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Research Article

Different Dominant Models and Fairness Concern of E-Supply Chain

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In this study, we examine the impact of the dominant enterprise's fairness concern on decisions in e-supply chains. Considering that the network platform's service level obviously influences product sales, an e-supply chain consisting of a single manufacturer and a single network platform is constructed. In this setting, four models of whether fairness concern is considered by the different dominant parties are investigated, and optimal decisions of the four models are compared and analyzed to study the impact of fairness concern. The findings show that when fairness concern is not taken into account, the profits when enterprises are dominating system are higher than when they are not dominating system. When fairness concern is considered, the dominant enterprise's fairness concern is beneficial to increase the subordinate enterprise's profit, but it will reduce its profit. And when the network platform dominates system and considers fairness concern, the sales price and the service level are the highest, indicating that consumers can get an enjoyable shopping experience. To sales price, it is negatively correlated with the fairness concern coefficient if manufacturer dominates the system, while it is positively correlated with the fairness concern coefficient if network platform dominates the system. Regardless of who has the fairness concern, fairness concern can improve the service level and increase consumer stickiness.

1. Introduction

With the rapid development of the Internet, a large number of traditional manufacturers began to choose online methods for sales, providing more choices and attracting more consumers [1–3]. This type of sales by a network platform gradually matured, promoting the building of an e-supply chain system. Kalakota and Robinson found that e-commerce combined business process, application system, and organizational structure to form a new pattern [4]. At the same time, more and more consumers preferred to shop online. A recent survey conducted by iResearch (http://www.iresearchchina.com/content/details8_23403.html) pointed out that, in China, if the network platform could provide more reliable information, the amount of online shopping market transactions and penetration rate would reach 5 trillion yuan and 14.8% in 2016. Research about eBay pointed out that 89% of transactions were one-time transactions, so the enhanced credit system made consumers more willing to make purchases [5], while the worse credit system hurt buyers [6]. These two aspects could both greatly improve the development of an e-supply chain. In an e-supply chain, the network platform stands on the neutral ground, providing all kinds of information, service, and communication for both manufacturers and consumers. In this manner, all partners save time, simplify procedures, and increase the number of sales.

With online consumers' growing awareness of self-protection and rights, more and more consumers nonetheless require fair network platforms [7], like Amazon and Tmall. The fairness concern has become an essential factor [8]. Ruffle suggested that both dominant and nondominant enterprises in the supply chain must decide fairly the distribution program [9]. Fairness concern means that a network platform considers equity and fairness. As part of that awareness of fairness concern, sales channels must try to be fair, sacrificing their profits to protect the weakest members. Otherwise, the party that lost may take punitive measures to reestablish fairness. Network platform teams who consider fairness build greater trust and favor from consumers. Presently, consumer demand for fairness has become an essential factor that affects to consume. In turn, the fairness concern has become a critical influencing factor in the development of a network platform.

How does the fairness concern affect decision-making, the operation of e-supply chain system? These problems are rarely involved in existing research. Extensive scholars have studied fairness-related behaviors in the traditional supply chain [10–12]. However, due to the great difference between the e-supply chain and the traditional supply chain, the existing conclusions about the fairness concern of the traditional supply chain have limited guidance on companies of the e-supply chain. Besides, few of researches have systematically studied fairness concern in the context of the e-supply chain. To fill this gap, we focus on different dominant models of the e-supply chain with the fairness concern.

The research problems are unique because this study considers the actual operation of e-supply chains so that the manufacturer and the network platform segment product profits through commissions. In the traditional supply chain, the retailer determines the sales price, but in the e-supply chains, the manufacturer sets this price. The network platform profits by providing sales services for manufacturers, which also means that it is necessary for the network platform to pay costs to guarantee the quality of the sales service. In practice, the market demand for products is closely related to the quality of the network platform's sales services. Generally, the higher the service level is, the higher the market demand for products will be [13, 14]. It is also reflected in the model of this study.

Moreover, unlike the study of fairness concern in traditional supply chains, it is often assumed that the utility of the subject of fairness concern is reduced because of the income gap [15–17]. This study argues that in e-supply chains, to establish a fair and equitable market environment, the decision-making body pays attention to the profits of itself and other members while making decisions. The research shows that, though such kind of fairness concern of the dominant companies in e-supply chains can reduce the profits, it will help to enhance consumer stickiness.

This article is composed of eight parts: Section 2 is a literature review. Section 3 explains the models and assumptions. Sections 4 and 5 present research on different dominant models. Section 6 presents the comparison. Section 7 has numerical illustrations. Finally, Section 8 presents the conclusion.

2. Literature Review

In recent years, most of the achievements in the study of e-supply chains have focused on enterprises strategies from the angle of using a network platform to gain profit. Few of them, however, have explored the influences of dominant enterprises with fairness concern or not. The following literature review examines three aspects: the development of the e-supply chain, dominant models, and research on fairness concern.

2.1. Development of E-Supply Chain. Among studies on e-supply chains, Thomas and Rainer aimed to explore the introduction of e-procurement systems and their contribution to the management of indirect goods supply chain [18]. They recognized the necessity of alignment of various e-procurement solutions along the procurement process and combined it with the supply chain. Sherer introduced a broader concept for supply chain management, the notion of value network advocacy [19]. Many information systems often separate supply from demand management and focus on linear information flows. Chiang et al. analyzed different operation modes between traditional and electronic channels, learning that the electronic channel is more beneficial in reducing sales price [20].

Many articles, including Liu and Zhang's, analyzed the situation where a traditional retailer faces new challenges from the e-channel [21]. Furthermore, Cattani et al. argued that the e-channel benefited both manufacturer and retailer as a mechanism for segmenting [22]. For this dual-channel model, Lu and Liu examined the pricing approach where manufacturers sold product through both conventional and e-channels [23]. Lu and Liu compared single- and dual-channel systems in a two-echelon supply chain, aiming at helping manufacturers decide whether or not to open an e-channel [24]. According to Raul and Raafat, the fact that e-supply chain management has advantages in improving efficiency and increasing profits was indicated by an example: the electronics manufacturing industry in North America [25]. Siddiqui and Raza investigated the state of e-supply chains research with a five-dimensional framework, finding that innovation, adoption, and barriers received significant attention in the earlier period, while in the latter period, the focus shifted to issues involving integration and collaboration [26]. Kiselicki et al. learned that several disadvantages characterizing the traditional model could potentially be solved through the e-supply chain model [27]. Zhang and Wang illustrated that manufacturers' direct selling through the e-supply chains could alleviate the side effects of the "bullwhip effect" in traditional supply chains [14]. Karray and Sigué found that the offline retailers' online sales channels can increase retailers' overall sales and showed that manufacturers' online sales prices are lower than retailers' online sales prices [28].

