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Joint service, pricing and advertising strategies with tourists' green tourism experience in a tourism supply chain

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ABSTRACT

We consider the supply chain in the tourism industry, in which tourists are susceptible to the tourists' green tourism experience when they make purchase decisions for a green tourism product. Our research considers a green tourism supply chain (GTSC) consisting of one scenic spot (SS) and one travel agency (TA), and studies the joint green tourism service, pricing and advertising problem of the SS and the TA. We establish Stackelberg differential game models between the SS and the TA in the centralized, decentralized and revenue-sharing scenarios, and apply Pontryagin's maximum principle to obtain the dynamic equilibrium solutions of the GTSC members. Based on the three different scenarios, we analyze influences of the tourists' green tourism experience concern level, the wholesale ticket price and the sharing ratio on the optimal decisions and performances of the GTSC. This paper is the first quantitative research to study the green tourism service effort, pricing and advertising strategies of the GTSC members and design GTSC improvement contract with considering the green tourism experience. Our results provide management insights for the SS and the TA to manage GTSC under the green tourism preferences and the green tourism experience of tourists.

1. Introduction

With the popularization of environmental protection, tourists are more and more willing to experience green tourism products. According to the Global Sustainable Travel Report in 2018, 87% of tourists prefer to consume green sustainable tourism products (Booking, 2018). The enhancement of public awareness of environmental protection promotes tourists' preference for green tourism products. Meanwhile, tourists are willing to pay more expensive prices for green tourism products. The Global Sustainable Travel Report pointed out that 67% of tourists are willing to pay 5% more for green tourism products to reduce the destroy of tourism activities to scenic spots (Booking, 2018). The survey conducted by MMGY Global also indicated that 32% of tourists are willing to pay 10% more for the green tourism products to show environmental responsibility (Travelagentcentral, 2020). As a result, designing and promoting green tourism products is one of the most effective ways for scenic spots and travel agencies to attract tourists. For example, the Korea Tourism Organization provided a variety of green eco-tourism products for green tourists (VisitKorea, 2020). Besides, governments are also actively promoting green tourism. As early as 1983, the World Conservation Union proposed the term "green tourism", which was defined as a tourism behavior of protecting the environment and improving the welfare of local residents in natural areas. In 1993, the National Parks and Wildlife Conservation Act was promulgated in England, aiming to strengthen the protection of ecological environment. In 2013, China promulgated the tourism law of the people's Republic of China to realize the rational utilization of tourism resources and the sustainable development of tourism. Restricted by the sustainable tourism policy and motivated by the high tourists demand towards green tourism products, reasonable tourism service greenness level and high green quality tourism products are critical to the effective operation and management of scenic spots and travel agencys. For readability, we use SS, TA and GTSC instead of scenic spot, travel agency and green tourism supply chain respectively in this paper.

The main feature of green tourism products is to provide tourists with the green quality tourism products. With the desire for green tourism, people pay more attention to the green quality and tourism service level of green tourism products than to their prices. For green tourism products, tourists often have an expected green quality before they purchase or experience them. The expected green quality of tourists

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is usually related to various market factors, such as the retail price and goodwill of green tourism products (Nieto-Garcia et al., 2017; Choi et al., 2019), advertising and green service efforts of SSs and TAs, etc (Huang and Bai, 2021). Meanwhile, tourists can directly perceive the green quality of the tourism products and generate the perceived green quality of the tourism products after they purchase and use green tourism products (Rahman and Soesilo, 2018). The perceived green quality depends on the green service efforts of SSs and TAs and the tourism resources. Tourists can get the green tourism experience of the tourism products by comparing the difference between the expected green quality and perceived green quality of green tourism products. When the perceived green quality is higher than the expected green quality, the tourist will has a positive green tourism experience, she will switch to the negative experience if the perceived green quality is lower than that. Green tourism experience is a critical factor affecting tourists' purchase behaviors.

As effective marketing tools to improve the revenues of SSs and TAs, the pricing and advertising of green tourism products are also the important factors affecting tourists' consumption. Due to the real-time nature and the ability to bring more profits for enterprises, dynamic pricing strategy is widely applied in transportation industry, healthcare industry, tourism industry, e-commerce industry and other industries (He et al., 2018b; Buratto et al., 2019). Tourism products, as service products closely related to climate conditions and geographical location, have different prices in different seasons. The dynamic pricing of tourism products can adjust the relationship between supply and demand, reduce the pressure of peak season, improve the utilization rate of tourism resources of slack season and promote the balanced development of tourism industry. Advertising is used by the travel agency to send information about green tourism products to tourists and to induce purchase (Malekian and Rasti-Barzoki, 2019; Xie et al., 2020). TA can release tourism product advertising via new media such as websites, traditional media such as newspapers and magazines, and local posters. An effective advertising strategy can not only improve the demand of tourists for tourism products, but also enhance the goodwill level of tourism products. In 2019, Global advertising spending reached $609.9 billion, an increase of 3.6% over 2018 (Firstoutdoormedia, 2019). Therefore, it is of great significance to study the advertising and pricing decision of the TA on green tourism products.

With the development of human civilization and the improvement of global economic level, tourism industry has become the fastest growing industry in the world (Lozano et al., 2016). People are keen to relieve the pressure of life through tourism, and more and more advocate green tourism (Galeazzo et al., 2020). Meanwhile, the competition among tourism enterprises is becoming more and more intense in order to win the favor of tourists. Poor green tourism experience of tourists, advertising and pricing of tourism products, and green service efforts of SSs and TAs can easily affect tourists' purchase behaviors, leading to the tourism enterprises can not operate smoothly. Therefore, SSs and TAs should invest in competitive green service efforts to provide more competitive green tourism products for tourists (Rahman and Soesilo, 2018), plan corresponding advertising activities to make tourists know more about green tourism products and enhance tourists' loyalties to products and brands (Moon and Han, 2019), and set an attractive retail price for green tourism products to stimulate product demand of tourists (Malekian and Rasti-Barzoki, 2019). Recently, scholars are more and more interested in advertising and pricing in tourism management practice (Jena and Meena, 2019; Khorshidvand et al., 2021). But it should not be forgotten that for green tourism products, the green service efforts of tourism enterprises and the green tourism experience of tourists also play an important role in the demand of tourists (Jena and Meena, 2019; Ponnapureddy et al., 2020). Although many literatures have studied green tourism, the previous researches on pricing and advertising ignore the impact of green service efforts of SSs and TAs and green tourism experience of tourists on the demand, while the researches on tourists' green tourism experience have never explored the pricing, advertising and green service efforts of tourism enterprises from a quantitative perspective. Therefore, we incorporate green tourism service efforts, pricing, advertising and tourists' green tourism experience into a dynamic framework to investigate the dynamic decision-makings of the GTSC. We are trying to address the following key problems:

1. What are the optimal green tourism service effort, advertising and pricing strategies for the SS and the TA in the centralized/decentralized/revenue-sharing scenarios?
2. How does the green tourism experience concern level of tourists affect the equilibrium strategies and maximal profits of the GTSC members in three different scenarios?
3. How do the wholesale ticket price of the SS and the sharing ratio of the TA affect the equilibrium strategies and performances of the GTSC in the three different scenarios?
4. Can the revenue-sharing contract between the SS and the TA improve the performance of the GTSC?

To answer these questions, we consider a GTSC composed of one SS and one TA. The SS acts as a leader to determine the green development, design and manufacture, and maintenance efforts, whereas the TA acts as a follower to determine the green marketing and consumption efforts, advertising effort and the retail price. We characterize the demand of tourists which is affected by the tourism service greenness level, goodwill level and retail price of the green tourism product and the green tourism experience of tourists. We obtain the green tourism service effort, advertising effort and pricing strategies in the centralized/decentralized/revenue-sharing scenario via Stackelberg differential game models. The analytical equilibrium solutions and the profits of the GTSC members in the three different scenarios are compared and analyzed. To improve the performance of the GTSC, we also design the cost-sharing contract between the SS and the TA, which provides reference for the contract selection of the GTSC members. As far as we know, our research is the first to explore the dynamic pricing, advertising and tourism service effort of the GTSC considering the green tourism experience of tourists, deduce the dynamic equilibrium solutions of the GTSC members, and analyze the influences of the green tourism experience concern level, the wholesale ticket price and the sharing ratio on the optimal decision-makings of the GTSC members and the performance of the GTSC. This study yields interesting findings and provides management insights for tourism management operators.

The rest of this study is organized as follows. Section 2 draws the literature review. Section 3 presents assumptions and notations of the model. Section 4 develops differential game models in different scenarios. Section 5 compares the analytical equilibrium solutions for all scenarios. Pareto improvement mechanism is designed and studied in Section 6. Conclusions and future researches are given in Section 7.

2. Literature review

Our paper relates to three representative literature streams: green sustainable tourism management, pricing and advertising decisions and tourists' green tourism experience.

2.1. Green sustainable tourism management

The first stream focusing on the management in green sustainable tourism. Most of the researches are about green hotel management (Kang et al., 2012; Chen, 2019; Nhat et al., 2019; Nam et al., 2020; Ponnapureddy et al., 2020). Lozano et al. (2016) established a tourism supply chain composed of one tour operator and several green hotels, and indicated that the tour operator can encourage the green operation of the hotels by subsidizing the green costs of them. Hussain et al. (2019) analyzed the impact of green technologies on the hotel supply chain management, and pointed out that green technologies improve the economic performance of the hotel supply chain, but has no obvious improvement on environmental performance. Asadi et al. (2020) identified the main influencing factors of hotel green management, and analyzed the impact of these factors on sustainable hotel supply chain management respectively. Other part of literatures focus on sustainable tourism supply chain management (Tol, 2007; Budeanu, 2009; Wang et al., 2012; Paramati et al., 2017; Richards and Font, 2019; Galeazzo et al., 2020). Sigala (2008) designed a theoretical model of sustainable tourism supply chain management, and applied this model to study the actual case of TUI. He et al. (2018) developed an evolutionary game model among the government, tourism enterprises and tourists, and explored the green incentive mechanism of the government to tourism enterprises. He et al. (2019) studied the strategic choice of traditional tourism strategy and green tourism innovation strategy of two competing tourism operators with considering the environmental preference of tourists. Huang et al. (2019) analyzed the behaviors of the tourism enterprises in the sustainable tourism supply chain, and designed a performance evaluation system of this sustainable tourism supply chain. Different from the above papers, we consider a GTSC consist of one SS and one TA, and establish differential game models to investigate the green tourism service efforts, advertising and pricing strategies of supply chain members in the dynamic environment.

2.2. Pricing and advertising decisions

The second representative stream of literature related to pricing and advertising decisions (Liu et al., 2015; Song et al., 2017; Farshbaf-Geranmayeh et al., 2018; He et al., 2018; Buratto et al., 2019; Xie et al., 2020; Taleizadeh et al., 2020; Khorshidvand et al., 2021). SeyedEsfahani et al. (2011) considered a supply chain composed of one manufacturer and one retailer, and studied the optimal advertising and pricing decisions of supply chain members. Lu et al. (2016) studied the optimal pricing and advertising strategies of the monopolistic firm. Jena et al. (2017) considered five different closed-loop supply chain scenarios and studied the optimal advertising and pricing strategies of supply chain members under the uncertain demand of remanufactured/new products and uncertain returns. Rad et al. (2018) established a vendor-buyer supply chain inventory model with imperfect products and shortages, and determined the optimal pricing and advertising strategies of supply chain members. Taboubi (2019) examined the optimal pricing and advertising strategies of the bilateral monopoly supply chain, and proposed the retail price incentive mechanism and the advertising allowance mechanism to mitigate the double marginalization. Chernonog and Avinadav (2019) investigated the pricing and advertising decisions of perishable product supply chain under asymmetric information, introduced three different contracts between manufacturer and retailer and analyzed the profit change of supply chain members. Considering a perishable product supply chain composed of one manufacturer and one retailer, Chernonog (2020) simulated the optimal pricing and advertising decisions of supply chain members. Considering a perishable product sales enterprise with psychological inventory effect, Dye (2020) obtained the optimal pricing, advertising and psychological inventory strategies. The difference between this stream of literature and our work is that we not only jointly investigate the green tourism service efforts, advertising and pricing strategies of the GTSC members, but also further consider the green tourism experience of tourists, and analyze the impacts of green tourism experience concern level, wholesale price and sharing ratio on the optimal decision-makings of the SS and the TA and supply chain performance.

