

Strategic Interactions Between Manufacturers' Blockchain Traceability Services and Platforms' Demand Information Sharing

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Article

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Abstract: This paper systematically investigates the strategic interaction between e-commerce platforms' demand information sharing strategies and manufacturers' adoption of blockchain traceability services under resale and agency models. By developing a multi-stage dynamic game model, we derive equilibrium outcomes under various market conditions and reveal several key insights. First, manufacturers exhibit an inherent incentive to adopt blockchain traceability services. Second, the platform's optimal information strategy depends on the sell mode, concealing demand information under the resale model but sharing it under the agency model. The analysis further uncovers significant free-riding behavior in the platform's decision-making process. Furthermore, two Pareto-optimal regions are identified, where both the platform and the manufacturer can achieve a win-win outcome. These findings offer new theoretical perspectives and practical implications for supply chain coordination in the digital economy era.

Keywords: blockchain technology; resale model; agency model; traceability service; information sharing

1 Introduction

The outbreak of the COVID-19 pandemic in 2019 served as a critical catalyst for the accelerated growth of global e-commerce, significantly advancing the digital transformation of traditional brick-and-mortar enterprises. Online platforms have since become central to corporate channel strategies. According to statistical data, China's online retail sales reached 14.2 trillion yuan in 2024, with physical goods accounting for 11.3 trillion yuan, equivalent to 24.5% of total retail sales of consumer goods. The continued expansion of online consumption has driven the diversification of e-commerce business models. Currently, the prevailing operational models of online platforms can be categorized into two primary types: reselling and agency. Under the reselling model, platforms purchase products from manufacturers at wholesale prices, assume ownership of the inventory, and retain full authority over retail pricing, thereby bearing inventory risk. In the agency model, manufacturers retain control over final pricing and leverage the platform to reach consumers, sharing revenue with the platform according to a predetermined percentage. These two models differ markedly in risk allocation, revenue structure, and operational decision-making. As such, they offer manufacturers at various developmental stages differentiated channel cooperation options and have emerged as a critical focus in research on e-commerce platform operations.

The uncertainty inherent in online retail demand stems from competitive interactions among platform sellers, the dynamic evolution of consumer behavior, and the growing

diversification of product demand. These factors collectively pose a fundamental challenge to channel collaboration between e-commerce platforms and manufacturers. In response to the operational risks arising from such uncertainty, leading platforms have invested substantially in information technologies to develop intelligent demand forecasting systems. Among these, big data analytics and user behavior mining have become critical tools for enhancing market responsiveness and optimizing operational decision-making. Industry practices, as exemplified by Amazon and JD.com, reveal that e-commerce platforms, by virtue of their strategic position as channel hubs, have accumulated vast amounts of transaction and user behavior data. This endows them with a more comprehensive understanding of market demand compared to manufacturers. Notably, platforms' information sharing strategies exhibit a strong correlation with their choice of business model. For instance, under its Seller Central (agency) model, Amazon shares demand information with manufacturers, whereas under its Vendor Central (reselling) model, it tends to retain such information. These observations suggest that differences in pricing authority and revenue-sharing mechanisms are key drivers shaping platforms' information-sharing decisions. Under demand uncertainty, the interplay between these factors becomes increasingly complex. Despite the practical significance of this issue, existing research has yet to systematically examine the mechanisms underlying demand information sharing on e-commerce platforms under different business models. Addressing this gap is essential not only for understanding how information resources are allocated in the platform economy but also for providing theoretical insights that can enhance the collaborative

efficiency of supply chains. Therefore, it has significant research potential.

The innovation and application of digital technologies serve as a core driver for optimizing operations within e-commerce platforms and supply chains. The implementation of advanced technologies, such as big data and artificial intelligence, has simultaneously enhanced platform service experiences and operational efficiency. Within this landscape, blockchain technology, characterized by its immutable and distributed ledger, demonstrates unique application value in supply chain management. Its capacity to optimize product traceability systems and mitigate counterfeiting issues has emerged as a critical direction for the digital transformation of supply chains. In practice, a growing number of manufacturers are actively embracing this technology. For instance, Nestlé, a global food industry giant, announced its participation in the IBM Food Trust blockchain program in April 2020 and pioneered the technology's application in its premium coffee brand, Zoegas. Through this initiative, consumers can now accurately trace product origin information—from the planting and harvesting of coffee beans to processing, transportation, and beyond—all meticulously recorded on the blockchain, ensuring end-to-end supply chain transparency. By enabling the traceability and verification of product lifecycle data, blockchain technology effectively enhances information transparency and fosters trust among supply chain participants, thereby strengthening brand competitiveness in the market. However, existing studies predominantly focus on the application outcomes of blockchain technology within supply chains, and few systematically explore it in combination with the demand information sharing strategies of e-commerce platforms under different sales models.

In summary, the demand information sharing strategies of e-commerce platforms and manufacturers' investment decisions in blockchain traceability technology under both reselling and agency selling models represent a research gap. Against this backdrop, this paper investigates the channel collaboration between e-commerce platforms and manufacturers. It aims to explore platforms' demand information sharing strategies under different business models, as well as manufacturers' corresponding blockchain technology investment decisions. The findings are intended to provide theoretical references and practical insights for optimizing channel collaboration between e-commerce platforms and manufacturers and for advancing the digital transformation of supply chains.

2 literature review

This article covers three aspects: traceability services, sharing of demand information, and sales models.

2.1 Blockchain traceability service

Blockchain-based traceability systems can effectively mitigate the issue of information tampering, thereby addressing the credibility challenges inherent in centralized traceability systems. This study primarily examines blockchain-enabled commodity traceability services. During purchasing decisions, consumers frequently exhibit skepticism regarding product authenticity. To enhance consumer trust, supply chain stakeholders, particularly manufacturers or platform operators, are increasingly adopting blockchain technology for traceability services. The immutable and

decentralized nature of blockchain technology significantly improves product reliability and supply chain transparency. Currently, a growing number of enterprises and platforms are implementing blockchain solutions for comprehensive traceability management across their product lines. Sun et al. (2023) examined blockchain adoption strategies for fresh agricultural enterprises operating in competitive markets. Their findings indicate that consumer preferences for traceability, along with key blockchain adoption factors, influence the strategic implementation of blockchain technology within a defined threshold. Yao et al. (2024) investigated the application of blockchain technology by manufacturers under resale and agency models. Their research elucidates the motivations behind manufacturers' adoption of blockchain and demonstrates how its implementation enhances supply chain transparency and traceability. Furthermore, the study reveals that leveraging blockchain technology can provide manufacturers with a competitive advantage in the marketplace. Li et al. (2024) explored the strategic game between manufacturers and retailers from the perspective of manufacturers introducing blockchain under the risk of information leakage. Liang et al. (2023) analyzed the profit comparison between traditional manufacturers and online retailers and supply chains under different sales models from the perspective of consumer behavior and with or without the adoption of blockchain technology. Pun et al. (2021) analyzed a market comprising a manufacturer and a counterfeiter, demonstrating that blockchain technology can be strategically employed by the manufacturer to verify product authenticity. Their findings suggest that blockchain adoption becomes particularly advantageous when counterfeit products exhibit intermediate quality levels, or

consumer distrust toward market products reaches a moderate threshold. Under these conditions, implementing blockchain technology serves as an effective mechanism for manufacturers to safeguard their economic interests.

2.2 Demand information sharing

The development of e-commerce has brought about new sales models and information sharing mechanisms, but it also faces challenges brought by the uncertainty of demand. How to select the optimal sales model and effectively share information in an uncertain demand environment has become an urgent problem that e-commerce enterprises need to solve. Yang et al. (2021) considered a supply chain composed of a manufacturer and a retailer, and studied the demand sharing strategies of retail e-commerce platform under the resale model or agency model. They pointed out that the after-sales service efficiency of upstream manufacturers has a relatively significant impact on the information sharing strategies of retail e-commerce platform, and that information sharing is not always beneficial to retail e-commerce platform. Ha et al. (2022) considered three factors: supplier encroachment, information sharing, and channel structure, and explored their interaction and influence in online retail platforms. The research finds that supplier encroachment and information sharing have a significant impact on the channel structure, and a reasonable channel structure in turn affects information sharing. Liu et al. (2021) examined a two-tier supply chain comprising a supplier responsible for preservation services and an online retailer providing value-added services. Their findings suggest that information sharing

cooperation is more likely to emerge under two conditions: when the supplier's freshness preservation investments demonstrate greater cost-effectiveness, or when the retailer's service investments achieve higher operational efficiency. Li et al. (2008) incorporated the dimension of confidentiality into the analysis and demonstrated its potential to incentivize retailers to share information. Liu et al. (2021) further extended this line of research by investigating platform strategies under different business models. Their analysis compared the resale model with the agency model, particularly focusing on the platform's introduction of service providers. The study revealed distinct information sharing patterns: under the agency model, platforms consistently share demand information with service providers, whereas in the resale model, such information sharing becomes contingent on the specific commission ratio arrangement. Lee et al. (2008) he considered the impact of technological advancements in information systems on supply chain management, discussed the influence of information sharing on supply chain performance, and emphasize the importance of information sharing in an environment of demand uncertainty.

