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# Information Disclosure Decision for Tourism O2O Supply Chain Based on Blockchain Technology

**Li Zhou [1], Chunqiao Tan [2,*] and Huimin Zhao [3]**

[1] School of Information, Beijing Wuzi University, Beijing 101149, China; zhoulibit@126.com
[2] School of Business, Nanjing Audit University, Nanjing 211815, China
[3] School of Business, Central South University, Changsha 410083, China; csuzhm@126.com
* Correspondence: 270268@nau.edu.cn

**Abstract:** (1) Background: With the development of blockchain technology and fierce competition between tourism platforms, tourism platforms can adopt blockchain technology to disclose product information to enhance their core competitiveness. As for a tourism O2O, i.e., online to offline, supply chain, the tourism platform sells the product online, and the tour operator provides services offline. (2) Methods: We establish a game theory model and study the optimal strategies of supply chain members in two scenarios (decentralized and centralized) when the online platform does not adopt or adopts blockchain technology. Then, we introduce a two-part tariff contract for coordination. Furthermore, we discuss the impact of the cost of adopting blockchain technology, disclosing information and the proportion of information-sensitive consumers on the optimal strategies. (3) Conclusions: When the costs of adopting blockchain technology and information disclosure are low, if the proportion of information-sensitive consumers is large, adopting blockchain technology is beneficial to supply chain members. Compared with a wholesale price contract, a two-part tariff contract can encourage the platform to improve information disclosure quality, so the tour operator can adjust their cooperation contract to achieve Pareto improvements. Under a two-part tariff contract, the tourism platforms are more likely to disclose information and can effectively regulate the operational performance of the tourism O2O supply chain.

**Keywords:** tourism O2O supply chain; blockchain technology; information disclosure; price decision; coordination

**MSC:** 91-10



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## 1. Introduction

In recent years, O2O, i.e., online to offline, has emerged as a new e-commerce model that is different from traditional models of e-commerce. In this model, consumers can obtain information, subscribe to products from an online channel, and then consume them at offline stores. The rapid development of the O2O model has promoted the rise of online tourism platforms. Some tour operators choose to cooperate with online tourism platforms to sell tourism products aimed at expanding market demand. As for a tourism O2O supply chain, tourism platform sells their product online, and the tour operator provides services offline. Through the division of labor and cooperation, both of them can focus on exerting their respective advantages to achieve a win-win situation. Under the O2O tourism model, consumers can book tourism products through an online platform anytime and anywhere. Before making their final decision, consumers often browse the information displayed on the web page of online tourism platforms, especially the existing reviews. However, the trustworthiness of the information is sometimes questioned because fake reviews are very common on online platforms [1]. Because the online platform is under the control of the data, so that information is asymmetric, there will be problems such as fake reviews, rating fraud, false propaganda, etc. This phenomenon puts consumers at an information disadvantage. According to the "Online Tourism Consumption Trends and Consumer Rights Protection Trend Report (2019)", the issues of online tourism platforms are mainly concentrated in ten aspects, including information leakage, false propaganda, tourism products by big data analysis to harm the revenue of existing consumers and review data fraud. Among them, Fliggy and Ctrip accounted for 8 complaints, and Qunar accounted for 6. Mafengwo was exposed to data fraud in 2018, including brushing to increase sales, submit false reviews, and falsify relevant data through online crawling (http://tradeinservices.mofcom.gov.cn/article/yanjiu/hangyezk/201904/81733.html, accessed on 23 April 2019). These problems not only affect the tourism experience of consumers and reduce consumer satisfaction but also damage the reputation of the tourism platform and weaken consumers' trust in the platform. The purchase behavior of consumers on the online tourism platform is affected by product evaluation and transaction security, but the current product review data lacks authenticity because it is controlled by the platform in the background [2]. Therefore, it is urgent to take measures to improve information asymmetry. As an emerging technology, blockchain is a distributed ledger based on a consensus mechanism [3], which is composed of interconnected blocks. Through these blocks, transaction data can be easily traced. Therefore, this technology can maintain the integrity, confidentiality, and availability of transaction data and has the functions of preventing risks and enhancing trust [4]. It will have great potential implications for the tourism industry [5]. According to information asymmetry, the online tourism platform can build a common review and rating system based on blockchain technology, which can avoid the above problems from the technical level. Therefore, the platform can adopt this mechanism, which can increase the trustworthiness of the information disclosure and consumers' trust in them.

In the traditional model, the reviews are manipulated by the online tourism platform. For example, on the website of Qunar, it is common for real reviews to be hidden or deleted. Some platforms fabricate user reviews to conduct false or misleading commercial propaganda in order to deceive and mislead consumers. Generally, a centralized data storage model is adopted, and the data is managed centrally. When the information is unfavorable to the relevant stakeholders, there is the possibility of artificially tampering with the product information. While building a system based on blockchain technology, the data will be stored on a peer-to-peer network. The task of adding and verifying new review data is taken over by nodes among the blockchain, which need to consume computing power. Therefore, the platform should reward the nodes who have added the data to the blockchain. Furthermore, the cost of adopting blockchain technology is high. Therefore, online tourism platforms need to balance the benefits and costs of adopting blockchain technology.

Based on the above background, considering the proportion of information-sensitive consumers and the cost of adopting blockchain technology, should the online tourism platform adopt blockchain technology to improve the quality of information disclosure? This is the focus of this paper. This paper mainly studies the following questions:

(1) Whether the online platform adopts blockchain technology or not, what are the optimal strategies of the tourism O2O supply chain members?
(2) Under what conditions should the online platform adopt blockchain technology to improve the quality of information disclosure?
(3) When a two-part tariff contract is used for supply chain coordination, how will the optimal strategies and profits of the supply chain members change?
(4) Under the two types of contracts, which parameter affects the optimal strategies?

The structure of this paper is organized as follows. In Section 2, we review the related literature. In Section 3, we describe the problems and build the benchmark model. In Section 4, an analysis of the optimal strategies and profits of the supply chain member without blockchain technology in two scenarios (decentralized scenario and centralized scenario) is presented. In Section 5, an analysis of the optimal strategies and profit of the supply chain member with blockchain technology in two scenarios is presented. In Section 6, we introduce the two-part tariff for supply chain coordination in two scenarios. In Section 7, some conclusions are verified by the numerical analysis. In Section 8, conclusions, management implications, and future research directions are given.

## 2. Literature Review

### 2.1. Tourism O2O

In recent years, the O2O model has become very common in the tourism industry [6]. Consumers can obtain information, book tourism products from an online channel, and then consume in an offline channel. It is difficult for some tourism firms to open an online channel due to technology and funding, so online platforms are usually developed by an online tourism agency [7]. More and more people search for ticket and hotel information before booking online and traveling. In O2O e-commerce, the perceived effectiveness of online reviews has an indirect effect on the consumer's purchase intention [8]. Filieri [9] pointed out that an increasing number of consumers make decisions about tourism products based on online reviews. Trust plays a crucial role in that process; an online platform, such as Airbnb, is responsible for building trust among the users [10]. However, it is common for managers to offer a discount to consumers in exchange for positive reviews and are prone to tampering with the reviews and ratings, so the trustworthiness of online information is low. The contents of consumer feedback are prone to being influenced by the sellers [11]. Online fake reviews and rating fraud often cause consumers to have wrong expectations and judgments towards tourism products, which affects the travel experience and even yields travel disputes. With the increase in tourism product reviews, the consumers can obtain information from the online tourism platform conveniently, although the trustworthiness of the information is unknown, which will increase the cognitive cost [12]. Sometimes, negative reviews are more reliable and crucial than positive reviews in the decision-making process [13]. At present, deceptive reviews can be identified through text analysis. However, this still does not solve the root problem of deceptive reviews as long as the reviews are manipulated by the online tourism platform. The existence of review manipulation can decrease the informativeness and quality of online reviews [14]. Zulfiqar [15] believes that a centralized underlying architecture is the fundamental reason for fake reviews and proposes a product review system based on blockchain technology, which is composed of a P2P network, to verify the truthfulness of consumer reviews. Cai and Zhu [16] presented how blockchain technology can be used to redesign the user feedback system to prevent information fraud.

