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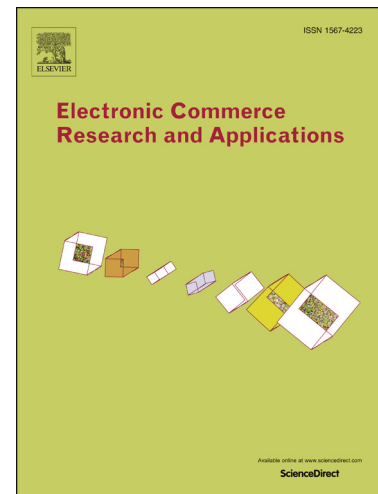
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Online selling mode choice and pricing in an O2O tourism supply chain considering corporate social responsibility

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Abstract

This paper considers an online-to-offline (O2O) tourism supply chain (TSC) consisting of an offline tourism service provider (TSP) and an online travel agency (OTA) who has a corporate social responsibility (CSR). We investigate three possible online selling modes: (1) the OTA purchases products from the TSP and sells them to end tourists (Mode R); (2) the OTA charges the TSP a profit-sharing rate (Mode M); (3) the TSP sells products through both the reselling and marketplace channels (Mode D). Based on these three modes, we establish three game-theoretic models to explore the optimal online selling mode and pricing decisions for the TSC and its members. Our analyses and results show that when Mode D is unavailable: if OTA's cost advantage is relatively low, the TSC members should set a moderate profit-sharing rate and choose Mode M; Conversely, Mode R is better for them under a moderate or not too high profit-sharing rate. When Mode D is also available: Mode M is always worse than Mode D, while Mode R may be better than Mode D under some conditions. Furthermore, we conduct numerical studies and sensitivity analyses, which demonstrate that in Mode D, the TSC should pay more attention to CSR and improve consumers' channel acceptance for the reselling channel to create more total utility.

Keywords: Tourism supply chain; Corporate social responsibility; Online selling mode choice; Pricing

1. Introduction

Thanks to the rapid development of Internet and information technology, continuous innovations on e-commerce have led to the emergence of a wide variety of online platform selling modes such as Expedia, Travelocity, Airbnb, Ctrip, Fliggy, and Meituan (i.e., online travel agencies, OTAs). In order to expand market share and enhance profitability, a growing number of companies, especially in the hospitality and tourism industry, have utilized these online platforms to distribute their services and products (Lee et al., 2018; Long and Shi, 2017; Thakran and Verma, 2013; Zhao et al., 2019). Additionally, some research studies have confirmed that more and more consumers are willing to book service products online (such as hotel, restaurant, and airline tickets) due to their convenience (Bilgihan and Bujisic, 2015; Inversini and Masiero, 2014; Kim et al., 2006). On the other hand, tourists can gather online information regarding price, service level, and product quality to make better purchasing decisions (Toh et al, 2011). This has brought about many opportunities as well as severe challenges for the survival and growth of tourism-related companies. For example, during this evolution, a variety of online selling modes whose efficiencies remain to be validated, have strengthened the difficulty of service firms' online operation management. A firm's online selling mode choice would influence a tourism supply chain (TSC) system's cost, pricing, and service level to a large extent (Inversini and Masiero, 2014; Wang et al., 2018). Naturally, how to adopt a more effective online selling mode has become critical for tourism businesses.

In business practice, there are three common online selling modes. The most widely known one is the reselling mode (Abhishek et al., 2015; He et al., 2019). Namely, the online travel agency (OTA) such as some professional travel agents (<https://www.wotif.com>) purchases service products from a tourism service provider (TSP) and sells them to end consumers. The second mode is the marketplace mode in which the OTA such as Kuoni

(<https://www.kuoniglobaltravelservices.com/index.asp>) or Expedia just charges the TSP a commission fee, but the TSP still determines the selling prices of its service products (Ling et al., 2014; Wang et al., 2018). The last one is the combination of the aforementioned two modes where the OTA not only distributes TSP's products independently but also allows the TSP to establish an e-shop on her platform to directly sell his products. This hybrid online selling mode has been rising in recent years such as Ctrip (<https://au.trip.com/?locale=en-AU>), JD (trip.jd.com), and Fliggy (Yan et al., 2019). For clarity, we hereafter call this mode as a dual selling mode. Intuitively, this burgeoning mode would bring new price competition for the online platforms. However, why do some OTAs still provide the dual selling mode for TSPs? A critical decision problem in the hospitality and tourism industries is which one of these three modes is the best choice for the TSC stakeholders.