2.3 sales models

The development of e-commerce has not only created new opportunities but also given rise to innovative sales models. Supply chain members make different decisions under different sales models. Abhishek et al. (2016) studied a supply chain comprising one manufacturer and two retail e-commerce platforms, investigating the strategic selection between resale and agency contracts. When the demand from online channels

has a negative impact on traditional channels, retail e-commerce platforms will choose agency contracts. Otherwise, retail e-commerce platforms rationally opt for resell contracts. Tian et al. (2018) conducted a study on a supply chain composed of two suppliers and one retailer, demonstrating the choice issues faced by retail e-commerce platforms when reselling, acting as an agent, or using both types of contracts simultaneously. Zhang et al. (2020) studied the demand information sharing strategies of retailers when suppliers seek offline expansion, as well as the differences in information sharing strategies and sales models of retailers under different offline entry costs and channel substitution rates. Hou et al. (2021) studied how the product quality differences between two manufacturers affect the optimal sales model of the platform. Li et al. (2025) conducted a comparative analysis of two types of services, namely third-party logistics services and platform logistics services, on the selection of resale models and agency models. The results indicated that platform services were beneficial to both the platform and the suppliers.

However, existing literature predominantly focuses on the impact of platforms' service efforts on their information sharing strategies, with relatively limited attention paid to manufacturers' service efforts, such as blockchain-based traceability services. In response to this gap, this paper proposes a novel analytical framework to investigate the multi-stage dynamic game between platforms' demand information sharing strategies and manufacturers' traceability service investment strategies. Specifically, this study seeks to address the following key questions: Do platforms' optimal information sharing strategies vary significantly across different sales models? How do

the optimal strategy portfolios for manufacturers and platforms change when manufacturers provide traceability service efforts, compared to scenarios where such services are absent? Under what conditions does the strategic interaction benefit only one party? Is there a combination of strategies that yields mutual benefits for both the platform and the manufacturer, that is, does a Pareto optimal region exist? By developing this multi-dimensional analytical framework, this study aims to provide both theoretical insights and practical implications for information sharing decisions in the platform economy.

The rest of this paper is organized as follows. Section 2 provides a literature review. Section 3 presents problem description and parameter assumptions. Section 4 presents model construction and solution, and obtains the equilibrium strategy. Section 5 presents comparative analysis of demand information sharing strategies. Section 6 employs numerical analysis to validate our theoretical findings. Finally, Section 7 concludes the paper with a summary of key insights. All proofs of the main paper are given in the Appendix.

3 Problem description and parameter assumptions

3.1 market demand

This paper considers the platform supply chain composed of a manufacturer (M) and an online platform (P, referred to as the "platform"), mainly analyzing whether the platform provides an information sharing strategy and whether the manufacturer provides a traceability service strategy under the resale model and the agency model,

and exploring the multi-stage dynamic game strategy between the platform and the manufacturer. Based on the existing actual situation and literature, this paper assumes that the manufacturer is the leader of the supply chain. Let the demand function be the following linear function:

$$q = \hat{\alpha} - p + \beta\tau \quad (1)$$

where $\hat{\alpha}$ is a random variable, and $\hat{\alpha} = \alpha + \theta$, θ represents the uncertainty of demand, following a normal distribution, with a mean of zero and a variance of σ_θ^2 . p is the retail, in order to facilitate analysis, elasticity coefficient of the retail price is assumed to 1. τ is the traceability service level of the manufacturer. $\beta(0 \leq \beta \leq 1)$ is the sensitivity coefficient of consumers to the traceability services provided by manufacturers. The cost of the traceability service provided by the manufacturer is $C(\tau) = \frac{1}{2}k\tau^2$, where k is the efficiency of the traceability service, A higher k indicates a lower efficiency of traceability services. without loss of generality, it is assumed that the commission rate is an exogenous variable. Assume the manufacturer and the platform are risk-neutral and aim to maximize their respective profits.

3.2 information structure

Due to its closer proximity to consumers and the use of modern advanced technologies for demand information prediction, the platform can more accurately forecast demand fluctuations. In this paper, the predicted demand fluctuation information is denoted as $\Gamma = \theta + \varepsilon$, where the demand prediction error ε follows a normal distribution with mean zero and variance σ_ε^2 . A larger variance indicates

greater errors in the platform's prediction of demand fluctuations. Assume that θ and ε are mutually independent.

Referring to (Ha et al.,2022) and (Shang et al.,2016), the platform can obtain the predicted demand fluctuation information using information

technology: $E[\theta|\Gamma] = \frac{\sigma_\theta^2}{\sigma_\theta^2 + \sigma_\varepsilon^2} \Gamma = \delta \Gamma$, $Var[\theta|\Gamma] = \frac{\sigma_\theta^2 \sigma_\varepsilon^2}{\sigma_\theta^2 + \sigma_\varepsilon^2}$. In the context of new retail,

the platform integrates cloud computing, big data analysis, and artificial intelligence to significantly enhance the accuracy of market demand predictions. Researches show that these technologies can not only capture real-time consumer behavior data but also identify potential market trends through deep learning algorithms. Consequently, it is evident that $Var[\theta|\Gamma] < \sigma_\theta^2$, indicating that the obtained demand information improves

the precision of predicting market potential. Define $\delta = \frac{\sigma_\theta^2}{\sigma_\theta^2 + \sigma_\varepsilon^2}$ as the precision of

the information. The larger $\delta(0 \leq \delta \leq 1)$, the more accurate the platform's demand prediction; $\delta = 1$ indicates that the platform's demand prediction is entirely accurate.

The main parameters and variables involved in this paper are shown in Table 1.

Table1 Main parameters and variables.

parameters	definition
and variables	
parameters	
i	Superscript, $i = R, A$, represent resale mode and agency mode, respectively

j	Superscript, the platform's demand information sharing strategy indicators, represent to share or not to share demand information, respectively
T	Subscript, the manufacturer provides traceability services
D	subscript, the manufacturer does not provide traceability services
M, P	subscript, the manufacturer and platform, respectively
d_T^{ij}, d_D^{ij}	the demand under mode i , strategy j
$\pi_{MT}^{ij}, \pi_{PT}^{ij}, \pi_T^{ij}$	profits of manufacturers, platforms and supply chains under mode i , strategy j when traceability services are available
$\pi_{MD}^{ij}, \pi_{PD}^{ij}, \pi_D^{ij}$	profits of manufacturers, platforms and supply chains under mode i , strategy j when there is no traceability service
variables	
w_T^{ij}, w_D^{ij}	the wholesale price under mode i , strategy j
p_T^{ij}, p_D^{ij}	the retail price under mode i , strategy j
τ^{ij}	the traceability service level under mode i , strategy j

3.3 sequence of events

The problem in this article can be described as a multi-stage game model, as shown in Figure 1. The main sequence of events is:

Strategy decision-making stage

Step 1 (S1): The platform decides to choose the resale model or the agency model;

Step 2 (S2): The platform decides whether to share the demand information with the

manufacturer before observing it. If the platform promises to share information, take the initiative to share it with the manufacturer; otherwise, do not share it. Simultaneously, the manufacturer decides whether to provide traceability service.

Price and investment level decision-making stage

Step 3 (S3): Under the resale model, the manufacturer determines the investment level τ of the traceability service and the wholesale price w ; under the agency model, the manufacturer determines the investment level τ of traceability services.

Step 4 (S4): Under the resale model, the platform determines the retail price p_p ; under the agency model, the manufacturer determines the retail price p_M .

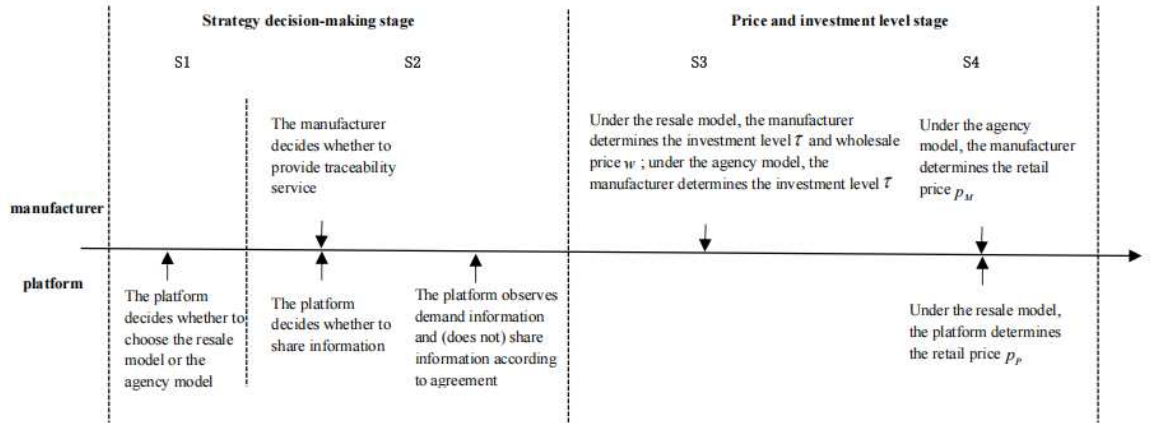


Figure 1 The Game Sequence of Events Between the Platform and the Manufacturer

4 Model construction and solution

4.1 Platform information sharing strategy based on resale model

Next, under the resale model and the agency model respectively, the strategy combination issues of the platform (sharing and not sharing demand information) and the manufacturer (providing and not providing traceability services) will be explored,

and the balanced results of different strategy combinations will be obtained.

4.1.1 The platform does not share demand information (RN)

The platform chooses not to share demand information under the resale model, which is the strategy RN , while the manufacturer chooses to provide traceability services, which is the strategy T . Therefore, if the strategy combination of the platform and the manufacturer is (RN, T) , then the expected profits of the manufacturer and the platform are:

$$E[\pi_{MT}^{RN}] = E\left[w_T^{RN} q_T^{RN} - \frac{k}{2} (\tau^{RN})^2\right] \quad (2)$$

$$E[\pi_{PT}^{RN} | \Gamma] = E\left[\left((p_T^{RN} - w_T^{RN}) q_T^{RN}\right) | \Gamma\right] \quad (3)$$

If the platform chooses not to share demand information under the resale model, that is, the strategy RN , and the manufacturer chooses not to provide traceability services, that is, the strategy D , then the demand function is $q_D = \alpha - p_D$. Therefore, if the strategy combination of the platform and the manufacturer is (RN, D) , then the expected profits of the manufacturer and the platform are:

$$E[\pi_{MD}^{RN}] = E[w_D^{RN} q_D^{RN}] \quad (4)$$

$$E[\pi_{PD}^{RN} | \Gamma] = E\left[\left((p_D^{RN} - w_D^{RN}) q_D^{RN}\right) | \Gamma\right] \quad (5)$$

The equilibrium solutions for the manufacturer and the platform are derived through backward induction, as shown in Lemma 1.