### 2.2. Blockchain Technology

In the field of supply chain management, blockchain technology has been applied to many industries. For example, in luxury goods, the Everledger platform based on blockchain technology is used for diamond quality identification and source recording of each diamond, including source, screen, certification, storage, and sale. Choi [17] established a model to compare the difference between traditional diamond retail channels and blockchain-based platform sales channels and then analyzed the value of blockchain technology to the diamond supply chain. Min [18] said that the distributed accounting characteristics of blockchain could help the supply chain reduce potential risks such as fraud, hacker attacks, and contract disputes. In the manufacturing industry, the adoption of blockchain technology in the supply chain can reduce the impact of supply interruption, which is beneficial to downstream enterprises to take preventive and proactive risk management measures to respond and achieve the stability of the supply chain [19]. Lin [20] analyzed the role of blockchain technology in food quality and safety management. An information traceability system can be established to prevent and detect food safety problems so that when problems occur, it is easy to find the root cause of the problem and pursue related responsibilities. Shen [21] pointed out that although traditional RFID technology can also track product information, the product information is subject to modification due to centralized management, so consumers do not trust it highly, but the blockchain technology uses a decentralized distributed ledger to display product information, which can avoid the phenomenon of data being arbitrarily modified and enhance consumer trust.

With the increasing application of blockchain technology and the prominent problem of information asymmetry in the tourism market, some scholars and practitioners have proposed applying blockchain technology to the tourism industry. At present, some tourism companies have also begun to adopt blockchain technology to enhance their competitive advantages [22], such as the Winding Tree in Switzerland, Tourism Chain in Russia, Cool Cousin in the United Kingdom, etc. These tourism companies support consumers to use Bitcoin as the payment option without third-party assistance and extra costs, which is easy, secure and traceable [23]. Blockchain technology has unique advantages in information protection. Willie [24] pointed out that blockchain technology can create a reliable and safe digital environment for the tourism industry, which can be used for the transmission and sharing of passenger information to provide better services to consumers. The shared database based on blockchain technology can be developed among the tourism companies, which can simplify the validation procedure and protect the tourist information from leakage [25]. Blockchain technology can also be used to monitor the movement of luggage during the trip so that a tourist can track their baggage and know where it is. In the traditional way, membership point activities are a common way for companies to create customer loyalty on the online tourism platform. Blockchain technology can make it more attractive and exchange consumers for token rewards. Using blockchain can also create a trusted scoring system to help consumers make correct decisions about tourism destinations [2].

From reviewing the related literature, we can know the characteristic of blockchain technology and its potential applications in the tourism industry. However, there are some limitations in the existing literature. The existing literature is mainly concentrated on the empirical analysis of blockchain technology applications in the tourism industry. Whether to adopt blockchain technology or not and under what conditions should blockchain technology be adopted have not been considered. Therefore, this paper is aimed at making up for these limitations of the existing literature.

## 3. Problem Description

We consider a tourism O2O supply chain composed of an online tourism platform and a tour operator; the structure is shown in Figure 1. The tour operator is responsible for providing the product or services offline, and the tourism platform is responsible for sales online. The two parties cooperate through the wholesale price contract; that is, the tour operator sells a tourism product with a fixed unit cost $c_T$ to the online tourism platform at a wholesale price $w$, and the platform sells the products to consumers at a sales price $p$. Additionally, the unit sales cost of each tourism product is $c_O$. Due to a large number of online tourism platforms, the phenomenon of homogeneity is more serious, and the competition in the online tourism platforms is relatively high; thus, the tour operator is in a leadership position and can choose a platform to cooperate with. The online tourism platform determines the sales price under the given wholesale price to ensure profit maximization. At present, online tourism platforms have problems such as fake reviews and rating fraud, which leads consumers to distrust these platforms. Blockchain technology has the characteristics of being non-tamperable, demonstrating traceability, requiring multi-agent verification, and exhibiting high transparency. Therefore, the online tourism platform can adopt blockchain technology to upload product information, transaction records, and consumer reviews to ensure that the information is reliable and traceable, which can strengthen consumers' trust in the platform and enhance the platform's competitive advantage. Suppose that the tourism platform builds a public alliance blockchain, which consists of the platform and miners as the nodes. When the platform wants to upload consumer reviews or product information, it needs to broadcast and send authentication requests to nodes on the blockchain. Then, the node needs to verify the consumer reviews and product information; only the verified data will be recorded on the blockchain in chronological order. Users authorized by the platform can send product information query requests to the blockchain and receive related product information. In the information validation process, nodes consume manpower and material resources. Therefore, the online tourism platform should reward nodes that participate in the validation so that the nodes will have the motivation to contribute their resources to participate in verifying the trustfulness of information. The reward can be regarded as the cost of the online tourism platform to improve the quality of information disclosure. If the online tourism platform chooses to disclose information through blockchain technology, it needs to invest a certain amount of funds to update the hardware and software facilities to implement blockchain technology. Suppose that the initial investment of blockchain technology is $F$, the quality of information before introducing blockchain technology is $\alpha_O$, and after the introduction of blockchain, the quality is $\alpha + \alpha_O$. For the convenience of subsequent comparison, we assume that $\alpha_O = 0$; then, the information disclosure quality after the introduction of blockchain technology is $\alpha$. The information disclosed through blockchain technology needs to be verified by other nodes. The greater improvement in information disclosure quality means that the nodes need to spend a lot of computing power to verify the information, and the online tourism platform also needs to pay more rewards. Therefore, it is assumed that the cost of improving information quality is $k\alpha^2/2$, where $k$ is the cost coefficient of information disclosure. On this basis, this research constructs a tourism O2O model: a tourism operator only provides a kind of tourism product, and an online tourism platform buys tourism products from the tourism operator at wholesale prices and then sells to consumers. Consumers who buy tourism products online need to go offline to enjoy the services provided by the tour operator. As the leader, the tourism operator determines the wholesale price, and the online tourism platform as the follower determines whether to introduce the blockchain to disclose information, the quality of information disclosure, and sales price.

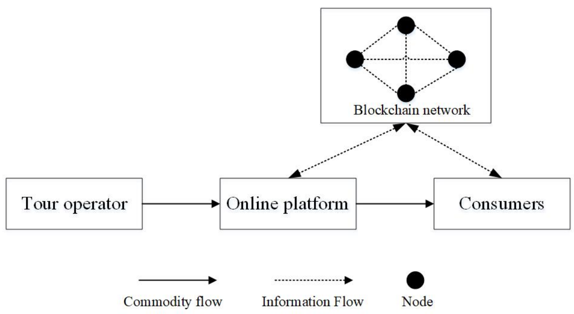


**Figure 1.** The structure of the tourism O2O supply chain.

The higher the quality of information disclosure, the more quickly consumers can understand the product and make purchase decisions, which can increase their utilities [26]. Now suppose that the utility of the consumer will be affected by perceived value [27], product price [28], and information disclosed quality [26]. Consumers' perceived value $v$ is uniformly distributed on [0, 1], and information-sensitive consumers have a sensitivity coefficient of 1 to the information quality. The online platform's decision to improve the quality of information disclosure can be marked as $\hat{\alpha}$, where $\hat{\alpha} \in (0, \alpha)$. Then, the utility functions of information-sensitive and information-insensitive consumers can be expressed as $v - p + \hat{\alpha}$ and $v - p$, respectively. Without loss of generality, the number of potential consumers in the market is normalized to 1, in which the proportion of information-sensitive consumers is $\lambda$, and the proportion of information-insensitive consumers is $1 - \lambda$. Then. the market demand function D can be expressed as:

$$D = \lambda \int_{p-\hat{\alpha}}^{1} f(v)dv + (1-\lambda) \int_{p}^{1} f(v)dv = 1 - p + \lambda\hat{\alpha} \quad (1)$$