Focusing on the small and medium enterprise, different e-supply chain functions, including e-commerce, e-procurement, e-collaboration, e-design, and e-planning, were analyzed in detail. While the work mentioned above laid a solid foundation on the theoretical research of the e-supply chain, these did not consider the effect of fairness concern in e-supply chain operations. Besides, from the perspective of the model constructed in the existing literature, the network platform is only regarded as a sales channel, and the cost of providing sales services is not considered. The basic goal of e-supply chain enterprises is to maximize profits; there are limitations due to the lack of the costs of network platforms in current studies.

2.2. Dominant Supply Chain Models. In studying supply chains, research regarding different dominant models is important to help the enterprise gain more profit in competition. In turn, many scholars have studied dominant models.

Draganska et al. focused on the issue of retailers dominating the system [29]. Chen and Zhang researched the coordinating mechanism of the dominant retailer [30]. Aiming at the channel power, Amrouche and Yan found that the stronger dominant retailer is at an advantage to the weaker retailer but at a disadvantage to the manufacturer [31]. Also, many scholars compared the different dominant models and explored cooperation in supply chains. For instance, Zhao et al. focused on optimal pricing decisions and analyzed the effects of manufacturers' competitive strategies under different power structures [32]. Huang and Ke found that the absolute dominant retailer could make the whole supply chain more efficient [33]. Concerning the coordination mechanism, Altug proved that different revenue sharing contracts could make different costs in the process of executing contracts [34].

With the development of the Internet, many traditional enterprises started to sell online. Lu and Liu found that, in a dual-channel supply chain, manufacturers would lose profit if the e-channel was inefficient [24]. However, Wang et al. pointed out that manufacturers selling online were a useful way to gain more profit from reliable retailers [35]. Zhao et al. studied how consumers' channel loyalty, product complementarity, and market structure affect online and offline supply chain pricing strategies [36]. Zhou et al. explored how the free-riding behavior in the e-supply chains influences pricing and service strategies under channel differential pricing and nondifferential pricing [37].

Nonetheless, these studies did not combine the effects of fairness concern and only considered the network platform as a traditional retailer, ignoring the operation change of network platform in e-supply chains.

2.3. Research on Fairness Concern. Along with the evolution and popularization of e-commerce and Internet technology, the network platform has taken on an increasingly important role in e-supply chains. With consumers increasingly concerned about fairness, manufacturers must also consider fairness to improve their reputations and competitiveness. Fairness has taken its place as a topic in supply chain studies. Cui et al. studied the impact of fairness concern in the supply chain. The study showed that the price incentive contract could coordinate supply chains when retailers concerned fairness [15]. Meanwhile, Ho and Zhang confirmed that the fairness concern is quite valuable in a supply chain system [38]. Qin et al. developed a behavioral model, embedding fairness concern into utility functions and finding that supply chain performance anomalies are mostly due to fairness concern. In traditional supply chains [12], Li et al. introduced retailer's fairness concern into the supplier encroachment problem, showing that the retailer's profit might decrease in its disadvantageous-inequality aversion degree [11].

Zhou et al. focused on a low-carbon supply chain, finding that a retailer's fairness concern could change CA-ERCS contracts under certain conditions [39]. Furthermore, Choi and Messinger presented an experimental study to confirm that fairness concern plays a significant role in competitive supply-chain relationships [40]. Chen et al. studied the impact of retailer's fairness concern on supply chain equilibrium strategies and performance [41]. With respect to the horizontal fairness concern and the vertical fairness concern of the upstream and downstream links, Nie and Du examined the impact of two types of fairness concern on the coordination of supply chains for quantity discount contracts [16]. Liu et al. (2018) discussed the impacts of distributional and peer-induced fairness concern optimal decisions of the logistics service supply chain [17].

These studies primarily explored the influences of fairness concern in a traditional supply chain instead of an e-supply chain. Fairness concern in the context of e-supply chains is an important issue, which is limited in the existing research. Therefore, in this study, three important factors are combined, including different dominant models, an e-supply chain, and the fairness concern. The key point is to examine the impact of fairness concern on the operation of e-supply chains under different dominant models.

3. Model Explanation and Assumptions

As a shared platform, network platform is not only used by one manufacturer in the actual operation process. As we all know, there are many merchants on each network platform. However, due to the differences in manufacturers' strengths, there are two situations in which they compete with network platform: some strong manufacturers, such as Dell and HP, have leading advantages in the decision-making process, but some small and medium-sized enterprises, compared with network platforms like JD and Amazon, are relatively weak, while network platform dominates system. Therefore, in this paper, an e-supply chain consisting of a single manufacturer and a single platform is constructed to simplify the model and focus on dominance.

As shown in Figure 1, an e-supply chain consists of a single manufacturer and a single network platform with a short life cycle of products. There is no retailer. Therefore, the manufacturer not only is responsible for production but also releases the sales information and sells products through the network platform. Meanwhile, the manufacturer needs to pay commission for the network platform according to the total amount of traded products and sales service provided by the platform.

Based on the proposed e-supply chain model, the differences between this study and the traditional study of SCM with a manufacturer and a retailer are as follows.

Firstly, with the prosperity of e-commerce, sales prices of products on major network platforms tend to be homogeneous. Network platforms are focusing on providing consumers with a better shopping experience and enhancing customer stickiness. However, in traditional supply chains, retailers wholesale products from manufacturers and set different sales prices to attract consumers in the sales process [42–45].

Secondly, in e-supply chains, network platform's revenue model is different. Specifically, the sales price is determined by the settled merchant, not the platform; the commission charged by the network platform is set at the initial stage of

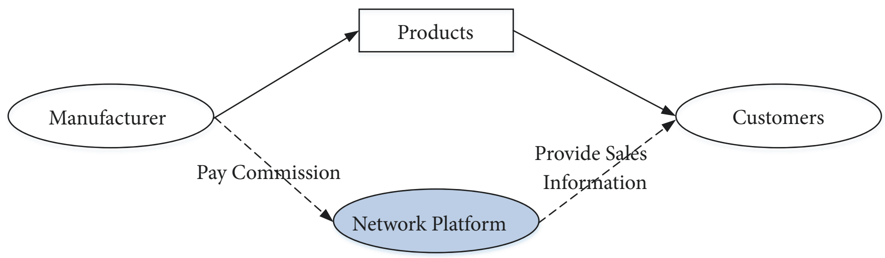

Figure 1: E-supply chain structure.

entering the platform. Moreover, different commissions are set for different categories of products on network platforms, such as Jingdong, Amazon, and eBay. Nevertheless, in traditional supply chains, retailers obtain products distribution income by setting the sales price.

Therefore, unlike the traditional supply chains where manufacturer's decision variable is the wholesale price and retailer's decision variable is the sales price, in e-supply chains, we set sales price as the manufacturer's decision variable, service level as the network platform's decision variable, and the commission as the exogenous variable, which is more in line with the actual operation. Currently, network platforms rely on big data to analyze consumers' behavior and carry out precision marketing services to effectively promote product sales. Therefore, the profit of the network platform mainly depends on providing marketing services.

