain limitations that offer promising directions for future research. First, our model assumes that either the platform or the manufacturer pays the logistics cost on behalf of consumers. Future research may consider settings in which consumers pay for logistics themselves or scenarios involving threshold-based shipping fee policies implemented by platforms or manufacturers. Second, this study focuses on the collaboration between the platform and the manufacturer through a reselling model within the platform channel. However, in practice, the two parties may also cooperate under an agency model. A comparative analysis of how these two cooperation models influence the platform's logistics strategy represents a promising direction for future research. Third, to better focus on the platform's logistics mode decision, this study assumes that the manufacturer lacks logistics capabilities and must rely on either the platform's logistics or third-party logistics. In reality, manufacturers may also possess their own logistics systems and provide delivery services directly to consumers. Therefore, when taking into account the manufacturer's self-operated logistics option, exploring the interaction between the platform and the manufacturer in logistics mode selection and product pricing decisions presents an interesting and valuable avenue for future research.

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Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability statement

No data was used for the research described in the article.

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Appendix A.

Proof of Table A.1. In ILS mode, we have $U_{dn} > U_{dm}$, $U_{pm} > U_{pn}$ when $0 < m < (1-\rho)p_p^I$, and $U_{pm} < U_{pn}$ when $m > (1-\rho)p_p^I$. When $0 < m < (1-\rho)p_p^I$, letting $U_{pm} > 0$ and $U_{pm} > U_{dn}$, the customers with valuations in the interval $\left[\rho p_p^I - s + m,\ \frac{p_d^I - \rho p_p^I - m}{\delta}\right]$ sign up for membership and buy product in the platform channel. Letting $U_{dn} > 0$ and $U_{dn} > U_{pm}$, the customers with valuations in the interval $\left[\frac{p_d^I - \rho p_p^I - m}{\delta},\ 1\right]$ do not sign up for membership but buy product in the direct channel. When $m > (1-\rho)p_p^I$, letting $U_{pn} > 0$ and $U_{pn} > U_{dn}$, the customers with valuations in the interval $\left[p_p^I - s,\ \frac{p_d^I - p_p^I}{\delta}\right]$ do not sign up for membership and buy product in the platform channel. Letting $U_{dn} > 0$ and $U_{dn} > U_{pn}$, the customers with valuations in the interval $\left[\frac{p_d^I - p_p^I}{\delta},\ 1\right]$ do not sign up for membership but buy product in the direct channel. Thus, Table A.1 is proved. □

Proof of Table A.2. In MLS mode, we have $U_{dm} > U_{dn}$ and $U_{pm} > U_{pn}$ when $0 < m < s$, $U_{dn} > U_{dm}$ and $U_{pm} > U_{pn}$ when $s < m < (1-\rho)p_p^M + s$, and $U_{dn} > U_{dm}$ and $U_{pn} > U_{pm}$ when $m > (1-\rho)p_p^M + s$. When $0 < m < s$, letting $U_{pm} > 0$ and $U_{pm} > U_{dm}$, the customers with valuations in the interval $\left[\rho p_p^M - s + m,\ \frac{p_d^M - \rho p_p^M}{\delta}\right]$ sign up for membership and buy product in the platform channel. And letting $U_{dm} > 0$ and $U_{dm} > U_{pm}$, the customers with valuations in the interval $\left[\frac{p_d^M - \rho p_p^M}{\delta},\ 1\right]$ sign up for membership and buy product in the direct channel. When $s < m < (1-\rho)p_p^M + s$, letting $U_{dn} > 0$ and $U_{dn} > U_{pm}$, the customers with valuations in the interval $\left[\frac{p_d^M - \rho p_p^M + s - m}{\delta},\ 1\right]$ do not sign up for membership and buy product in the direct channel. And letting $U_{pm} > 0$ and $U_{pm} > U_{dn}$, the customers with valuations in the interval $\left[\rho p_p^M - s + m,\ \frac{p_d^M - \rho p_p^M + s - m}{\delta}\right]$ sign up for membership and buy product in the platform channel. When $m > (1-\rho)p_p^M + s$, letting $U_{dn} > 0$ and $U_{dn} > U_{pn}$, the customers with valuations in the interval $\left[\frac{p_d^M - p_p^M}{\delta},\ 1\right]$ do not sign up for membership and buy product in the direct channel. And letting $U_{pn} > 0$ and $U_{pn} > U_{dn}$, the customers with valuations in the interval $\left[p_p^M,\ \frac{p_d^M - p_p^M}{\delta}\right]$ do not sign up for membership and buy product in the platform channel. Thus, Table A.2 is proved. □