2.3. Tourist experience

Researches on tourism experience mainly focus on the relationship between tourism experience and tourist satisfaction (Quan and Wang, 2004; Cutler et al., 2014; Chiu et al., 2014; Ghaderi et al., 2019). Tan et al. (2013) explored the essence of creative tourism from the perspective of tourists, and used the grounded theory approach to build the creative tourism experience model. De Vos and Witlox (2017) analyzed the relationship between tourist satisfaction and tourists' well-being, travel mode choice, tourism preference and residential location. Taking Jerusalem's religious tourism as an example, Albayrak et al. (2018) investigated tourists' perception experience of religious tourism, and found that tourists' religious tourism experience significantly affected tourist satisfaction. Taking island tourism as an example, Moon and Han (2019) investigated the relationship among tourists' island tourism experience, tourist perception, tourist satisfaction and tourist loyalty. Agyeiwaah et al. (2019) examined the relationship among the tourism experience, tourism satisfaction and tourism loyalty of culinary tourism by using a structural equation model approach. Based on the yoga tourism in India, Sharma & Nayak (2019) established a correlation model between tourists' yoga tourism experience and tourist satisfaction. Tourism experience information is an important factor influencing tourists' purchase of tourism products. By reviewing the aforementioned papers of tourism experience, we find that so far no scholars have quantitatively analyzed the impact of tourism experience on tourists' purchase decisions. Therefore, our research fills this gap and becomes the first quantitative work to explore the relationship between tourists' green tourism experience and tourists' purchase decisions. In addition, the tourists' green tourism experience also has significant impacts on the operation strategies of the SS and the TA. Therefore, it is necessary to further analyze the impact of the tourism experience concern level of tourists on the optimal tourism service efforts, pricing and advertising strategies of the SS and the TA.

The contributions of this paper are summarized as follows. First, we characterize the dynamic trajectory of the greenness level of tourism service, which not only involves the improvement of greenness level brought by green tourism service efforts of the SS and the TA, but also considers the decay of the greenness level of tourism service over time. Our model well depicts the change of the greenness level of tourism service with the advancement of environmental protection technology or the improvement of tourism service standard. Second, the green tourism experience of tourists is described by mathematical expression, and quantitative research is carried out in this paper. Green tourism experience is an important factor affecting tourists' purchase behaviors, and also plays a significant role in the operation decision-makings of the SS and the TA, but it has never been quantitatively studied before. Our research is the first quantitative analysis work of green tourism experience in the field of tourism management to analyze how the tourism experience concern level of tourists affects their own purchase decisions, as well as the optimal tourism service efforts, advertising and pricing decisions of the GTSC members. Third, the revenue-sharing contract between the SS and the TA, which transfers part of the revenue of the TA to the SS, can not improve the performance of supply chain. We find that the revenue-sharing contract can neither coordinate the GTSC dynamically nor achieve the Pareto improvement of the GTSC, but deteriorates the profits of the SS and the TA. Fourth, the cost sharing scenario is considered in the extension section, and the revenue-sharing contract and the cost sharing contract are analyzed and compared. The results show that the cost sharing contract is better than revenue-sharing contract. Although it can not coordinate the GTSC, but it can achieve its Pareto improvement.

3. Model description and assumptions

Facing the increasing awareness of sustainable tourism, scenic spots and travel agencies are interested in improving the environmental performance of tourism products to achieve sustainable economic and environmental development (Knobloch et al., 2017). We consider a GTSC composed of one scenic spot and one travel agency, in which the scenic spot is responsible for green development, green design and manufacture, and green maintenance for tourism resources and provides tickets for travel agency. The travel agency carries out green marketing and green consumption for tourism resources, and finally provides green tourism products for tourists. The green tourism services provided by the scenic spot and travel agency stimulates the demand of tourists for green tourism products due to the green tourism preference of tourists. In addition, the green tourism experience occurred by tourists' perception of green tourism products also greatly affects the purchase decisions of tourists. The problem discussed in this paper is presented in Fig. 1.

The travel agency negotiates with the scenic spot and reaches an agreement before offering green tourism product to tourists. For simplicity, we assume that the scenic spot determines its green tourism service effort $g_1(t)$ and the wholesale ticket price provided to the travel agency ω, the travel agency controls its green tourism service effort $g_2(t)$, the advertising effort $f(t)$ and the retail price of the green tourism product $p(t)$. The SS and the TA make decisions autonomously to maximize their own profits. The travel agency takes the scenic spot's wholesale ticket price and green tourism service effort $g_1(t)$ into consideration when making its own decisions on pricing, advertising effort and green tourism service effort $g_2(t)$. Therefore, we model the association between the SS and the TA as a Stackelberg game, in which the scenic spot is dominant and the travel agency is the follower. The notation used in this paper are presented in Table 1.

Let $Q(t)$ indicate the greenness level of tourism service. Due to the increasing environmental awareness of tourists and their preference for green tourism products, the SS and the TA actively invest in green tourism service efforts to improve the greenness level of tourism service. On the other hand, the existing investments are aging over time, thus the greenness level of tourism service is in a state of natural depreciation. The differential equation of the greenness level of tourism service is expressed as

$$\dot{Q}(t) = \rho_1 g_1(t) + \rho_2 g_2(t) - \delta Q(t)\ ,\ Q(0) = Q_0, \tag{1}$$

where ρ_1 and ρ_2 are green tourism service sensitivities to green tourism service efforts of the SS and the TA, $\delta > 0$ refers to the decay rate of the greenness level of tourism service.

The green tourism service efforts of the SS and the TA can alleviate the deterioration of the natural environment caused by the development of tourism resources, raise the greenness level of tourism products, and have a positive impact on the goodwill of green tourism products. Moreover, the goodwill of tourism products is also positively affected by the advertising effort of the travel agency (He et al., 2019; Khorshidvand et al., 2021). Therefore, the differential equation of goodwill can be described as

$$\dot{G}(t) = \varepsilon f(t) + \eta Q(t) - \tau G(t)\ ,\ G(0) = G_0, \tag{2}$$

where $G(t)$ refers to the goodwill of green tourism products, η and ε are respectively the sensitivity of product goodwill to the greenness level of tourism service and the advertising effort.

The green quality of green tourism products which related to the green tourism service efforts of the SS and the TA perceived by tourists is expressed as

Table 1
Notations of parameters and variables.

Notations	Descriptions
Parameters	
ρ_1, ρ_2	Impacts of green service efforts on greenness level of tourism service
ε, η	Impacts of advertising effort and tourism service greenness level on goodwill level
κ_1, κ_2, κ_3	Effects of green tourism experience, tourism service greenness level, goodwill level on product sales
λ_1, λ_2	Effects of green service efforts on service quality of green tourism product
δ, τ	Decay rates of the green tourism service and goodwill of green tourism product
r	Di/scount rates of the SS and the TA
ω	Wholesale ticket price of the scenic spot
Variables	
$Q(t)$	Accumulated tourism service greenness level of green tourism product
$G(t)$	Accumulated goodwill level of green tourism product
$q(t)$	Green quality of green tourism product
$\tilde{q}(t)$	Tourist's expected green quality of green tourism product
$S(t)$	Sales of green tourism product
$C_{g_1}(t)$, $C_{g_2}(t)$, $C_f(t)$	Cost functions of the SS and the TA
$V_S(t)$, $V_R(t)$	Value functions of the SS and the TA
Decision variables	
$g_1(t)$, $g_2(t)$	Green service efforts toward green tourism service of the SS and the TA
$f(t)$	Advertising effort toward tourism product goodwill level of the travel agency
$p(t)$	Retail price of the travel agency

$$q(t) = \lambda_1 g_1(t) + \lambda_2 g_2(t) + \lambda_3,$$

where λ_3 is the initial service quality of green tourism products, λ_1 and λ_2 are the sensitivity of perceived green quality to green tourism service efforts $g_1(t)$ and $g_2(t)$. According to He et al. (2018), tourists will expect that a famous travel agency provides a higher green quality tourism product, or a tourism product with high goodwill should have a good green quality. Therefore, we assume that

$$\tilde{q}(t) = \phi G(t),$$

where $\phi > 0$ is a positive parameter related to the expected green quality of tourists. When tourists purchase and use green tourism products, they can perceive the green quality of tourism products through the green service efforts of the SS and TA. After the tourism products are used, the tourists can obtain the green tourism experience by comparing the expected green quality and perceived green quality of green tourism products. Based on this assumption, we express the tourists' green tourism experience which is formed by tourists' purchase, use and

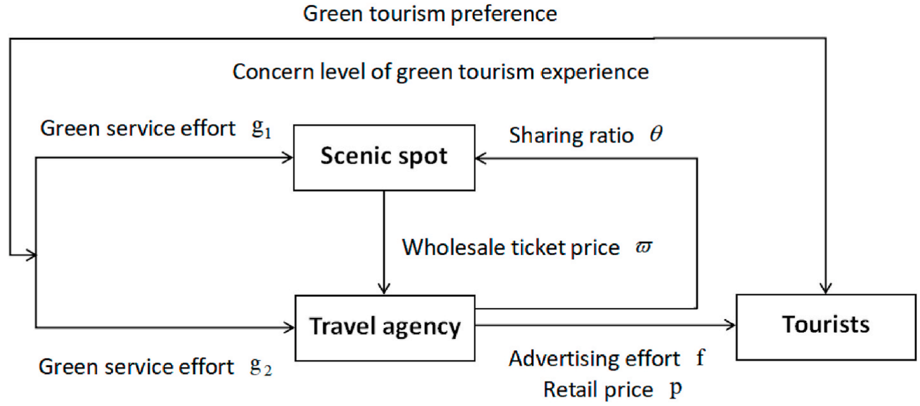

Fig. 1. The structure of green tourism supply chain.

perceive of green tourism product represent as $q(t)-\widetilde{q}(t)$. We can consider that the tourists have a pleasant green tourism experience for green tourism products when $q(t)-\widetilde{q}(t)\geq 0$, and green qualities of tourism products is worthy of the name.

In our paper, the tourist demand of green tourism product $S(t)$ in a separable multiplicative way between price and non-price factors. We denoted the demand of green tourism products as

$$S(t)=(a-bp(t))(\kappa_1(q(t)-\widetilde{q}(t))+\kappa_2 Q(t)+\kappa_3 G(t)).$$

The price factor is $a-bp(t)$, where a is the market capacity of green tourism products and b is the price sensitivity of tourists. As mentioned above, the demand of tourists for green tourism product is related to the goodwill level, the tourism service greenness level and the green tourism experience of tourists. The non-price factor $\kappa_1(q(t)-\widetilde{q}(t))+\kappa_2 Q(t)+\kappa_3 G(t)$, where κ_2 indicates the influence of the tourism service greenness level on demand, i.e. tourists' green preference for tourism products; κ_3 indicates the influence of goodwill level on demand, i.e. the brand preference of tourists for the travel agency; κ_1 indicates the concern level of tourists to green tourism experience. Specifically, the term $q(t)>\widetilde{q}(t)$ means that the perceived green quality of green tourism products is higher than the expected green quality, which will form a positive green tourism experience, and the demand of tourists for tourism products increase (Ye et al., 2020). On the contrary, the perceived green quality is lower than expected, which will occur a negative tourism experience and reduce tourists' demand for green tourism products.

Similar to El Ouardighi et al. (2016), we assume that green tourism service cost functions of the SS and the TA and advertising cost function of TA are quadratic in green tourism service efforts and the advertising effort. In addition, the unit cost of the scenic spot is normalized as 0 (Giovanni, 2011).

$$C_{g_1}(t)=\frac{g_1(t)^2}{2},\ C_{g_2}(t)=\frac{g_2(t)^2}{2},\ C_f(t)=\frac{f(t)^2}{2},$$

4. Model solutions and discussions

In this section, we first introduce the tourism service greenness level and goodwill level dynamics in the centralized scenario, where the SS and the TA maximize the profits of the whole channel by determining the retail price of green tourism products, green tourism service efforts and advertising effort. Then, we discuss a decentralized scenario, in which the SS makes the green tourism service effort $g_1(t)$, while the TA controls the retail price of green tourism products, the green tourism service effort $g_2(t)$ and advertising effort. The SS and the TA make decisions independently to maximize their own profit. The SS is the leader of Stackelberg game, and the TA is the follower. Finally, we consider a revenue-sharing contract between the SS and the TA. θ represents the sharing ratio of the TA in revenue generated from each unit, $1-\theta$ is the sharing ratio of the SS. In other words, on the basis of decentralized scenario, the TA needs to pay a percentage of the revenue generated by itself in addition to a wholesale ticket price for each unit purchased to the SS. All proofs of the propositions and corollaries are put in the Appendix.