Notations are as follows:

c : manufacturer's cost of production;

p : manufacturer's per unit sales price;

s : the service level of the network platform. The higher the service level, the higher the service cost. Following the assumption in [46], the cost function is assumed as $C(s) = ks^2/2$. $k(k > 0)$ is the elasticity coefficient of the service level.

q : market demand for products. The service level of the network platform will affect the sales of products. According to [47], sales function is assumed as

$$q = \alpha - \beta p + \gamma s \quad (1)$$

$\alpha(\alpha > 0)$, $\beta(\beta > 0)$, and $\gamma(\gamma > 0)$, respectively, indicate market saturation, price's influence coefficient to sales, and service level's influence coefficient to sales. In this model, assuming $0 < \gamma < \beta < \alpha$ means that consumers' sensitivity to price is higher than sensitivity to service.

ρ : a commission that manufacturer pays for the network platform's sales service. It indicates that the manufacturer is required to pay commission for the unit sales. Therefore, the total commission that the network platform can obtain is ρq.

Manufacturer, network platform, and e-supply chain's profit functions could be expressed as

$$\pi_m = (p - \rho - c) q \quad (2)$$

$$\pi_e = \rho q - \frac{ks^2}{2} \quad (3)$$

$$\pi = (p - c) q - \frac{ks^2}{2} \quad (4)$$

To ensure the optimal decisions make sense, assume that $\rho > \lambda k$ and $\alpha > \beta(\rho + c)$. In the e-supply chain, because of the different dominant models, there are two kinds of models: one is dominated by the manufacturer, and the other is dominated by the network platform. In order to improve their reputation and ensure coordination in the supply chain, the dominant enterprises will consider the fairness concern. According to whether the dominant enterprises consider the fairness concern, the e-supply chain presents four decision-making models, as shown in Figure 2.

4. E-Supply Chain Dominated by Manufacturer

If the manufacturer's strength is greater than the network platform, the manufacturer will have the dominant power and become the dominant enterprise in the e-supply chain. Considering that the dominant manufacturer is fairness concerned or not, there are two decision-making modes.

4.1. Dominant Manufacturer without Fairness Concern. When the manufacturer is dominant without the fairness concern, e-supply chain members make decisions in an order: manufacturer gives the sales price (p) firstly; then, the network platform provides the corresponding service level (s) according to the price. So, manufacturer and network platform constitute the Stackelberg game [48, 49].

According to the backward induction method, the steps are as follows:

First of all, according to $\partial^2\pi_e/\partial s^2 = -k < 0$, π_e is a strictly concave function about s. By $\partial\pi_e/\partial s = 0$, the response function of service level is

$$s^* = \frac{\rho\gamma}{k} \quad (5)$$

Secondly, taking (5) into π_m, according to $\partial^2\pi_m/\partial p^2 = -2\beta < 0$, π_m is a strictly concave function about p. By $\partial\pi_m/\partial p = 0$, optimal sales price and service level are as follows:

$$p^{*M} = \frac{\alpha + \beta(c + \rho)}{2\beta} + \frac{\rho\gamma^2}{2\beta k} \quad (6)$$

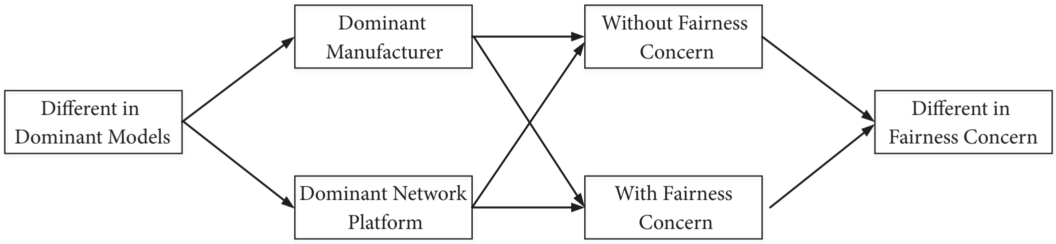

Figure 2: Decision models with different dominant models.

$$s^{*M} = \frac{\rho\gamma}{k} \tag{7}$$

Lastly, manufacturer and network platform's optimal profit could be expressed as follows:

$$\pi_m^{*M} = \frac{\left[\rho\gamma^2 + \alpha k - \beta k (c+\rho)\right]^2}{4\beta k^2} \tag{8}$$

$$\pi_e^{*M} = \frac{\rho\left[\alpha - \beta(c+\rho)\right]}{2} \tag{9}$$

4.2. Dominant Manufacturer with Fairness Concern. In e-supply chains, manufacturers are mainly responsible for providing products, so increasing their reputation is necessary for sustained development. To achieve this aim, manufacturers must consider fairness, even though it will reduce profit. This study utilizes a simplified fairness utility function to simplify the calculation in [16, 50]. Assuming that the sensitivity of the network platform facing loss and profit is the same, the utility function can be expressed as follows:

$$\begin{aligned} u_m &= \pi_m - \lambda(\pi_m - \pi_e) \\ &= (1-\lambda)(p-\rho-c)(\alpha - \beta p + \gamma s) \\ &\quad + \lambda\rho(\alpha - \beta p + \gamma s) - \frac{\lambda k s^2}{2} \end{aligned} \tag{10}$$

$0 < \lambda < 1$ is the fairness concern coefficient of the manufacturer. The closer it gets to 0, the lower the degree of fairness concern. On the contrary, the closer it gets to 1, the higher the degree of fairness concern. In reality, the fairness concern's degree is almost less than 0.5 ($\lambda < 0.5$).

When the manufacturer is dominant with fairness concern, e-supply chain members make decisions in an order like the case without fairness concern, while the manufacturer decides based on the utility function. According to the backward induction method, the steps are as follows:

First, according to Section 4.1, the response function of service level is

$$s^* = \frac{\rho\gamma}{k} \tag{11}$$

Second, taking (11) into u_m, according to $\partial^2 u_m/\partial p^2 = -2\beta(1-\lambda) < 0$, u_m is a strictly concave function about p. By $\partial u_m/\partial p = 0$, optimal sales price and service level are as follows:

$$p^{*\lambda M} = \frac{\alpha k + \rho\gamma^2}{2\beta k} + \frac{c+\rho}{2} - \frac{\lambda\rho}{2(1-\lambda)} \tag{12}$$

$$s^{*\lambda M} = \frac{\rho\gamma}{k} \tag{13}$$

Manufacturer and network platform's optimal profits could be expressed as follows:

$$\begin{aligned} \pi_m^{*\lambda M} = &\left[\frac{\alpha k + \rho\gamma^2}{2\beta k} - \frac{\lambda\rho}{2(1-\lambda)} - \frac{c+\rho}{2}\right] \\ &\cdot \left[\frac{\alpha k + \rho\gamma^2}{2k} + \frac{\lambda\beta\rho}{2(1-\lambda)} - \frac{\beta(c+\rho)}{2}\right] \end{aligned} \tag{14}$$

$$\pi_e^{*\lambda M} = \frac{\rho\left[\alpha(1-\lambda) - \beta c(1-\lambda) - \beta\rho(1-2\lambda)\right]}{2(1-\lambda)} \tag{15}$$

5. E-Supply Chain Dominated by Network Platform

In the e-supply chain, if the network platform's strength is greater than the manufacturer's, the network platform will dominate the system. Considering that the dominant network platform is fairness concerned or not, there are two decision-making modes.