As Long and Shi (2017) argued, it is difficult for small or medium-sized tourism firms to establish and operate their own online channels due to their relatively higher setup cost and lower competitiveness compared to that of professional network platform service providers. Therefore, in this paper, we concentrate on an OTA's different online selling modes instead of the TSP's own online channel. As a matter of fact, most tourism companies (e.g., hotels, restaurants) indeed have no online websites of their own.

Nowadays, an increasing number of tourism enterprises improve their operation ways to achieve a better Corporate Social Responsibility (CSR) (Arya and Mittendorf, 2015; Inoue and Lee, 2011), which can be interpreted as organizational actions and policies that take into account stakeholders' expectations and the triple bottom line of economic, social, and environmental performance. The prior literature has shown that CSR in tourism and hospitality industry has become an important and hot research topic (Coles et al., 2013). For example, some studies confirm that more and more guests prefer to buy products from a

socially responsible company (Font et al., 2012; Kang et al., 2010). This implies that it is of great and practical significance to consider CSR while analyzing a tourism service firm's online selling mode choice and pricing setting. From the practical perspective, a majority of larger and comprehensive online companies would be more likely to consider CSR like Expedia, Alibaba (Fliggy), and TripAdvisor compared to the smaller firms. For example, Airbnb has proposed a CSR ranking approach to rank companies' ratings (https://www.csrhub.com/CSR_and_sustainability_information/Airbnb-Inc). In reality, TSP's CSR behavior might be lower than OTA and some smaller TSPs even have no one. To save space and simplify the mathematic model, we normalize TSP's possible CSR behavior to zero in this research.

Motivated by real business problems, we consider a two-stage TSC involving an upstream TSP and a downstream OTA in this paper. The primary purpose of this study is to answer the following crucial questions in a TSC setting. First, what are the optimal pricing decisions for tourism firms under different online selling modes? Second, which mode is best for the entire TSC or its members? If the TSC has a pure selling mode, is it better to switch to the dual selling mode? More importantly, how can the TSC members set an appropriate profit-sharing rate to achieve win-win outcomes?

To answer these tricky questions, we develop three game-theoretic models by incorporating consumers' channel acceptance and OTA's CSR behavior. We first derive demand functions based on consumers' utility functions and then derive the optimal solutions employing the backward induction approach. Based on the equilibrium outcomes, we further analyze the online selling mode preference of each stakeholder. Our main findings show that consumers' channel acceptance and OTA's cost advantage, profit-sharing rate, and CSR behavior jointly influence the TSC's optimal selling mode and pricing. Specifically, we find that the marketplace mode is always worse than the dual-selling mode but may be better than

the reselling mode. Additionally, the dual selling mode is better in most situations compared to the reselling mode, whereas it is worse when the cost advantage is moderate (or high) and the consumers' channel acceptance is relatively low. Through numerical simulations and sensitivity analyses, we further demonstrate that OTA's CSR behavior could benefit the TSC and higher consumers' channel acceptance would improve the total utility in the dual selling mode.

The remaining of this article proceeds as follows. We summarize the related literature and highlight the main differences of this study in Section 2, followed by Section 3 where we describe three common online selling modes and formulate consumers' purchasing decisions and firm's CSR behavior. Afterwards, Section 4 explores the optimal solutions under three online selling modes. We analyze the selling mode preferences and present the equilibrium sale mode from different perspectives in Section 5. Then, the numerical examples and sensitivity analyses are conducted in Section 6. Finally, we conclude this paper with managerial implications and propose some potential future avenues in Section 7. All proofs are presented in Appendices.