## 4. The Scenario without Adopting Blockchain Technology

When the tour operator does not adopt blockchain technology, that is $\hat{\alpha} = 0$. Then, the demand can be expressed as:

$$D = 1 - p \tag{2}$$

### 4.1. Decentralized Scenario (WN)

In the decentralized scenario, the tour operator and the online tourism platform only focus on their own profits. The sequence of events is as follows: the tour operator charges wholesale prices from the online tourism platform. After that, the online tourism platform determines the sale price $p$. In this case, there is a Stackelberg game between the tour operator and the online tourism platform. The profit functions of the tour operator and online tourism platform are, respectively, expressed as:

$$\Pi_T(w) = (1-p)(w-c_T) \tag{3}$$

$$\Pi_O(p) = (1-p)(p-w-c_O) \tag{4}$$

**Proposition 1.** In the decentralized scenario, if the online tourism platform does not adopt blockchain technology to disclose information, the equilibrium results, including the sales price $p^{WN}$, wholesale price $w^{WN}$, market demand $D^{WN}$, online tourism platform profit ${\Pi_O}^{WN}$, tour operator profit ${\Pi_T}^{WN}$ and supply chain total profit $\Pi^{WN}$, are shown as follows:

$$p^{WN} = \frac{3+c_T+c_O}{4} \tag{5}$$

$$w^{WN} = \frac{1+c_T-c_O}{2} \tag{6}$$

$$D^{WN} = \frac{1-c_T-c_O}{4} \tag{7}$$

$$\prod\nolimits_T^{WN} = \frac{(1-c_O-c_T)^2}{8} \tag{8}$$

$$\prod\nolimits_O^{WN} = \frac{(1-c_O-c_T)^2}{16} \tag{9}$$

$$\prod\nolimits^{WN} = \frac{3(1-c_O-c_T)^2}{16} \tag{10}$$

**Proof of Proposition 1.** In the decentralized scenario, when the online platform does not adopt blockchain technology, the tour operator is the leader and determines the wholesale price; the online platform is the follower and determines the sales price. By using backward induction, we can first determine the second-order derivative of the platform's profit with respect to to $p$: $\frac{\partial^2 \prod_O}{\partial^2 p} = -2 < 0$, then we can find $\prod_O$ is concave in $p$. Then, the optimal sales price $p(w)$ can be obtained according to $\frac{\partial \prod_O}{\partial p} = 0$. Substituting $p(w)$ into the provider's profit function $\prod_T$ and determining the second derivative with respect to $w$, then we can obtain $\frac{\partial^2 \prod_T}{\partial^2 w} = -1 < 0$ and find that $\prod_T$ is also concave in $w$. Then we can get the optimal wholesale price w of the provider through solving $\frac{\partial \prod_T}{\partial w} = 0$. By substituting $w$ into Formulas (3) and (4), we can obtain the optimal equilibrium results. □

From Proposition 1, we can know that the price strategy and profits of the tour operator and online tourism platform are related to the unit cost of both parties. Among them, the wholesale price and sales price are positively correlated with unit production cost and unit sales cost, while the profits of both parties are negatively correlated with these unit costs. This is because as the unit costs of the tour operator and online tourism platform increase, the product sales price will increase, which can reduce product demand and lead to a decline in the profits of the tour operator and the online platform.

### *4.2. Centralized Scenario (WC)*

In the centralized scenario, if the online tourism platform does not adopt blockchain technology to disclose more information, the tour operator and the online tourism platform make decisions jointly. The total profit function of the tourism O2O supply chain can be expressed as

$$\prod(p) = (p - c_O - c_T)(1 - p) \tag{11}$$

**Proposition 2.** In the centralized scenario, if the online tourism platform does not adopt blockchain technology, the equilibrium results, including sales price $p^{WC}$, market demand $D^{WC}$, and supply chain total profit $\Pi^{WC}$ are:

$$p^{WC} = \frac{1 + c_O + c_T}{2} \tag{12}$$

$$D^{WC} = \frac{1 - c_O - c_T}{2} \tag{13}$$

$$\prod^{WC} = \frac{(1 - c_O - c_T)^2}{4} \tag{14}$$

**Proof of Proposition 2.** In the centralized scenario, when the online platform does not adopt blockchain technology, the tour operator and online platform determine the sales price jointly. We can first calculate the second-order derivative of the supply chain total profit with respect to $p$: $\frac{\partial^2 \prod}{\partial^2 p} = -2 < 0$, then, we can know that $\prod$ is concave in $p$. Therefore, the optimal sales price $p$ can be obtained according to $\frac{\partial \prod}{\partial p} = 0$. Substituting $p$ into Formula (11), we can obtain the optimal equilibrium results. □

**Corollary 1.** If the online tourism platform does not adopt blockchain technology to improve the information disclosure quality, then we have: $p^{WC} < p^{WN}$,$D^{WC} > D^{WN}$, $\prod^{WC} > \prod^{WN}$.

**Proof of Corollary 1.** By comparing Equations (5) and (12), (7) and (13), and (10) and (14), we can obtain $p^{WN} - p^{WC} = \frac{1-c_O-c_T}{4} > 0$, $D^{WC} - D^{WN} = \frac{1-c_O-c_T}{4} > 0$, and $\prod^{WC} - \prod^{WN} = \frac{(1-c_O-c_T)^2}{16} > 0$. □

Corollary 1 indicates that without blockchain technology, the sales price of the tourism product in the centralized scenario is lower than in the decentralized scenario, whereas the market demand and total revenue of the supply chain in the centralized scenario are greater than that in the decentralized scenario. It notes that when the node enterprises in the supply chain make decisions aimed at the overall profit maximization, the supply chain performance in that scenario is greater than that in the decentralized scenario.

## 5. The Scenario with Adopting Blockchain Technology

When the online platform adopts blockchain technology to improve the quality of information disclosure, that is $\hat{\alpha} = \alpha$, then the market demand can be expressed as:

$$D = \lambda \int_{p-\alpha}^{1} dv + (1-\lambda) \int_{p}^{1} dv = 1 - p + \lambda\alpha \tag{15}$$

### 5.1. Decentralized Scenario (BN)

In the decentralized scenario, if the online tourism platform adopts blockchain technology to improve the quality of information disclosure, the profits of the online tourism platform and tour operator can be expressed as:

$$\prod\nolimits_T(w) = (w - c_T)(1 - p + \lambda\alpha) \tag{16}$$

$$\prod\nolimits_O(p, \alpha) = (p - w - c_O)(1 - p + \lambda\alpha) - \frac{k}{2}\alpha^2 - F \tag{17}$$

**Proposition 3.** In the decentralized scenario, if the online tourism platform adopts blockchain technology to disclose information, the equilibrium results, including the information disclosure quality $\alpha^{BN}$, sales price $p^{BN}$, wholesale sales price $w^{BN}$, market demand $D^{BN}$, online tourism platform profit $\Pi_O{}^{BN}$, tour operator profit $\Pi_T{}^{BN}$ and supply chain total profit $\Pi^{BN}$ are:

$$\alpha^{BN} = \frac{\lambda(1 - c_T - c_O)}{4k - 2\lambda^2} \tag{18}$$

$$p^{BN} = \frac{(1 + c_O + c_T)\left(k - \lambda^2\right) + 2k}{4k - 2\lambda^2} \tag{19}$$

$$w^{BN} = \frac{1 - c_O + c_T}{2} \tag{20}$$

$$D^{BN} = \frac{k(1 - c_O - c_T)}{4k - 2\lambda^2} \tag{21}$$

$$\prod\nolimits_O^{BN} = \frac{k(1 - c_O - c_T)^2}{16k - 8\lambda^2} - F \tag{22}$$

$$\prod\nolimits_T^{BN} = \frac{k(1 - c_O - c_T)^2}{8k - 4\lambda^2} \tag{23}$$

$$\prod\nolimits^{BN} = \frac{3k(1 - c_O - c_T)^2}{16k - 8\lambda^2} - F \tag{24}$$

**Proof of Proposition 3.** In the decentralized scenario, when the online platform adopts blockchain technology, the tour operator is the leader and determines the wholesale price; the online platform is the follower and determines the sales price and the quality of information disclosure. By using backward induction, we can first determine the second-order partial derivatives of the platform's profit with respect to $p$ and $\alpha$, and the corresponding Hessian matrix is as follows: $H = \begin{bmatrix} \frac{\partial^2 \prod_O}{\partial p^2} & \frac{\partial^2 \prod_O}{\partial p \partial \alpha} \\ \frac{\partial^2 \prod_O}{\partial \alpha \partial p} & \frac{\partial^2 \prod_O}{\partial \alpha^2} \end{bmatrix} = \begin{bmatrix} -2 & \lambda \\ \lambda & -k \end{bmatrix}$. Because the Hessian matrix is a negative definite matrix, $\prod_O$ is a strictly concave function of $\alpha$ and $p$. By solving $\frac{\partial \prod_O}{\partial p} = 0$, $\frac{\partial \prod_O}{\partial \alpha} = 0$, we can obtain the optimal strategies $p(w)$ and $\alpha(w)$. Substituting $p(w)$ and $\alpha(w)$ into the provider's profit function and determining the second derivative with respect to w, then we can obtain $\frac{\partial^2 \prod_T}{\partial^2 w} = \frac{-2k}{2k-\lambda^2} < 0$ and find that $\prod_T$ is concave in $w$. Then, we can get the optimal wholesale price w of the provider through solving $\frac{\partial \prod_T}{\partial w} = 0$. By substituting w into Formulas (16) and (17), we can obtain the optimal equilibrium results. □

From Proposition 3, in the decentralized scenario, if the online tourism platform adopts blockchain technology to improve the quality of information disclosure, the optimal decision of the online tourism platform is related to the cost of information disclosure and the proportion of information-sensitive consumers. However, the tour operator does not consider these factors when making decisions and only considers the unit costs of both parties.