4.1. The centralized scenario

The SS and the TA are vertically integrated as a whole system under the centralized scenario. The objective is to find the optimal retail price of green tourism product, advertising effort of the travel agency and green tourism service efforts of the SS and the TA while maximizing the channel profits. The optimization problem for the centralized scenario is given by

$$\max_{p,g_1,g_2,f} V^C(t)=\int_0^\infty e^{-rt}\{p(t)S(t)-C_{g_1}(t)-C_{g_2}(t)-C_f(t)\}dt, \tag{3}$$

For any $Q(t)>0$ and $G(t)>0$, the maximal profit of the centralized supply chain at time t in the Hamilton-Jacobi-Bellman equation satisfies the equation

$$rV^C=\max_{p,g_1,g_2,f}\left(\begin{array}{l} p(a-bp)(\kappa_1\lambda_3+\kappa_1\lambda_1 g_1+\kappa_1\lambda_2 g_2+\kappa_2 Q+(\kappa_3-\kappa_1\phi)G)-\frac{g_1^2}{2}-\frac{g_2^2}{2}-\frac{f^2}{2} \\ +V_Q^{C'}(\rho_1 g_1+\rho_2 g_2-\delta Q)+V_G^{C'}(\varepsilon f+\eta Q-\tau G) \end{array}\right).$$

The following proposition give the optimal equilibrium solutions of the GTSC under the centralized scenario.

Proposition 1. *The differential game* (1)-(3) *has a unique equilibrium solution solution as follows*

(i) *The optimal green tourism service effort g_1^{C*} of the SS, the optimal green tourism service effort g_2^{C*}, advertising effort f^{C*} and green tourism product's retail price p^{C*} of the TA are as follows*

$$p^{C*}=\frac{a}{2b},\ g_1^{C*}=\frac{\kappa_1\lambda_1 a^2}{4b}+\frac{a^2((r+\tau)\kappa_2+(\kappa_3-\kappa_1\phi)\eta)\rho_1}{4b(r+\delta)(r+\tau)},$$

$$g_2^{C*}=\frac{\kappa_1\lambda_2 a^2}{4b}+\frac{a^2((r+\tau)\kappa_2+(\kappa_3-\kappa_1\phi)\eta)\rho_2}{4b(r+\delta)(r+\tau)},\ f^{C*}=\frac{a^2(\kappa_3-\kappa_1\phi)\varepsilon}{4b(r+\tau)}.$$

(ii) *The equilibrium tourism service greenness level Q^{C*} and goodwill level G^{C*} are given by*

$$\begin{cases} Q^{C*}(t)=Q_\infty^C+\left(Q_0-Q_\infty^C\right)e^{-\delta t}, \\ G^{C*}(t)=G_\infty^C+\frac{\eta}{(\tau-\delta)}\left(Q_0-Q_\infty^C\right)e^{-\delta t}+\left(G_0-G_\infty^C-\frac{\eta\left(Q_0-Q_\infty^C\right)}{(\tau-\delta)}\right)e^{-\tau t}, \end{cases}$$

where

$$Q_\infty^C=\frac{(r+\delta)(r+\tau)(\rho_1+\rho_2)\kappa_1\lambda_1 a^2+((r+\tau)\kappa_2+(\kappa_3-\kappa_1\phi)\eta)\rho_1 a^2\left(\rho_1^2+\rho_2^2\right)}{4b(r+\delta)(r+\tau)\delta},$$

$$G_\infty^C=\frac{a^2\delta(r+\delta)(\kappa_3-\kappa_1\phi)\varepsilon^2+\eta(r+\delta)(r+\tau)(\rho_1+\rho_2)\kappa_1\lambda_1 a^2+((r+\tau)\kappa_2+(\kappa_3-\kappa_1\phi)\eta)\eta\rho_1 a^2\left(\rho_1^2+\rho_2^2\right)}{4b(r+\delta)(r+\tau)\delta\tau}.$$

(iii) *The maximal profit of the GTSC* V^{C*} *is*

$$V^{C*}=\frac{a^2((r+\tau)\kappa_2+(\kappa_3-\kappa_1\phi)\eta)}{4b(r+\delta)(r+\tau)}Q^{C*}+\frac{a^2(\kappa_3-\kappa_1\phi)}{4b(r+\tau)}G^{C*}$$
$$+\frac{\kappa_1a^4(\rho_1\lambda_1+\rho_2\lambda_2)((r+\tau)\kappa_2+(\kappa_3-\kappa_1\phi)\eta)}{16rb^2(r+\delta)(r+\tau)}+\frac{a^4\left(\rho_1^2+\rho_2^2\right)((r+\tau)\kappa_2+(\kappa_3-\kappa_1\phi)\eta)^2}{32rb^2(r+\delta)^2(r+\tau)^2}$$
$$+\frac{a^4(\kappa_3-\kappa_1\phi)^2\varepsilon^2}{32rb^2(r+\tau)^2}+\frac{a^2}{4br}\left(\kappa_1\lambda_3+\frac{a^2\kappa_1^2\lambda_1^2}{8b}+\frac{\kappa_1^2\lambda_2^2a^2}{8b}\right).$$

Proposition 1 indicates that all the equilibrium solutions under the centralized scenario remain constant over time. From the perspective of the GTSC managers, they can directly maintain constant retail price of tourism products, green tourism service efforts and advertising effort. The retail price of green tourism product relatives to market potential a and price sensitivity parameter b. The sensitivities of tourism product green quality relative to green tourism service efforts λ_1 and λ_2 positively affect the green tourism service efforts of the SS and the TA. The sensitivity of goodwill depend on advertising effort of the travel agency has a positive impact on advertising effort. On the contrary, the decay rate of goodwill δ has a negative impact on green tourism service efforts and advertising effort. In addition, a non-negative optimal advertising effort is ensured by assuming that $\kappa_3>\kappa_1\phi$. At last, the tourism service greenness level and goodwill level of tourism product achieve steady states as time passes toward infinity.

Corollary 1. *For the optimal solutions p^{C*}, g_1^{C*}, g_2^{C*} and f^{C*} with respect to key parameters ρ_1, ρ_2, ε, η, κ_1, κ_2 and κ_3. (i) We have $\frac{\partial g_1^{C*}}{\partial \rho_1}>0$ and $\frac{\partial g_2^{C*}}{\partial \rho_2}>0$; (ii) We have $\frac{\partial f^{C*}}{\partial \varepsilon}>0$, $\frac{\partial g_1^{C*}}{\partial \eta}>0$ and $\frac{\partial g_2^{C*}}{\partial \eta}>0$; (iii) We have $\frac{\partial g_1^{C*}}{\partial \kappa_1}>0$ when $\lambda_1(r+\tau)(r+\delta)>\phi\eta\rho_1$, and $\frac{\partial g_1^{C*}}{\partial \kappa_1}<0$ when $\lambda_1(r+\tau)(r+\delta)<\phi\eta\rho_1$; (iv) We have $\frac{\partial g_2^{C*}}{\partial \kappa_1}>0$ when $\lambda_2(r+\tau)(r+\delta)>\phi\eta\rho_2$, and $\frac{\partial g_2^{C*}}{\partial \kappa_1}<0$ when $\lambda_2(r+\tau)(r+\delta)<\phi\eta\rho_2$; (v) We have $\frac{\partial f^{C*}}{\partial \kappa_1}<0$, $\frac{\partial g_1^{C*}}{\partial \kappa_2}>0$ and $\frac{\partial g_2^{C*}}{\partial \kappa_2}>0$; (vi) We have $\frac{\partial f^{C*}}{\partial \kappa_3}>0$, $\frac{\partial g_1^{C*}}{\partial \kappa_3}>0$ and $\frac{\partial g_2^{C*}}{\partial \kappa_3}>0$.*

Corollary 1 *shows that the SS and the TA will invest more efforts in green tourism service to improve the greenness level of tourism service when the green tourism service efforts are more effective to the tourism service greenness level. Meanwhile, the more sensitive the goodwill level of product related to the advertising efforts and the greenness level of tourism service, the more advertising effort and green tourism service efforts are invested by the SS and the TA. Tourists pay sufficiently high attention to the green tourism experience when $\lambda_1(r+\tau)(r+\delta)>\phi\eta\rho_1$, then g_1^{C*} increases with the increase of κ_1. The TA implements a relatively low advertising effort to satisfy their higher expected green quality of the green tourism product when tourists' demand is more sensitive to green tourism experience. Moreover, the TA makes a relatively high advertising effort to improve the goodwill of the green tourism product when the demand of tourists is sensitive to the goodwill level. Finally, when the sensitivity of tourists' demand to the levels of tourism service greenness and goodwill is more significant, the SS and the TA invest more in green tourism service efforts.*

4.2. The decentralized scenario

The SS and the TA make decisions independently to maximize their own profit under the decentralized scenario. As the Stackelberg leader, the SS decides its green tourism service effort $g_1(t)$ first. Then the TA chooses the advertising effort, the green tourism service effort $g_2(t)$ and the retail price of green tourism product. The decision problems of the SS and the TA are respectively expressed as

$$V_S(t)=\int_0^\infty e^{-rt}\left\{\omega S(t)-C_{g_1}(t)\right\}dt, \tag{4}$$

$$\max_{p,g_2,f}V_R(t)=\int_0^\infty e^{-rt}\left\{(p(t)-\omega)S(t)-C_{g_2}(t)-C_f(t)\right\}dt. \tag{5}$$

For any $Q(t)>0$ and $G(t)>0$, the maximal profits of the SS and the TA at time t in the Hamilton-Jacobi-Bellman equation satisfy the following equations

$$rV_S^D=\max_{g_1}\left(\begin{array}{c}\omega(a-bp)(\kappa_1\lambda_3+\kappa_1\lambda_1g_1+\kappa_1\lambda_2g_2+\kappa_2Q+(\kappa_3-\kappa_1\phi)G)-\frac{g_1^2}{2}\\ +V_{SQ}^{D'}(\rho_1g_1+\rho_2g_2-\delta Q)+V_{SG}^{D'}(\varepsilon f+\eta Q-\tau G)\end{array}\right),$$

$$rV_R^D=\max_{p,g_2,f}\left(\begin{array}{c}(p-\omega)(a-bp)(\kappa_1\lambda_3+\kappa_1\lambda_1g_1+\kappa_1\lambda_2g_2+\kappa_2Q+(\kappa_3-\kappa_1\phi)G)-\frac{g_2^2}{2}-\frac{f^2}{2}\\ +V_{RQ}^{D'}(\rho_1g_1+\rho_2g_2-\delta Q)+V_{RG}^{D'}(\varepsilon f+\eta Q-\tau G)\end{array}\right).$$

Proposition 2 summarizes the optimal equilibrium solutions of the Stackelberg game between the SS and the TA under the decentralized scenario.

Proposition 2. *The differential game* (1) (2) (4) (5) *has a unique equilibrium solution solution as follows*:

(i) *The optimal green tourism service effort g_1^{D*} of the SS, the optimal green tourism service effort g_2^{D*} and advertising effort f^{D*} of the TA and retail price of green tourism product p^{D*} are as follows*

$$p^{D*}=\frac{a+\omega b}{2b},\quad g_1^{D*}=\frac{\omega(a-\omega b)\kappa_1\lambda_1}{2}+\frac{\rho_1\omega(a-\omega b)((r+\tau)\kappa_2+(\kappa_3-\kappa_1\phi)\eta)}{2(r+\delta)(r+\tau)},$$

$$g_2^{D*}=\frac{\kappa_1\lambda_2(a-\omega b)^2}{4b}+\frac{\rho_2(a-\omega b)^2((r+\tau)\kappa_2+(\kappa_3-\kappa_1\phi)\eta)}{4b(r+\tau)(r+\delta)},\quad f^{D*}=\frac{\varepsilon(a-\omega b)^2(\kappa_3-\kappa_1\phi)}{4b(r+\tau)}.$$

(ii) *The equilibrium tourism service greenness level* Q^{D^*} *and goodwill level* G^{D^*} *are given by*

$$\begin{cases} Q^D(t) = Q^D_\infty + \left(Q_0 - Q^D_\infty\right)e^{-\delta t}, \\ G^D(t) = G^D_\infty + \dfrac{\eta}{(\tau-\delta)}\left(Q_0 - Q^D_\infty\right)e^{-\delta t} + \left(G_0 - G^D_\infty - \dfrac{\eta\left(Q_0 - Q^D_\infty\right)}{(\tau-\delta)}\right)e^{-\tau t}, \end{cases}$$

where

$$Q^D_\infty = \frac{\begin{pmatrix} (a-\omega b)(r+\delta)(r+\tau)(2\rho_1\lambda_1\omega b + \rho_2\lambda_2(a-\omega b))\kappa_1 \\ +(a-\omega b)((r+\tau)\kappa_2 + (\kappa_3 - \kappa_1\phi)\eta)\left(2\rho_1^2\omega b + \rho_2^2(a-\omega b)\right) \end{pmatrix}}{4b(r+\delta)(r+\tau)\delta},$$

$$G^D_\infty = \frac{\begin{pmatrix} \varepsilon^2(a-\omega b)^2(r+\delta)(\kappa_3-\kappa_1\phi)\delta + \eta\kappa_1(a-\omega b)(r+\delta)(r+\tau)(2\rho_1\lambda_1\omega b + \rho_2\lambda_2(a-\omega b)) \\ +\eta(a-\omega b)((r+\tau)\kappa_2 + (\kappa_3-\kappa_1\phi)\eta)\left(2\rho_1^2\omega b + \rho_2^2(a-\omega b)\right) \end{pmatrix}}{4b\tau(r+\delta)(r+\tau)\delta}.$$