2. Literature review

In this section, we will review the relevant literature from the following three streams: (1) selling mode choice, (2) tourism product pricing, and (3) corporate social responsibility. We also highlight the main differences between this paper and the existing studies.

2.1. Selling mode choice

There are a great number of papers investigating the interaction between Internet and traditional/offline selling channels from various aspects such as channel operational cost difference (Wang et al., 2016), online channel preference/acceptance (He et al., 2019; Zhang et al., 2017), multi-channel coordination (Pu et al., 2017; Wang et al., 2018) and online to

offline cooperation (Guo et al., 2013; Ling et al., 2015; Long and Shi, 2017; Yan and Pei, 2019). Our paper is the most closely related to the less-studied branch of channel management literature, i.e., online selling channel management. Liu and Zhang (2014) discuss the impacts of product-related and channel-related factors on consumers' choice of online hotel booking channels. They uncover that a hotel's own website exhibits a higher quality. Hagiwara and Wright (2014) and Abhishek et al. (2015) both compare the online agency selling mode and the conventional reselling mode. They identify the optimal channel decisions based on product categories and analyze the impact of an online channel on offline market share. Zhou et al. (2017) investigate the pricing and rebate strategies of an online store cooperating with a cash back platform. They demonstrate that lower consumers' willingness of buying through the cash back website is always beneficial for the online shop but not always so for the cash back platform. Zhang et al. (2019) study the strategic interaction between a platform's contract choice and a manufacturer's product quality design. Their findings show that the platform prefers revenue-sharing contract when manufacturer's quality decision is less flexible than contract decision. Wang et al. (2018) investigate the online retail channel choice in terms of direct sale or consignment with a revenue-sharing mechanism. They point out that the online retailer's revenue allocation rate and selling cost can significantly affect the manufacturer's channel decision. He et al. (2019) study the strategic introduction of online presale mode for fresh products and explore two different pricing strategies, namely, penetration-pricing and skimming-pricing. They show that online grocery's delivery cost and circulation loss rate of fresh products can significantly change the firms' pricing strategies.

The works of Yan et al. (2019) and Ye et al. (2018) are very close to our research. The former concentrates on analyzing the issue of online channel opening decision in the retail industry and assume that the online platform (e.g., JD.com) is more efficient

transportation-wise than the upstream manufacturer. By contrast, in the hospitality and tourism industry, transportation may not be an issue because consumers often need to attend the services at the sites of the offline service providers. In this regard, this paper largely differentiates from these previous studies on dual-channel literature. The latter focuses on the interaction between the hotel's offline channel and the OTA's online channel. Our study differs from the literature by investigating two selling channels, both of which employ the online platform rather than an upstream firm's direct channel or offline channel. Furthermore, we consider the online platform's CSR behavior, the main feature not found in those related studies.

2.2. Tourism product pricing

Extensive research has dealt with various pricing issues regarding tourism service products (Ji and Crompton, 2017; Niavis and Tsiotas, 2018; Xu et al., 2015). Casaló et al. (2015) design a 2×2 experimental research to study how the peers' opinions and online hotel ratings and prices affect consumers' booking behaviors. Their finding indicates that information published in well-known online travel communities would be more useful and credible. Tkalec and Vizek (2016) study how tourism association activities influence the price levels of consumer goods, of consumer services and of both using a dataset covering new member states and candidate countries in the European Union. They show that tourism association activities would enhance the overall price levels in the economy. Barreda et al. (2017) investigate how global mega-sports events impact the pricing strategies of hotels and how the Brazilian host regions respond to FIFA World Cup events. They show that these events did not necessarily lead to higher hotel revenue. Merkert and Webber (2018) focus on managing price and seats in airlines to address the issues of rigid capacity and high demand seasonality. They claim that there are strong seasonal variations in both the average fare and seat of the airline.