**Corollary 2.** In the decentralized scenario, if the online platform adopts blockchain technology to improve the quality of information disclosure, then

(1) $\frac{\partial \alpha^{BN}}{\partial \lambda} > 0, \frac{\partial p^{BN}}{\partial \lambda} > 0, \frac{\partial D^{BN}}{\partial \lambda} > 0, \frac{\partial \prod_O^{BN}}{\partial \lambda} > 0, \frac{\partial \prod_T^{BN}}{\partial \lambda} > 0$;
(2) $\frac{\partial \alpha^{BN}}{\partial k} < 0, \frac{\partial p^{BN}}{\partial k} < 0, \frac{\partial D^{BN}}{\partial k} < 0, \frac{\partial \prod_O^{BN}}{\partial k} < 0, \frac{\partial \prod_T^{BN}}{\partial k} < 0$.

**Proof of Corollary 2.** By calculating the first-order derivative of $\alpha$, $p$, $w$, $\prod_O^{BN}$ and $\prod_T^{BN}$ with respect to $\lambda$ and $k$, respectively, then we can obtain the results. □

Corollary 2 indicates that the quality of tourism product information disclosure, product sales prices, market demand, tourism operator profit, and online tourism platform profit are all positively correlated with the proportion of information-sensitive consumers and negatively correlated with the cost coefficient of information disclosure. It shows that as the proportion of information-sensitive consumers increases, the introduction of blockchain technology to improve information disclosure quality on online platforms will increase product demand, tourism operators will increase sales prices, and ultimately, the profits of supply chain members will increase. On the contrary, when the information disclosure cost coefficient increases, the online tourism platform will reduce the quality of information disclosure, the market demand will decrease, and the profits of supply chain members will also decrease.

**Corollary 3.** In the decentralized scenario, if the online platform adopts blockchain technology to improve the quality of information disclosure,

(1) When $\lambda \geq \hat{\lambda^N}$, then we have $\prod_O^{BN} \geq \prod_O^{WN}$, where $\hat{\lambda^N} = \sqrt{\frac{32Fk}{16F+(1-c_O-c_T)^2}}$;
(2) $p^{BN} > p^{WN}$, $D^{BN} > D^{WN}$, $w^{BN} = w^{WN}$, $\prod_T^{BN} > \prod_T^{WN}$;
(3) When $\lambda \geq \sqrt{\frac{32Fk}{[16F+3(1-c_O-c_T)^2]}}$, then we have $\prod^{BN} > \prod^{WN}$.

**Proof of Corollary 3.** (1) By simplifying Equations (9) and (22), we can obtain $\prod_O{}^{BN} - \prod_O{}^{WN} = \frac{(1-c_O-c_T)^2}{16(2k-\lambda^2)} - F$. Then, we can obtain that when $\lambda \geq \sqrt{\frac{32Fk}{16F+(1-c_O-c_T)^2}}$, $\prod_O^{BN} \geq \prod_O^{WN}$.
(2) By comparing Equations (5) and (19), (6) and (20), (7) and (21), and (8) and (23), respectively, we can obtain: $p^{BN} - p^{WN} = \frac{\lambda^2(1-c_O-c_T)}{8k-4\lambda^2} > 0, D^{BN} - D^{WN} = \frac{\lambda^2(1-c_O-c_T)}{4k-2\lambda^2} > 0$, $w^{BN} - w^{WN} = 0, \prod_T^{BN} - \prod_T^{WN} = \frac{\lambda^2(1-c_O-c_T)^2}{16k-8\lambda^2} > 0$.
(3) By comparing Equations (10) and (24), we can obtain: $\prod^{BN} - \prod^{WN} = \frac{3\lambda^2(1-c_O-c_T)^2}{32k-16\lambda^2} - F$. When $\geq \sqrt{\frac{32Fk}{16F+3(1-c_O-c_T)^2}}$, then we have $\prod^{BN} > \prod^{WN}$. □

From (1) in Corollary 3, we know that when the proportion of information-sensitive consumers in the market is lower than a certain threshold, the online travel platform will not adopt blockchain technology to improve the quality of information disclosure. Only when the proportion of information-sensitive consumers is large enough is it beneficial for the online platform to adopt blockchain technology. This is because when the proportion of consumers who are sensitive to the quality of the information in the market is large, the improvement of the quality of information disclosure will stimulate consumers to generate more consumer demand, making the profit increase greater than the cost of information disclosure. It can be seen from (2) that regardless of whether the online tourism platform adopts blockchain technology to improve the quality of information disclosure, the wholesale price remains unchanged because the wholesale price is only related to the unit cost of the tour operator and online travel platform. The adoption of blockchain technology to improve the quality of information disclosure has increased the market demand for travel products, and online travel platforms will increase the sales prices of the product. The decision of the online travel platform to adopt blockchain technology to improve the quality of information disclosure is always beneficial to tour operators because it will increase the market demand and thus increase the profit of tour operators. Here, (3) notes that only when the proportion of consumers who are sensitive to information quality is higher than the threshold will the decision to adopt blockchain technology to improve the quality of information disclosure increase the overall revenue of the supply chain.

### 5.2. Centralized Scenario (BC)

In the centralized scenario, if the online platform adopts blockchain technology to improve the quality of information disclosure, the total profit of the supply chain can be expressed as:

$$\prod = (p - c_T - c_O)(1 - p + \lambda\alpha) - \frac{k}{2}\alpha^2 - F \tag{25}$$

In this case, the tour operator and online travel platform as a whole, with the goal of maximizing overall profit, jointly determine the quality of product information disclosure and sales price $p$.

**Proposition 4.** In the centralized scenario, if the online tourism platform adopts blockchain technology to disclose information, the equilibrium results, including sales price $p^{BC}$, market demand $D^{BC}$ and supply chain total profit $\Pi^{BC}$ , are:

$$p^{BC} = \frac{k + (k - \lambda^2)(c_T + c_O)}{2k - \lambda^2} \tag{26}$$

$$\alpha^{BC} = \frac{\lambda(1 - c_T - c_O)}{2k - \lambda^2} \tag{27}$$

$$D^{BC} = \frac{k(1 - c_T - c_O)}{2k - \lambda^2} \tag{28}$$

$$\prod^{BC} = \frac{k(1 - c_T - c_O)^2}{4k - 2\lambda^2} - F \tag{29}$$

**Proof of Proposition 4.** In the centralized scenario, if the online platform adopts blockchain technology, the tour operator and the online platform jointly determine the sales price and the quality of information disclosure. We can first calculate the second-order partial derivatives of the supply chain total profit with respect to $p$ and $\alpha$, and the corresponding Hessian matrix is as follows: $H = \begin{bmatrix} \frac{\partial^2 \prod}{\partial p^2} & \frac{\partial^2 \prod}{\partial p \partial \alpha} \\ \frac{\partial^2 \prod}{\partial \alpha \partial p} & \frac{\partial^2 \prod}{\partial \alpha^2} \end{bmatrix} = \begin{bmatrix} -2 & \lambda \\ \lambda & -k \end{bmatrix}$. Because the Hessian matrix is a negative definite matrix, $\prod$ is a strictly concave function of $\alpha$ and $p$. By solving $\frac{\partial \Pi}{\partial p} = 0$, $\frac{\partial \Pi}{\partial \alpha} = 0$, we can obtain the optimal strategies $p$ and $\alpha$. By substituting $p$ and $\alpha$ into the supply chain total profit function, then we can obtain the optimal equilibrium results. □

Note that in Proposition 4, in the centralized scenario, when the tour operator and online platform as a whole adopt blockchain technology, the optimal decisions are also related to the cost of information disclosure and the proportion of information-sensitive consumers.