(iii) *The maximal profits of the SS* $V_S^{D^*}$ *and the TA* $V_R^{D^*}$ *are*

$$V_S^{D^*} = \alpha_{21}Q^{D^*} + \beta_{21}G^{D^*} + \gamma_{21}\ ,\ V_R^{D^*} = \alpha_{22}Q^{D^*} + \beta_{22}G^{D^*} + \gamma_{22}.$$

where

$$\alpha_{21} = \frac{\omega(a-\omega b)((r+\tau)\kappa_2 + (\kappa_3-\kappa_1\phi)\eta)}{2(r+\delta)(r+\tau)}, \beta_{21} = \frac{\omega(a-\omega b)(\kappa_3-\kappa_1\phi)}{2(r+\tau)},$$

$$\gamma_{21} = \frac{\alpha_{21}\kappa_1(a-\omega b)}{2r}\left(\rho_1\lambda_1\omega + \frac{\rho_2\lambda_2(a-\omega b)}{2b}\right) + \frac{\alpha_{22}\kappa_1\lambda_2\rho_2\omega(a-\omega b)}{2r} + \frac{{\alpha_{21}}^2{\rho_1}^2 + 2\beta_{21}\beta_{22}\varepsilon^2 + 2\alpha_{21}\alpha_{22}{\rho_2}^2}{2r} + \frac{\omega(a-\omega b)}{2r}\left(\kappa_1\lambda_3 + \frac{\omega(a-\omega b){\kappa_1}^2{\lambda_1}^2}{4} + \frac{{\kappa_1}^2{\lambda_2}^2(a-\omega b)^2}{4b}\right),$$

$$\alpha_{22} = \frac{(a-\omega b)^2\left(\left(r+\tau\right)\kappa_2 + \left(\kappa_3-\kappa_1\phi\right)\eta\right)}{4b(r+\tau)(r+\delta)}, \beta_{22} = \frac{(a-\omega b)^2\left(\kappa_3-\kappa_1\phi\right)}{4b(r+\tau)},$$

$$\gamma_{22} = \frac{\alpha_{22}\kappa_1(a-\omega b)}{2r}\left(\rho_1\lambda_1\omega + \frac{\rho_2\lambda_2(a-\omega b)}{2b}\right) + \frac{\alpha_{21}\kappa_1\lambda_1\rho_1(a-\omega b)^2}{4br} + \frac{{\alpha_{22}}^2{\rho_2}^2 + {\beta_{22}}^2\varepsilon^2 + 2\alpha_{21}\alpha_{22}{\rho_1}^2}{2r} + \frac{(a-\omega b)^2}{4br}\left(\kappa_1\lambda_3 + \frac{\omega(a-\omega b){\kappa_1}^2{\lambda_1}^2}{2} + \frac{{\kappa_1}^2{\lambda_2}^2(a-\omega b)^2}{8b}\right).$$

We explore a scenario in which the SS, as the leader of the Stackelberg game, decides the green tourism service effort $g_1^{D^*}$*, the TA as the follower, determines the green tourism service effort* $g_2^{D^*}$*, advertising effort* f^{D^*} *and retail price of green tourism product* p^{D^*}*. The analytical equilibrium retail price, green tourism service efforts, advertising effort, greenness level of tourism service, goodwill level of green tourism product and profits of the GTSC members under the decentralized scenario are shown in Proposition 2. Comparing the results of above propositions, it is not difficult to find that the TA increases the retail price of green tourism product, while reducing the green tourism service effort and advertising effort in the decentralized scenario. This is due to the setting of scenario and the long-term decisions of TA to pursue profit maximization.*

Corollary 2. *For the optimal equilibrium solutions* p^{D^*}*,* $g_1^{D^*}$*,* $g_2^{D^*}$ *and* f^{D^*} *with respect to parameter* ω*. (i) We have* p^{D^*} *and* $g_1^{D^*}$ *increase with an increase in* ω*; (ii) We have* $g_2^{D^*}$ *and* f^{D^*} *decrease as* ω *is increasing.*

Recall that ω *denotes the wholesale ticket price of the SS. Corollary 2 shows that the retail price of green tourism product increases as the wholesale ticket price increases. The reason for this phenomenon is that the TA buy tickets at a higher wholesale price, its prefers to set a higher retail price of green tourism product to keep profit. When the wholesale ticket price of the SS increases, the SS has the responsibility to provide tourists with a higher green quality tourism product, so he will invest more effort in green tourism service. In contrast, the TA reduces its green tourism service effort when the wholesale ticket price of the SS increases. This is because the relatively high wholesale ticket price leads to a relatively low profit of the TA, thus the TA reduces its green tourism service effort to decrease its expenditure on green tourism service. In addition, the TA also tends to reduce advertising effort to save costs as the wholesale ticket price of SS increases.*

4.3. The revenue-sharing scenario

Similar to the decentralized scenario, the SS dominates the supply chain and announces the green tourism service effort $g_1(t)$ first under the revenue-sharing scenario. And then, the TA sets the green tourism service effort $g_2(t)$, advertising effort and the retail price of green tourism

Table 2
Optimal solutions of models.

Scenarios	Optimal solutions	
Centralized	$p^{C^*}=\frac{a}{2b}$	$g_1^{C^*}=\frac{\kappa_1\lambda_1 a^2}{4b}+\frac{a^2((r+\tau)\kappa_2+(\kappa_3-\kappa_1\phi)\eta)\rho_1}{4b(r+\delta)(r+\tau)}$
	$f^{C^*}=\frac{a^2(\kappa_3-\kappa_1\phi)\varepsilon}{4b(r+\tau)}$	$g_2^{C^*}=\frac{\kappa_1\lambda_2 a^2}{4b}+\frac{a^2((r+\tau)\kappa_2+(\kappa_3-\kappa_1\phi)\eta)\rho_2}{4b(r+\delta)(r+\tau)}$
Decentralized	$p^{D^*}=\frac{a+\omega b}{2b}$	$g_1^{D^*}=\frac{\omega(a-\omega b)\kappa_1\lambda_1}{2}+\frac{\rho_1\omega(a-\omega b)((r+\tau)\kappa_2+(\kappa_3-\kappa_1\phi)\eta)}{2(r+\delta)(r+\tau)}$
	$f^{D^*}=\frac{(a-\omega b)^2(\kappa_3-\kappa_1\phi)\varepsilon}{4b(r+\tau)}$	$g_2^{D^*}=\frac{\kappa_1\lambda_2(a-\omega b)^2}{4b}+\frac{\rho_2(a-\omega b)^2((r+\tau)\kappa_2+(\kappa_3-\kappa_1\phi)\eta)}{4b(r+\tau)(r+\delta)}$
Revenue-sharing	$p^{N^*}=\frac{a\theta+\omega b}{2b\theta}$	$g_1^{N^*}=\frac{(a\theta(1-\theta)+\omega b(1+\theta))(a\theta-\omega b)\kappa_1\lambda_1}{4b\theta^2}+\frac{(a\theta(1-\theta)+\omega b(1+\theta))(a\theta-\omega b)((r+\tau)\kappa_2+(\kappa_3-\kappa_1\phi)\eta)\rho_1}{4b(r+\tau)(r+\delta)\theta^2}$
	$f^{N^*}=\frac{(a\theta-\omega b)^2(\kappa_3-\kappa_1\phi)\varepsilon}{4b(r+\tau)\theta}$	$g_2^{N^*}=\frac{\kappa_1\lambda_2(a\theta-\omega b)^2}{4b\theta}+\frac{\rho_2(a\theta-\omega b)^2((r+\tau)\kappa_2+(\kappa_3-\kappa_1\phi)\eta)}{4b(r+\tau)(r+\delta)\theta}$

product. In addition, the TA pays the SS a wholesale price for each unit ticket of SS, plus a certain proportion of the income of the TA. The decision problems of the SS and the TA can be written as

$$\max_{g_1} V_S(t)=\int_0^{\infty} e^{-rt}\left\{((1-\theta)p(t)+\omega)S(t)-C_{g_1}(t)\right\}dt, \tag{6}$$

$$\max_{p,g_2,f} V_R(t)=\int_0^{\infty} e^{-rt}\left\{(\theta p(t)-\omega)S(t)-C_{g_2}(t)-C_f(t)\right\}dt. \tag{7}$$

For any $Q(t)>0$ and $G(t)>0$, the maximal profits of the SS and the TA satisfy the Hamilton-Jacobi-Bellman equations as

$$rV_S^N=\max_{g_1}\left(\begin{array}{l}((1-\theta)p+\omega)(a-bp)(\kappa_1\lambda_3+\kappa_1\lambda_1 g_1+\kappa_1\lambda_2 g_2+\kappa_2 Q\\ +(\kappa_3-\kappa_1\phi)G)-\frac{g_1^2}{2}+V_{SQ}^{N'}(\rho_1 g_1+\rho_2 g_2-\delta Q)+V_{SG}^{N'}(\varepsilon f+\eta Q-\tau G)\end{array}\right),$$

$$rV_R^N=\max_{p,g_2,f}\left(\begin{array}{l}(\theta p-\omega)(a-bp)(\kappa_1\lambda_3+\kappa_1\lambda_1 g_1+\kappa_1\lambda_2 g_2+\kappa_2 Q+(\kappa_3-\kappa_1\phi)G)-\frac{g_2^2}{2}-\frac{f^2}{2}\\ +V_{RQ}^{N'}(\rho_1 g_1+\rho_2 g_2-\delta Q)+V_{RG}^{N'}(\varepsilon f+\eta Q-\tau G)\end{array}\right).$$

The optimal equilibrium solution of the SS and the TA under the revenue-sharing scenario can be expressed as the following propositions.

Proposition 3. *The differential game* (1) (2) (6) (7) *has a unique equilibrium solution as follows*

(i) *The optimal green tourism service effort $g_1^{N^*}$ of the SS, the optimal green tourism service effort $g_2^{N^*}$ and advertising effort f^{N^*} of the TA and retail price of green tourism products p^{N^*} are as follows*

$$p^{N^*}=\frac{a\theta+\omega b}{2b\theta},\ g_2^{N^*}=\frac{\kappa_1\lambda_2(a\theta-\omega b)^2}{4b\theta}+\frac{\rho_2(a\theta-\omega b)^2((r+\tau)\kappa_2+(\kappa_3-\kappa_1\phi)\eta)}{4b(r+\tau)(r+\delta)\theta},\ f^{N^*}=\frac{(a\theta-\omega b)^2(\kappa_3-\kappa_1\phi)\varepsilon}{4b(r+\tau)\theta},$$
$$g_1^{N^*}=\frac{(a\theta(1-\theta)+\omega b(1+\theta))(a\theta-\omega b)\kappa_1\lambda_1}{4b\theta^2}+\frac{(a\theta(1-\theta)+\omega b(1+\theta))(a\theta-\omega b)((r+\tau)\kappa_2+(\kappa_3-\kappa_1\phi)\eta)\rho_1}{4b(r+\tau)(r+\delta)\theta^2}.$$

(ii) *The equilibrium tourism service greenness level Q^{N^*} and goodwill level G^{N^*} are given by*

$$\begin{cases}Q^{N^*}(t)=Q_\infty^N+\left(Q_0-Q_\infty^N\right)e^{-\delta t},\\ G^{N^*}(t)=G_\infty^N+\frac{\eta}{(\tau-\delta)}\left(Q_0-Q_\infty^N\right)e^{-\delta t}+\left(G_0-G_\infty^D-\frac{\eta\left(Q_0-Q_\infty^N\right)}{(\tau-\delta)}\right)e^{-\tau t},\end{cases}$$

where

$$Q_{\infty}^{N}=\frac{\left(\begin{array}{c}(r+\tau)(r+\delta)\left(\frac{(a\theta(1-\theta)+\omega b(1+\theta))(a\theta-\omega b)\lambda_1\rho_1}{\theta}+\lambda_2(a\theta-\omega b)^2\rho_2\right)\kappa_1\\+((r+\tau)\kappa_2+(\kappa_3-\kappa_1\phi)\eta)\left(\frac{(a\theta(1-\theta)+\omega b(1+\theta))(a\theta-\omega b)\rho_1^2}{\theta}+(a\theta-\omega b)^2\rho_2^2\right)\end{array}\right)}{4b\delta(r+\tau)(r+\delta)\theta},$$

$$G_{\infty}^{N}=\frac{\left(\begin{array}{c}\delta(r+\delta)(a\theta-\omega b)^2(\kappa_3-\kappa_1\phi)\varepsilon^2+\eta(r+\tau)(r+\delta)\left(\frac{(a\theta(1-\theta)+\omega b(1+\theta))(a\theta-\omega b)\lambda_1\rho_1}{\theta}+\lambda_2(a\theta-\omega b)^2\rho_2\right)\kappa_1\\+\eta((r+\tau)\kappa_2+(\kappa_3-\kappa_1\phi)\eta)\left(\frac{(a\theta(1-\theta)+\omega b(1+\theta))(a\theta-\omega b)\rho_1^2}{\theta}+(a\theta-\omega b)^2\rho_2^2\right)\end{array}\right)}{4b\delta(r+\tau)(r+\delta)\theta\tau}.$$