Proof of Table A.3. In ILS mode, we first look at the scenario that the membership fee is low ($i.e.$, $0 < m < (1-\rho)p_p^I$). We use backward induction to solve the optimization problems. The profits for the manufacturer and the platform are given by equations (5) and (6). The platform and manufacturer decide on their product prices simultaneously. The problem is maximizing equations (5) and (6) subject to $m < (1-\rho)p_p^I$. We utilize the KKT conditions to solve the problem. For manufacturer's problem, from $\frac{d(-\pi_M^I)}{dp_d^I} + u_1\frac{d\left(m-(1-\rho)p_p^I\right)}{dp_d^I} = 0$, we get $m - (1-\rho)p_p^I < 0$, $u_1\left(m - (1-\rho)p_p^I\right) = 0$, and $u_1 \geq 0$. For platform's problem, from $\frac{d(-\pi_P^I)}{dp_p^I} + u_2\frac{d\left(m-(1-\rho)p_p^I\right)}{dp_p^I} = 0$, we get $m - (1-\rho)p_p^I < 0$, $u_2\left(m - (1-\rho)p_p^I\right) = 0$, and $u_2 \geq 0$. Combining the above two problems, we have $p_d^{I*} = \frac{3w^I(1+\delta)+f^I(3+2\delta)+\delta(2+c+s+2\delta)}{3+4\delta}$ and $p_p^{I*} = \frac{3f^I-3m+3w^I+\delta+2c\delta+2(-2m+s+w^I)\delta}{(3+4\delta)\rho}$. We substitute them into the optimal problem to maximize the manufacturer profit (Eq. 5) subject to $m - (1-\rho)p_p^{I*} < 0$. The manufacturer decides on the wholesale price w^I. Applying the KKT conditions as well, we get $w^{I*} = \frac{1}{2}\left(1 + s + \frac{-f^I+s}{1+\delta} - \frac{9s+8c\delta}{9+8\delta}\right)$. Then substitute $p_d^{I*} = \frac{3w^I(1+\delta)+f^I(3+2\delta)+\delta(2+c+s+2\delta)}{3+4\delta}$, $p_p^{I*} = \frac{3f^I-3m+3w^I+\delta+2c\delta+2(-2m+s+w^I)\delta}{(3+4\delta)\rho}$, and $w^{I*} = \frac{1}{2}\left(1+s+\frac{-f^I+s}{1+\delta} - \frac{9s+8c\delta}{9+8\delta}\right)$ into equation (6) to decide on the logistics fee f^I. We get $f^{I*} = \frac{9(1+c+s)+(17+10c+6s)\delta+8\delta^2}{2(9+8\delta)}$. Substituting it backwards into the above optimal expression, then we have $w^{I*} = \frac{1-c+s+\delta-2c\delta+2s\delta}{4+4\delta}$, $p_d^{I*} = \frac{c(9+6\delta)+3(1+\delta)(9+8\delta)+s(27+26\delta)}{4(9+8\delta)}$, and $p_p^{I*} = \frac{9(3+c-4m+3s)+(51+18c-68m+50s)\delta+8(3+c-4m+3s)\delta^2}{4(1+\delta)(9+8\delta)\rho}$. We also get the condition $0 < m < m_1$, where $m_1 = \frac{1}{36+68\delta+32\delta^2}\big(27 + 9c + 27s + 51\delta + 18c\delta + 50s\delta + 24\delta^2 + 8c\delta^2 + 24s\delta^2 - 27\rho - 9c\rho - 27s\rho - 51\delta\rho - 18c\delta\rho - 50s\delta\rho - 24\delta^2\rho - 8c\delta^2\rho - 24s\delta^2\rho\big)$. We substitute the equilibrium solutions into the profit function and demand function. The equilibrium profit of the manufacturer and platform are $\pi_M^{I*} = \frac{1}{32}\left(2 - 5c + 4c^2 + 5s - 8cs + 4s^2 + 2\delta + \frac{2(c-s)^2}{1+\delta} - \frac{81(c-s)^2}{(9+8\delta)^2} - \frac{9(-1+3c-3s)(c-s)}{9+8\delta}\right)$ and $\pi_P^{I*} = \frac{1}{8(1+\delta)(9+8\delta)}\big(6s(1+\delta)(3+2\delta) + c^2(3+2\delta)^2 + s^2(3+2\delta)^2 + (1+\delta)^2(9+8\delta) - 2c(3+2\delta)(3+3s+3\delta+2s\delta)\big)$. The equilibrium member demand is $D_m^{I*} = \frac{(s-c)(3+2\delta)}{9+8\delta}$. The equilibrium total consumer demand is $D^{I*} = \frac{1}{4}\left(1 + s + \frac{s\delta - c(3+2\delta)(3+4\delta)}{(1+\delta)(9+8\delta)}\right)$.