5.1. Dominant Network Platform without Fairness Concern. When the network platform is dominant without the fairness concern, members in the e-supply chain make decisions in an order: network platform provides the service level (s) first; then, the manufacturer gives the corresponding sales price (p) according to the service level. Thus, manufacturer and network platform constitute the Stackelberg game, led by the network platform and followed by the manufacturer. According to the backward induction method, the steps are as follows:

First of all, according to $\partial^2\pi_m/\partial p^2 = -2\beta < 0$, π_m is a strictly concave function about p. By $\partial\pi_m/\partial p = 0$, the response function of sales price is

$$p^* = \frac{\alpha + \gamma s + \beta(c+\rho)}{2\beta} \tag{16}$$

Secondly, taking (16) into π_e, according to $\partial^2\pi_e/\partial s^2 = -k < 0$, π_e is a strictly concave function about s. By $\partial\pi_e/\partial s = 0$, optimal service level is as follows:

$$s^{*E} = \frac{\rho\gamma}{2k} \tag{17}$$

Thirdly, optimal sales price can be expressed as follows:

$$p^{*E} = \frac{\rho\gamma^2}{4\beta k} + \frac{\alpha + \beta(c+\rho)}{2\beta} \tag{18}$$

Manufacturer and network platform's optimal profits are as follows:

$$\pi_m^{*E} = \frac{\left[\rho\gamma^2 + 2\alpha k - 2\beta k(c+\rho)\right]^2}{16\beta k^2} \tag{19}$$

$$\pi_e^{*E} = \frac{\rho\left[\rho\gamma^2 + 4\alpha k - 4\beta k(c+\rho)\right]}{8k} \tag{20}$$

5.2. Dominant Network Platform with Fairness Concern. The network platform is mainly responsible for providing information. Increasing consumers' trust on the platform is the key to promote sales. To achieve that aim, the network platform will consider fairness and forwardly give up some profits to pursue fairness, forming a fair marketing environment. According to the literature in [16, 50], the simplified fairness utility function is used. Assuming that the sensitivity of a network platform facing loss and profit is the same, the utility function can be expressed as follows:

$$\begin{aligned} u_e &= \pi_e - \lambda(\pi_e - \pi_m) \\ &= (1-\lambda)\left[\rho(\alpha - \beta p + \gamma s) - \frac{ks^2}{2}\right] \\ &\quad + \lambda(\rho - c - p)(\alpha - \beta p + \gamma s) \end{aligned} \tag{21}$$

$0 < \lambda < 1$ is the fairness concern coefficient of the network platform. The closer it gets to 0, the lower is the degree of fairness concern. On the contrary, the closer it gets to 1, the higher is the degree of fairness concern. In reality, the fairness concern's degree is almost less than 0.5 ($\lambda < 0.5$).

When the network platform is dominant with the fairness concern, the decision sequence is the same as the case without fairness concern, but network platform aims to maximize utility. According to the backward induction method, the steps are as follows:

First, according to Section 5.1, the response function of sales price is

$$p^* = \frac{\alpha + \gamma s + \beta(c+\rho)}{2\beta} \tag{22}$$

Secondly, taking (22) into u_e, according to $\partial^2 u_e/\partial s^2 = -k(1-\lambda) < 0$, u_e is a strictly concave function about s. By $\partial u_e/\partial s = 0$, optimal service level is as follows:

$$s^{*\lambda E} = \frac{\gamma\left[\beta\rho(1-2\lambda) + \lambda(\alpha - \beta c)\right]}{2\beta k(1-\lambda) - \lambda\gamma^2} \tag{23}$$

Thirdly, optimal sales price can be expressed as follows:

$$\begin{aligned} p^{*\lambda E} &= \frac{\alpha + \beta(c+\rho)}{2\beta} \\ &\quad + \frac{\gamma^2\left[\beta\rho(1-2\lambda) + \lambda(\alpha - \beta c)\right]}{2\beta\left[2\beta k(1-\lambda) - \lambda\gamma^2\right]} \end{aligned} \tag{24}$$

Manufacturer and network platform's optimal profits are as follows:

$$\pi_m^{*\lambda E} = \frac{\beta(1-\lambda)^2\left[\rho\gamma^2 + 2\alpha k - 2\beta k(c+\rho)\right]^2}{4\left[2\beta k(1-\lambda) - \lambda\gamma^2\right]^2} \tag{25}$$

$$\begin{aligned} \pi_e^{*\lambda E} &= \frac{\beta\rho(1-\lambda)\left[\rho\gamma^2 + 2\alpha k - 2\beta k(c+\rho)\right]}{2\left[2\beta k(1-\lambda) - \lambda\gamma^2\right]^2} \\ &\quad - \frac{k\gamma^2\left[\beta\rho + \lambda\alpha - \lambda\beta(c+2\rho)\right]^2}{2\left[2\beta k(1-\lambda) - \lambda\gamma^2\right]^2} \end{aligned} \tag{26}$$

6. Comparison in Models

By comparing the different dominant models, the following properties and conclusions can be obtained.

Property 1. The decision variables, s and p, are related to the commission's change. The regularities are as follows:

(1) $s^{*\lambda E} > s^{*M} = s^{*\lambda M} > s^{*E}$; $s^{*M}, s^{*\lambda M}, s^{*E}, s^{*\lambda E}$ have positive correlations with ρ;

(2) $p^{*\lambda E} > p^{*M} > p^{*E} > p^{*\lambda M}$; $p^{*M}, p^{*\lambda M}, p^{*E}, p^{*\lambda E}$ have positive correlations with ρ.

Proof process is in Appendix A Proof 1.

As for the sales price and service level, three conclusions can be made:

(1) The network platform's service level is the highest when the network platform is dominant with fairness concern and is the lowest when the network platform is dominant without fairness concern. The reason is that when the network platform dominates the system, providing service is the main cost and it would be reduced forwardly. However, when the network platform considers fairness concern, it would improve the service level to attract consumers and increase product sales.

(2) The sales price reaches the highest point when the network platform dominates system with fairness concern and reaches the lowest point when the manufacturer dominates system with fairness concern. When the fairness concern is not considered, the sales price in the model of the dominant manufacturer is higher than the dominant network platform. Without the fairness concern, the manufacturer would increase the price to improve revenue, but a fairness concern could change this situation. A network platform with fairness concern would raise its service level, which could make the manufacturer raise the sales price to earn more profits, because the improved service level is conducive to market demand. A manufacturer with fairness concern would reduce the price, which could help increase demand and make fairness in the supply chain system.