Lemma 1 (1) Under the resale model, the strategy combination of the platform and the manufacturer is (RN, T) , and the equilibrium result is:

$$w_T^{RN} = \frac{4\alpha k}{8k - \beta^2}, \quad \tau^{RN} = \frac{\alpha\beta}{8k - \beta^2}, \quad p_T^{RN} = \frac{6\alpha k}{8k - \beta^2} + \frac{1}{2}\partial\Gamma, \quad d_T^{RN} = \frac{2\alpha k}{8k - \beta^2} + \frac{1}{2}\partial\Gamma,$$

$$E[\pi_{MT}^{RN}] = \frac{\alpha^2 k}{8k - \beta^2}, \quad E[\pi_{PT}^{RN}] = \frac{4\alpha^2 k^2}{(8k - \beta^2)^2} + \frac{1}{4}f.$$

Where $f = \frac{\sigma_\theta^4}{\sigma_\theta^2 + \sigma_\varepsilon^2} = \frac{\sigma_\theta^2}{\sigma_\theta^2 + \sigma_\varepsilon^2} \sigma_\theta^2 = \delta \sigma_\theta^2$, all the expressions containing f in the

subsequent text have such a relationship. According to the law of iterated expectation

$$E[\pi_{MT}^{RN}] = E[E[\pi_{MT}^{RN} | \Gamma]].$$

(2) Under the resale model, the strategy combination of the platform and the manufacturer is (RN, D) , and the equilibrium result is:

$$w_D^{RN} = \frac{\alpha}{2}, \quad p_D^{RN} = \frac{3\alpha}{4} + \frac{1}{2}\partial\Gamma, \quad d_D^{RN} = \frac{\alpha}{4} + \frac{1}{2}\partial\Gamma,$$

$$E[\pi_{MD}^{RN}] = \frac{\alpha^2}{8}, \quad E[\pi_{PD}^{RN}] = \frac{\alpha^2}{16} + \frac{1}{4}f.$$

To ensure that the equilibrium result is positive, it should be satisfied $k > k_1$, where $k_1 = \beta^2 / 8$, k represents the traceability efficiency of the manufacturer's blockchain traceability service. Smaller k indicates a higher efficiency of traceability services.

4.1.2 The platform shares demand information (RS)

The platform chooses to share demand information under the resale model, which is the strategy RS , while the manufacturer chooses to provide traceability services, which is the strategy T . Therefore, if the strategy combination of the platform and the manufacturer is (RS, T) , then the expected profits of the manufacturer and the platform are:

$$E[\pi_{PT}^{RS} | \Gamma] = E\left[\left((p_T^{RS} - w_T^{RS})q_T^{RS}\right) | \Gamma\right] \quad (6)$$

$$E[\pi_{MT}^{RS} | \Gamma] = E\left[\left(w_T^{RS} q_T^{RS} - \frac{k}{2} (\tau^{RS})^2\right) | \Gamma\right] \quad (7)$$

If the platform chooses to share demand information under the resale model, that is, the strategy RS , and the manufacturer chooses not to provide traceability services, that is, the strategy D , then the demand function is $q_D = \alpha - p_D$. Therefore, if the strategy combination of the platform and the manufacturer is (RS, D) , then the expected profits of the manufacturer and the platform are:

$$E[\pi_{PD}^{RS} | \Gamma] = E\left[\left(p_D^{RS} - w_D^{RS}\right) q_D^{RS} | \Gamma\right] \quad (8)$$

$$E[\pi_{MD}^{RS} | \Gamma] = E\left[w_D^{RS} q_D^{RS} | \Gamma\right] \quad (9)$$

The equilibrium solutions for the manufacturer and the platform are derived through backward induction, as shown in Lemma 2.

Lemma 2 (1) Under the resale model, the strategy combination of the platform and the manufacturer is (RS, T) , and the equilibrium result is:

$$w_T^{RS} = \frac{4k\alpha}{8k - \beta^2} + \frac{4k}{8k - \beta^2} \delta\Gamma, \quad \tau^{RS} = \frac{\alpha\beta}{8k - \beta^2} + \frac{\beta}{8k - \beta^2} \delta\Gamma, \quad p_T^{RS} = \frac{6k\alpha}{8k - \beta^2} + \frac{6k}{8k - \beta^2} \delta\Gamma,$$

$$d_T^{RS} = \frac{2k\alpha}{8k - \beta^2} + \frac{2k}{8k - \beta^2} \delta\Gamma, \quad E[\pi_{MT}^{RS}] = \frac{k\alpha^2}{8k - \beta^2} + \frac{kf}{8k - \beta^2}, \quad E[\pi_{PT}^{RS}] = \frac{4\alpha^2 k^2}{(8k - \beta^2)^2} + \frac{4k^2 f}{(8k - \beta^2)^2}.$$

(2) Under the resale model, the strategy combination of the platform and the manufacturer is (RS, D) , and the equilibrium result is:

$$w_D^{RS} = \frac{\alpha}{2} + \frac{1}{2} \delta\Gamma, \quad p_D^{RS} = \frac{3\alpha}{4} + \frac{3}{4} \delta\Gamma, \quad d_D^{RS} = \frac{\alpha}{4} + \frac{1}{4} \delta\Gamma,$$

$$E[\pi_{MD}^{RS}] = \frac{\alpha^2}{8} + \frac{1}{8} f, \quad E[\pi_{PD}^{RS}] = \frac{\alpha^2}{16} + \frac{1}{16} f.$$

It can be concluded from Lemma 1 and Lemma 2 that, under the resale model, regardless of whether the manufacturer provides traceability services or not, the

platform tends not to share demand information with the manufacturer. This reflects the platform's cautious attitude towards information control under the resale model, aiming to maximize its own interests and reduce operational risks.

4.2 Platform information sharing strategy based on agency mode

4.2.1 The platform does not share demand information (AN)

The platform chooses not to share demand information under the agency model, which is the strategy AN , while the manufacturer chooses to provide traceability services, which is the strategy T . Therefore, if the strategy combination of the platform and the manufacturer is (AN, T) , then the expected profits of the manufacturer and the platform are:

$$E[\pi_{MT}^{AN}] = E\left[(1-\gamma)p_{PT}^{AN}q_{PT}^{AN} - \frac{k}{2}(\tau^{AN})^2\right] \quad (10)$$

$$E[\pi_{PT}^{AN} | \Gamma] = E\left[(\gamma p_{PT}^{AN} q_{PT}^{AN}) | \Gamma\right] \quad (11)$$

If the platform chooses not to share demand information under the agency model, that is, the strategy AN , and the manufacturer chooses not to provide traceability services, that is, the strategy D , then the demand function is $q_D = \alpha - p_D$. Therefore, if the strategy combination of the platform and the manufacturer is (AN, D) , then the expected profits of the manufacturer and the platform are:

$$E[\pi_{MD}^{AN}] = E\left[(1-\gamma)p_{MD}^{AN}q_{MD}^{AN}\right] \quad (12)$$

$$E[\pi_{PD}^{AN} | \Gamma] = E\left[(\gamma p_{PD}^{AN} q_{PD}^{AN}) | \Gamma\right] \quad (13)$$

The equilibrium solutions for the manufacturer and the platform are derived through backward induction, as shown in Lemma 3.

Lemma 3 (1) Under the agency model, the strategy combination of the platform and the manufacturer is (AN, T) , and the equilibrium result is:

$$p_T^{AN} = \frac{2\alpha k}{4k - (1-\gamma)\beta^2}, \quad \tau^{AN} = \frac{\alpha\beta(1-\gamma)}{4k - (1-\gamma)\beta^2}, \quad d_T^{AN} = \frac{2\alpha k}{4k - (1-\gamma)\beta^2} + \delta\Gamma,$$

$$E[\pi_{MT}^{AN}] = \frac{\alpha^2 k(1-\gamma)}{4k - (1-\gamma)\beta^2}, \quad E[\pi_{PT}^{AN}] = \frac{4\gamma k^2 \alpha^2}{(4k - (1-\gamma)\beta^2)^2}.$$

(2) Under the agency model, the strategy combination of the platform and the manufacturer is (AN, D) , and the equilibrium result is:

$$p_D^{AN} = \frac{\alpha}{2}, \quad d_D^{AN} = \frac{\alpha}{2} + \delta\Gamma, \quad E[\pi_{MD}^{AN}] = \frac{\alpha^2(1-\gamma)}{4}, \quad E[\pi_{PD}^{AN}] = \frac{\alpha^2\gamma}{4}.$$

To ensure that the equilibrium result is positive, it should be satisfied $k > k_2$, where $k_2 = (1-\gamma)\beta^2 / 4$.