Then we look at the scenario that the membership fee is high ($i.e.$, $m > (1-\rho)p_p^I$). The problem is maximizing equations (5) and (6) subject to $m > (1-\rho)p_p^I$. We also use the KKT conditions to solve the problem. For manufacturer's problem, from $\frac{d(-\pi_M^I)}{dp_d^I} + u_1\frac{d\left((1-\rho)p_p^I - m\right)}{dp_d^I} = 0$, we get $(1-\rho)p_p^I - m < 0$, $u_1\left((1-\rho)p_p^I - m\right) = 0$, and $u_1 \geq 0$. For platform's problem, from $\frac{d(-\pi_P^I)}{dp_p^I} + u_2\frac{d\left((1-\rho)p_p^I - m\right)}{dp_p^I} = 0$, we get $(1-\rho)p_p^I - m < 0$, $u_2\left((1-\rho)p_p^I - m\right) = 0$, and $u_2 \geq 0$. Combining the above two problems, we have $p_d^{I*} = \frac{3w^I(1+\delta)+f^I(3+2\delta)+\delta(2+c+s+2\delta)}{3+4\delta}$ and $p_p^{I*} = \frac{3(f^I+w^I)+(1+2c+2s+2w^I)\delta}{3+4\delta}$. We substitute them into the optimal problem to maximize the manufacturer profit (Eq. 5) subject to $m - (1-\rho)p_p^{I*} > 0$. The manufacturer decides on the wholesale price w^I. Then we get $w^{I*} = \frac{1}{2}\left(1 + s + \frac{-f^I+s}{1+\delta} - \frac{9s+8c\delta}{9+8\delta}\right)$. Then substitute $p_d^{I*} = \frac{3w^I(1+\delta)+f^I(3+2\delta)+\delta(2+c+s+2\delta)}{3+4\delta}$, $p_p^{I*} = \frac{3(f^I+w^I)+(1+2c+2s+2w^I)\delta}{3+4\delta}$, and $w^{I*} = \frac{1}{2}\left(1 + s + \frac{-f^I+s}{1+\delta} - \frac{9s+8c\delta}{9+8\delta}\right)$ into equation (6) to decide on the logistics fee f^I. We get the same logistics fee $f^{I*} = \frac{9(1+c+s)+(17+10c+6s)\delta+8\delta^2}{2(9+8\delta)}$. Substituting it backwards into the above optimal expression, then we have $w^{I*} = \frac{1-c+s+\delta-2c\delta+2s\delta}{4+4\delta}$, $p_d^{I*} = \frac{c(9+6\delta)+3(1+\delta)(9+8\delta)+s(27+26\delta)}{4(9+8\delta)}$, and $p_p^{I*} = \frac{1}{4}\left(3 + c + 3s + \frac{-c+s}{1+\delta} + \frac{9(c-s)}{9+8\delta}\right)$. We get the condition $m > m_1$. Thus, Proposition 1(2) is proved. We then substitute these equilibrium solutions into the profit function and demand function. The equilibrium profit of the manufacturer and platform are $\pi_M^{I*} = \frac{1}{32}\left(2 - 5c + 4c^2 + 5s - 8cs + 4s^2 + 2\delta + \frac{2(c-s)^2}{1+\delta} - \frac{81(c-s)^2}{(9+8\delta)^2} - \frac{9(-1+3c-3s)(c-s)}{9+8\delta}\right)$ and $\pi_P^{I*} = \frac{1}{8(1+\delta)(9+8\delta)}\big(6s(1+\delta)(3+2\delta) + c^2(3+2\delta)^2 + s^2(3+2\delta)^2 + (1+\delta)^2(9+8\delta) - 2c(3+2\delta)(3+3s+3\delta+2s\delta)\big)$. The equilibrium member demand is $D_m^{I*} = 0$. The equilibrium total consumer demand is $D^{I*} = \frac{1}{4}\left(1 + s + \frac{s\delta - c(3+2\delta)(3+4\delta)}{(1+\delta)(9+8\delta)}\right)$. □

Proof of Table A.4. In MLS mode, we first look at the scenario that the membership fee is low ($i.e.$, $0 < m < s$). We use backward induction to solve the optimization problems. The profits for the manufacturer and the platform are given by equations (7) and (8). The platform and manufacturer decide on their product prices simultaneously. The second derivative for the platform profit is $\frac{d^2\pi_P^M}{dp_p^{M\,2}} = -\frac{2(1+\delta)\rho^2}{\delta}$, and the second derivative for the manufacturer profit is $\frac{d^2\pi_M^M}{dp_d^{M\,2}} = -\frac{2}{\delta}$. We find the profit function π_P^M is a concave function of p_p^M ($i.e.$, $\frac{d^2\pi_P^M}{dp_p^{M\,2}} < 0$) and the profit function