(3) No matter which party is dominant in the supply chain, the network platform's service level and sales price both increase with the growth of commission. The direct revenue of the network platform is the commission which is proportional to the service level. The more commission the manufacturer pays, the more the capital for better sales

service the manufacturer obtains. However, the increase in commission would directly increase the manufacturer's cost, making the manufacturer raise its price to maintain the balance and ensure that the profit does not decline.

Property 2. The profits of manufacturer and network platform, π_m and π_e, are related to the commission's change. The regularities are as follows:

(1) $\pi_m^{*M} > \pi_m^{*E}$; $\pi_m^{*\lambda E} > \pi_m^{*\lambda M}$; $\pi_m^{*M} > \pi_m^{*\lambda M}$; $\pi_m^{*\lambda E} > \pi_m^{*E}$; $\pi_m^{*M}, \pi_m^{*\lambda M}, \pi_m^{*\lambda E}, \pi_m^{*E}$ have negative correlations with ρ;

(2) $\pi_e^{*E} > \pi_e^{*M}$; $\pi_e^{*\lambda M} > \pi_e^{*\lambda E}$; $\pi_e^{*\lambda M} > \pi_e^{*M}$; $\pi_e^{*E} > \pi_e^{*\lambda E}$; $\pi_e^{*M}, \pi_e^{*\lambda M}, \pi_e^{*\lambda E}, \pi_e^{*E}$ have positive correlations with ρ.

Proof process is in Appendix B Proof 2.

As for the profits of the manufacturer and network platform, two conclusions can be reached:

(1) Without the fairness concern, the dominant enterprise would gain more profit. This situation could change, after considering fairness. The dominant enterprise would sacrifice profit to achieve fairness, showing less gain than the case without fairness concern. It is because the enterprise with more power is required to consider fairness firstly by the government, consumers or third-party regulator. So, the dominant enterprise would consider the other party's profit status and reduce profit to achieve the objective. Moreover, consumers' stickiness could rise with an increasing degree of fairness, laying a solid foundation for long-term profit growth for the whole supply chain system.

(2) As commission increases, the manufacturer's profit decreases, but the network platform's profit increases. The commission is one of the manufacturer's costs, as well as the only revenue of network platform. The change of commission could significantly affect these two enterprises, decreasing the manufacturer's profit and increasing the network platform's.

Property 3. The decision variables, s and p, are related to the change of fairness concern coefficient. The regularities are as follows:

(1) $s^{*M} = s^{*\lambda M} > s^{*E}$; $s^{*\lambda E} > s^{*E}$; when $\lambda < \lambda_1$, $s^{*\lambda E} < s^{*M}$; when $\lambda > \lambda_1$, $s^{*\lambda E} > s^{*M}$; $\lambda_1 = \beta k\rho/(\alpha k + \rho\gamma^2 - \beta ck)$.

(2) $s^{*\lambda E}$ has a positive correlation with λ;

(3) $p^{*\lambda M}$ has a negative correlation with λ; $p^{*\lambda E}$ has a positive correlation with λ.

Proof process is in Appendix C Proof 3.

Regarding the sales price and service level, two conclusions can be reached:

(1) When the manufacturer dominates the system, the network platform's service level does not change with the fairness concern coefficient. However, the service level increases with the increase of fairness concern coefficient when the network platform dominates the system. The higher the fairness concern coefficient, the greater effort paid by network platform, leading to a higher service level.

(2) When the network platform is dominant with fairness concern, the sales price will increase with the growth of the degree of fairness concern, since that network platform would improve the service level firstly upon considering fairness. As a result, it increases the network platform's cost, making the network platform require a higher commission and lead sales price increase. When the manufacturer is dominant with a fairness concern, the increase in fairness concern coefficient will make the price decline. In order to achieve fairness, the manufacturer would sacrifice profit to attract consumers by lower sales price.

Property 4. The profits of manufacturer and network platform, π_m and π_e, are related to the change of fairness concern's degree; the regularities are as follows:

(1) $\pi_m^{*M} > \pi_m^{*E}$; $\pi_m^{*\lambda E} > \pi_m^{*\lambda M}$; $\pi_m^{*M} > \pi_m^{*\lambda M}$; $\pi_m^{*\lambda E} > \pi_m^{*E}$;

(2) $\pi_m^{*\lambda M}$decreases with the growth of λ; $\pi_m^{*\lambda E}$ increases with the growth of λ;

(3) $\pi_e^{*E} > \pi_e^{*M}$; $\pi_e^{*\lambda M} > \pi_e^{*\lambda E}$; $\pi_e^{*\lambda M} > \pi_e^{*M}$; $\pi_e^{*E} > \pi_e^{*\lambda E}$;

(4) $\pi_e^{*\lambda E}$ decreases and $\pi_e^{*\lambda M}$ increases with the growth of λ.

Proof process is in Appendix D Proof 4.

Regarding the profits of manufacturer and network platform, two conclusions can be obtained:

(1) Manufacturer's profit increases with the growth of fairness concern coefficient when network platform dominates the supply chain but decreases when the manufacturer dominates the supply chain. Furthermore, without a fairness concern, the manufacturer's profit under the model with the dominant manufacturer is higher than under the model with the dominant network platform. On the other hand, when the dominant enterprise starts considering fairness, this situation would change. Manufacturer's profit under the model with the dominant manufacturer is lower than under the model with the dominant network platform. In reality, the network platform would sacrifice its profit to achieve fairness concern when it dominates, increasing the profit of the manufacturer and the whole supply chain system. The situation is opposite when the manufacturer dominates the system because that fairness concern could increase the supply chain's profit and decrease the dominant enterprise's profit, thus leading to the nondominant enterprise getting more profit.

(2) Network platform's profit increases with the growth of the fairness concern coefficient when the manufacturer dominates the system but decreases when the network platform dominates the system. Without a fairness concern, the network platform could gain more profit when it is dominant in the supply chain. After considering a fairness concern, the network platform could earn more profit when the manufacturer is dominant in the supply chain. It is because the fairness concern could make the dominant party more willing to give up its profit for fairness. The higher the fairness concern coefficient is, the more profit the dominant enterprise gives up. After considering fairness, consumers' purchase intentions would enhance, and product sales would increase. As a result, the entire supply chain system's profit

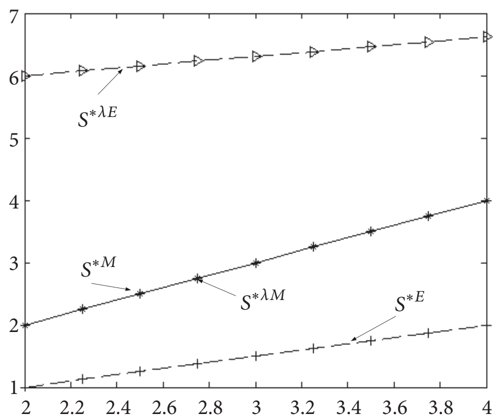

Figure 3: Change rule of service level as ρ changes.