**Corollary 4.** If the online platform adopts blockchain technology to improve the quality of information disclosure, we have

(1) $\alpha^{BC} > \alpha^{BN}, D^{BC} > D^{BN}, \prod^{BC} > \prod^{BN}$;
(2) When $\lambda^2 > k$, then $p^{BC} > p^{BN}$, else $p^{BC} \leq p^{BN}$.

**Proof of Corollary 4.** By comparing Equations (18) and (27), (19) and (26), (21) and (28), and (24) and (29), respectively, then we can obtain: $\alpha^{BC} - \alpha^{BN} = \frac{\lambda(1-c_T-c_O)}{4k-2\lambda^2} > 0$, $p^{BC} - p^{BN} = \frac{(\lambda^2-k)(1-c_O-c_T)}{4k-2\lambda^2}$, $D^{BC} - D^{BN} = \frac{k(1-c_T-c_O)}{4k-2\lambda^2} > 0$, and $\prod^{BC} - \prod^{BN} = \frac{k(1-c_T-c_O)^2}{16k-8\lambda^2} > 0$. When $\lambda^2 > k$, we have $p^{BC} > p^{BN}$, or else $p^{BC} \leq p^{BN}$. □

From Corollary 4, it can be seen that the quality of information disclosure, market demand, and the total profit of supply chain members in the centralized scenario are greater than those under the decentralized scenario. When the proportion of information-sensitive consumers is large enough, the sales price in the centralized scenario is higher than in the decentralized scenario. The increase in revenue shows that through cooperation, both parties can achieve Pareto improvement. This is because in the decentralized scenario, both parties only consider their own profits when making decisions, and there is a double marginal effect, which results in the overall revenue of the tourism O2O supply chain being less than in the centralized scenario. Therefore, to avoid the double marginal effect between upstream and downstream members of the tourism O2O supply chain, both parties can cooperate to increase their own profits.

**Corollary 5.** (1) When $1 \geq \lambda \geq \hat{\lambda^C}$, then $\prod^{BC} \geq \prod^{WC}$, where $\hat{\lambda^C} = \sqrt{\frac{8Fk}{(1-c_O-c_T)^2+4F}}$, else $\prod^{BC} < \prod^{WC}$.
(2) $\hat{\lambda^C} < \hat{\lambda^N}$.

**Proof of Corollary 5.** (1) By comparing Equations (14) and (29), then we can obtain: $\prod^{BC} - \prod^{WC} = \frac{(1-c_T-c_O)^2}{4k-2\lambda^2} - F$. When $\lambda \geq \sqrt{\frac{8Fk}{(1-c_O-c_T)^2+4F}}$, we have $\prod^{BC} \geq \prod^{WC}$, else $\prod^{BC} < \prod^{WC}$.

(2) By comparing $\hat{\lambda^C}$ and $\hat{\lambda^N}$, we have $\hat{\lambda^C} - \hat{\lambda^N} = \sqrt{\frac{2k}{1+\frac{(1-c_O-c_T)^2}{4F}}} - \sqrt{\frac{2k}{1+\frac{(1-c_O-c_T)^2}{16F}}} < 0$.
□

(1) in Corollary 5 indicates that in the centralized scenario, when the proportion of information-sensitive consumers is larger than a certain threshold, adopting blockchain technology is beneficial to the supply chain. From (2) in Corollary 5, we know that in the centralized scenario, the possibility of the online travel platform adopting blockchain technology to disclose tourism product information is greater than in the decentralized scenario. This is because, in the centralized scenario, the online travel platform decides whether to disclose information to maximize the overall performance of the supply chain rather than just from the perspective of its own benefits.

## 6. Two-Part Tariff Contract for the Tourism O2O Supply Chain Coordination

According to the above analysis, we can find that when the tourism O2O supply chain members adopt wholesale price contracts and the decentralized decision-making condition, the two parties only consider their revenues, which will create a double marginal effect, resulting in a decrease in the overall efficiency of the supply chain. According to existing research, the two-part tariff contract is intended to distribute profits based on maximizing overall profits, which can increase the benefits of all parties and achieve a win-win situation [29]. Next, we adopt a two-part tariff contract to coordinate the supply chain. The specific form of the contract is shown as $(w, M)$. The tour operator first determines the wholesale price $w$ and the fixed payment $M$ charged to the online tourism platform. On this basis, the online tourism platform determines the product sales price $p$ and the quality of information disclosure aimed at maximizing its profit.

### *6.1. Without Adopting Blockchain Technology (WT)*

Under the two-part tariff contract, if the online tourism platform does not adopt blockchain technology to improve the quality of information disclosure, the profits of the online tourism platform, tour operator, and supply chain can be expressed as follows:

$$\prod_O = (p - w - c_O)(1 - p) - M \tag{30}$$

$$\prod_T = (w - c_T)(1 - p) + M \tag{31}$$

$$\prod = (p - c_T - c_O)(1 - p) \tag{32}$$

**Proposition 5.** Under the two-part tariff contract, if the online tourism platform does not adopt blockchain technology to disclose information, the equilibrium results, including wholesale price $w^{WT}$, sales price $p^{WT}$, market demand $D^{WT}$, online tourism platform profit $\Pi_O{}^{WT}$, tour operator profit $\Pi_T{}^{WT}$ and supply chain total profit $\Pi^{WT}$, are:

$$w^{WT} = c_T \tag{33}$$

$$p^{WT} = \frac{1 + c_T + c_O}{2} \tag{34}$$

$$D^{WT} = \frac{1 - c_T - c_O}{2} \tag{35}$$

$$\prod_O{}^{WT} = \frac{(1 - c_T - c_O)^2}{4} - M \tag{36}$$

$$\prod_T{}^{WT} = M \tag{37}$$

$$\prod{}^{WT} = \frac{(1 - c_T - c_O)^2}{4} \tag{38}$$

**Proof of Proposition 5.** Under the two-part tariff contract, if the online platform does not adopt blockchain technology, the tour operator as the leader determines the wholesale price, then the online platform determines the sales price, and finally, the online platform pays the fixed fee to the operator. By using backward induction, we can first determine the second-order derivative of the platform's profit with respect to $p$: $\frac{\partial^2 \prod_O}{\partial^2 p} = -2 < 0$. Then, we can find $\prod_O$ is concave in $p$. Then the optimal sales price $p(w, M)$ can be obtained according to $\frac{\partial \prod_O}{\partial p} = 0$. By substituting $p(w, M)$ into the supply chain total profit function

$\prod$ and determining the second-order derivative with respect to $w$, then we can obtain $\frac{\partial^2\prod}{\partial^2 w} = -\frac{1}{2} < 0$ and find that $\prod$ is also concave in $w$. Then we can get the optimal wholesale price w of the provider through solving $\frac{\partial\prod}{\partial w} = 0$. By substituting w into Formulas (30)–(32), then we can obtain the optimal equilibrium results. □

Note that for Proposition 5, under the coordination of the two-part tariff contract, the wholesale price of tourism products is equal to its unit production cost. That is to say, the tour operator aims to maximize the total profit of the supply chain when making the decision, and the income is the fixed payment collected from the online tourism platform, equivalent to a certain percentage of the supply chain's total profit.

**Corollary 6.** (1) $w^{WT} < w^{WN}$, $p^{WT} = p^{WC} < p^{WN}$, $D^{WT} = D^{WC} > D^{WN}$, and $\prod^{WT} = \prod^{WC} > \prod^{WN}$;

(2) When $\frac{(1-c_O-c_T)2}{8} \le M \le \frac{3(1-c_O-c_T)2}{16}$, $\prod_O{}^{WT} > \prod_O{}^{WN}$, $\prod_T{}^{WT} > \prod_T{}^{WN}$.

**Proof of Corollary 6.** (1) By comparing Equations (6) and (33), (5) and (34), (7) and (35), and (10) and (38), respectively, we can obtain: $w^{WN} - w^{WT} = \frac{1-c_O-c_T}{2} > 0$, $p^{WN} - p^{WT} = \frac{1-c_O-c_T}{4} > 0$, $D^{WT} - D^{WN} = \frac{1-c_O-c_T}{4} > 0$, and $\prod^{WT} - \prod^{WN} = \frac{(1-c_O-c_T)^2}{16} > 0$.