π_M^M is a concave function of p_d^M (*i.e.*, $\frac{d^2\pi_M^M}{dp_d^{M^2}} < 0$). Setting the first derivatives for the platform and manufacturer to zero simultaneously (*i.e.*, $\frac{d\pi_P^M}{dp_p^M} = 0$ and $\frac{d\pi_M^M}{dp_d^M} = 0$), the optimal values are $p_d^{M*} = \frac{3w^M(1+\delta)+f^M(3+2\delta)+\delta(2+c-2m+s+2\delta)}{3+4\delta}$ and $p_p^{M*} = \frac{3(f^M+w^M)+(1+2c-4m+2s+2w^M)\delta}{(3+4\delta)\rho}$. We substitute it into the optimal problem to maximize the manufacturer profit (*i.e.*, Eq. 7). The manufacturer decides on the wholesale price. The second derivative for the manufacturer profit is $\frac{d^2\pi_M^M}{dw^{M^2}} = -\frac{2(1+\delta)(9+8\delta)}{(3+4\delta)^2}$, and π_M^M is a concave function of w^M (*i.e.*, $\frac{d^2\pi_M^M}{dw^{M^2}} < 0$). Then we can get $w^{M*} = \frac{1}{2}\big(1 + s - \frac{f^M+m-s}{1+\delta} - \frac{9s+8c\delta}{9+8\delta}\big)$ through $\frac{d\pi_M^M}{dw^M} = 0$. Next, we substitute the above optimal solutions into equation (8). The platform decides on the logistics fee. The profit function π_P^M is a concave function of f^M (*i.e.*, $\frac{d^2\pi_P^M}{df^{M^2}} < 0$). We have $f^{M*} = \frac{1}{8}\big(4+5c-8m+3s+4\delta-\frac{9(c-s)}{9+8\delta}\big)$ through $\frac{d\pi_P^M}{df^M} = 0$. Substituting $f^{M*} = \frac{1}{8}\big(4+5c-8m+3s+4\delta-\frac{9(c-s)}{9+8\delta}\big)$ backwards into the above optimal solutions, then we have $w^{M*} = \frac{1-c+s+\delta-2c\delta+2s\delta}{4+4\delta}$, $p_d^{M*} = \frac{1}{16}\big(12+3c-16m+13s+12\delta+\frac{9(c-s)}{9+8\delta}\big)$, and $p_p^{M*} = \frac{9(3+c-4m+3s)+(51+18c-68m+50s)\delta+8(3+c-4m+3s)\delta^2}{4(1+\delta)(9+8\delta)\rho}$. Thus, Proposition 2(1) is proved. The equilibrium profit and equilibrium demand in this case are as follows. The equilibrium profit of the manufacturer and platform are $\pi_M^{M*} = \frac{1}{32}\big(2-5c+4c^2+5s-8cs+4s^2+2\delta+\frac{2(c-s)^2}{1+\delta}-\frac{81(c-s)^2}{(9+8\delta)^2}-\frac{9(-1+3c-3s)(c-s)}{9+8\delta}\big)$ and $\pi_P^{M*} = \frac{1}{8(1+\delta)(9+8\delta)}\big(6s(1+\delta)(3+2\delta)+c^2(3+2\delta)^2+s^2(3+2\delta)^2+(1+\delta)^2(9+8\delta)-2c(3+2\delta)(3+3s+3\delta+2s\delta)\big)$. The equilibrium member demand is $D_m^{M*} = \frac{1}{4}\big(1+s+\frac{s\delta-c(3+2\delta)(3+4\delta)}{(1+\delta)(9+8\delta)}\big)$. The equilibrium total consumer demand is $D^{M*} = \frac{1}{4}\big(1+s+\frac{s\delta-c(3+2\delta)(3+4\delta)}{(1+\delta)(9+8\delta)}\big)$.