4.2.2 The platform shares demand information (AS)

The platform chooses to share demand information under the agency model, which is the strategy AS , while the manufacturer chooses to provide traceability services, which is the strategy T . Therefore, if the strategy combination of the platform and the manufacturer is (AS, T) , then the expected profits of the manufacturer and the platform are:

$$E[\pi_{MT}^{AS} | \Gamma] = E\left[\left((1-\gamma)p_{PT}^{AS}q_{PT}^{AS} - \frac{k}{2}(\tau^{AS})^2\right) | \Gamma\right] \quad (14)$$

$$E[\pi_{PT}^{AS} | \Gamma] = E\left[\left(\gamma p_{PT}^{AS}q_{PT}^{AS}\right) | \Gamma\right] \quad (15)$$

If the platform chooses to share demand information under the agency model, that is, the strategy AS , and the manufacturer chooses not to provide traceability services, that is, the strategy D , then the demand function is $q_D = \alpha - p_D$. Therefore, if the strategy

combination of the platform and the manufacturer is (AS, D) , then the expected profits of the manufacturer and the platform are:

$$E[\pi_{MD}^{AS} | \Gamma] = E[(1-\gamma)p_{MD}^{AS}q_{MD}^{AS} | \Gamma] \quad (16)$$

$$E[\pi_{PD}^{AS} | \Gamma] = E[\gamma p_{PD}^{AS}q_{PD}^{AS} | \Gamma] \quad (17)$$

The equilibrium solutions for the manufacturer and the platform are derived through backward induction, as shown in Lemma 4.

Lemma 4 (1) Under the agency model, the strategy combination of the platform and the manufacturer is (AS, T) , and the equilibrium result is:

$$\begin{aligned} p_T^{AS} &= \frac{2k\alpha}{4k-(1-\gamma)\beta^2} + \frac{2k}{4k-(1-\gamma)\beta^2} \delta\Gamma, \quad \tau^{AS} = \frac{(1-\gamma)\alpha\beta}{4k-(1-\gamma)\beta^2} + \frac{(1-\gamma)\beta}{4k-(1-\gamma)\beta^2} \delta\Gamma, \\ d_T^{AS} &= \frac{2k\alpha}{4k-(1-\gamma)\beta^2} + \frac{2k}{4k-(1-\gamma)\beta^2} \delta\Gamma, \quad E[\pi_{MT}^{AS}] = \frac{k\alpha^2(1-\gamma)}{4k-(1-\gamma)\beta^2} + \frac{k(1-\gamma)f}{4k-(1-\gamma)\beta^2}, \\ E[\pi_{PT}^{AS}] &= \frac{4\gamma k^2 \alpha^2}{(4k-(1-\gamma)\beta^2)^2} + \frac{4\gamma k^2 f}{(4k-(1-\gamma)\beta^2)^2}. \end{aligned}$$

(2) Under the agency model, the strategy combination of the platform and the manufacturer is (AS, D) , and the equilibrium result is:

$$\begin{aligned} p_D^{AS} &= \frac{\alpha}{2} + \frac{1}{2} \delta\Gamma, \quad d_D^{AS} = \frac{\alpha}{2} + \frac{1}{2} \delta\Gamma, \\ E[\pi_{MD}^{AS}] &= \frac{\alpha^2(1-\gamma)}{4} + \frac{(1-\gamma)f}{4}, \quad E[\pi_{PD}^{AS}] = \frac{\gamma\alpha^2}{4} + \frac{\gamma f}{4}. \end{aligned}$$

$E[\pi_{MT}^{AS}] > E[\pi_{MT}^{AN}]$ and $E[\pi_{PT}^{AS}] > E[\pi_{PT}^{AN}]$, The optimal strategy combination of the platform and the manufacturer is (AS, T) , That is, under the agency model, the platform tends to share demand information while manufacturers provide traceability services. $E[\pi_{MD}^{AS}] > E[\pi_{MD}^{AN}]$ and $E[\pi_{PD}^{AS}] > E[\pi_{PD}^{AN}]$, shows that the optimal strategy combination of the platform and the manufacturer is (AS, D) , That is, under the

agency model, the platform tends to share demand information with manufacturers, while manufacturers do not provide traceability services.

In conclusion, under the resale model, the platform tends not to share demand information with the manufacturer. Under the agency model, the platform tends to share information with the manufacturer, and whether the manufacturer provides traceability services does not affect the platform's strategic decisions.

Next, under the resale model and agency model, taking the equilibrium results of each member where the manufacturer does not provide traceability services as the benchmark, analyze the impact of the manufacturer providing traceability services on the equilibrium results of each member with different demand information sharing strategies, and obtain Proposition 1.

Proposition 1 Under the resale model and agency model, the impact of the manufacturer's provision of traceability services on the equilibrium outcome is as follows:

(1) Under the resale model, the relationships among the equilibrium wholesale price, retail price and demand are respectively:

$$w_T^{RN} > w_D^{RN}, p_T^{RN} > p_D^{RN}, d_T^{RN} > d_D^{RN};$$

$$w_T^{RS} > w_D^{RS}, p_T^{RS} > p_D^{RS}, d_T^{RS} > d_D^{RS};$$

(2) Under the agency model, the relationships among the equilibrium wholesale price, retail price and demand are respectively:

$$p_T^{AN} > p_D^{AN}, d_T^{AN} > d_D^{AN}; p_T^{AS} > p_D^{AS}, d_T^{AS} > d_D^{AS};$$

Proposition 1 explain the influence of traceability services provided by the

manufacturer on the equilibrium outcomes for supply chain members under various models. Under the resale model, regardless of whether the platform shares demand information, the manufacturer's optimal strategy is to provide traceability services. This leads to an increase in wholesale prices, retail prices, and market demand. For the manufacturer, traceability services boost consumer confidence in the product, thereby expanding market demand. Meanwhile, since the manufacturer independently bears the cost of traceability, they raise wholesale prices to offset these expenses and enhance profitability. For the platform, the traceability function adds differentiated value to the products and stimulates the growth of consumer demand. Consequently, the platform will accordingly increase the retail price. Although higher retail prices may slightly dampen demand, the increased demand driven by traceability services more than compensates for this effect. Therefore, the rise in both retail prices and demand benefits the platform as well.

Under the agency model, regardless of whether the platform decides to share demand information, the manufacturer's optimal strategy remains providing traceability services. This results in an increase in retail prices and market demand. For the manufacturer, providing traceability services increases product demand while also imposing additional costs on the manufacturer. To cover these costs and boost profits, the manufacturer raises retail prices. For the platform, with the added traceability feature, the product becomes more appealing to consumers, leading to increased demand. Its retail price will also increase accordingly. While higher retail prices might have a slight negative impact on demand, the significant demand growth spurred by

traceability services outweighs this effect. Ultimately, the concurrent increase in retail prices and demand generates positive returns for the platform.

The above analysis illustrates the impact of the manufacturer's provision of traceability services on the equilibrium outcome. However, considering that the manufacturer needs to bear certain costs when providing traceability services, the following is an analysis of the conditions required for the manufacturer to offer traceability services.

Proposition 2: Under the resale model and the agency model, the conditions for manufacturers to provide traceability services are as follows:

(1) Under the resale model, when $0 < k \leq k_1$, the manufacturer does not provide traceability services; when $k > k_1$, the manufacturer provides traceability services.

(2) Under the agency model, when $0 < k \leq k_2$, the manufacturer does not provide traceability services; when $k > k_2$, the manufacturer provides traceability services.

where $k_1 = \beta^2/8$, $k_2 = (1-\gamma)\beta^2/4$.

Proposition 2 reveals the cost-benefit trade-off mechanism for the manufacturer in their traceability service decisions. When traceability efficiency is too low (i.e., k exceeds the threshold value), the implementation cost surpasses the incremental revenue, leading the manufacturer to abandon providing traceability services. Conversely, when traceability efficiency is sufficiently high (i.e., k is below the threshold value), the product premium brought about by traceability (manifested as an increase in wholesale prices in the resale model and an increase in retail prices in the agency model) and the effect of demand expansion are sufficient to cover the additional

costs. At this point, providing traceability services becomes a dominant strategy for the manufacturer. In this scenario, providing traceability services becomes the dominant strategy for the manufacturer. Further analysis indicates that under the agency model, as k increases (indicating a decrease in efficiency), the manufacturer will simultaneously reduce the retail price and the traceability level. However, the sensitivity of the traceability level to cost changes is significantly higher than that of the retail price. This implies that the manufacturer primarily alleviates cost pressures by drastically reducing traceability investments rather than lowering prices, thereby maintaining the relative advantage of providing traceability services. This result also indicates that enhancing traceability efficiency does not necessarily lead to direct profit increases. The core of the manufacturer's decision-making lies in balancing traceability cost efficiency with market premium capabilities.

5 Comparative analysis of demand information Sharing strategies

5.1 Comparative analysis of balanced profits

Proposition 3 Under both the resale and agency models, the platform's equilibrium profit is higher when the manufacturer provides traceability services than when it does not, as the platform gains additional revenue from the manufacturer's investment, thereby indicating obvious “free-riding” behavior.

$$\begin{aligned} (1) \quad & E[\pi_{PT}^{RN}] > E[\pi_{PD}^{RN}], \quad E[\pi_{PT}^{RS}] > E[\pi_{PD}^{RS}]; \\ (2) \quad & E[\pi_{PT}^{AN}] > E[\pi_{PD}^{AN}], \quad E[\pi_{PT}^{AS}] > E[\pi_{PD}^{AS}]; \end{aligned}$$

Given the practical context, the provision of traceability services by the manufacturer significantly boosts market demand; therefore, this paper assumes a demand signal $\Gamma > 0$. A comparative analysis of equilibrium outcomes under different strategy combinations reveals that, under the resale model, when the manufacturer bears the cost of providing traceability services, the platform exhibits obvious "free-riding" behavior. Specifically, although the manufacturer raises the wholesale price to partially offset the traceability costs, the service enhances consumer trust in the product, leading to an expansion of market demand. Consequently, the increase in the retail price exceeds the corresponding rise in the wholesale price. Throughout this process, the platform captures additional gains through the retail price premium without incurring any traceability costs. Compared to the scenario where the manufacturer does not offer traceability, the introduction of this service significantly elevates the platform's profit level. Under the agency model, the manufacturer's provision of traceability services also effectively stimulates market demand and drives up retail prices, which directly increases the manufacturer's profit and, via the commission sharing mechanism, leads to a concurrent rise in the platform's revenue.