Another research direction on tourism product pricing focuses on establishing mathematical models (Guo and Zheng, 2017; Long and Shi, 2017; He et al., 2019). Zheng and Guo (2016) examine restaurants' optimal pricing when engaging in online channels with a third-party website. Their research shows that when the offline demand is relatively small, a restaurant should join a third-party website and provides a price discount. Wang et al. (2017) develop two models on dual channels to explore complementary products' pricing and service decisions. They consider two pricing strategies: consistent pricing and inconsistent pricing. Their findings indicate that consistent pricing can slightly improve profit but the channel conflict would hurt the chain members to some extent. Jena and Jog (2017) develop two Stackelberg game models (i.e., tour operator or local operator as a leader) to study the price competition in a TSC considering advertising investment. They show that the two-part tariff mechanism is superior to the cooperative advertising mechanism.

Most of these papers mainly investigate the effects of tourism products pricing on consumers' purchasing behaviors or cooperative pricing decisions between tour operators and third-party agents. Our paper differs by analyzing the online selling mode choice, which is a practical but rarely studied issue in the tourism industry.

2.3. Corporate social responsibility

A growing number of empirical studies report that firms' CSR behaviors can significantly affect the operation performances of themselves and their business partners (Font et al., 2012; Su et al., 2017). Kang et al. (2010) examine the relationship between CSR activities of hospitality firms and financial performance. They suggest that the hotel, casino, restaurant and airline companies make CSR investment plans from a long-term perspective. Inoue and Lee (2011) examine the effects of five dimensions of CSR, namely, employee relations, product quality, community relations, environmental issues, and diversity issues on the financial performance of tourism-related firms. They report that CSR has positive and

different financial effects across various tourism-related industries. Levy and Park (2011) survey US-based hotel executives to identify the benefits obtained from implementing CSR. They find that encouraging firms to learn CSR activities from a holistic perspective can help implement CSR programs. Fatma et al. (2016) develop a new scale and carry out qualitative research to measure consumer perception of CSR activities. Wells et al. (2016) employ qualitative methods to examine whether the consolidative model of CSR development is reflected in environmental CSR in heritage tourism from the perspectives of employees and visitors. We refer readers to Coles et al. (2013) for a review on CSR in the tourism industry. This paper differs from the previous studies by examining how the CSR behaviors of tourism-related firms affect the selling mode choice and pricing setting in an O2O tourism supply chain.

3. Model setting

3.1. Online selling mode

In this paper, we consider an O2O tourism supply chain (TSC) consisting of a tourism service provider (TSP) who provides tourism service products offline and an online travel agency (OTA) who distributes the products online. In business practice, there are three common online business modes. The first one is known as the reselling mode (Mode R) where the OTA purchases the tourism service products from the TSP at a wholesale price and then decides on a retail price and resells the products to tourists. The second one is the marketplace mode (Mode M) where the OTA charges the TSP a profit-sharing rate, but the retail price is still decided by the TSP. We employ r to denote the profit-sharing rate on TSP's profit. We further assume that r is exogenous because it is generally a longer-term and larger-scale decision relative to the wholesale and retail prices (Abhishek et al., 2015; Yan et al., 2019). The last online business mode (Mode D) combines the previous two selling

modes. In this scenario, the TSP sells its tourism products through the reselling channel and the marketplace channel simultaneously. Throughout this research, both supply chain members are assumed to be risk-neutral with no information asymmetry. Moreover, it is assumed that the TSP is the leader and the OTA is the follower in the Stackelberg game (Guo et al., 2013; Long and Shi, 2017).

3.2. Consumers' purchasing decisions

In this subsection, we derive the demand functions in different selling modes based on the consumer utility theory. Following the literature (Wang et al., 2018; Zhang et al., 2017), we assume that tourists are heterogeneous and their perceived value v for the tourism service product is independently distributed from 0 to 1, with the density of 1. We hereafter use $F(x)$ and $f(x)$ to denote its cumulative distribution and probability distribution functions, respectively. When the TSC adopts Mode R or Mode M, a consumer purchases a product with a utility $u^i = v - p^i$ ($i = R, M$), where p^i is the retail price in Mode R or Mode M. When the consumer's utility is non-negative, s/he will buy resulting in the corresponding demand $d^i = \int_{p^i}^1 f(x) dx$. When dual selling mode (Mode D) is available, consumers can purchase products from reselling channel or marketplace channel. It is supposed that with Mode D available, the consumers buy products from the reselling channel with discount value θv compared to the marketplace channel, where the parameter $\theta \in (0,1)$ denotes utility discount. It can be regarded as consumers' acceptance for the reselling channel (hereafter consumers' channel acceptance). This assumption is reasonable because in the marketplace channel, TSP directly managing and providing the tourism products is more trustworthy to the consumers (Lien et al., 2015), thereby leading to a higher consumer utility. Hence, a consumer will obtain a utility $u_1^D = v - p_1$ from the marketplace channel or $u_2^D = \theta v - p_2$ from the reselling channel, where p_j ($j = 1,2$) denote the retail