Next, we look at the scenario that the membership fee is medium (*i.e.*, $s < m < (1-\rho)p_p^M + s$). The problem is maximizing equations (7) and (8) subject to $m-(1-\rho)p_p^M - s < 0$. We use KKT conditions. For manufacturer's problem, from $\frac{d(-\pi_M^M)}{dp_d^M} + u_3\frac{d\left(m-(1-\rho)p_p^M-s\right)}{dp_d^M} = 0$, we get $m-(1-\rho)p_p^M-s<0$, $u_3\big(m-(1-\rho)p_p^M-s\big)=0$, and $u_3 \geq 0$. For platform's problem, from $\frac{d(-\pi_P^M)}{dp_p^M} + u_4\frac{d\left(m-(1-\rho)p_p^M-s\right)}{dp_p^M} = 0$, we get $m-(1-\rho)p_p^M-s<0$, $u_4\big(m-(1-\rho)p_p^M-s\big)=0$, and $u_4 \geq 0$. Combining these two problems, we have $p_d^{M*} = \frac{(1+\delta)(c+2g-s+3w^M+2\delta)}{3+4\delta}$ and $p_p^{M*} = \frac{g-3m+s+3w^M+\delta+2\left(c+(c-2m+s+w^M)\delta\right)}{(3+4\delta)\rho}$. We substitute them into equation (7) and maximize equation (7) subject to $m-(1-\rho)p_p^{M*}-s<0$. We can get $w^{M*} = \frac{1}{2}\big(1-c+s-\frac{g}{1+\delta}+\frac{c+8g-s}{9+8\delta}\big)$. Substituting it backwards into $p_d^{M*} = \frac{(1+\delta)(c+2g-s+3w^M+2\delta)}{3+4\delta}$ and $p_p^{M*} = \frac{g-3m+s+3w^M+\delta+2\left(c+(c-2m+s+w^M)\delta\right)}{(3+4\delta)\rho}$. We have the equilibrium results $p_d^{M*} = \frac{-2c(1+\delta)+g(11+8\delta)+(1+\delta)(9+2s+8\delta)}{2(9+8\delta)}$ and $p_p^{M*} = \frac{4c(1+\delta)^2+g(5+4\delta)+(1+\delta)\left(9+8\delta+2s(7+6\delta)-2m(9+8\delta)\right)}{2(1+\delta)(9+8\delta)\rho}$. We also get the condition $s < m < m_2$ in this case, where $m_2 = \frac{9+5g+18s+17\delta+4g\delta+34s\delta+8\delta^2+16s\delta^2-9\rho-5g\rho-17\delta\rho-4g\delta\rho-8\delta^2\rho}{18+34\delta+16\delta^2}$. Thus, Proposition 2(2) is proved. The equilibrium profit and equilibrium demand are as follows. The equilibrium profit of the manufacturer and platform are $\pi_M^{M*} = \frac{1}{4\delta(1+\delta)(9+8\delta)}\big(4c^2(1+\delta)^3-8c(1+\delta)^2(g+s+s\delta)+2g(1+\delta)\big(4s(1+\delta)-\delta(9+8\delta)\big)+(1+\delta)^2\big(4s^2(1+\delta)+\delta(9+8\delta)\big)+g^2\big(4+\delta(13+8\delta)\big)\big)$ and $\pi_P^{M*} = \frac{(3+2\delta)^2\left(g+s+s\delta-c(1+\delta)\right)^2}{\delta(1+\delta)(9+8\delta)^2}$. The equilibrium member demand is $D_m^{M*} = \frac{(3+2\delta)\left(g-c(1+\delta)+s(1+\delta)\right)}{\delta(9+8\delta)}$. The equilibrium total consumer demand is $D^{M*} = \frac{1}{4}\big(2-c+s-\frac{2g}{1+\delta}+\frac{c+8g-s}{9+8\delta}\big)$.

Finally, we look at the scenario that the membership fee is high (*i.e.*, $m > (1-\rho)p_p^M + s$). The problem is maximizing equations (7) and (8) subject to $(1-\rho)p_p^M + s - m < 0$. We use KKT conditions. For manufacturer's problem, from $\frac{d(-\pi_M^M)}{dp_d^M} + u_5\frac{d\left((1-\rho)p_p^M+s-m\right)}{dp_d^M} = 0$, we get $(1-\rho)p_p^M+s-m<0$, $u_5\big((1-\rho)p_p^M+s-m\big)=0$, and $u_5 \geq 0$. For platform's problem, from $\frac{d(-\pi_P^M)}{dp_p^M} + u_6\frac{d\left((1-\rho)p_p^M+s-m\right)}{dp_p^M} = 0$, we get $(1-\rho)p_p^M+s-m<0$, $u_6\big((1-\rho)p_p^M+s-m\big)=0$, and $u_6 \geq 0$. Combining these two problems, we have $p_d^{M*} = \frac{(1+\delta)(2g+3w^M+2\delta)}{3+4\delta}$ and $p_p^{M*} = \frac{g+3w^M+\delta+2w^M\delta}{3+4\delta}$. We substitute them into equation (7) and maximize equation (7) subject to $m-(1-\rho)p_p^{M*}-s>0$. We can get $w^{M*} = \frac{1}{2}-\frac{g}{18+34\delta+16\delta^2}$. Substituting it backwards into $p_d^{M*} = \frac{(1+\delta)(2g+3w^M+2\delta)}{3+4\delta}$ and $p_p^{M*} = \frac{g+3w^M+\delta+2w^M\delta}{3+4\delta}$. We have the equilibrium results $p_d^{M*} = \frac{1}{2}\big(1+g+\delta+\frac{2g}{9+8\delta}\big)$ and $p_p^{M*} = \frac{1}{2}\big(1+g\big(\frac{1}{1+\delta}-\frac{4}{9+8\delta}\big)\big)$. We also get the condition $m > m_2$ in this case. Thus, Proposition 2(3) is proved. The equilibrium profit and equilibrium demand are as follows. The equilibrium profit of the manufacturer and platform are $\pi_M^{M*} = \frac{1}{4}\big(1+\delta+g\big(-2+\frac{g(4+\delta(13+8\delta))}{\delta(1+\delta)(9+8\delta)}\big)\big)$ and $\pi_P^{M*} = \frac{g^2(3+2\delta)^2}{\delta(1+\delta)(9+8\delta)^2}$. The equilibrium member demand is $D_m^{M*} = 0$. The equilibrium total consumer demand is $D^{M*} = \frac{1}{2}-\frac{g}{2(1+\delta)}+\frac{2g}{9+8\delta}$. □