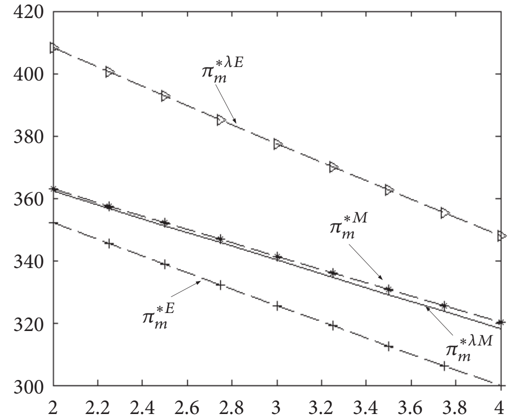

Figure 5: Change rule of manufacturer's profit as ρ changes.

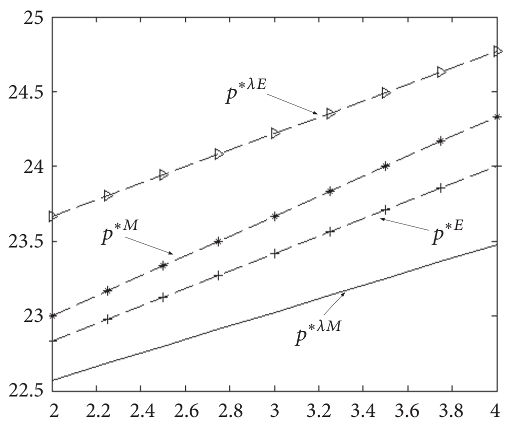

Figure 4: Change rule of sales price as ρ changes.

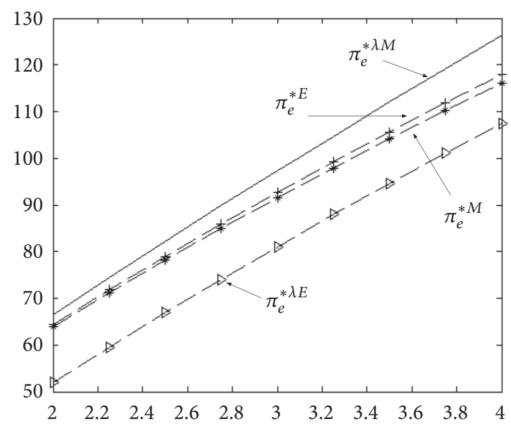

Figure 6: Change rule of network platform's profit as ρ changes.

would increase, and the nondominant enterprise's profit would also increase.

7. Numerical Illustrations

In order to verify conclusions, numerical illustrations are utilized for our results analysis.

Assume that $\alpha = 100, \beta = 3, \gamma = 1, k = 1, c = 10, \lambda = 0.3$ and let ρ be the independent variable. The commission is uniformly distributed between $[2, 4]$. The change rule of service level, sales price, profit of manufacturer, and profit of the network platform with ρ's change are shown in Figures 3–6.

As shown in Figures 3–6, three conclusions can be obtained:

(1) No matter which enterprise is dominant, the service level, the sales price, and the network platform's profit would increase with the growth of commission, while the manufacturer's profit would decrease.

(2) Network platform's service level becomes the highest when it is dominant with fairness concern and becomes lowest when it is dominant without fairness concern. It is because the enhanced service level can increase the market demand when the network platform dominates the system and considers fairness, while the decision motivation would reduce costs and maximize the profit under the model without fairness concern. Besides, when the manufacturer is dominant, the network platform's service level does not change with the fairness concern coefficient. On the other hand, the sales price reaches highest when the network platform dominates with a fairness concern and reaches lowest when the manufacturer dominates with a fairness concern.

(3) Without a fairness concern, the dominant enterprise in the supply chain could gain more profit. However, after considering fairness, the dominant party profits less. It is because enterprises with more power would sacrifice their profit to achieve fairness.

Assume that $\alpha = 100, \beta = 3, \gamma = 1, k = 1, c = 10, \rho = 3$ and let λ be the independent variable. The fairness concern coefficient is uniformly distributed between [0,0.5]. The change rule of service level, sales price, profits of manufacturer, and profits of network platform with λ's change are shown in Figures 7–10.

As shown in Figures 7–10, two conclusions can be obtained:

(1) When the network platform dominates with a fairness concern, the service level is improved with the growth of

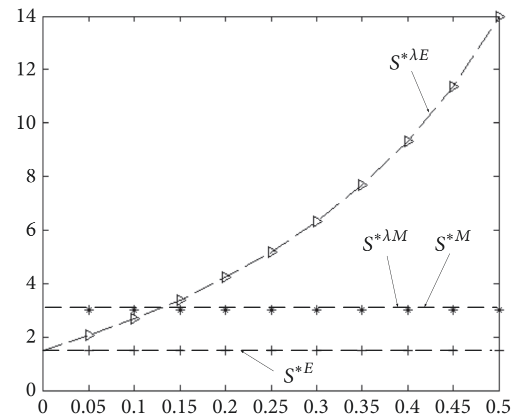

FIGURE 7: Change rule of service level as λ changes.

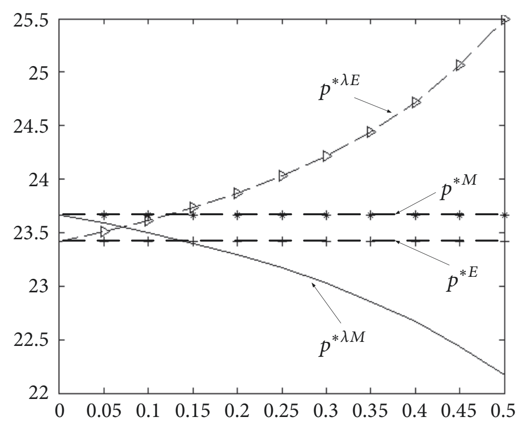

FIGURE 8: Change rule of sales price as λ changes.

fairness concern's coefficient. In other models, however, the service level is irrelevant to fairness concern. As for the sales price, when the network platform dominates with fairness concern, it increases with the growth of fairness concern's coefficient to gain more profit by the increased market demand due to the enhanced service level. When the manufacturer dominates with fairness concern, it decreases with the growth of fairness concern's degree to attract more consumers.

(2) Regarding the manufacturer's and network platform's profits, they both change with the fairness concern's coefficient. Specifically, as fairness concern's coefficient increases, if network platform dominates the system, manufacturer's profit increases and network platform's profit decreases, while they will show the opposite trend if manufacturer dominates the system. Furthermore, the fairness concern would decrease the dominant enterprise's profit.