(iii) *The maximal profits of the SS $V_S^{N^*}$ and the TA $V_R^{N^*}$ are*

$$V_S^{N^*}=\alpha_{31}Q^{N^*}+\beta_{31}G^{N^*}+\gamma_{31}\ ,\ V_R^{N^*}=\alpha_{32}Q^{N^*}+\beta_{32}G^{N^*}+\gamma_{32}.$$

where

$$\alpha_{31}=\frac{(a\theta(1-\theta)+\omega b(1+\theta))(a\theta-\omega b)((r+\tau)\kappa_2+(\kappa_3-\kappa_1\phi)\eta)}{4b(r+\tau)(r+\delta)\theta^2},\beta_{31}=\frac{(a\theta(1-\theta)+\omega b(1+\theta))(a\theta-\omega b)(\kappa_3-\kappa_1\phi)}{4b(r+\tau)\theta^2},$$

$$\gamma_{31}=\left(\frac{\rho_1\lambda_1(a\theta(1-\theta)+\omega b(1+\theta))}{\theta}+\rho_2\lambda_2\left(a\theta-\omega b\right)\right)\frac{\kappa_1(a\theta-\omega b)\alpha_{31}}{4br\theta}+\frac{(a\theta(1-\theta)+\omega b(1+\theta))(a\theta-\omega b)\kappa_1\lambda_2\rho_2\alpha_{32}}{4br\theta^2}$$
$$+\frac{(a\theta(1-\theta)+\omega b(1+\theta))(a\theta-\omega b)}{4br\theta^2}\left(\kappa_1\lambda_3+\frac{{\kappa_1}^2{\lambda_2}^2(a\theta-\omega b)^2}{4b\theta}+\frac{(a\theta(1-\theta)+\omega b(1+\theta))(a\theta-\omega b){\kappa_1}^2{\lambda_1}^2}{8b\theta^2}\right)$$
$$+\frac{{\alpha_{31}}^2{\rho_1}^2+2\beta_{31}\beta_{32}\varepsilon^2+2\alpha_{31}\alpha_{32}{\rho_2}^2}{2r},$$

$$\alpha_{32}=\frac{(a\theta-\omega b)^2\left((r+\tau)\kappa_2+(\kappa_3-\kappa_1\phi)\eta\right)}{4b(r+\tau)(r+\delta)\theta},\beta_{32}=\frac{(a\theta-\omega b)^2(\kappa_3-\kappa_1\phi)}{4b(r+\tau)\theta},$$

$$\gamma_{32}=\left(\frac{\rho_1\lambda_1(a\theta(1-\theta)+\omega b(1+\theta))}{\theta}+\rho_2\lambda_2\left(a\theta-\omega b\right)\right)\frac{\kappa_1(a\theta-\omega b)\alpha_{32}}{4br\theta}+\frac{\kappa_1\lambda_1\rho_1(a\theta-\omega b)^2\alpha_{31}}{4br\theta}+\frac{{\alpha_{32}}^2{\rho_2}^2+{\beta_{32}}^2\varepsilon^2}{2r}$$
$$+\frac{(a\theta-\omega b)^2}{4br\theta}\left(\kappa_1\lambda_3+\frac{(a\theta(1-\theta)+\omega b(1+\theta))(a\theta-\omega b){\kappa_1}^2{\lambda_1}^2}{4b\theta^2}+\frac{{\kappa_1}^2{\lambda_2}^2(a\theta-\omega b)^2}{8b\theta}\right)+\frac{\alpha_{31}\alpha_{32}{\rho_1}^2}{r}.$$

Under this scenario, the TA, as follower of the Stackelberg game, will share part of the revenue to the SS. According to the result of Proposition 3, it is clear that the revenue-sharing between the SS and the TA will further increases the retail price of green tourism products.

Corollary 3. *For the optimal solutions p^{N^*}, $g_1^{N^*}$, $g_2^{N^*}$ and f^{N^*} with respect to parameter θ. (i) We have $\frac{\partial p^{N^*}}{\partial\theta}<0$; (ii) We have $\frac{\partial g_1^{N^*}}{\partial\theta}>0$ when*

$$0<\theta<\frac{(\omega b)^2}{3^{\frac{1}{3}}\left((3a^2b\omega)^2+\left((9a^4b^2\omega^2)^2-3a^6b^6\omega^6\right)^{\frac{1}{2}}\right)^{\frac{1}{3}}}+\frac{\left((3a^2b\omega)^2+\left((9a^4b^2\omega^2)^2-3a^6b^6\omega^6\right)^{\frac{1}{2}}\right)^{\frac{1}{3}}}{3^{\frac{2}{3}}+a^2},\qquad(8)$$

and $\frac{\partial g_1^{N^*}}{\partial\theta}<0$ when

$$\frac{(\omega b)^2}{3^{\frac{1}{3}}\left((3a^2b\omega)^2+\left((9a^4b^2\omega^2)^2-3a^6b^6\omega^6\right)^{\frac{1}{2}}\right)^{\frac{1}{3}}}+\frac{\left((3a^2b\omega)^2+\left((9a^4b^2\omega^2)^2-3a^6b^6\omega^6\right)^{\frac{1}{2}}\right)^{\frac{1}{3}}}{3^{\frac{2}{3}}+a^2}<\theta<1,\qquad(9)$$

(iii) *We have $\frac{\partial g_2^{N^*}}{\partial\theta}>0$ and $\frac{\partial f^{N^*}}{\partial\theta}>0$ when $\frac{\omega b}{a}<\theta<1$, and $\frac{\partial g_2^{N^*}}{\partial\theta}<0$ and $\frac{\partial f^{N^*}}{\partial\theta}<0$ when $0<\theta<\frac{\omega b}{a}$.*

We discover that the green tourism service effort of the SS increases with an increase in θ when condition (8) is satisfied. This is because the SS needs to invest more in green tourism service effort to attract tourists when the sharing ratio is relatively low. In contrast, when condition (9) is satisfied, the cost of SS's green tourism service effort can not exchange for higher income, so the green tourism service effort of the SS will decrease with the increase of θ. We also find that when $0<\theta<\frac{\omega b}{a}$, that is, the sharing ratio of the TA is sufficiently low, the green tourism service and advertising efforts of the TA decrease as θ increases. This is because the green tourism service and advertising costs of the TA are not consistent with the income. Then the TA prefers to spend less on green tourism service and advertising efforts to reduce its own costs. On the contrary, $g_2^{N^*}$ and f^{N^*} increase with an increase in θ when the sharing ratio satisfy $\frac{\omega b}{a}<\theta<1$. This is because the increased

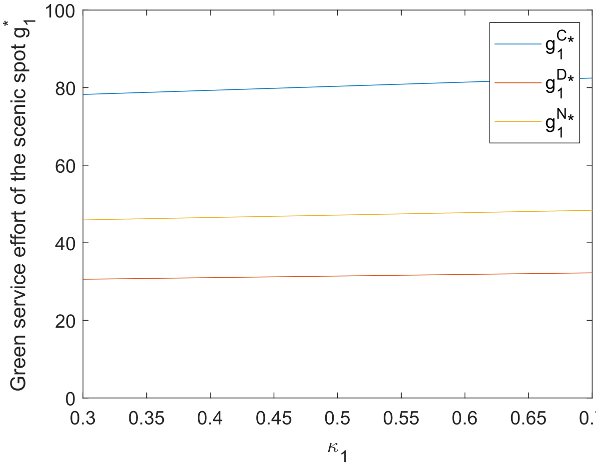

Fig. 2. g_1^* with.κ_1

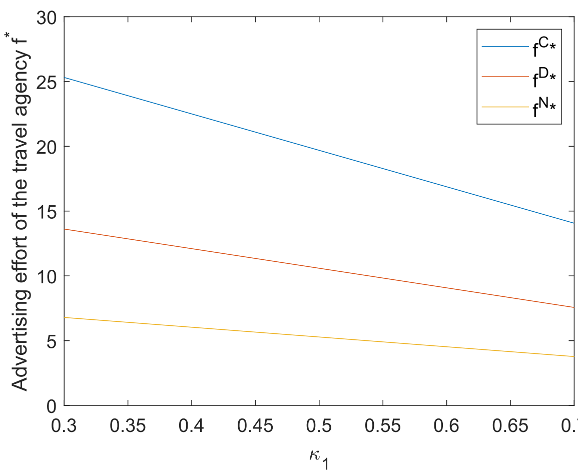

Fig. 3. f^* with.κ_1

advertising and green tourism service efforts of the TA improve the green quality and goodwill level of the tourism product, and thus improving the product sales and total profit.

5. Comparison between scenarios

Some interesting conclusions can be observed from Table 2 by the comparison of three scenarios.

Proposition 4. *The relationship of the optimal retail price p^*under different scenarios is as follow*

$$p^{C^*} < p^{D^*} < p^{N^*}.$$

We observe from Proposition 4 that the retail price of green tourism product in the decentralized scenario is higher than that in the centralized scenario. This is because the TA gets more profit by charging a higher retail price under the scenario of decentralized. In addition, the retail price of green tourism products set by TA in the revenue-sharing scenario is the highest among the three scenarios.

Proposition 5. *The relationship of the optimal advertising effort f^*under different scenarios is as follows*

$$f^{C^*} > f^{D^*} > f^{N^*}.$$

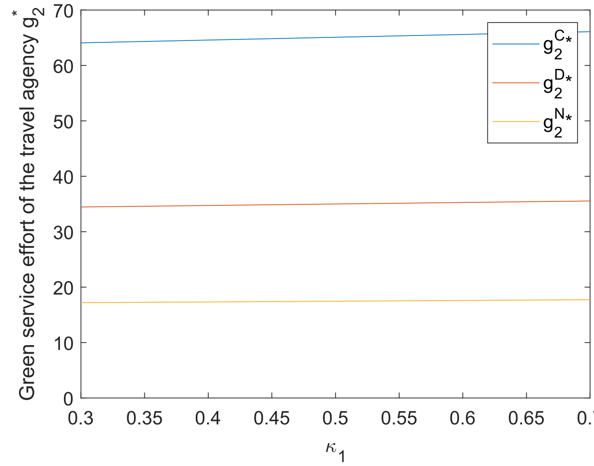

Fig. 4. g_2^* with.κ_1

The advertising effort of the TA has improved the goodwill level of green tourism product. It is indicate that the advertising effort of the TA in the revenue-sharing scenario is lower than those in the decentralized and centralized scenarios from Proposition 5. This is because the TA shares the revenue of green tourism product with the SS and bear the advertising expenditure of green tourism products alone. Therefore, the TA is willing to reduce the advertising effort to reduce the advertising expenditure. Moreover, the advertising effort of the TA in the centralized scenario is greater than that in the decentralized scenario.

Proposition 6. *The ordinal relationship of the optimal tourism service efforts $g_1^*$and $g_2^*$are as follows*

$$g_1^{C^*} > g_1^{N^*} > g_1^{D^*},\ g_2^{C^*} > g_2^{D^*} > g_2^{N^*}.$$

The green tourism service efforts of the SS and the TA improve the green quality of tourism product and the greenness level of tourism service. We observe from Proposition 6 that the green tourism service efforts of the SS and the TA in the centralized scenario are the largest, because the high green tourism service efforts attract more tourists which preference for green tourism product. Compared with the decentralized scenario, the SS in the revenue-sharing scenario invests more in green tourism service effort. This is because the SS shares the TA's income in the revenue-sharing scenario, and a higher quality green tourism products will attract more tourists. While the total income of the TA increases, and the SS' s profit increases

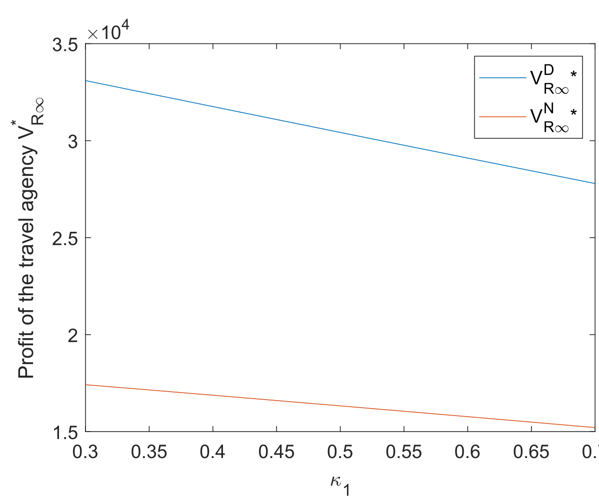

Fig. 5. $V_{R\infty}^*$ with.κ_1.