Proof of Proposition 1. In ILS mode, $\frac{dp_d^{I*}}{dc} = \frac{9+6\delta}{36+32\delta} > 0$, and $\frac{dp_p^{I*}}{dc} = \frac{9+18\delta+8\delta^2}{36\rho+68\delta\rho+32\delta^2\rho} > 0$. In MLS mode, if $0 < m < s$, $\frac{dp_d^{M*}}{dc} = \frac{9+6\delta}{36+32\delta} > 0$, and $\frac{dp_p^{M*}}{dc} = \frac{9+18\delta+8\delta^2}{36\rho+68\delta\rho+32\delta^2\rho} > 0$. If $s < m < m_2$, $\frac{dp_d^{M*}}{dc} = -\frac{1+\delta}{9+8\delta} < 0$ and $\frac{dp_p^{M*}}{dc} = \frac{2+2\delta}{9\rho+8\delta\rho} > 0$. Otherwise, $\frac{dp_d^{M*}}{dc} = 0$ and $\frac{dp_p^{M*}}{dc} = 0$. □

Proof of Proposition 2. Taking first order derivatives of the equilibrium member demand in ILS and MLS mode with respect to δ. In ILS mode, we have $\frac{dD_m^{I*}}{d\delta} = \frac{6(c-s)}{(9+8\delta)^2}$ when $0 < m < m_1$. We assume $s > c$, so it is easy to find $\frac{dD_m^{I*}}{d\delta} < 0$. Otherwise, we have $\frac{dD_m^{I*}}{d\delta} = 0$. In MLS mode, we have $\frac{dD_m^{M*}}{d\delta} = \frac{(c-s)(-9+8\delta^2)}{4(1+\delta)^2(9+8\delta)^2}$ and thus $\frac{dD_m^{M*}}{d\delta} > 0$ when $0 < m < s$, $\frac{dD_m^{M*}}{d\delta} = \frac{-g(27+48\delta+16\delta^2)+c(27+48\delta+22\delta^2)-s(27+48\delta+22\delta^2)}{\delta^2(9+8\delta)^2}$ and $\frac{dD_m^{M*}}{d\delta} < 0$ when $s < m < m_2$, and $\frac{dD_m^{M*}}{d\delta} = 0$ when $m > m_2$. □

Proof of Proposition 3. Taking first order derivatives of the equilibrium member demand in ILS and MLS mode with respect to g. In ILS mode, we have $\frac{dD_m^{I*}}{dg} = 0$. In MLS mode, we have $\frac{dD_m^{M*}}{dg} = \frac{3+2\delta}{9\delta+8\delta^2}$ when $s < m < m_2$. It is easy to find $\frac{dD_m^{M*}}{dg} > 0$. In other cases, we can find $\frac{dD_m^{M*}}{dg} = 0$. □

Proof of Proposition 4. The manufacturer's selling price in the direct channel in ILS mode (*i.e.*, p_d^{I*}) is given in Proposition 1, and the manufacturer's selling price in the direct channel in MLS mode (*i.e.*, p_d^{M*}) is given in Proposition 2. We first look at the case when $0 < m < s$, and we have $p_d^{I*} > p_d^{M*}$. When $s < m < m_2$, letting $p_d^{I*} - p_d^{M*} > 0$, we have $s > s_3$, and letting $p_d^{I*} - p_d^{M*} < 0$, we have $s < s_3$. When $m > m_2$, letting $p_d^{I*} - p_d^{M*} > 0$, we have $s > s_4$, and letting $p_d^{I*} - p_d^{M*} < 0$, we have $s < s_4$. We define $s_3 = \frac{2g(11+8\delta)-c(13+10\delta)-(1+\delta)(9+8\delta)}{23+22\delta}$ and $s_4 = \frac{2g(11+8\delta)-c(9+6\delta)-(1+\delta)(9+8\delta)}{27+26\delta}$. □