In conclusion, regardless of whether under the resale model or the agency model, the manufacturer's provision of traceability services contributes to an increase in the platform's profit, thereby demonstrating the platform's pronounced "free-riding" behavior.

Proposition 4 Regardless of whether under the resale model or the agency model, when the manufacturer chooses to provide traceability services, its equilibrium profit is

higher than in the scenario without such services. Specifically:

$$(1) \quad E[\pi_{MT}^{RN}] > E[\pi_{MD}^{RN}], \quad E[\pi_{MT}^{RS}] > E[\pi_{MD}^{RS}];$$

$$(2) \quad E[\pi_{MT}^{AN}] > E[\pi_{MD}^{AN}], \quad E[\pi_{MT}^{AS}] > E[\pi_{MD}^{AS}];$$

Equilibrium analysis indicates that under the resale model, although the manufacturer incurs additional costs by offering traceability services, it can mitigate this cost pressure by increasing the wholesale price, thereby passing part of the cost downstream. At the same time, traceability enhances consumer trust in the product, effectively stimulating market demand. As a result, the manufacturer achieves higher net gains and a significant increase in profits. Under the agency model, traceability services also effectively stimulate consumer demand and promote the increase of the retail prices, thereby contributing to the growth of the manufacturer's profit. Therefore, under both the resale and agency models, the provision of traceability services by the manufacturer contributes to an increase in its profit. Next, we further analyze the strategic interactions between the platform and the manufacturer.

5.2 Strategic game analysis between the platform and the manufacturer

Proposition 5: Under resale and agency models, by comparing the platform's profit under different strategy combinations, we investigate the platform's preferred strategy combination, as shown in Figure 2.

(1) First, consider the case when $0 \leq \gamma \leq 1/4$, the platform's preferred strategy combinations are as follows:

(i) When $0 \leq k \leq k_1$, the platform prefers the strategy combination (RN, D) (see

region R_1 in Figure 2).

(ii) When $k \geq k_1$, the platform prefers the strategy combination (RN, T) (see region R_2 in Figure 2).

(2) when $1/4 \leq \gamma \leq 1/2$, the platform's preferred strategy combinations are as follows:

(i) When $0 \leq k \leq k_1$, $0 < \delta < \min\{\delta_1, 1\}$, the platform prefers the strategy combination (AS, D) (see region R_3 in Figure 2); When $0 \leq k \leq k_1$, $\min\{\delta_1, 1\} < \delta < 1$, the platform prefers the strategy combination (RN, D) (see region R_4 in Figure 2).

(ii) When (a) $k_1 \leq k \leq k_2$, or (b) $k > k_2$ and $\min\{\max\{0, \delta_2\}, 1\} < \delta < 1$, the platform prefers the strategy combination (RN, T) (see region R_5 and R_7 in Figure 2).

(iii) When (a) $k \geq k_1$, and $0 < \delta < \min\{\max\{0, \delta_2\}, 1\}$, the platform prefers the strategy combination (AS, T) (see region R_6 in Figure 2);

where δ_1 and δ_2 can be seen in the proof.

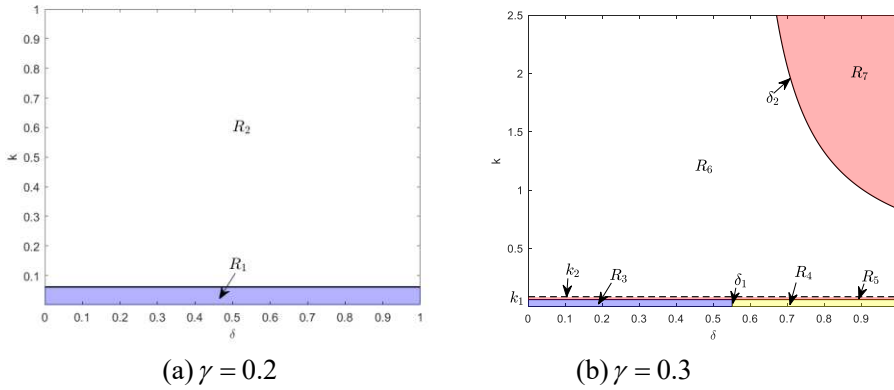


Figure 2 The optimal strategy combination expected by the platform

Note: the parameters in the figure are $\alpha=250$, $\sigma_0=90$, $\beta=0.7$, $\gamma=\{0.2, 0.3\}$.

Based on the analysis presented in Figure 2, the platform's preferred strategy combination is influenced by the commission rate γ , the efficiency of traceability services k , and the accuracy of information δ . From Proposition 5 and Figure 2, we

can draw the following conclusions: First, when $0 < \gamma < 1/4$, the platform's commission rate is relatively low. Specifically, when $0 < k \leq k_1$, the platform prefers the strategy combination (RN, D) (as depicted by R_1 in Figure 2a); whereas when $k > k_1$, the platform favors the strategy combination (RN, T) (as shown by R_2 in Figure 2a). This preference arises because, under the condition $0 < \gamma < 1/4$, the platform's lower commission rate makes it with significant informational advantages and pricing power in a resale model. In detail, the platform retains demand information and leverages its informational advantage for decision-making, thereby achieving higher profits compared to an agency model. Consequently, the platform is more inclined to adopt a strategy of not sharing demand information, that is, the strategy RN .

When $1/4 < \gamma < 1/2$, the platform's commission rate increases. Combining this with Figure 2, we can draw the following conclusions: First, when $0 < k \leq k_1$ and $0 < \delta < \min\{\delta_1, 1\}$, the platform prefers the strategy combination (AS, D) (as depicted by R_3 in Figure 2b). This preference can be attributed to two factors: On one hand, the platform's information accuracy is relatively low, leading it to favor sharing demand information. Although the platform gives up its informational advantage, sharing information helps manufacturers in making informed decisions based on demand data, thereby mitigating the negative impact of low information precision. On the other hand, when $0 < k \leq k_1$, even though the manufacturer's traceability service efficiency is high, the manufacturer tends not to provide traceability services. Consequently, the platform prefers the strategy combination (AS, D) .

However, when $0 < k \leq k_1$ and $\min\{\delta_1, 1\} < \delta < 1$, the information accuracy improves. In this scenario, the platform prefers the strategy combination (RN, D) . This is because the platform possesses an informational advantage and pricing power. Higher information accuracy enhances the platform's information superiority, enabling it to make better pricing decisions and ultimately increasing its profitability.

Secondly, when $k_1 < k \leq k_2$, the platform prefers the strategy combination (RN, T) (as depicted by R_5 in Figure 2b). Regardless of the accuracy of the information, the platform tends to choose strategy RN , that is, not sharing demand information in the resale model. At this point, the platform hopes that manufacturers will proactively provide traceability services. This strategy can have a dual effect: on the one hand, the traceability services provided by manufacturers will stimulate the growth of market demand; On the other hand, the retail price of the product has also increased accordingly. This ultimately leads to an increase in the platform's profits, while also reflects the free-riding behavior of the platform.

Thirdly, when $k > k_2$ and $0 < \delta < \min\{\max\{0, \delta_2\}, 1\}$, the platform prefers the strategy combination (AS, T) (as depicted by R_6 in Figure 2b), when the accuracy of the information is relatively low, the platform will share the demand information with the manufacturer. The manufacturer can make better pricing decisions based on the demand information to better reflect the demand, thereby alleviating the impact brought by the uncertainty of demand information.

Fourthly, when $k > k_2$ and $\min\{\max\{0, \delta_2\}, 1\} < \delta < 1$, the platform prefers the strategy combination (RN, T) (as depicted by R_7 in Figure 2b). That is, when the

accuracy of information improves, the platform will retain the demand information because under the resale model, the platform can obtain more profits through pricing power.

Corollary 1 Through the profit analysis and comparison of the platform and the manufacturer under different strategy combinations, the preferred strategy combinations of the platform and the manufacturer are obtained, and the Pareto optimal region is ultimately determined.

(1) In region R_3 , when $0 \leq k \leq k_1$ and $0 < \delta < \min\{\delta_1, 1\}$, equilibrium strategy (AS, D) makes the platform and the manufacturer optimal (Pareto I) ;

(2) In region R_6 , when $k > k_2$ and $0 < \delta < \min\{\max\{0, \delta_2\}, 1\}$, equilibrium strategy (AS, T) makes the platform and the manufacturer optimal (Pareto II) ;

Under the optimal strategy conditions of a given platform, manufacturers and platforms can reach a cooperative consensus within Pareto-optimal regions. According to Corollary 1 and Figure 3, two such optimal Pareto regions exist: Pareto I and Pareto II.

In the Pareto I region, the platform adopts strategy AS , while the manufacturer selects strategy D . Even if the manufacturer does not provide traceability services, the platform will share demand information when the prediction accuracy is low. This information-sharing mechanism significantly enhances the manufacturer's profit levels. Specifically, the demand information provided by the platform helps the manufacturer better understand market dynamics, thereby optimizing production plans and inventory management. Consequently, this leads to improved operational efficiency and profitability. Through this approach, the manufacturer can achieve profit growth without incurring additional costs, leveraging the platform's informational advantages.