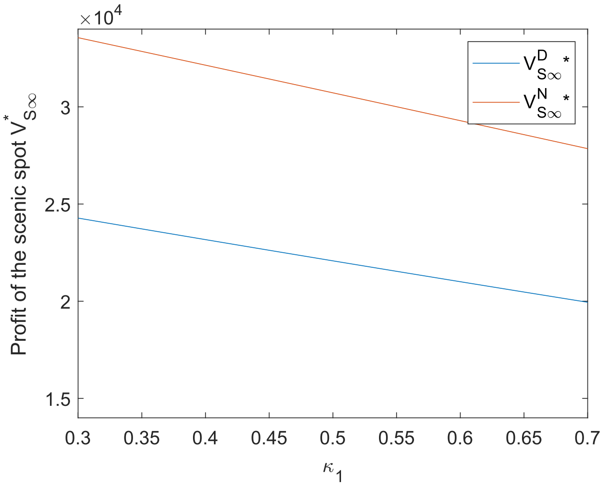

Fig. 6. $V^*_{S\infty}$ with.κ_1.

correspondingly. However, the green tourism service effort of the TA is the lowest in the revenue-sharing scenario because the TA needs to reduce the expenditure of green tourism service to ensure its own profits.

6. Numerical study

Numerical study are drawn to better illustrate our theoretical results. We set $r = 0.15$, $a = 15$, $b = 2$, $\rho_1 = 0.6$, $\rho_2 = 0.5$, $\lambda_1 = 1.6$, $\lambda_2 = 1.2$, $\lambda_3 = 1$, $\varepsilon = 0.7$, $\phi = 0.5$, $\kappa_2 = 0.7$, $\kappa_3 = 0.6$, $\delta = 0.2$, $\tau = 0.2$, $\eta = 0.5$, $G_0 = 5$, $Q_0 = 5$, $t = \infty$, which are comely used in the this section. Then in each following subsection we provide numerical study to observe the influence of key parameters on the theoretical results of the equilibrium strategies in different scenarios and give some managerial insights. The selection of these parameters comes from the previous literatures on operation management (Liu et al., 2016; Zhou and Ye, 2018; Jena and Meena, 2019), which mainly investigate the advertising, service and pricing of products.

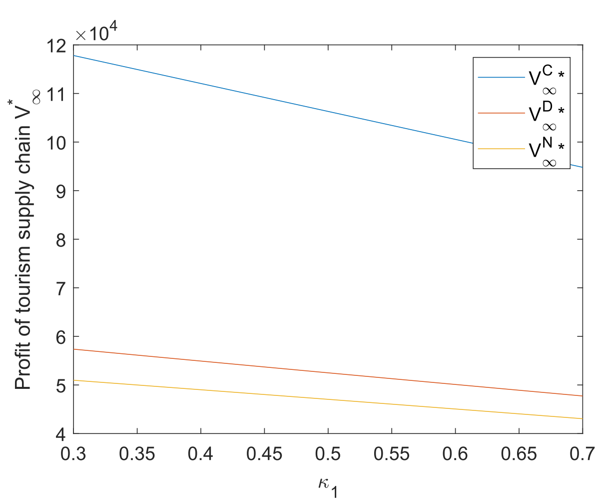

Fig. 7. V^*_∞ with.κ_1.

6.1. Effects of κ_1 on green tourism service efforts, advertising effort and market demand ($\omega = 2, \theta = 0.7$)

In this subsection, we investigate the effects of tourists' green tourism experience concern level κ_1 on the advertising effort and the green tourism service efforts. Fig. 2 shows the impacts of the tourists' green tourism experience concern level on the green tourism service effort of the SS. The results show that the green tourism service efforts of the SS increase with the increasing of green tourism experience concern level under three different scenarios. This is because when tourist improves its concern level for green tourism experience, the SS will improve its green tourism service effort to provide tourists with a higher quality green tourism products to increase the sales of green tourism products. In addition, the green tourism service efforts of the SS is the highest in the centralized scenario, and the lowest in the decentralized scenario. Fig. 3 shows that the advertising effort of the TA in the revenue-sharing scenario is the lowest, which makes the goodwill level of tourism products lower than that of other scenarios. The reason for this phenomenon is that the TA not only undertakes the advertising activities of green tourism products alone, but also shares part of the revenue to the SS. Reducing the advertising effort can decrease the advertising expenditure of the TA. Moreover, with the improvement of green tourism experience concern level, tourists pay more attention to the green quality of tourism product compared with the goodwill. Therefore, the TA can appropriately reduce its advertising effort. Fig. 4 shows that the green tourism service effort of the TA in the revenue-sharing scenario is lower than those in centralized and decentralized scenarios. In general, the green tourism service efforts increase with the increasing of tourists' green tourism experience concern level under three scenarios.

6.2. Effects of κ_1 on the profits of the GTSC members

Using the same parameters in Subsection 6.1, we study the impacts of tourists' green tourism experience concern level κ_1 on the profits of the SS, the TA and the GTSC. Fig. 5 shows that the profit of the TA decreases as the green tourism experience concern level increases. This is because the green tourism service effort of the TA increases with the green tourism experience concern level, and the green tourism service expenditures of the TA increase at the same time, resulting in the decrease of its profit. Fig. 5 also shows that the profit of the TA in the decentralized scenario is higher than that in the revenue-sharing scenario. The profit of the SS decreases with the increasing of tourists' green tourism experience concern level (see Fig. 6). This is because the carrier of green tourism experience is the SS. Therefore, the SS needs to make a lot of green tourism service effort to stimulate tourists' demand for green tourism products with the increasing of tourists' green tourism experience concern level. Furthermore, Fig. 6 indicates that the SS gets a higher profit in the revenue-sharing scenario compared with the decentralized scenario. Fig. 7 presents that the profits of the GTSCs in three scenarios are decreasing when the tourists' green tourism experience concern level increases. If tourists pay more attention to the green tourism experience, it is better for the SS and the TA to increase their green tourism service efforts and provide a higher quality green tourism product for tourists. Fig. 7 also shows that the profits of the GTSC reach the lowest when there exists a revenue-sharing contract between the SS and the TA. In general, it can be seen from Figs. 5–7 that the revenue-sharing contract between the SS and the TA can not achieve the Pareto improvement of the GTSC.

6.3. Effects of wholesale price ($\kappa_1 = 0.5, \theta = 0.7$)

We discuss the influence of wholesale ticket price on equilibrium solutions and profits. Fig. 8(a) shows the changing of optimal green tourism service efforts, the optimal advertising effort and the optimal retail price of green tourism products with the different wholesale ticket

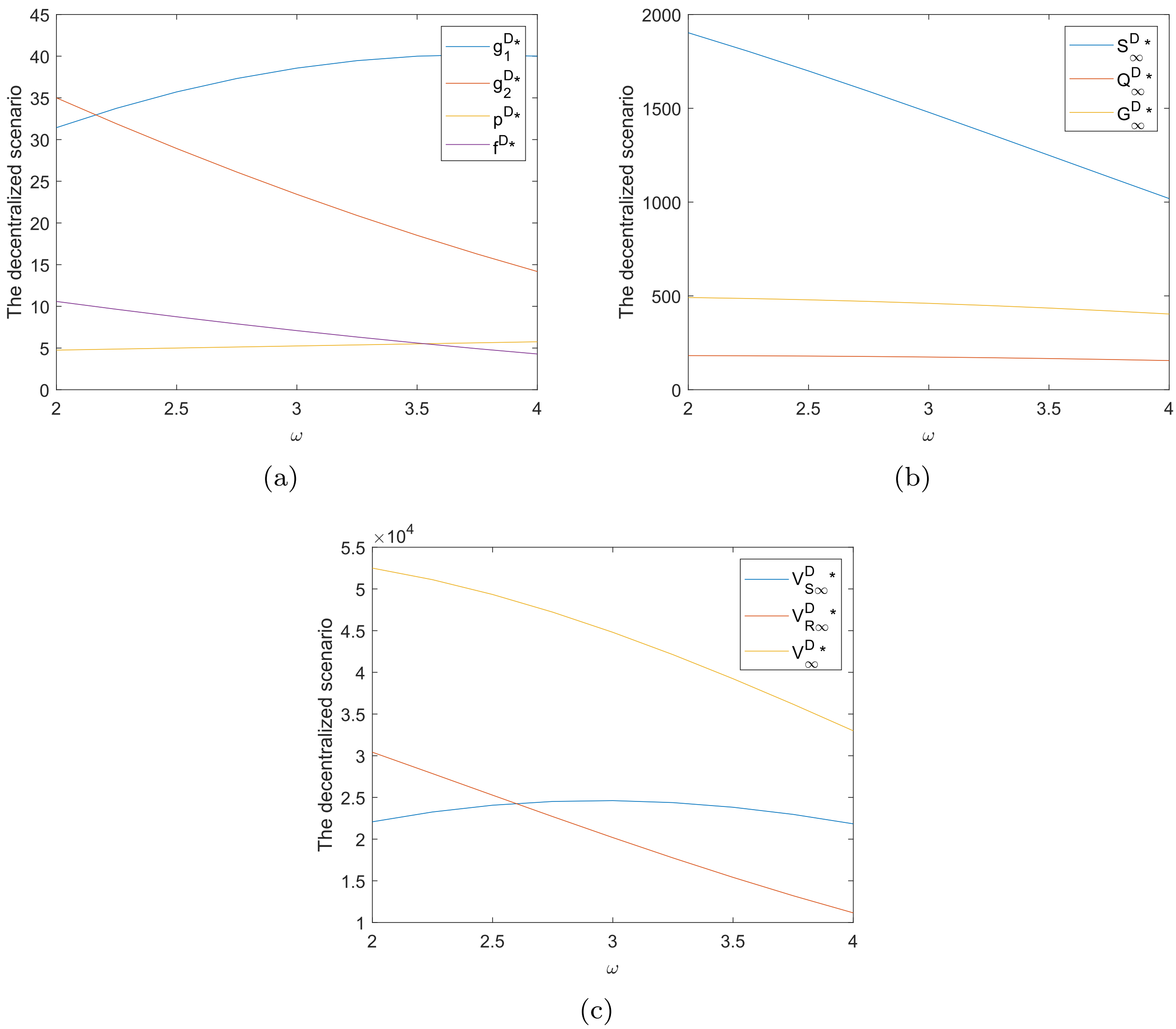

Fig. 8. Effects of ϖ under the decentralized scenario.

prices. As shown in the blue curve in Fig. 8(a), the optimal green tourism service effort g_1^{D*} is increasing with the wholesale ticket price, which means that a higher wholesale ticket price can more effectively stimulate the green tourism service effort of the SS. This is because the tourism products with relatively high wholesale ticket price should keep relatively high green quality, which makes the SS make more green tourism service effort. The red curve in Fig. 8(a) shows that a higher wholesale ticket price can not stimulate the TA to make more green tourism service effort. Instead, a relatively low wholesale ticket price charged by the SS can encourage the TA make more green tourism service effort g_2^{D*}. This result can be explained that a relatively high wholesale price of the SS increases the cost of the TA, then the TA will not invest more in the green tourism service effort. The advertising effort of the TA decreases with the increase of wholesale ticket price as shown in Fig. 8(a) purple curve. It is easy to understand that the TA prefer to reduce its expenditure on advertising when other costs increase. In addition, by observing the yellow curve in Fig. 8(a), it is also find that the retail price of green tourism product also increases when the wholesale ticket price increases, but the gaps between these different retail prices are not obvious. Therefore, we point out that the higher wholesale ticket prices make the retail prices of green tourism products rise slightly, but it has a strong attack on the enthusiasm of the TA.