Proof of Proposition 5. The platform's selling price in the platform channel in ILS mode (*i.e.*, p_p^{I*}) is given in Table A.3, and the platform's selling price in the platform channel in MLS mode (*i.e.*, p_p^{M*}) is given in Table A.4. When $0 < m < s$ and $m_3 < m < m_2$, we have $p_p^{I*} \geq p_p^{M*}$. When $s < m < m_3$, we have $p_p^{I*} < p_p^{M*}$. When $m > m_2$, letting $p_p^{I*} - p_p^{M*} \geq 0$, we have $s > s_5$. Letting $p_p^{I*} - p_p^{M*} < 0$ under the condition $m > m_2$, we have $s < s_5$. We define $s_5 = \frac{2g(5+4\delta)-c(3+2\delta)(3+4\delta)-(1+\delta)(9+8\delta)}{27+50\delta+24\delta^2}$. Hence, Proposition 5 is proved. □

Proof of Proposition 6. From the equilibrium member demand and total demand in the two logistics sharing modes, shown in Proof of Tables A.3 and A.4, we can easily find that $D^{I*} = D^{M*}$ when $0 < m < m_1$. Under this condition, letting $D_m^{I*} - D_m^{M*} > 0$, we have $s > \frac{5}{2} + c + 4\delta + \frac{3}{6+4\delta}$. Letting $D_m^{I*} - D_m^{M*} < 0$, we have $s < \frac{5}{2} + c + 4\delta + \frac{3}{6+4\delta}$. We can verify that $\frac{5}{2} + c + 4\delta + \frac{3}{6+4\delta} > \max\{c,\ \hat{s}_1,\ \hat{s}_2\}$. When $m_1 < m < s$, we can show that $D_m^{I*} < D_m^{M*}$ and $D^{I*} = D^{M*}$. Propositions 6(1) and 6(2) are proved. When $m > s$, we have $D^{I*} - D^{M*} > 0$. However, under this condition, the result of $D_m^{I*} - D_m^{M*}$ has the different sign. Specifically, we have $D_m^{I*} - D_m^{M*} < 0$ when $s < m < m_2$, and $D_m^{I*} - D_m^{M*} = 0$ when $m > m_2$. Therefore, the rest of Proposition 6 can be proved. □

Proof of Corollary 1. We compare the platform's equilibrium profit in these modes, which are shown in Proof of Tables A.3 and A.4. Letting $\Pi_P = \pi_P^{I*} - \pi_P^{M*}$, when $0 < m < s$, we can find the platform's profit is the same in the ILS mode as in the MLS mode (*i.e.*, $\Pi_P = 0$). When $s < m < m_2$, we can verify that $\Pi_P < 0$. When $m > m_2$, the first derivative of Π_P with respect to s is positive (*i.e.*, $\frac{d\Pi_P}{ds} > 0$), and $\Pi_P(s_6) = 0$. If $s > s_6$, we have $\Pi_P > 0$, otherwise, we have $\Pi_P < 0$, where $s_6 = c + \frac{\frac{2\sqrt{2}\sqrt{-\delta(3+2\delta)^2(9+8\delta)\left(-g^2(3+2\delta)^2+\delta^2(1+\delta)^2(9+8\delta)\right)}}{\delta(9+8\delta)} - 3(1+\delta)(3+2\delta)}{(3+2\delta)^2}$ and $s_6 > \max\{c,\ \hat{s}_1,\ \hat{s}_2\}$.

We then compare the manufacturer's equilibrium profit in these modes. Letting $\Pi_M = \pi_M^{I*} - \pi_M^{M*}$, similarly, when $0 < m < s$, we can find the manufacturer's profit is the same in the ILS mode as in the MLS mode (*i.e.*, $\Pi_M = 0$). When $s < m < m_2$, we can verify that $\Pi_M < 0$. When $m > m_2$, the first derivative of Π_M with respect to s is positive (*i.e.*, $\frac{d\Pi_M}{ds} > 0$), and $\Pi_M(s_7) = 0$. If $s > s_7$, we have $\Pi_M > 0$, otherwise, we have $\Pi_M < 0$, where $s_7 = \frac{1}{4(3+2\delta)(27+90\delta+64\delta^2)}\left((1+\delta)(9+8\delta)^2\left(-5 + \frac{9(9+8\delta)+\frac{4c(3+2\delta)(27+90\delta+64\delta^2)}{1+\delta}}{(9+8\delta)^2}\right) + 8\sqrt{s_8}\right.$, $s_8 = \frac{1}{\delta(1+\delta)^2(9+8\delta)^3}\big(-2g\delta(1+\delta)(3+2\delta)(9+8\delta)(27+90\delta+64\delta^2) + g^2(3+2\delta)(27+90\delta+64\delta^2)(4+\delta(13+8\delta)) + \delta(1+\delta)^2(9+8\delta)(81+16\delta(18+\delta(19+6\delta)))\big)$ and $s_7 > \max\{c,\ \hat{s}_1,\ \hat{s}_2\}$. □

TABLE A.1. Consumer demands in ILS mode.