In the Pareto II region, the platform again chooses strategy AS , but the

manufacturer opts for strategy T . Although the lower efficiency of traceability services results in a decline in service level, the manufacturer can still adjust pricing strategies flexibly based on the demand information shared by the platform, leading to profit growth. By making precise price adjustments, the manufacturer can effectively respond to market changes and meet the diverse needs of consumers, thereby maintaining a competitive advantage in a fiercely competitive market environment.

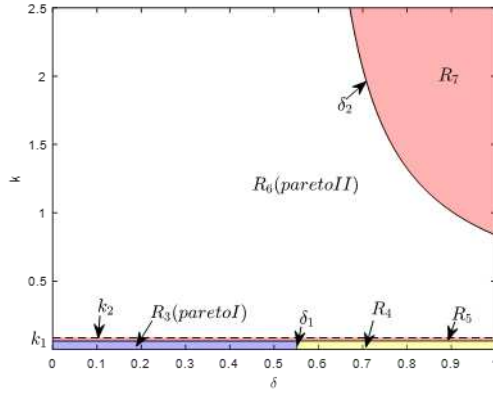


Figure 3 Pareto's optimal area

Note: the parameters in the figure are $\alpha=250$, $\sigma_0=90$, $\beta=0.7$, $\gamma=0.3$.

6 Numerical analysis

Next, we will discuss the impact of traceability service efficiency on manufacturers' profits and the influence of demand uncertainty on the platform's demand information sharing strategy.

6.1 The impact of traceability service efficiency on manufacturers' profits

This section analyzes the impact of traceability service efficiency on manufacturers' profits under different scenarios $\alpha=250$, $\sigma_0=90$, $\beta=0.7$, $\gamma=\{0.2, 0.3\}$.

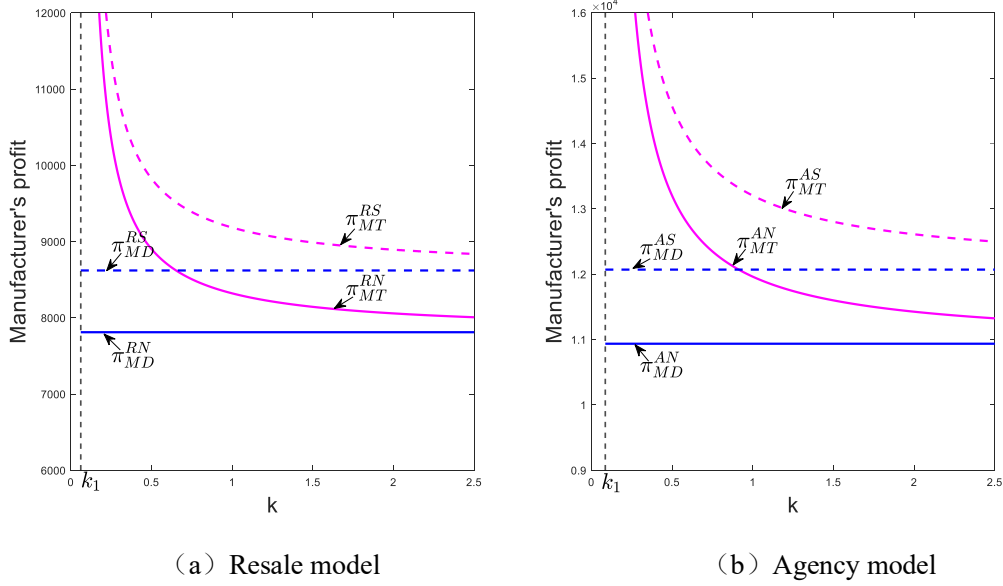


Figure 4 The impact of traceability service efficiency on manufacturers' profits

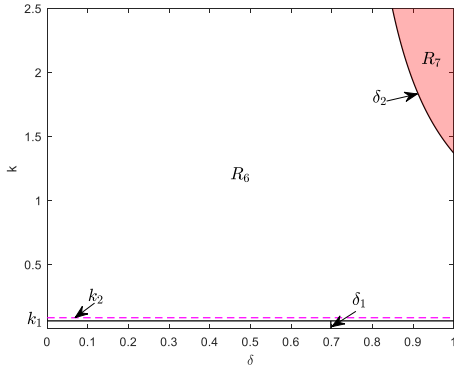
Figure 4 validates the conclusions of Propositions 2 and 4. In the reselling mode, when $0 < k \leq k_1$, the manufacturer chooses not to offer traceability services (Strategy D); when $k > k_1$, the manufacturer chooses to provide traceability services (Strategy T). In the case where traceability services are offered, the manufacturer's profit declines as k increases. This decline occurs because a higher k indicates lower efficiency in traceability efforts, which in turn reduces both the wholesale price and the level of traceability service. Although the service level decreases, the reduced efficiency raises the manufacturer's traceability costs, ultimately leading to lower profits.

In the agency mode, as established in Proposition 2, the manufacturer does not provide traceability services when $0 < k \leq k_2$ (Strategy D), and does so when $k > k_2$ (Strategy T). When traceability services are provided, profits again decrease with an increase in k . This is due to the fact that a higher k diminishes the efficiency of traceability, thereby suppressing both the retail price and the service level. Despite the

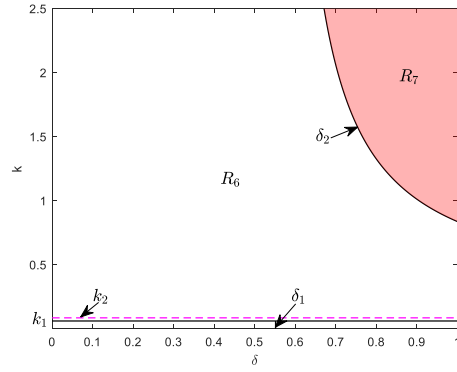
reduction in service level, the associated costs rise as efficiency declines, which erodes the manufacturer's profitability.

From the perspective of demand information sharing by the platform, the agency mode exerts a more positive influence on manufacturer profitability than the reselling mode. Regardless of whether the platform shares demand information, the manufacturer has an incentive to enhance the level of traceability services and shows a clear preference for the agency mode. This preference becomes particularly pronounced when the platform adopts the agency mode and simultaneously shares demand information.

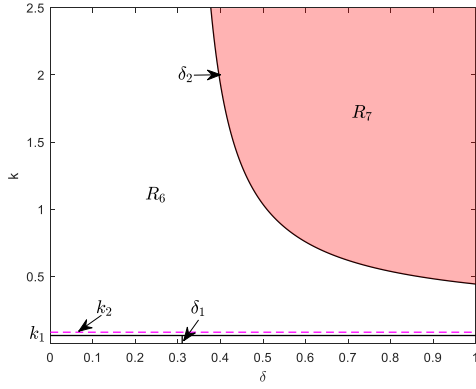
6.2 The impact of uncertainty in demand on the platform's demand information sharing strategy



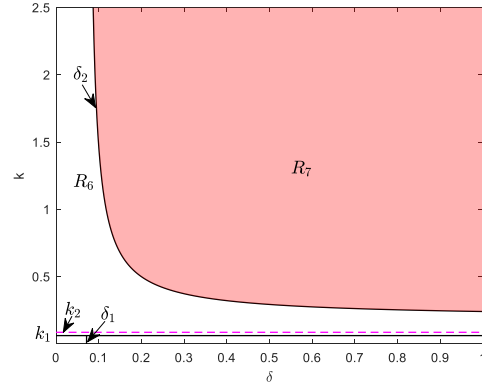
(a) $\sigma_0=80$



(b) $\sigma_0=90$



(c) $\sigma_0=120$



(d) $\sigma_0=250$

Figure 5 The impact of demand uncertainty on the platform's demand information sharing strategy

Note: region R_3 (strategy combinations (AS,D)), region R_4 (strategy combinations (RN,D)),

region R_6 (strategy combinations (AS,T)), region R_7 (strategy combinations (RN,T)).

An increase in demand uncertainty σ_0 simultaneously reduces both δ_1 and δ_2 , thereby altering the extents of regions R_3 , R_4 , R_6 and R_7 in Figure 5. Since the analytical logic underlying region R_3 and R_4 is analogous to that of region R_6 and R_7 , and to maintain visual clarity, the figure does not explicitly label region R_3 and R_4 ; however, its definition remains consistent with that in Figure 2(b). Accordingly, the subsequent analysis focuses primarily on how changes in R_3 affect region R_4 .

As σ_0 increases, the curve δ_2 shifts persistently leftward. This indicates that greater demand uncertainty enlarges region R_7 while correspondingly shrinking region R_6 . Such a shift suggests that the platform adopts the agency model and shares demand information (Strategy AS) only when information precision δ is sufficiently low. In contrast, under most other conditions, the platform prefers the reselling model while continuing to share demand information (Strategy RN). This

tendency becomes particularly pronounced when $\sigma_0=250$, at which point region R_7 occupies nearly the entire parameter space.

In summary, as demand uncertainty intensifies, the platform's incentive to withhold demand information becomes stronger. This is because the platform can leverage its informational advantage to acquire more accurate demand forecasts, thereby extracting higher profits. Under such conditions, the platform increasingly favors the reselling model and opts not to share information. Only when demand uncertainty is relatively low does the platform find it feasible to adopt the agency model and share information.