(2) By comparing Equations (9) and (36), (8) and (37), respectively, we can obtain $\prod_O{}^{WT} - \prod_O{}^{WN} = \frac{3(1-c_O-c_T)^2}{16} - M$ and $\prod_T{}^{WT} - \prod_T{}^{WN} = M - \frac{(1-c_O-c_T)^2}{16}$. It is obvious that when $\frac{(1-c_O-c_T)2}{8} \le M \le \frac{3(1-c_O-c_T)2}{16}$, $\prod_O{}^{WT} > \prod_O{}^{WN}$ and $\prod_T{}^{WT} > \prod_T{}^{WN}$. □

From (1) Corollary 6, we can observe that when the online tourism platform does not adopt blockchain technology, the wholesale price and sales price of the product under the two-part tariff contract are less than under the wholesale price contract, but the market demand and the total profit of the supply chain are higher than those under the wholesale price contract. Because the two-part tariff contracts can effectively avoid the double marginal effect, the product sales price and wholesale price under the two-part tariff contract are lower than under the wholesale price contract. The price drop brings about a substantial increase in demand, which in turn improves the efficiency of the supply chain. (2) Corollary 6 shows that only when the fixed payment M in the two-part tariff contract meets a certain condition, in which the online tourism platform and tourism operator under the two-part tariff contract are higher than those under the wholesale price contract, will both parties have an incentive to use a two-part tariff contract for coordination.

*6.2. With Adopting Blockchain Technology (BT)*

Under the two-part tariff contract, if the online tourism platform adopts blockchain technology to improve the quality of information disclosure, the profits of the online tourism platform, tour operator, and supply chain can be expressed as:

$$\prod{}_O = (p - w - c_O)(1 - p + \lambda\alpha) - \frac{k}{2}\alpha^2 - F - M \quad (39)$$

$$\prod{}_T = (w - c_T)(1 - p + \lambda\alpha) + M \quad (40)$$

$$\prod = (p - c_T - c_O)(1 - p + \lambda\alpha) - \frac{k}{2}\alpha^2 - F \quad (41)$$

In this case, there is a two-stage dynamic game between the tour operator and online tourism platform. In the first stage, the tour operator first determines $w$ and $M$; In the second stage, the online tourism platform determines the sales price $p$ and the quality of information disclosure from the perspective of maximizing the overall profit

**Proposition 6.** Under the two-part tariff contract, if the online tourism platform adopts blockchain technology to disclose information, the equilibrium results, including wholesale price $w^{BT}$, sales price $p^{BT}$, information disclosure quality $\alpha^{BT}$, market demand $D^{BT}$, online tourism platform profit $\Pi_O{}^{BT}$ , tourism operator profit $\Pi_T{}^{BT}$ and supply chain total profit $\Pi^{BT}$, are:

$$w^{BT} = c_T \tag{42}$$

$$p^{BT} = \frac{k + \left(k - \lambda^2\right)(c_T + c_O)}{2k - \lambda^2} \tag{43}$$

$$\alpha^{BT} = \frac{\lambda(1 - c_T - c_O)}{2k - \lambda^2} \tag{44}$$

$$D^{BT} = \frac{k(1 - c_O - c_T)}{2k - \lambda^2} \tag{45}$$

$$\prod_O{}^{BT} = \frac{k(1 - c_T - c_O)^2}{4k - 2\lambda^2} - F - M \tag{46}$$

$$\prod_T{}^{BT} = M \tag{47}$$

$$\prod^{BT} = \frac{k(1 - c_T - c_O)^2}{4k - 2\lambda^2} - F \tag{48}$$

**Proof of Proposition 6.** Similar to the proof of Proposition 3. □

Note that in Proposition 6, under the two-part tariff contract, if the online tourism platform adopts blockchain technology to improve the quality of information disclosure, the wholesale price of the product will still be equal to the unit production cost of the tourism product, but the sales price, information disclosure quality, market demand and the total profit of the supply chain are related to the unit cost of information disclosure and the proportion of information-sensitive consumers. The respective profits of the online tourism platform and tour operator still depend on the total profit of the supply chain.

**Corollary 7.** (1) $\alpha^{BT} = \alpha^{BC} > \alpha^{BN}$, $D^{BT} = D^{BC} > D^{BN}$, and $\prod^{BT} = \prod^{BC} > \prod^{BN}$;
(2) If $\lambda^2 > k$, then $p^{BT} = p^{BC} > p^{BN}$, else $p^{BC} = p^{BT} \leq p^{BN}$.

**Proof of Corollary 7.** (1) By comparing Equations (18), (27) and (44), we can obtain $\alpha^{BT} = \alpha^{BC} > \alpha^{BN}$. By comparing Equations (21), (28) and (45), we can obtain $D^{BT} = D^{BC} > D^{BN}$. By comparing Equations (24), (29) and (48), we can obtain that $\prod^{BT} = \prod^{BC} > \prod^{BN}$.

(2) By comparing Equations (19), (26) and (43), we can know that if if $\lambda^2 > k$, then we have $p^{BT} = p^{BC} > p^{BN}$; else $p^{BC} = p^{BT} \leq p^{BN}$. □

From Corollary 7, it follows that when the online tourism platform improves the quality of information disclosure, the market demand and total profit of supply chain members under the two-part tariff g contract are greater than under the wholesale price contract. When the proportion of information-insensitive consumers in the market is sufficiently large, the sales price under the two-part tariff contract is higher than under the wholesale price contract. Compared with the ordinary wholesale price contract, the total profit of the supply chain has increased, indicating that through cooperation, both parties can achieve Pareto improvement. This is because under the wholesale price contract, both parties only consider their own profits when making decisions, and there is a double marginal effect, which leads to the overall revenue of the tourism O2O supply chain being less than in the centralized decision-making condition. When the two parties use the two-part tariff contract for cooperation, it can effectively avoid double marginal effects and achieve Pareto improvement. Therefore, to avoid the double marginal effect between upstream and downstream members of the tourism O2O supply chain, both parties can adopt the two-part tariff contract for cooperation.

**Corollary 8.** (1) When $\frac{k(1-c_T-c_O)^2}{8k-4\lambda^2} \leq M \leq \frac{3k(1-c_T-c_O)^2}{16k-8\lambda^2}$, then $\prod_O{}^{BT} > \prod_O{}^{BN}$ and $\prod_T{}^{BT} > \prod_T{}^{BN}$.

(2) Under the two-part tariff contract, when $\lambda \geq \hat{\lambda^T}$, then $\prod_O^{BT} \geq \prod_O^{WT}$, $\prod^{BT} \geq \prod^{WT}$, where $\hat{\lambda^T} = \sqrt{\frac{8Fk}{4F+(1-c_O-c_T)^2}}$.

(3) $\hat{\lambda^T} = \hat{\lambda^C} < \hat{\lambda^N}$.

**Proof of Corollary 8.** (1) By comparing Equations (22) with (46), we can obtain $\prod_O{}^{BT} - \prod_O{}^{BN} = \frac{3k(1-c_O-c_T)^2}{16k-8\lambda^2} - M$. By comparing Equations (23) with (47), we have $\prod_T{}^{BT} - \prod_T{}^{BN} = M - \frac{k(1-c_O-c_T)^2}{8k-4\lambda^2}$. When $\frac{k(1-c_T-c_O)^2}{8k-4\lambda^2} \leq M \leq \frac{3k(1-c_T-c_O)^2}{16k-8\lambda^2}$, then we have $\prod_O{}^{BT} > \prod_O{}^{BN}$, $\prod_T{}^{BT} > \prod_T{}^{BN}$.

(2) By comparing Equations (36) with (46), we can obtain $\prod_O^{BT} - \prod_O^{WT} = \prod^{BT} - \prod^{WT} = \frac{\lambda^2(1-c_O-c_T)^2}{8k-4\lambda^2} - F$. When $\lambda \geq \sqrt{\frac{8Fk}{4F+(1-c_O-c_T)^2}}$, then we have $\prod_O^{BT} \geq \prod_O^{WT}$ and $\prod^{BT} \geq \prod^{WT}$.