prices in the marketplace and reselling channels under Mode D, respectively. A customer will purchase from the channel with a higher consumer utility. Solving $u_1^D(v^*) = u_2^D(v^*)$, we can obtain the indifference point between two channels as $v^* = (p_1 - p_2)/(1 - \theta)$. Therefore, we can derive the demand functions in the marketplace and the reselling channels under Model D as: $d_1 = \int_{v^*}^1 f(x) dx$ and $d_2 = \int_{p_2/\theta}^{v^*} f(x) dx$. The total demand is $d^D = d_1 + d_2$. For ease of exposition, we hereafter call the two prices in Model D as direct and indirect retail prices and their corresponding demands as direct and indirect demands, respectively. Note that we do not consider the possibility of $\theta p_1 \leq p_2$ where there is no demand in one channel, which implies that the dual selling mode degenerates into a pure selling mode.

We summarize the demand functions in the three selling modes as below. In the pure reselling mode:

$$d^R = \int_{p^R}^1 f(x) dx = 1 - p^R \quad (1)$$

In the pure marketplace mode:

$$d^M = \int_{p^M}^1 f(x) dx = 1 - p^M \quad (2)$$

In the dual selling mode:

$$\begin{cases} d_1 = \int_{\frac{p_1 - p_2}{1 - \theta}}^1 f(x) dx = 1 - \frac{p_1 - p_2}{1 - \theta} \\ d_2 = \int_{\frac{p_2}{\theta}}^{\frac{p_1 - p_2}{1 - \theta}} f(x) dx = \frac{p_1 - p_2}{1 - \theta} - \frac{p_2}{\theta} \end{cases} \quad (3)$$

3.3. Corporate social responsibility

Following Panda and Modak (2016), we employ the consumer surplus (CS) as a proxy of OTA's CSR behavior. Furthermore, we use λ ($0 \leq \lambda \leq 1$) to denote the degree of OTA's CSR behavior relative to her profitability. A higher λ means that the OTA has a higher CSR preference. Particularly, $\lambda = 0$ means that OTA has no CSR behavior while $\lambda = 1$ indicates

that the OTA has a complete CSR behavior. According to the consumers' utility calculation formula (Huang et al., 2019), we can derive the CS for each selling mode as follows. In the pure reselling mode:

$$CS^R = \int_{p^R}^1 (v - p^R) dv \quad (4)$$

In the pure marketplace mode:

$$CS^M = \int_{p^M}^1 (v - p^M) dv \quad (5)$$

In the dual selling mode:

$$CS^D = \int_{\frac{p_1 - p_2}{1 - \theta}}^1 (v - p_1) dv + \int_{\frac{p_2}{\theta}}^{\frac{p_1 - p_2}{1 - \theta}} (\theta v - p_2) dv \quad (6)$$

4. Model equilibrium and analysis

In this section, we study the optimal wholesale and/or retail price through a pure selling mode (Mode R or Mode M) or a dual-selling mode (Mode D). We assume that the marketplace channel has a higher selling cost than the reselling channel. Put it differently, the TSP selling through OTA's platform is less efficient than the OTA. It is realistic because the OTA often enjoys the economy of scale resulting in a cost advantage. We use c_0 and c to denote the OTA's online selling cost and its relative cost advantage (hereafter cost advantage). Thus, the TSP's selling cost through the marketplace channel can be expressed as $c_0 + c$. Without loss of generality, we normalize the selling cost of OTA to 0 (i.e., $c_0 = 0$) (Zheng and Guo, 2016). To ensure the coexistence of two channels under Mode D, we further assume $c \leq \bar{c}_0 = (1 - \theta)(2 - \lambda)/[2 - \theta - \lambda(1 - \theta)]$. This assumption is needed but reasonable because a cost advantage, which is too high, means the marketplace channel too ineffective to keep.