7 Conclusion

Previous literature has predominantly examined retailer service investments in the context of new retail. In contrast, this study focuses on value-added service investments initiated by manufacturers, specifically the adoption of blockchain technology for product traceability services. We investigate a platform supply chain system consisting of a manufacturer and a platform under demand uncertainty. The platform decides whether to share demand information under either the reselling or agency mode, while the manufacturer determines whether to invest in blockchain-based traceability services. By constructing a dynamic game-theoretic model that captures demand information sharing and traceability service investment, we derive the optimal pricing and investment decisions for supply chain members under different strategy combinations. Through comparative analysis of the strategic interactions between the platform and the manufacturer, we identify dominant strategy combinations for each party and further

uncover two Pareto-optimal regions that are win-win for both the platform and the manufacturer. Specific research findings:

(1) Under the resale model, when $0 < k \leq k_1$, the manufacturer does not provide traceability services; when $k > k_1$, the manufacturer provide traceability services;

Under the Agency model, when $0 < k \leq k_2$, the manufacturer does not provide traceability services; when $k > k_2$, the manufacturer provide traceability services.

(2) Whether in the resale model or the agency model, the platform's equilibrium profit is higher when the manufacturer provides traceability services compared to scenarios without such services. This suggests that platforms may benefit from manufacturers' investments in traceability, indicating potential "free-riding" behavior by the platform.

(3) Whether in the resale model or the agency model, the manufacturer's equilibrium profit is higher when the manufacturer provides traceability services compared to scenarios without such services.

(4) The platform tends not to share the demand information strategy under the resale model, while it tends to share the demand information strategy under the resale model

(5) In region R_3 , when $0 \leq k \leq k_1$ and $0 < \delta < \min\{\delta_1, 1\}$, equilibrium strategy

(AS, D) makes the platform and the manufacturer optimal (Pareto I); In region R_6 ,

when $k > k_2$ and $0 < \delta < \min\{\max\{0, \delta_2\}, 1\}$, equilibrium strategy (AS, T) makes

the platform and the manufacturer optimal (Pareto II). Therefore, there exists a Pareto

region that is a win-win situation for both the platform and the manufacturer (region

R_3 and region R_6).

The main research finding of this study cover three aspects. First, we demonstrate

that manufacturers possess an intrinsic incentive to adopt blockchain-based traceability services. Second, the platform's optimal information sharing policy depends on sales formats: platforms withhold demand information under reselling, yet share information under agency arrangements. A deeper analysis further reveals a pronounced "free-riding" behavior during platform decision-making, wherein one party leverages the other's informational investment without commensurate contribution. Third, we identify two Pareto-optimal regions within the parameter space, where both platform and manufacturer can achieve mutually beneficial outcomes through coordinated action. The foregoing findings deliver novel theoretical perspectives and practical implications for supply chain coordination amid the digital economy. While we verify and analyze the baseline model via numerical experiments in this paper, the proposed model still suffers from inherent limitations, which possess substantial potential for future refinement and extension. These limitations mainly manifest in three respects. (1) All supply chain members are presumed risk-neutral in the present model. The effects of diverse risk preferences and risk aversion on the interactive decisions of supply chain partners deserve future systematic research. (2) While we focus exclusively on manufacturer-led service investments, it is also possible to consider the impact of different service investments made by manufacturers and platforms and how this interaction affects equilibrium outcomes and strategic combinations. (3) The current model assumes a single manufacturer scenario. Future research could incorporate manufacturer competition to investigate its impact on equilibrium solutions and the strategic interplay between manufacturers and platforms.

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Ethical Approval

This article does not contain any studies with human participants performed by any of the authors.

Informed Consent

This article does not contain any studies with human participants performed by any of the authors.

Appendix:

Proof of Lemma 1:

First, consider the platform's strategy RN , the first and second derivatives of the expected profit $E[\pi_{PT}^{RN}|\Gamma]$ of the platform with respect to p_T^{RN} are respectively:

$$\frac{dE[\pi_{PT}^{RN}|\Gamma]}{dp_T^{RN}} = \alpha + E[\theta|\Gamma] - 2p_T^{RN} + w_T^{RN} + \beta\tau^{RN}, \quad \frac{d^2E[\pi_{PT}^{RN}|\Gamma]}{d(p_T^{RN})^2} = -2 < 0, \text{ The expected}$$

profit of the platform is a concave function of p_T^{RN} . Therefore, let

$$\frac{dE[\pi_{PT}^{RN}|\Gamma]}{dp_T^{RN}} = 0, \text{ obtain } p_T^{RN} = \frac{\alpha + E[\theta|\Gamma] + w_T^{RN} + \beta\tau^{RN}}{2}.$$

Under the strategy RN , because the platform cannot sharing demand information, then Manufacturer make decisions on wholesale prices and traceability investment levels based on expected demand, Substitute p_T^{RN} into the manufacturer's expected

profit, let $\frac{\partial E[\pi_{MT}^{RN}]}{\partial w_T^{RN}} = 0$ and $\frac{\partial E[\pi_{MT}^{RN}]}{\partial \tau^{RN}} = 0$, solve the equation, we can get :

$$w_T^{RN} = \frac{4\alpha k}{8k - \beta^2}, \quad \tau^{RN} = \frac{\alpha\beta}{8k - \beta^2}. \quad \text{the Hessian matrix is :}$$

$$H = \begin{bmatrix} \frac{\partial^2 E[\pi_{MT}^{RN}]}{\partial (w_T^{RN})^2} & \frac{\partial^2 E[\pi_{MT}^{RN}]}{\partial w_T^{RN} \partial \tau^{RN}} \\ \frac{\partial^2 E[\pi_{MT}^{RN}]}{\partial \tau^{RN} \partial w_T^{RN}} & \frac{\partial^2 E[\pi_{MT}^{RN}]}{\partial (\tau^{RN})^2} \end{bmatrix} = \begin{bmatrix} -1 & \beta/2 \\ \beta/2 & -2k \end{bmatrix}, \text{ and } |H| = 2k - \beta^2/4. \text{ To make the}$$

Hessian matrix a negative definite matrix, the constraints should be satisfied

$k > k_1$, where $k_1 = \beta^2/8$.

Therefore, it can be obtained that the equilibrium result under the strategy is:

$$w_T^{RN} = \frac{4\alpha k}{8k - \beta^2}, \quad \tau^{RN} = \frac{\alpha\beta}{8k - \beta^2}, \quad p_T^{RN} = \frac{6\alpha k}{8k - \beta^2} + \frac{1}{2}\delta\Gamma, \quad d_T^{RN} = \frac{2\alpha k}{8k - \beta^2} + \frac{1}{2}\delta\Gamma,$$

$$E[\pi_{MT}^{RN}] = \frac{\alpha^2 k}{8k - \beta^2}, \quad E[\pi_{PT}^{RN}] = \frac{4\alpha^2 k^2}{(8k - \beta^2)^2} + \frac{1}{4}f.$$

The proof Lemma 2、 Lemma 3、 Lemma 4 is similar to Lemma 1.

Proof of Proposition 1:

(1) The impact of manufacturers providing traceability services on equilibrium

outcomes under the agency model:

(a) $w_T^{RN} = \frac{4\alpha k}{8k - \beta^2}, \quad w_D^{RN} = \frac{\alpha}{2}$, when $\beta = 0$, then $w_T^{RN} = \frac{\alpha}{2} = w_D^{RN}$. When β increases,

w_T^{RN} gradually increases. Therefore, when $0 < \beta < 1$, then $w_T^{RN} > w_D^{RN}$.

(b) $p_T^{RN} = \frac{6\alpha k}{8k - \beta^2} + \frac{1}{2}\delta\Gamma, \quad p_D^{RN} = \frac{3\alpha}{4} + \frac{1}{2}\delta\Gamma$ (To simplify the analysis process, this

article assumes $\Gamma > 0$), Similarly, it can be obtained, when $0 < \beta < 1$, then

$p_T^{RN} > p_D^{RN}$. The rest can be proved similarly.

(2) The impact of manufacturers providing traceability services on equilibrium

outcomes under the agency model:

$p_T^{AN} = \frac{2\alpha k}{4k - (1-\gamma)\beta^2}, \quad p_D^{AN} = \frac{\alpha}{2}$, Similarly, it can be obtained, when $0 < \beta < 1$, the

$p_T^{AN} > p_D^{AN}$. The rest can be proved similarly.

Proof of Proposition 2: Based on the equilibrium results of Lemmas 1.1 to 1.4, the

following conclusions can be obtained. Under the resale model, when $0 < k \leq k_1$, The

manufacturer does not provide traceability services; when $k > k_1$, the manufacturer

provides traceability services. Therefore, by analyzing different scenarios, we can

obtain:

$$\pi_{MT}^{RN} - \pi_{MD}^{RN} = \frac{\alpha^2 \beta^2}{8(8k - \beta^2)}, \pi_{MT}^{RS} - \pi_{MD}^{RS} = \frac{(\alpha^2 + f) \beta^2}{8(8k - \beta^2)}.$$

Under the resale model, when $0 < k \leq k_1$, $\pi_{MT}^{RN} < \pi_{MD}^{RN}, \pi_{MT}^{RS} < \pi_{MD}^{RS}$; when $k > k_1$, $\pi_{MT}^{RS} > \pi_{MD}^{RS}, \pi_{MT}^{RS} > \pi_{MD}^{RS}$, where $k_1 = \beta^2/8$.

Under the agency model, when $0 < k \leq k_2$, The manufacturer does not provide traceability services; when $k > k_2$, The manufacturer provides traceability services.

Therefore, by analyzing different scenarios, we can obtain:

$$\pi_{MT}^{AN} - \pi_{MD}^{AN} = \frac{\alpha^2 (1-\gamma) \beta^2}{4(4k - (1-\gamma) \beta^2)}, \pi_{MT}^{AS} - \pi_{MD}^{AS} = \frac{(1-\gamma)^2 (\alpha^2 + f) \beta^2}{4(4k - (1-\gamma) \beta^2)}.$$

Under the resale model, when $0 < k \leq k_2$, $\pi_{MT}^{RN} < \pi_{MD}^{RN}, \pi_{MT}^{RS} < \pi_{MD}^{RS}$; when $k > k_2$, $\pi_{MT}^{RS} > \pi_{MD}^{RS}, \pi_{MT}^{RS} > \pi_{MD}^{RS}$. where $k_2 = (1-\gamma) \beta^2/4$.