As shown in Fig. 8(b), the greenness level of tourism service decreases with the increase of wholesale ticket price, and the goodwill level of tourism product also decreases as the wholesale ticket price increasing. This is because the green tourism service and advertising efforts of the TA decrease with the increase of wholesale ticket price, which makes the greenness level of tourism service and the goodwill level of tourism product also decrease. On the other hand, Fig. 8(b) also points that a relatively high wholesale ticket price will reduce product sales of green tourism products. This is because the demand for green tourism product of tourists always decrease with the increase of tourism product price (see Fig. 8(a)). Fig. 8(c) shows that the profit of the SS is the concave function of the wholesale ticket price. A relatively high wholesale ticket price will bring more profit to the SS. However, tourists reduce the demand for green tourism products when the wholesale ticket price is too high, then the profit of the SS reducing. As shown in the red curve in Fig. 8(c), the TA can obtain a higher profit when the wholesale price is relatively low. This is because the profit of the TA always decreases with the increase of wholesale ticket price. Fig. 8(c) also indicates that the total profit of the GTSC decreases as the wholesale ticket price increasing. This result can be explained that a relatively high

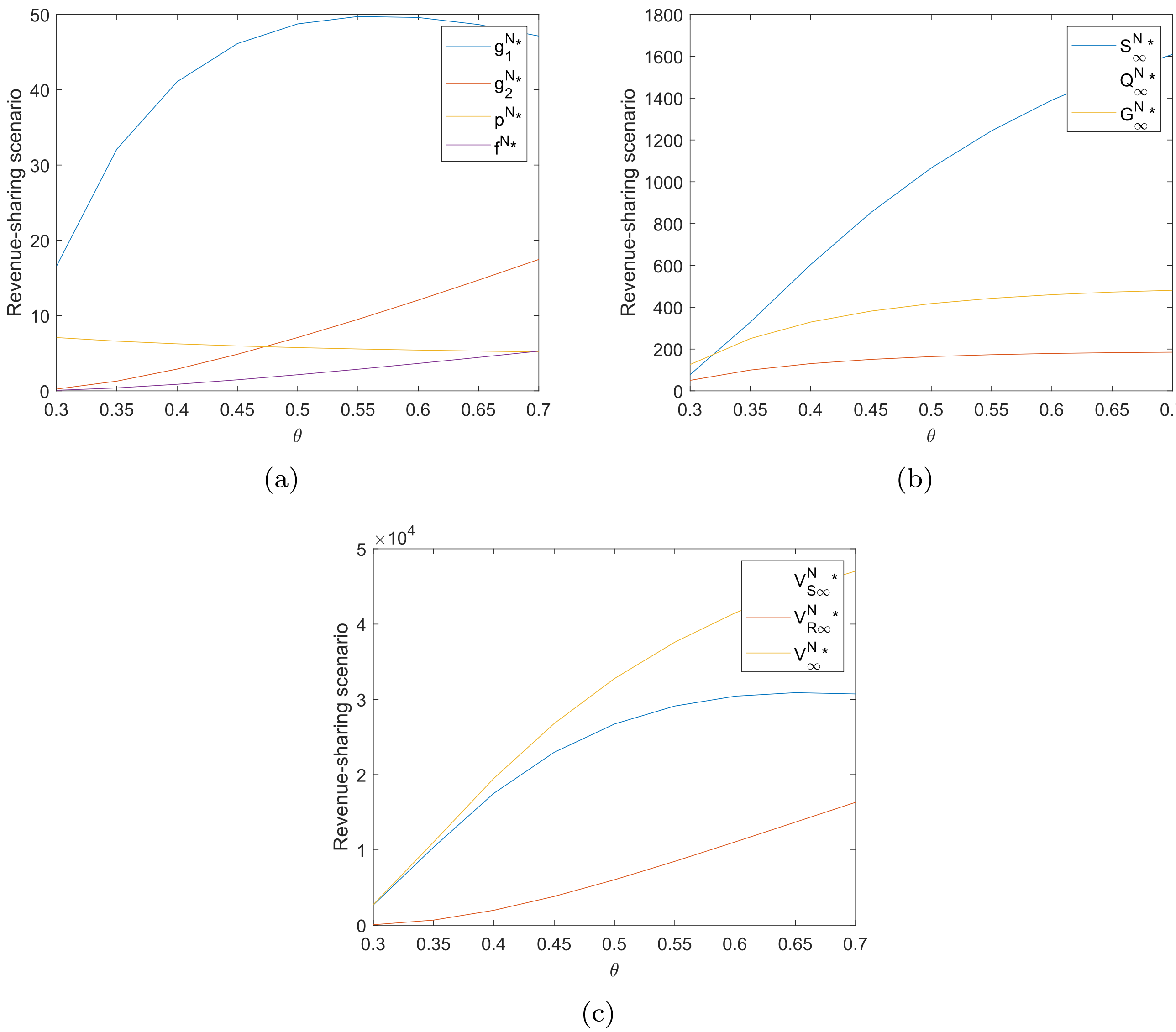

Fig. 9. Effects of θ under the revenue-sharing scenario.

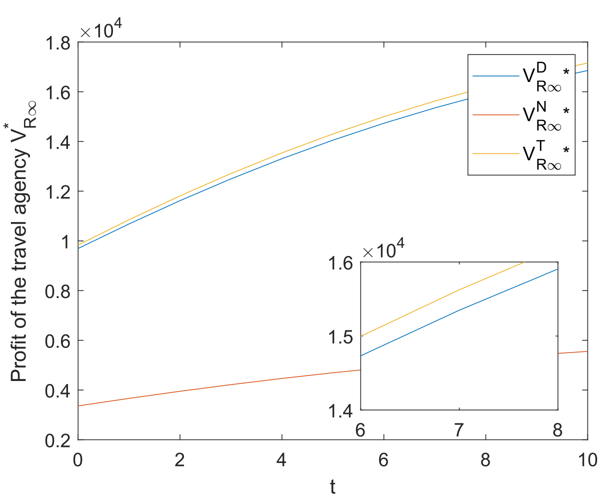

Fig. 10. $V_{R\infty}^*$ with *t*.

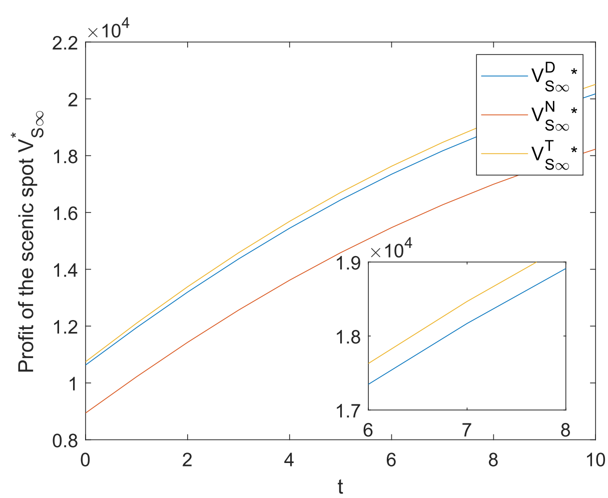

Fig. 11. $V_{S\infty}^*$ with *t*.

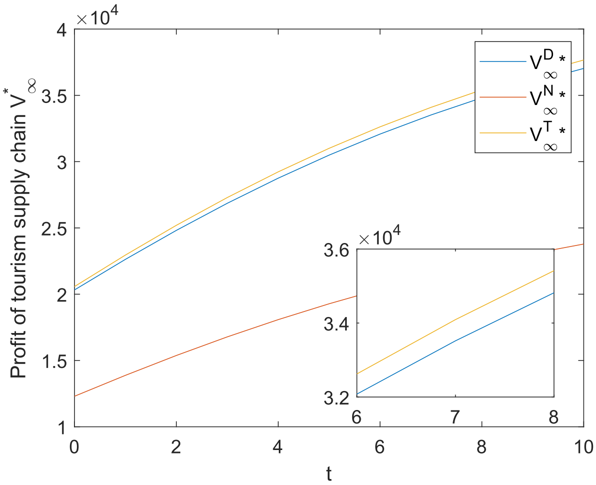

Fig. 12. V_∞^* with t.

wholesale ticket price attacks the green tourism service and advertising efforts of the TA, increase the retail prices of green tourism products, and ultimately reduce the sales of green tourism products.

6.4. *Effects of sharing ratio* ($\varpi = 2, \kappa_1 = 0.5$)

We next study the impact of sharing ratio on the performance of the GTSC. Fig. 9(a) shows the changing of optimal green tourism service efforts, the optimal advertising effort and the optimal retail price of green tourism products with the different sharing ratios. The red curve in Fig. 9(a) depicts the impact of sharing ratio on the optimal green tourism service effort g_2^{N*}. When the share ratio is relatively high, the profit of the TA increases with the increase of share ratio. Therefore, the TA increases its green tourism service effort to improve the demand of tourists for green tourism products, and obtains a higher profit. As shown in the blue curve in Fig. 9 (a), the optimal green tourism service effort g_1^{N*} is a concave function of the sharing ratios. This means that the changes of the optimal green tourism service effort g_1^{N*} can be divided into two stages. In the first stage, a higher sharing ratio can more effectively stimulate the green tourism service effort g_1^{N*}. However, the green tourism service effort g_1^{N*} decreases with the increase of sharing ratios in the second stage. The purple curve in Fig. 9(a) shows that a relatively high sharing ratio leads to an increase in advertising effort. The reason is that the increase of advertising effort can bring higher profit for the TA. Moreover, the yellow curve in Fig. 9(a) shows that the retail price of green tourism product decreases as the sharing ratio increasing. One reason is that the TA will appropriately reduce the retail price of tourism products to stimulate the demand of tourists for green tourism products.

As shown in Fig. 9(b), both the greenness level of tourism service and the goodwill level of tourism product increase slowly as the sharing ratio increases. This is because the green tourism service and advertising efforts of the TA increase with the increase of sharing ratio when the share ratio is relatively high. Fig. 9(c) also shows that the sales of green tourism product increases as the sharing ratio increasing. This is because the higher greenness level of tourism service and goodwill level of tourism product stimulate the demand of tourists for green tourism products. On the other hand, a relatively high sharing ratio makes the TA reduce the retail price of tourism product, and thus also stimulates tourists to purchase the tourism product. The profit of the SS is a concave function of sharing ratio (see Fig. 9 (c) blue curve). In other word, the profit of the SS initially is increasing with the increase of sharing ratio, but when the sharing ratio exceeds a certain threshold, the profit of the SS is decreasing. This is because the increased sharing ratio can improve the sales of tourism product when the sharing ratio is relatively low, and the profit of the SS increases accordingly. However, when the sharing ratio is relatively high, the sharing income of the SS decreases. As shown in the red curve in Fig. 9(c), the profit of the TA is increasing with the increase of share ratio. On the one hand, a higher sharing ratio brings a higher sharing profit to the TA. On the other hand, the lower retail price also stimulates the demand of tourists for green tourism products, and the profit of the TA increases. At last, it is found that the GTSC can achieve a higher profit when the sharing ratio is relatively high.

7. Extension

In this section, we consider that the SS supports the TA with an advertising participation rate used to promote green tourism products, that is, the SS and the TA jointly launch the advertising activities. Many researches have shown that cooperative advertising can effectively improve the performance of supply chain (Buratto et al., 2019; Ma et al., 2020). Thus we introduce a cost-sharing contract into advertising activities to investigate the coordination of the GTSC. We assume that the SS provide the advertising participation rate φ to encourage the TA to make more in advertising effort to promote green tourism product. Therefore, the optimization problems of the SS and the TA are respectively expressed as follows

$$\max_{g_1,\varphi} V_S(t) = \int_0^\infty e^{-rt}\{\omega S(t) - C_{g_1}(t) - \varphi C_f(t)\}dt, \tag{10}$$

$$\max_{p,g_2,f} V_R(t) = \int_0^\infty e^{-rt}\{(p(t)-\omega)S(t) - C_{g_2}(t) - (1-\varphi)C_f(t)\}dt. \tag{11}$$

For any $Q(t) > 0$ and $G(t) > 0$, the maximal profits of the SS and the TA satisfy the Hamilton-Jacobi-Bellman equations as

$$rV_S^T = \max_{g_1,\varphi}\begin{pmatrix}\omega(a-bp)(\kappa_1\lambda_3+\kappa_1\lambda_1 g_1+\kappa_1\lambda_2 g_2+\kappa_2 Q+(\kappa_3-\kappa_1\phi)G)-\frac{g_1^2}{2}-\frac{\varphi f^2}{2}\\ +V_{SQ}^{T'}(\rho_1 g_1+\rho_2 g_2-\delta Q)+V_{SG}^{T'}(\varepsilon f+\eta Q-\tau G)\end{pmatrix}.$$

$$rV_R^T = \max_{p,g_2,f}\begin{pmatrix}(p-\omega)(a-bp)(\kappa_1\lambda_3+\kappa_1\lambda_1 g_1+\kappa_1\lambda_2 g_2+\kappa_2 Q+(\kappa_3-\kappa_1\phi)G)-\frac{g_2^2}{2}-\frac{(1-\varphi)f^2}{2}\\ +V_{RQ}^{T'}(\rho_1 g_1+\rho_2 g_2-\delta Q)+V_{RG}^{T'}(\varepsilon f+\eta Q-\tau G)\end{pmatrix}.$$

Similarly, we can easily get the optimal equilibrium solutions of the SS and the TA under the cost-sharing scenario. We have the following proposition after simple algebra.