8. Conclusion

This article aims at an e-supply chain consisting of one manufacturer and one network platform, researching on four decision-making models based on the fairness concern. The conclusions are as follows:

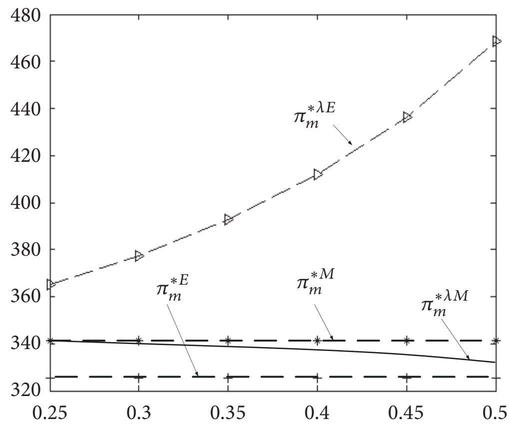

FIGURE 9: Change rule of manufacturer's profit as λ changes.

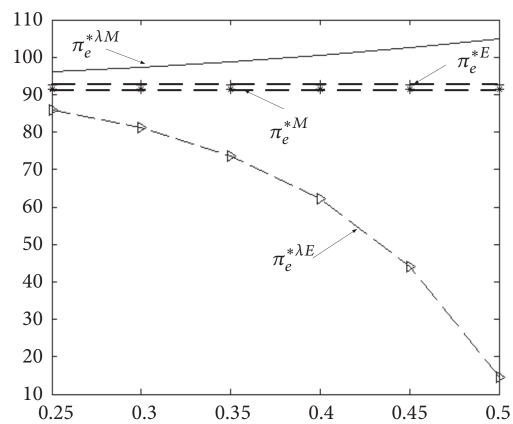

FIGURE 10: Change rule of network platform's profit as λ changes.

As for consumers, if they want a higher service level, they must pay more. Meanwhile, sales price, service level, and profit of network platform increase with the growth of commission; on the contrary, the manufacturer's profit decreases. Second, when the variables are within a certain range, service level and sales price are both the highest under the model with the dominant network platform considering the fairness concern. Furthermore, these two decision variables have positive correlations with fairness concern coefficient when the network platform is dominant.

We also found fairness concern is an important factor in enhancing consumer stickiness, so the dominant enterprises will sacrifice their profit to consider fairness. On the other hand, both the manufacturer and network platform are not willing to consider fairness concern when they are dominant.

Based on findings of this study, the following management implications can be obtained:

First of all, with the improvement of the online shopping environment and the economic advantages of e-commerce, the sales volume of products is affected not only by the sales price but also by the service level of network platform. Therefore, whether it is the manufacturer or the network platform that dominates the system, enterprises should improve product quality and endeavor to provide better service to consumers. Secondly, although the fairness concern of dominant enterprises would reduce their profits, it is conducive to improving benefits of nondominant parties, which contributes to promoting cooperation in e-supply chains and the enhancement of service level. Therefore, in the process of cooperation, the dominant enterprises should appropriately adjust the decision-making targets according to the actual situation and actively coordinate the upstream and downstream enterprises to maintain the long-term stable development of e-supply chains.

In exploring the e-supply chain, some issues remain for further study. These include how the e-supply chain coordinate and reach its best state under different dominant models, how pricing under different dominant models is. Coordination and pricing have a significant impact on e-supply chain operations. Research on these issues will help enterprises to make better decisions.

Appendix

A. Proof of Property 1

By assuming that $\rho > \lambda k$, $k\beta > \gamma^2$, $\alpha > \beta(\rho + c)$, $\lambda < 0.5$.

(1)

$$\begin{aligned}
s^{*\lambda E} - s^{*M} &= \frac{\gamma\left[\lambda\alpha k + \lambda\rho\gamma^2 - \beta k\left(\lambda c + \rho\right)\right]}{k\left[2\beta k\left(1-\lambda\right) - \lambda\gamma^2\right]} > 0; \\
s^{*\lambda M} - s^{*E} &= \frac{\rho\gamma}{2k} > 0; \\
\frac{\partial s^{*E}}{\partial \rho} &= \frac{\gamma}{2k} > 0; \\
\frac{\partial s^{*M}}{\partial \rho} &= \frac{\partial s^{*\lambda M}}{\partial \rho} = \frac{\gamma}{k} > 0; \\
\frac{\partial s^{*\lambda E}}{\partial \rho} &= \frac{\beta\gamma\left(1-2\lambda\right)}{2\beta k\left(1-\lambda\right) - \lambda\gamma^2} > 0.
\end{aligned} \tag{A.1}$$

We can see that Property 1(1) holds.

(2)

$$\begin{aligned}
p^{*\lambda E} - p^{*M} &= \frac{\gamma^2\left[\lambda\alpha k + \lambda\rho\gamma^2 - \beta k\left(\rho + \lambda c\right)\right]}{2\beta k\left[2\beta k\left(1-\lambda\right) - \lambda\gamma^2\right]} > 0; \\
p^{*M} - p^{*E} &= \frac{\rho\gamma^2}{4\beta k} > 0; \\
p^{*E} - p^{*\lambda M} &= \frac{\rho\left[2\lambda\beta k - \gamma^2\left(1-\lambda\right)\right]}{4\beta k\left(1-\lambda\right)} > 0. \\
\frac{\partial p^{*M}}{\partial \rho} &= \frac{\gamma^2}{2\beta k} + \frac{1}{2} > 0; \\
\frac{\partial p^{*\lambda M}}{\partial \rho} &= \frac{\gamma^2}{2\beta k} + \frac{1-2\lambda}{2\left(1-\lambda\right)} > 0; \\
\frac{\partial p^{*E}}{\partial \rho} &= \frac{\gamma^2}{4\beta k} + \frac{1}{2} > 0; \\
\frac{\partial p^{*\lambda E}}{\partial \rho} &= \frac{2\beta k\left(1-\lambda\right) + \gamma^2\left(1-3\lambda\right)}{2\left[2\beta k\left(1-\lambda\right) - \lambda\gamma^2\right]} > 0
\end{aligned} \tag{A.2}$$

We can see that Property 1(2) holds.