4.1. Pure reselling mode (Mode R)

In Mode R, the TSP as a first mover announces his wholesale price. Then the OTA decides on her retail price. The TSP aims to maximize his profit and the OTA aims to maximize her total utility (profit + CSR utility). According to the demand functions mentioned before, the optimization problems of TSP and OTA are shown in Eqs. (7)-(8). Furthermore, the entire TSC's total utility function is shown in Eq. (9). We henceforth utilize $\Pi_l^i, U_l^i, CS^i (i = R, M, D; l = TSP, OTA, TSC)$ to denote the profit and utility functions of the chain members and the whole TSC. The superscript * is used to denote the optimal solutions.

$$\max_{w^R} \Pi_{TSP}^R = w^R \left[\int_{p^R}^1 f(x) dx \right] \quad (7)$$

$$\max_{p^R} U_{OTA}^R = (p^R - w^R) \left[\int_{p^R}^1 f(x) dx \right] + \lambda \left[\int_{p^R}^1 (v - p^R) dv \right] \quad (8)$$

$$U_{TSC}^R = p^R \left[\int_{p^R}^1 f(x) dx \right] + \lambda \left[\int_{p^R}^1 (v - p^R) dv \right] \quad (9)$$

The equilibrium pricing policies, and hence the profits and utilities of the TSP and the OTA are derived by backward induction. For clarity, we move all proofs into Appendix A and summarize the optimal solutions of three modes in Table 1.

4.2. Pure marketplace mode (Mode M)

In Mode M, there exists a basic profit-sharing contract between the TSP and the OTA. In this setting, the TSP determines the retail price and the OTA shares a part of TSP's profit. Based on the demand functions mentioned before, we can have the profit function of TSP and the utility functions of OTA and the whole TSC as follows.

$$\max_{p^M} \Pi_{TSP}^M = (1 - r)(p^M - c) \left[\int_{p^M}^1 f(x) dx \right] \quad (10)$$

$$U_{OTA}^M = r(p^M - c) \left[\int_{p^M}^1 f(x) dx \right] + \lambda \left[\int_{p^M}^1 (v - p^M) dv \right] \quad (11)$$

$$U_{TSC}^M = (p^M - c) \left[\int_{p^M}^1 f(x) dx \right] + \lambda \left[\int_{p^M}^1 (v - p^M) dv \right] \quad (12)$$

4.3. Dual selling mode (Mode D)

In Mode D, the TSP and the OTA employ both the reselling and marketplace channels. The decision timing is as follows. First, the TSP announces his wholesale and retail prices in anticipation of the OTA's price decision. Afterwards, the OTA determines her retail price in the reselling channel. They aim to maximize the total profit and utility from both channels. Based on the demand functions obtained earlier, we can derive the TSP's total profit and the total utility functions of OTA and the TSC as below.

$$\max_{p_1, w^D} \Pi_{TSP}^D = (1-r)(p_1-c) \left[\int_{\frac{p_1-p_2}{1-\theta}}^1 f(x) dx \right] + w^D \left[\int_{\frac{p_2}{\theta}}^{\frac{p_1-p_2}{1-\theta}} f(x) dx \right] \quad (13)$$

$$\begin{aligned} \max_{p_2} U_{OTA}^D &= r(p_1-c) \left[\int_{\frac{p_1-p_2}{1-\theta}}^1 f(x) dx \right] + (p_2-w^D) \left[\int_{\frac{p_2}{\theta}}^{\frac{p_1-p_2}{1-\theta}} f(x) dx \right] + \lambda \\ &\quad \left[\int_{\frac{p_1-p_2}{1-\theta}}^1 (v-p_1) dv + \int_{\frac{p_2}{\theta}}^{\frac{p_1-p_2}{1-\theta}} (\theta v-p_2) dv \right] \end{aligned} \quad (14)$$