Range	$0 < m < (1-\rho)p_p^I$	$m > (1-\rho)p_p^I$
Demand	$D_{dm}^I = 0$, $D_{pm}^I = \dfrac{p_d^I - \rho p_p^I - m}{\delta} - (\rho p_p^I - s + m)$, $D_{dn}^I = 1 - \dfrac{p_d^I - \rho p_p^I - m}{\delta}$, $D_{pn}^I = 0$.	$D_{dm}^I = 0$, $D_{pm}^I = 0$, $D_{dn}^I = 1 - \dfrac{p_d^I - p_p^I}{\delta}$, $D_{pn}^I = \dfrac{p_d^I - p_p^I}{\delta} - (p_p^I - s)$.

TABLE A.2. Consumer demands in MLS mode.

Range	$0 < m < s$	$s < m < (1-\rho)p_p^M + s$	$m > (1-\rho)p_p^M + s$
Demand	$D_{dm}^M = 1 - \dfrac{p_d^M - \rho p_p^M}{\delta}$, $D_{pm}^M = \dfrac{p_d^M - \rho p_p^M}{\delta} - \left(\rho p_p^M - s + m\right)$, $D_{dn}^M = 0$, $D_{pn}^M = 0$.	$D_{dm}^M = 0$, $D_{pm}^M = \dfrac{p_d^M - \rho p_p^M + s - m}{\delta} - \left(\rho p_p^M - s + m\right)$, $D_{dn}^M = 1 - \dfrac{p_d^M - \rho p_p^M + s - m}{\delta}$, $D_{pn}^M = 0$.	$D_{dm}^M = 0$, $D_{pm}^M = 0$, $D_{dn}^M = 1 - \dfrac{p_d^M - p_p^M}{\delta}$, $D_{pn}^M = \dfrac{p_d^M - p_p^M}{\delta} - p_p^M$.

TABLE A.3. Equilibrium results in ILS mode.

Range	$0 < m < m_1$	$m > m_1$
Equilibrium results	$w^{I*} = \dfrac{1 + \delta - (1+2\delta)A_1}{4(1+\delta)}$, $p_d^{I*} = \dfrac{3(1+\delta)}{4} + \dfrac{c(9+6\delta) + s(27+26\delta)}{4(9+8\delta)}$, $p_p^{I*} = \dfrac{A_3}{4\rho} + \dfrac{A_1\delta}{4(1+\delta)(9+8\delta)\rho}$.	$w^{I*} = \dfrac{1 + \delta - (1+2\delta)A_1}{4(1+\delta)}$, $p_d^{I*} = \dfrac{3(1+\delta)}{4} + \dfrac{c(9+6\delta) + s(27+26\delta)}{4(9+8\delta)}$, $p_p^{I*} = \dfrac{A_2}{4} + \dfrac{A_1\delta}{4(1+\delta)(9+8\delta)}$.

Notes. $A_1 = c - s$, $A_2 = 3 + c + 3s$, $A_3 = 3 + c - 4m + 3s$.

TABLE A.4. Equilibrium results in MLS mode.

Range	$0 < m < s$	$s < m < m_2$	$m > m_2$
Equilibrium results	$f^{M*} = \dfrac{A_3 - 1 + 2\delta}{4} + \dfrac{3A_1(A_4 - 3)}{8A_4}$, $w^{M*} = \dfrac{1 + \delta - (1+2\delta)A_1}{4(1+\delta)}$, $p_d^{M*} = \dfrac{A_3 + 3\delta}{4} - \dfrac{A_1\delta}{2A_4}$, $p_p^{M*} = \dfrac{A_3}{4\rho} + \dfrac{A_1\delta}{4A_5\rho}$.	$w^{M*} = \dfrac{1}{2}\left(1 - \dfrac{A_1(A_4 - 1)}{A_4} - \dfrac{g}{A_5}\right)$, $p_d^{M*} = \dfrac{(1+\delta)(A_4 - 2A_1) + g(A_4 + 2)}{2A_4}$, $p_p^{M*} = \dfrac{(1+\delta)[A_4(A_3 - 1) - A_1] + g(A_4 + 1)}{4A_5\rho}$.	$w^{M*} = \dfrac{1}{2} - \dfrac{g}{2A_5}$, $p_d^{I*} = \dfrac{1+\delta}{2} + \dfrac{g(A_4 + 2)}{2A_4}$, $p_p^{I*} = \dfrac{1}{2} + \dfrac{g(A_4 + 1)}{4A_5}$.

Notes. $A_1 = c - s$, $A_3 = 3 + c - 4m + 3s$, $A_4 = 9 + 8\delta$, $A_5 = (1+\delta)A_4$.