Proposition 7. *The differential game* (1) (2) (10) (11) *has a unique equilibrium solution as follows*

(i) *The optimal green tourism service effort* $g_1^{T^*}$ *and advertising participation rate* φ^{N^*}, *the optimal green tourism service effort* $g_2^{T^*}$ *and advertising effort* f^{T^*} *and the retail price* p^{T^*} *are as follows*

$$p^{T^*}=\frac{a+\omega b}{2b},\ g_1^{T^*}=\frac{\omega(a-\omega b)\kappa_1\lambda_1}{2}+\frac{\rho_1\omega(a-\omega b)((r+\tau)\kappa_2+(\kappa_3-\kappa_1\phi)\eta)}{2(r+\delta)(r+\tau)},\ \varphi^{N^*}=\frac{3\omega b-a}{\omega b+a},$$

$$g_2^{T^*}=\frac{\kappa_1\lambda_2(a-\omega b)^2}{4b}+\frac{\rho_2(a-\omega b)^2((r+\tau)\kappa_2+(\kappa_3-\kappa_1\phi)\eta)}{4b(r+\tau)(r+\delta)},\ f^{T^*}=\frac{\varepsilon(a-\omega b)^2(\kappa_3-\kappa_1\phi)}{4b(1-\varphi)(r+\tau)}.$$

(ii) *The equilibrium tourism service greenness level* Q^{T^*} *and goodwill level* G^{T^*} *are given by*

$$\begin{cases} Q^{T^*}(t)=Q_\infty^T+\left(Q_0-Q_\infty^T\right)e^{-\delta t},\\ G^{T^*}(t)=G_\infty^T+\dfrac{\eta}{(\tau-\delta)}\left(Q_0-Q_\infty^T\right)e^{-\delta t}+\left(G_0-G_\infty^T-\dfrac{\eta\left(Q_0-Q_\infty^T\right)}{(\tau-\delta)}\right)e^{-\tau t},\end{cases}$$

where

$$Q_\infty^T=\frac{\begin{pmatrix}(a-\omega b)(r+\delta)(r+\tau)(2\rho_1\lambda_1\omega b+\rho_2\lambda_2(a-\omega b))\kappa_1\\ +(a-\omega b)((r+\tau)\kappa_2+(\kappa_3-\kappa_1\phi)\eta)\left(2\rho_1^2\omega b+\rho_2^2(a-\omega b)\right)\end{pmatrix}}{4b(r+\delta)(r+\tau)\delta},$$

$$G_\infty^T=\frac{\begin{pmatrix}\dfrac{\varepsilon^2(a-\omega b)^2(r+\delta)(\kappa_3-\kappa_1\phi)\delta}{(1-\varphi)}+\eta\kappa_1(a-\omega b)(r+\delta)(r+\tau)(2\rho_1\lambda_1\omega b+\rho_2\lambda_2(a-\omega b))\\ +\eta(a-\omega b)((r+\tau)\kappa_2+(\kappa_3-\kappa_1\phi)\eta)\left(2\rho_1^2\omega b+\rho_2^2(a-\omega b)\right)\end{pmatrix}}{4b\tau(r+\delta)(r+\tau)\delta}.$$

(iii) *The maximal profits of the SS* $V_S^{T^*}$ *and the TA* $V_R^{T^*}$ *are*

$$V_S^{T^*}=\alpha_{41}Q^{T^*}+\beta_{41}G^{T^*}+\gamma_{41},\ V_R^{T^*}=\alpha_{42}Q^{T^*}+\beta_{42}G^{T^*}+\gamma_{42}.$$

where

$$\alpha_{41}=\frac{\omega(a-\omega b)((r+\tau)\kappa_2+(\kappa_3-\kappa_1\phi)\eta)}{2(r+\delta)(r+\tau)},\beta_{41}=\frac{\omega(a-\omega b)(\kappa_3-\kappa_1\phi)}{2(r+\tau)},$$

$$r\gamma_{41}=\frac{\alpha_{41}\kappa_1(a-\omega b)}{2}\left(\rho_1\lambda_1\omega+\frac{\rho_2\lambda_2(a-\omega b)}{2b}\right)+\frac{\alpha_{42}\kappa_1\lambda_2\rho_2\omega(a-\omega b)}{2}+\frac{\alpha_{41}{}^2\rho_1{}^2}{2}+\alpha_{41}\alpha_{42}\rho_2{}^2+\frac{\omega(a-\omega b)}{2}\left(\kappa_1\lambda_3+\frac{\omega(a-\omega b)\kappa_1{}^2\lambda_1{}^2}{4}+\frac{\kappa_1{}^2\lambda_2{}^2(a-\omega b)^2}{4b}\right)$$

$$+\frac{\beta_{41}\beta_{42}\varepsilon^2}{(1-\varphi)}-\frac{\varphi\beta_{42}{}^2\varepsilon^2}{2(1-\varphi)^2},\alpha_{42}=\frac{(a-\omega b)^2\left((r+\tau)\kappa_2+(\kappa_3-\kappa_1\phi)\eta\right)}{4b(r+\tau)(r+\delta)},\beta_{42}=\frac{(a-\omega b)^2(\kappa_3-\kappa_1\phi)}{4b(r+\tau)},$$

$$r\gamma_{42}=\frac{\alpha_{42}\kappa_1(a-\omega b)}{2}\left(\rho_1\lambda_1\omega+\frac{\rho_2\lambda_2(a-\omega b)}{2b}\right)+\frac{\alpha_{41}\kappa_1\lambda_1\rho_1(a-\omega b)^2}{4b}+\frac{\alpha_{42}{}^2\rho_2{}^2}{2}+\frac{\beta_{42}{}^2\varepsilon^2}{2(1-\varphi)}+\alpha_{41}\alpha_{42}\rho_1{}^2+\frac{(a-\omega b)^2}{4b}\left(\kappa_1\lambda_3+\frac{\omega(a-\omega b)\kappa_1{}^2\lambda_1{}^2}{2}+\frac{\kappa_1{}^2\lambda_2{}^2(a-\omega b)^2}{8b}\right).$$

Proposition 7 shows that the advertising participation rate φ^{N^*} *has a significant impact on the equilibrium advertising effort and the equilibrium goodwill of green tourism product. For a given advertising participation rate, we can derive the analytic equilibrium solution. In addition, we can further analyze the influence of advertising participation rate on the equilibrium strategies and profits of the GTSC members.*

Observation 1. The value of φ^* affects on the performances of the SS, the TA and the GTSC.

The management insight of the above observation is that both the SS and the TA can obtain more profits when there exits a positive advertising participation rate φ^*. This is because under the cost-sharing scenario, the TA can adjust its advertising effort to attract more tourists.

Proposition 8. *The ordinal relationship of profits of the SS* V_S^*, *the TA* V_R^* *and the GTSC* V^* *are as follows*

$$V_S^{T^*}>V_S^{D^*}>V_S^{N^*},\ V_R^{T^*}>V_R^{D^*}>V_R^{N^*},\ V^{C^*}>V^{T^*}>V^{D^*}>V^{N^*}.$$

From the perspective of the profits of the SS and the TA, the profits under the three scenarios are increasing in turn. The change of the GTSC from decentralized to cost-sharing is a Pareto improvement. When the SS supports *the advertising activities and subsidizes the advertising costs of the* TA, *the goodwill level of green tourism product is enhancing. The demands of tourists* *for green tourism product increase in cost-sharing scenario, and the profits of the SS and the TA will be higher than that in decentralized scenario. The essence of revenue sharing contract is that the TA allocates part of its revenue to the SS. The transition from decentralized scenario to revenue-sharing scenario expands the double marginalization effect among GTSC members. Therefore, revenue-sharing contract can not achieve Pareto improvement of the GTSC.*

Using the parameter setting in the previous section, the maximum profits of the SS, the TA and the GTSC in the four scenarios are shown in Figs. 10–12. When there is a revenue-sharing contract between the SS and the TA, the TA not only undertakes the expenditure of advertising activities, but also shares part of the revenue to the SS, which makes the double marginalization effect between upstream and downstream more exaggerative. Moreover, it is found that the profits of the SS and the TA in the cost-sharing scenario are the highest among the three scenarios because the advertising subsidy from the SS stimulates the advertising activities of the TA. The number of tourists who buy green tourism products increases, and the profits of the GTSC members increase correspondingly. Neither revenue-sharing contract nor cost sharing contract can achieve the coordination of the GTSC, but cost-sharing contract can make the GTSC get Pareto improvement as shown in Fig. 12. Thus the SS and the TA prefer cost-sharing contract over revenue-sharing contract.

8. Conclusions

Popularization of environmental protection drive tourists to choose green tourism products, and promote SSs and TAs to provide green tourism products. The goodwill level and the retail price of green tourism products, the greenness level of tourism service and the green tourism experience of tourists are significant factors that affect the purchase behaviors of tourists. Meanwhile, these factors force the GTSC members to provide high-quality green tourism products to achieve the sustainable development of tourism resources. Our research considered a GTSC composed of one SS and one TA, proposed the four scenarios (i.e. centralized, decentralized, revenue-sharing and cost-sharing), and established related differential game models to study the optimal green tourism service, pricing and advertising strategies of the GTSC members. In addition, we investigated the relationship among green tourism experience of the tourists, the green tourism service efforts and the advertising effort, and explored how the green tourism experience concern level, the wholesale ticket price and the sharing ratio affect the green tourism service efforts, the advertising effort, the retail price, the tourism service greenness level, the goodwill level, the product sales and the profits of the SS, the TA and GTSC. Some main managerial insights of our study are summarized as follows:

1. Due to the preference for green tourism of the tourists, the GTSC members should provide green tourism products to cater tourists' preference for green tourism. In addition, the SS and the TA should also educate tourists to purchase green tourism products, so as to promote the improvement of green quality of tourism products and realize the sustainable development and utilization of tourism resources.
2. The tourist's green tourism experience concern level that motivates the green tourism service activities of the SS and the TA can stimulate the GTSC members to provide a higher green quality tourism product, but it can not bring a higher profits to the SS and the TA and the GTSC. A relatively low green tourism experience concern level can stimulate the TA to invest more in advertising effort, and improve the profits of the GTSC members. Therefore, a reasonable green tourism experience concern level of the tourists is an effective guarantee for the smooth operation of the GTSC.
3. The profit of the SS is a concave function of the wholesale ticket price in the decentralized scenario, which increases first and then decreases with the increase of the wholesale ticket price; while the profits of the TA and the GTSC always decreases with the increase of the wholesale ticket price. Therefore, the wholesale ticket price can be used as a bargaining point between the SS and the TA in the decentralized scenario. The SS can sell ticket to the TA at the optimal wholesale price to obtain its maximal profit.
4. The profits of the TA and the GTSC are increasing with the increase of sharing ratio in the revenue-sharing scenario. By contrast, the profit of the SS is increasing with the increase of sharing ratio until its reach a threshold. Once the sharing ratio exceeds this threshold, the profit of the SS decreases as the sharing ratio increasing. Therefore, when the sharing ratio of the TA exceeds this threshold, the SS can provide TA with a relatively low wholesale ticket price so as to negotiate a lower sharing rate.
5. The revenue-sharing contract between the SS and the TA can neither coordinate the GTSC, nor make the GTSC achieve Pareto improvement. Therfore, the SS and the TA are more willing to operate the GTSC in the cost-sharing scenario compared with revenue-sharing scenario.

There are serval potential extensions for future investigation. First, GTSCs often have multiple SSs and TAs. One possible future opportunity is to study a more complicated GTSC network. Second, the coordination mechanism between the SS and the TA can be further studied in the revenue-sharing scenario. Third, the green tourism experience we consider in our study is mainly affected by tourists' expected green quality and perceived green quality. The empirical experiments of green tourism experience can be further carried out to identify the main influencing factors of green tourism experience. Last, this paper mainly analyzes the joint green tourism service, advertising and pricing strategies of the GTSC under the green tourism preference of tourists. We can incorporate the impact of government green tourism subsidy and environmental policies on the decision-makings of the GTSC members into future research.

Declarations of competing interest

None.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jretconser.2021.102563.

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