Proof of Proposition 3:

According to $E[\pi_{PT}^{RN}] = \frac{4\alpha^2 k^2}{(8k - \beta^2)^2} + \frac{1}{4}f, E[\pi_{PD}^{RN}] = \frac{\alpha^2}{16} + \frac{1}{4}f$, obtain

$$E[\pi_{PT}^{RN}] > E[\pi_{PD}^{RN}];$$

According to $E[\pi_{PT}^{RS}] = \frac{4\alpha^2 k^2}{(8k - \beta^2)^2} + \frac{4k^2 f}{(8k - \beta^2)^2}, E[\pi_{PD}^{RS}] = \frac{\alpha^2}{16} + \frac{1}{16}f$, obtain

$$E[\pi_{PT}^{RS}] > E[\pi_{PD}^{RS}];$$

According to $E[\pi_{PT}^{AN}] = \frac{4\gamma k^2 \alpha^2}{(4k - (1-\gamma) \beta^2)^2}, E[\pi_{PD}^{AN}] = \frac{\alpha^2 \gamma}{4}$, obtain

$$E[\pi_{PT}^{AN}] > E[\pi_{PD}^{AN}];$$

According to $E[\pi_{PT}^{AS}] = \frac{4\gamma k^2 \alpha^2}{(4k - (1-\gamma) \beta^2)^2} + \frac{4\gamma k^2 f}{(4k - (1-\gamma) \beta^2)^2}, E[\pi_{PD}^{AS}] = \frac{\gamma \alpha^2}{4} + \frac{\gamma f}{4}$,

obtain $E[\pi_{PT}^{AS}] > E[\pi_{PD}^{AS}]$.

Proof of Proposition 4:

According to $E[\pi_{MT}^{RN}] = \frac{\alpha^2 k}{8k - \beta^2}$, $E[\pi_{MD}^{RN}] = \frac{\alpha^2}{8}$, obtain $E[\pi_{MT}^{RN}] > E[\pi_{MD}^{RN}]$;

According to $E[\pi_{MT}^{RS}] = \frac{k\alpha^2}{8k - \beta^2} + \frac{kf}{8k - \beta^2}$, $E[\pi_{MD}^{RS}] = \frac{\alpha^2}{8} + \frac{1}{8}f$, obtain

$$E[\pi_{MT}^{RS}] > E[\pi_{MD}^{RS}];$$

According to $E[\pi_{MT}^{AN}] = \frac{\alpha^2 k(1-\gamma)}{4k - (1-\gamma)\beta^2}$, $E[\pi_{MD}^{AN}] = \frac{\alpha^2(1-\gamma)}{4}$, obtain

$$E[\pi_{MT}^{AN}] > E[\pi_{MD}^{AN}];$$

According to $E[\pi_{MT}^{AS}] = \frac{k\alpha^2(1-\gamma)}{4k - (1-\gamma)\beta^2} + \frac{k(1-\gamma)f}{4k - (1-\gamma)\beta^2}$,

$$E[\pi_{MD}^{AS}] = \frac{\alpha^2(1-\gamma)}{4} + \frac{(1-\gamma)f}{4}, \text{ obtain } E[\pi_{MT}^{AS}] > E[\pi_{MD}^{AS}].$$

Proof of Proposition 5: (1) When $0 \leq \gamma \leq 1/4$, $k_1 < k_2$, from the perspective of the platform, the preferred strategy combinations of the platform are as follows:

(i) When $0 \leq \gamma \leq 1/4$ and $0 < k \leq k_1$, based on previous analysis, it can be concluded that the manufacturer can only choose not to provide traceability services under both resale and agency models, i.e., strategy D . In contrast, the platform's optimal strategy under the resale model is RN , while its optimal strategy under the agency model

is AS . Comparative analysis reveals that $\pi_{PD}^{RN} - \pi_{PD}^{AS} = \frac{(1-4\gamma)\alpha^2 + 4(1-\gamma)\delta\sigma_0^2}{16} > 0$.

(ii) When $0 \leq \gamma \leq 1/4$, $k_1 < k \leq k_2$, $\pi_{PD}^{RN} - \pi_{PD}^{AS} = \left(\frac{4\alpha^2 k^2}{(8k - \beta^2)^2} - \frac{\gamma\alpha^2}{4} \right) + \left(\frac{\delta\sigma_0^2}{4} - \frac{\gamma\delta\sigma_0^2}{4} \right) > 0$.

(iii) When $0 \leq \gamma \leq 1/4$ and $k > k_2$, $\pi_{PT}^{RN} > \pi_{PT}^{AS}$;

(2) When $1/4 \leq \gamma \leq 1/2$, $k_1 < k_2$, The preferred strategy combinations of the platform are as follows:

(i) When $1/4 \leq \gamma \leq 1/2$ and $0 < k \leq k_1$, based on previous analysis, the platform's preferred strategy under the resale model is RN , while its preferred strategy under the agency model is AS . The manufacturer, however, prefers not to provide traceability services under both sales models, adopting strategy D . Consequently, by comparing the strategy combinations (RN, D) and (AS, D) , we obtain

$$\pi_{PD}^{RN} - \pi_{PD}^{AS} = \frac{(1-4\gamma)\alpha^2 + 4(1-\gamma)\delta\sigma_0^2}{16}, \text{ let } \delta_1 = \frac{(4\gamma-1)\alpha^2}{4(1-\gamma)\sigma_0^2}, \text{ when } 0 < \delta < \min\{\delta_1, 1\},$$

$$\pi_{PD}^{RN} < \pi_{PD}^{AS}; \text{ when } \min\{\delta_1, 1\} < \delta < 1, \pi_{PD}^{RN} > \pi_{PD}^{AS}.$$

(ii) When $1/4 \leq \gamma \leq 1/2$ and $k_1 < k \leq k_2$, $\pi_{PT}^{RN} > \pi_{PD}^{AS}$;

(iii) When $1/4 \leq \gamma \leq 1/2$ and $k > k_2$, Based on the comparative analysis of the equilibrium results, it can be obtained $\pi_{PT}^{RN} - \pi_{PT}^{AS} =$

$$\frac{16\alpha^2 k^2 \left[(4k - (1-\gamma)\beta^2)^2 - \gamma(8k - \beta^2)^2 \right] + \delta\sigma_0^2 (8k - \beta^2)^2 \left[(4k - (1-\gamma)\beta^2)^2 - 16\gamma k^2 \right]}{4(8k - \beta^2)^2 (4k - (1-\gamma)\beta^2)^2}$$

According to the analysis, it can be obtained, when $1/4 \leq \gamma \leq 1/2, k > k_2$ and $0 < \delta < \min\{\max\{0, \delta_2\}, 1\}$, $\pi_{PT}^{RN} < \pi_{PT}^{AS}$; when $1/4 \leq \gamma \leq 1/2, k > k_2$ and $\min\{\max\{0, \delta_2\}, 1\} < \delta < 1$, $\pi_{PT}^{RN} > \pi_{PT}^{AS}$. The expression of δ_2 here is,

$$\delta_2 = \frac{16\alpha^2 k^2 \left[\gamma(8k - \beta^2)^2 - (4k - (1-\gamma)\beta^2)^2 \right]}{\sigma_0^2 (8k - \beta^2)^2 \left[(4k - (1-\gamma)\beta^2)^2 - 16\gamma k^2 \right]}.$$

Proof of Corollary 1: From the manufacturer's perspective: when $0 \leq k \leq k_1$,

analyze the relative sizes of π_{MD}^{RS} and π_{MD}^{AS} ; when $k_1 \leq k \leq k_2$, analyze the relative sizes of π_{MT}^{RS} and π_{MD}^{AS} ; when $k > k_2$, analyze the relative sizes of π_{MT}^{RS} and π_{MT}^{AS} .

When $0 \leq \gamma \leq 1/2$, The preferred strategy combinations of manufacturers are

respectively:

(i) When $0 \leq \gamma \leq 1/2$ and $0 < k \leq k_1$, $\pi_{MD}^{RS} - \pi_{MD}^{AS} = \frac{(2\gamma-1)(\alpha^2 + \delta\sigma_0^2)}{8} < 0$, the

preferred strategy combination of the manufacturer (AS, D) .

(ii) When $0 \leq \gamma \leq 1/2$ and $k_1 < k \leq k_2$,

$$\pi_{MT}^{RS} - \pi_{MD}^{AS} = \frac{[4k - (1-\gamma)(8k - \beta^2)](\alpha^2 + \delta\sigma_0^2)}{4(8k - \beta^2)} < 0, \quad \text{the preferred strategy}$$

combination of the manufacturer (AS, D) .

(iii) When $0 \leq \gamma \leq 1/2$ and $k > k_2$, $\pi_{MT}^{RS} - \pi_{MT}^{AS} = \frac{4k^2(2\gamma-1)(\alpha^2 + \delta\sigma_0^2)}{(8k - \beta^2)(4k - (1-\gamma)\beta^2)} < 0$, the

preferred strategy combination of the manufacturer (AS, T) .

First, we analyze the platform's strategy preferences. The platform exhibits distinct preferences for different strategy combinations based on various conditions. Next, we examine the manufacturer's strategy preferences, considering their optimal choices under similar conditions. Through this analysis, it becomes evident that both the platform and the manufacturer can reach a consensus within the Pareto-optimal region. As illustrated in Corollary 1 and Figure 3, there exist optimal Pareto region (pareto I and Pareto II) where both the platform and the manufacturer achieve their best possible decisions simultaneously.