(3) By comparing $\hat{\lambda^T}$, $\hat{\lambda^C}$ and $\hat{\lambda^N}$, we can obtain $\hat{\lambda^T} = \hat{\lambda^C}$ and $\hat{\lambda^T} = \hat{\lambda^C} - \hat{\lambda^N} \sqrt{\frac{2Fk}{F+\frac{1}{4}(1-c_O-c_T)^2}} - \sqrt{\frac{2Fk}{F+\frac{1}{16}(1-c_O-c_T)^2}} < 0$. □

From (1) in Corollary 8, we can observe that when the fixed payment under the two-part tariff contract is within a certain range, that is, the fixed payment from the online tourism platform to the tourism operator meets certain conditions, which can make the profits of the online tourism platform and tour operator not lower than the profits under the wholesale price contract, then both parties will have the incentive to accept the two-part tariff for coordination. Subsequently, the online tourism platform and tour operator can achieve Pareto improvement.

From (2) in Corollary 8, it can be seen that under the two-part tariff contract, when the proportion of information-sensitive consumers in the market is large enough, the adoption of blockchain technology is the best choice for the online tourism platform, which can increase its profit and the overall profit of the supply chain. This is because when the proportion of information-sensitive consumers is large, it means that more consumers are sensitive to information quality. The adoption of blockchain technology to improve the quality of information disclosure by the online tourism platform can improve the utility of these consumers, thereby encouraging information-sensitive consumers to purchase tourism products, which can expand the market demand. When the above conditions are met, the marginal benefit of improving the quality of information disclosure is larger than the cost, so the profits of the online tourism platform and the whole supply chain can be improved. Note that (3) in Corollary 8 shows that the online tourism platform under the two-part tariff contract is more likely to adopt blockchain technology to improve the quality of information disclosure than under the wholesale price contract. This is because the online tourism platform and tour operator share different proportions of the total supply chain revenue through fixed payment M under the two-part tariff contract. This mechanism can ensure that both parties aim to maximize the overall profit of the supply chain. Therefore, under a two-part tariff contract, the online tourism platform decides whether to improve the quality of information disclosure from an overall perspective rather than just considering its own benefits.

## 7. Numerical Analysis

In this section, we verify the above results through mathematical simulation and compare the equilibrium results under different scenarios and the effect of the proportion of information-sensitive consumers on the results more intuitively. Without loss of generality, we consider that the values of the parameters are $F = 0.05$, $k = 0.8$, $c_O = 0.01$, and $c_T = 0.01$. Additionally, the proportion of consumers who are sensitive to information changes from 0 to 1. Figure 2 shows the effect of the proportion of information-sensitive consumers on the sales price in different scenarios. When the online tourism platform adopts blockchain technology to improve the quality of information disclosure, the sales price of tourism products under the two-part tariff contract, which is equivalent to that in the centralized scenario, shows an increasing trend as the proportion of information-sensitive consumers increases; when the proportion of information-sensitive consumers is small, the sales price under the two-part tariff contract is lower than under the wholesale price contract. Only when the proportion of information-sensitive consumers is sufficiently large will the sales price under the two-part tariff contract be higher than the sales price under the wholesale price contract. When the online tourism platform does not adopt blockchain technology to improve the quality of information disclosure, the sales price of tourism products under the wholesale price contract is always higher than the sales price under the two-part tariff contract. Besides, we can observe that no matter what kind of contract is implemented, the sales price after improving the quality of information disclosure is always higher than without improving the quality of information disclosure. This is because there is always a certain percentage of consumers in the market who are sensitive to information; as long as the quality of information disclosure is improved, this part of consumers will be stimulated to purchase, and market demand will increase. Therefore, online tourism platforms will increase their product sales prices.

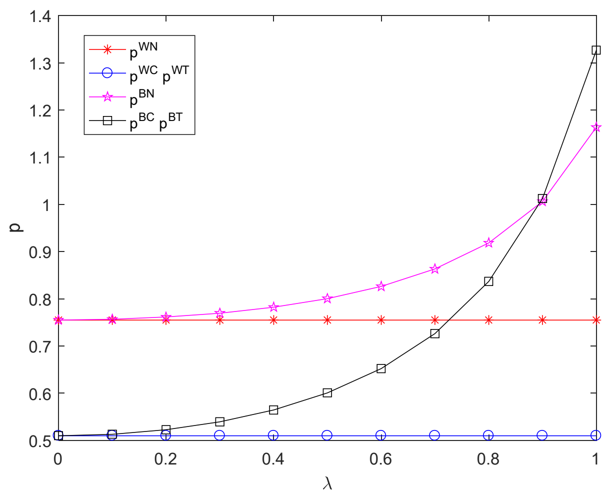


**Figure 2.** Sales price in different scenarios.

Figure 3 shows the effect of the proportion of information-sensitive consumers on the information disclosure quality in different scenarios. Under the two types of contracts, when the proportion of information-sensitive consumers increases, the quality of information disclosure also increases, and the quality under the two-part tariff contract is always higher than that under the wholesale price contract. This means that when the proportion of information-sensitive consumers in the market increases, it is the best strategy for online tourism platforms to improve the quality of information disclosure.

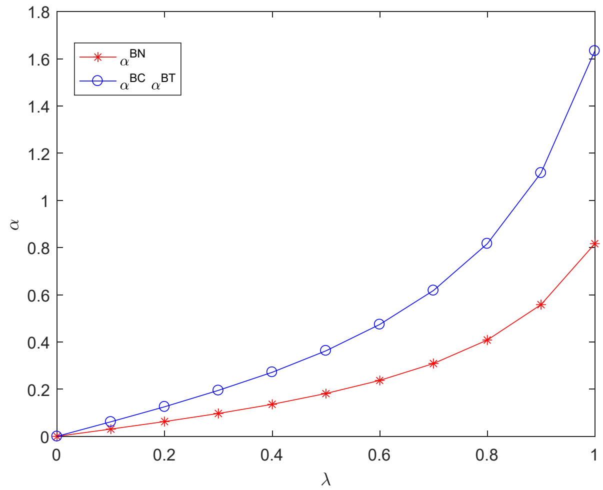


**Figure 3.** The quality of information disclosure in two types of contracts.

Figure 4 shows the effect of the proportion of information-sensitive consumers on the market demand in different scenarios. As long as there are information-sensitive consumers in the market, the market demand with blockchain technology is greater than without blockchain technology under both contracts. When the proportion of information-sensitive consumers increases and when the online tourism platform adopts blockchain technology to improve the quality of information disclosure under the two types of contracts, market demand will also increase. Additionally, it can be seen that regardless of whether the online tourism platform introduces blockchain technology, the market demand under the two-part tariff contract is also always higher than under the wholesale price contract. This is because the two-part tariff contract can effectively avoid double marginal effects, making the product sales price lower than under the wholesale price contract, which in turn will stimulate consumers to purchase; therefore, the market demand in the two-part tariff is greater.

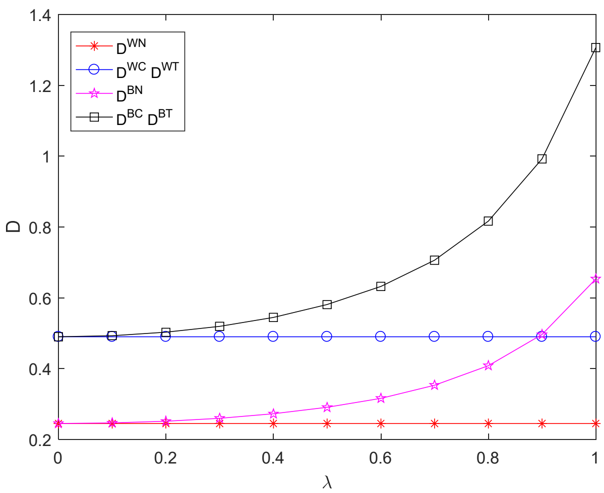


**Figure 4.** The demand in different scenarios.

Figure 5 shows the effect of the proportion of information-sensitive consumers on the supply chain total profit in different scenarios. We can observe that the total profit of the supply chain under the two-part tariff contract is always higher than under the wholesale price contract. Under the two types of contracts, when the online tourism platform adopts blockchain technology to improve the quality of information disclosure, the total profit of the supply chain increases as the proportion of information-sensitive consumers increases. When the proportion of information-sensitive consumers is low, the adoption of blockchain technology under the two types of contracts will cause the total profit of the supply chain to be lower than without blockchain technology. This is because when the proportion of information-sensitive consumers is small, the marginal benefit of improving the quality of information disclosure is less than the fixed cost of introducing blockchain technology and the marginal cost of improving the quality of information disclosure. Therefore, only when the proportion of information-sensitive consumers in the market is large enough will the adoption of blockchain technology to improve the quality of information disclosure benefit the whole supply chain. It also can be seen that the intersection of the total profit of the supply chain while improving the quality of information disclosure and not improving the quality of information disclosure under the two-part tariff contract is on the left side of that under the wholesale price contract. This means that the two-part tariff contract is less dependent on the proportion of information-sensitive consumers than the wholesale price contract; that is to say, the online tourism platform is more likely to adopt blockchain technology to improve the quality of information disclosure under the two-part tariff contract than the wholesale price contract.