B. Proof of Property 2

(1)

$$\begin{aligned}
\pi_m^{*M} - \pi_m^{*E} &= \frac{\rho\gamma^2\left[3\rho\gamma^2 + 4\alpha k - 4\beta k\left(c+\rho\right)\right]}{16\beta k^2} > 0; \\
\pi_m^{*M} - \pi_m^{*\lambda M} &= \frac{\beta\lambda^2\rho^2}{4\left(1-\lambda\right)^2} > 0; \\
\pi_m^{*\lambda E} - \pi_m^{*E} &= \frac{\lambda\gamma^2\left[4\beta k\left(1-\lambda\right) - \lambda\gamma^2\right]\left[2\alpha k + \rho\gamma^2 - 2\beta k\left(c+\rho\right)\right]^2}{16\beta k^2\left[2\beta k\left(1-\lambda\right) - \lambda\gamma^2\right]^2} > 0; \\
\pi_m^{*\lambda E} - \pi_m^{*\lambda M} &= \beta\left[\frac{\alpha k + \rho\gamma^2}{2\beta k} + \frac{\lambda\rho}{2\left(1-\lambda\right)} - \frac{c+\rho}{2}\right]^2 + \frac{\beta\left(1-\lambda\right)^2\left[2\alpha k + \rho\gamma^2 - 2\beta k\left(c+\rho\right)\right]^2}{4\left[2\beta k\left(1-\lambda\right) - \lambda\gamma^2\right]^2} > 0 \\
\frac{\partial \pi_m^{*M}}{\partial \rho} &= -\frac{\left(\beta k - \gamma^2\right)\left[\rho\gamma^2 + \alpha k - \beta k\left(c+\rho\right)\right]}{2\beta k^2} < 0; \\
\frac{\partial \pi_m^{*E}}{\partial \rho} &= -\frac{\left(2\beta k - \gamma^2\right)\left[\rho\gamma^2 + 2\alpha k - 2\beta k\left(c+\rho\right)\right]}{8\beta k^2} < 0
\end{aligned}$$

$$\frac{\partial \pi_m^{*\lambda E}}{\partial \rho} = -\frac{\beta (1-\lambda)^2 \left(2\beta k - \gamma^2\right)\left[\rho\gamma^2 + 2\alpha k - 2\beta k (c+\rho)\right]}{2\left[\lambda\gamma^2 - 2\beta k (1-\lambda)\right]^2} < 0;$$

$$\frac{\partial \pi_m^{*\lambda M}}{\partial \rho} = -\frac{\left[\beta k (1-2\lambda) + \gamma^2 (1-\lambda)\right]\left[\left(\alpha k + \rho\gamma^2\right)(1-\lambda) - \beta k (\rho + c - \lambda c)\right]}{4\beta k^2 (1-\lambda)^2} - \frac{\left[\beta k - \gamma^2 (1-\lambda)\right]}{2\beta k (1-\lambda)}\left[\frac{\alpha k + \rho\gamma^2}{2k} + \frac{\lambda\beta\rho}{2(1-\lambda)} - \frac{\beta (c+\rho)}{2}\right] < 0 \tag{B.1}$$

We can see that Property 2(1) holds.

(2)

$$\pi_e^{*E} - \pi_e^{*M} = \frac{\rho^2\gamma^2}{8k} > 0;$$

$$\pi_e^{*\lambda M} - \pi_e^{*M} = \frac{\lambda\beta\rho^2}{2(1-\lambda)} > 0;$$

$$\pi_e^{*E} - \pi_e^{*\lambda E} = \frac{\lambda^2\gamma^2\left[\rho\gamma^2 + 2\alpha k - 2\beta k (c+\rho)\right]^2}{8k\left[2\beta k (1-\lambda) - \lambda\gamma^2\right]^2} > 0;$$

$$\pi_e^{*\lambda M} - \pi_e^{*\lambda E} = \frac{k\gamma^2\left[\lambda\alpha + \beta\rho - \lambda\beta (c+2\rho)\right]^2}{2\left[2\beta k (1-\lambda) - \lambda\gamma^2\right]^2} + \frac{\rho\left[\alpha (1-\lambda) - \beta (c+\rho) + \lambda\beta (c+2\rho)\right]}{2(1-\lambda)} - \frac{\beta\rho (1-\lambda)\left[\rho\gamma^2 + 2\alpha k - 2\beta k (c+\rho)\right]}{2\left[2\beta k (1-\lambda) - \lambda\gamma^2\right]^2} > 0 \tag{B.2}$$

$$\frac{\partial \pi_e^{*M}}{\partial \rho} = \frac{\alpha - \beta (c+2\rho)}{2} > 0;$$

$$\frac{\partial \pi_e^{*E}}{\partial \rho} = \frac{\rho\gamma^2 + 2\alpha k - 2\beta k (c+2\rho)}{4k} > 0;$$

$$\frac{\partial \pi_e^{*\lambda M}}{\partial \rho} = \frac{\alpha (1-\lambda) - \beta (c+2\rho) + \lambda\beta (c+4\rho)}{2(1-\lambda)} > 0.$$

We can see that Property 2(2) holds.

C. Proof of Property 3

(1)

$$s^{*M} = s^{*\lambda M} = \frac{\rho\gamma}{k}; \tag{C.1}$$

when

$$s^{*\lambda E} - s^{*M} = \frac{\gamma\left[\lambda\alpha k + \lambda\rho\gamma^2 - \beta k (\lambda c + \rho)\right]}{k\left[2\beta k (1-\lambda) - \lambda\gamma^2\right]} = 0,$$

$$\lambda_1 = \frac{\beta k\rho}{\alpha k + \rho\gamma^2 - \beta c k}. \tag{C.2}$$

(2)

$$\frac{\partial s^{*\lambda E}}{\partial \lambda} = \frac{\beta\gamma\left[\rho\gamma^2 + 2\alpha k - 2\beta k (c+\rho)\right]}{\left[2\beta k (1-\lambda) - \lambda\gamma^2\right]^2} > 0; \tag{C.3}$$

(3)

$$\frac{\partial p^{*\lambda M}}{\partial \lambda} = -\frac{\rho}{2(1-\lambda)^2} < 0;$$

$$\frac{\partial p^{*\lambda E}}{\partial \lambda} = \frac{\gamma^2\left[2\alpha k + \rho\gamma^2 - 2\beta k (c+\rho)\right]}{2\left[2\beta k (1-\lambda) - \lambda\gamma^2\right]^2} > 0. \tag{C.4}$$

We can see that Property 3 holds.

D. Proof of Property 4

Property 4 (1) and (3)'s proofs are the same as Proof 2 (1) and (2).

(1)

$$\frac{\partial \pi_m^{*\lambda M}}{\partial \lambda} = -\frac{\lambda\beta\rho^2}{2(1-\lambda)^3} < 0;$$

$$\frac{\partial \pi_m^{*\lambda E}}{\partial \lambda} = \frac{\beta\gamma^2 (1-\lambda)\left[\rho\gamma^2 + 2\alpha k - 2\beta k (c+\rho)\right]^2}{2\left[2\beta k (1-\lambda) - \lambda\gamma^2\right]^3} > 0; \tag{D.1}$$

(2)

$$\frac{\partial \pi_e^{*\lambda M}}{\partial \lambda} = \frac{\beta\rho^2}{2(1-\lambda)^2} > 0;$$

$$\frac{\partial \pi_e^{*\lambda E}}{\partial \lambda} = -\frac{\lambda\beta\gamma^2\left[\rho\gamma^2 + 2\alpha k - 2\beta k (c+\rho)\right]^2}{2\left[2\beta k (1-\lambda) - \lambda\gamma^2\right]^3} < 0 \tag{D.2}$$

We can see that Property 4 holds.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare no conflicts of interest.

Disclosure

The founding sponsors had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript; and in the decision to publish the results.

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