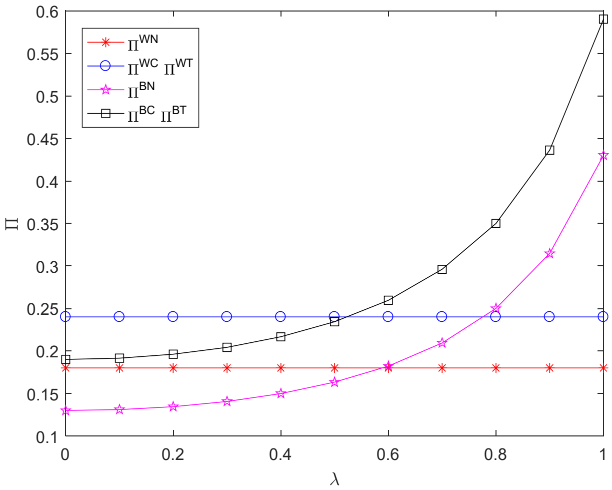


**Figure 5.** The supply chain total profit in different scenarios.

Figures 6 and 7 show the range of the fixed payment M under the two-part tariff contract. When the online tourism platform does not adopt blockchain technology to improve the quality of information disclosure, the fixed payment in the two-part tariff contract should ensure the profit of the online tourism platform and tour operator are not lower than those under the wholesale price contract. The value range of M is the area shown by the vertical stripes in Figure 6. As can be seen from the figure, the range of M is fixed. Figure 7 shows that when the online tourism platform adopts blockchain technology to improve the quality of information disclosure, the profits of the online tourism platform and tour operator under the wholesale price contract and the total profits of the supply chain under the two pricing contracts all increase as the proportion of information-sensitive consumers increases. The area shown by the vertical stripes in Figure 7 represents the range of M under the two-part tariff contract. It can be seen that the value and range of M both increase as the proportion of information-sensitive consumers increases, which means that as the proportion of information-sensitive consumers increases, the fixed payment that the tour operator charges online tourism platform will also be dynamically adjusted. This is because when the proportion of information-sensitive consumers increases, the profit of the online tourism platform will increase after improving the quality of information disclosure.

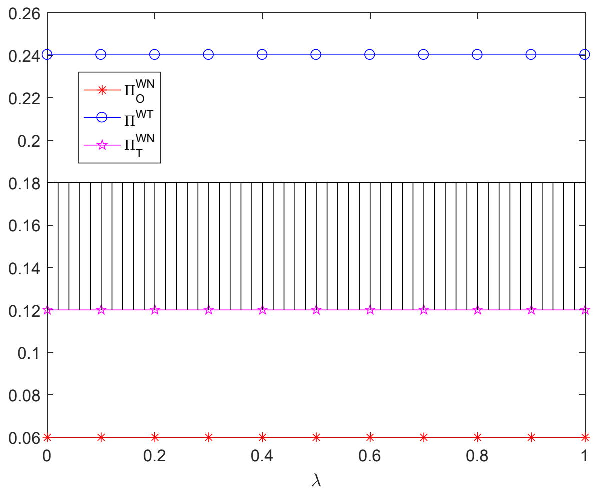


**Figure 6.** The range of fixed payments without blockchain technology.

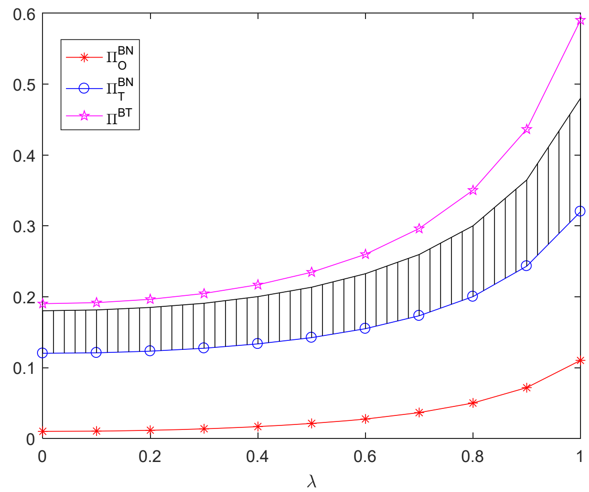


**Figure 7.** The range of fixed payments with blockchain technology.

## 8. Conclusions

The development of blockchain technology provides an opportunity for online tourism platforms to improve the quality of information disclosure in the tourism O2O supply chain. Whether the technology should be used to improve the quality of information disclosure to enhance its competitiveness is a question that online tourism platforms need to balance. This paper constructs a tourism O2O supply chain consisting of a tour operator and an online tourism platform. We study the optimal pricing strategy and the quality of information disclosure of the supply chain under different cooperation situations. After that, we obtain the following research conclusions and management implications:

(1) The initial investment cost of adopting blockchain technology, the cost of information disclosure, and the proportion of information-sensitive consumers have an important influence on the information disclosure decision of the online tourism platform. When the information disclosure cost coefficient is large, or the proportion of information-sensitive consumers in the market is small, the incremental income generated by the improvement of the information disclosure quality is less than the initial investment cost, which will cause the net profit of the online tourism platform to decrease. Therefore, the online tourism platform should not adopt blockchain technology to improve the quality of information disclosure. Only when the cost of information disclosure is small, or the proportion of information-sensitive consumers is large, making the profit when disclosing the infor-

mation greater than when not disclosing, is the introduction of blockchain technology to improve the quality of information disclosure beneficial to the online tourism platform;

(2) Improving the quality of information disclosure under the wholesale price contract always benefits the tour operator. While under the two-part tariff contract, only when the initial cost of introducing blockchain technology is small can the tour operator benefit from improving the quality of information disclosure. Under the wholesale price contract, the online tourism platform only considers its own benefit when making decisions. Only when the marginal benefits of improving the quality of information disclosure are higher than the cost of information disclosure will the online tourism platforms choose to adopt blockchain technology to improve the quality of information disclosure. In the two-part tariff contract, when the overall profit of the supply chain from improving the quality of information disclosure is higher than the cost of information disclosure, the online tourism platform will choose to introduce blockchain technology to improve the quality of information disclosure. Therefore, to encourage the online tourism platform to improve the quality of information disclosure, the tour operator can adjust the method of cooperation with the online tourism platform, changing from the traditional wholesale price contract to the two-part tariff contract. Under the two-part tariff contract, the online tourism platform is more likely to improve the quality of information disclosure compared with wholesale price contracts, and both parties can achieve Pareto improvement and achieve a win-win situation;

(3) The fixed payment in the two-part tariff contract has an important influence on the decisions of the online tourism platform and the tour operator. Only when the profits of the online tourism platform and the tour operator under the two-part tariff contract are higher than the wholesale price contract will the two parties accept this coordination contract. Regardless of whether the online tourism platform chooses to improve the quality of information disclosure, there is an interval value for the fixed payment, which improves the profits of both parties in the supply chain. When the online tourism platform chooses to improve the quality of information disclosure, the fixed payment is related to the proportion of information-sensitive consumers. If there are more information-sensitive consumers in the market, the fixed payment in the two-part tariff is also larger. This is because when the proportion of information-sensitive consumers increases, product sales price and market demand will increase, so improving the quality of information disclosure can increase the overall profit of the supply chain. Therefore, the fixed payment in the two-part tariff contract will also increase.

This paper mainly studies the information disclosure and pricing strategy in a tourism O2O supply chain. Future research can consider the impact of competition between supply chains on information disclosure and pricing decisions. Furthermore, for a platform, multiple tour operators that provide tourism products with the same quality can replace each other. The distribution problem of product information disclosure level under the limited resources from the perspective of online tourism platforms needs to be explored.

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