$$\begin{aligned} U_{TSC}^D &= (p_1-c) \left[\int_{\frac{p_1-p_2}{1-\theta}}^1 f(x) dx \right] + p_2 \left[\int_{\frac{p_2}{\theta}}^{\frac{p_1-p_2}{1-\theta}} f(x) dx \right] + \lambda \\ &\quad \left[\int_{\frac{p_1-p_2}{1-\theta}}^1 (v-p_1) dv + \int_{\frac{p_2}{\theta}}^{\frac{p_1-p_2}{1-\theta}} (\theta v-p_2) dv \right] \end{aligned} \quad (15)$$

Table 1. The optimal solutions in different selling modes.

Notation	Model R	Model M	Model D
w^*	$\frac{1}{2}$	N/A	$\frac{[1-(1-c)r]\theta}{2}$
p^*	$\frac{3-2\lambda}{2(2-\lambda)}$	$\frac{1+c}{2}$	$\frac{1+c}{2}$
d^*	$\frac{1}{2(2-\lambda)}$	$\frac{1-c}{2}$	$\frac{\theta[2+c(1-\lambda)-\lambda]}{2(2-\lambda)}$
Π_{TSP}^*	$\frac{1}{4(2-\lambda)}$	$\frac{(1-c)^2(1-r)}{4}$	$\frac{(1-\theta)(2-\lambda)-c[2-\theta-\lambda(1-\theta)]}{2(1-\theta)(2-\lambda)}$
U_{OTA}^*	$\frac{1}{8(2-\lambda)}$	$\frac{(1-c)^2(2r+\lambda)}{8}$	$\frac{c}{2(1-\theta)(2-\lambda)}$
U_{TSC}^*	$\frac{3}{8(2-\lambda)}$	$\frac{(1-c)^2(2+\lambda)}{8}$	$\frac{\left\{ \begin{aligned} &(1-r)(1-\theta)(2-\lambda)(1-2c) \\ &+ c^2\{2-\theta-[r(2-\lambda)+\lambda](1-\theta)\} \end{aligned} \right\}}{4(1-\theta)(2-\lambda)}$
			$\frac{\left\{ \begin{aligned} &(1-\theta)(2-\lambda)[2(1-c)^2r+\lambda(1-2c)] \\ &+ c^2[\theta(1-\lambda)^2+(2-\lambda)\lambda] \end{aligned} \right\}}{8(1-\theta)(2-\lambda)}$
			$\frac{(1-\theta)(4-\lambda^2)(1-2c)+c^2[4-\lambda^2-\theta(1-\lambda^2)]}{8(1-\theta)(2-\lambda)}$

$$CS^* = \frac{1}{8(2-\lambda)^2} - \frac{(1-c)^2}{8} - \frac{\left\{ (1-\theta)(2-\lambda)^2(1-2c) + c^2[(2-\lambda)^2 - \theta(3-4\lambda+\lambda^2)] \right\}}{8(1-\theta)(2-\lambda)^2}$$

Based on Table 1, we first explore how CSR influences the pricing policies in the three different selling modes. Taking the first derivatives of optimal prices with respect to CSR yields the following results.

Proposition 1.

- (i) *In Mode R, CSR does not affect the wholesale price but lower the retail price (i.e., $\partial w^{R*}/\partial\lambda = 0$; $\partial p^{R*}/\partial\lambda < 0$).*
- (ii) *In Mode M, CSR does not affect the retail price (i.e., $\partial p^{M*}/\partial\lambda = 0$).*
- (iii) *In Mode D, CSR will decrease the indirect retail price but does not affect the wholesale and direct retail prices (i.e., $\partial w^{D*}/\partial\lambda = \partial p_1^*/\partial\lambda = 0$; $\partial p_2^*/\partial\lambda < 0$).*

From Proposition 1, we can see that OTA's CSR behavior impacts the pricing policies of chain members to some extent. To be more specific, the OTA will decrease the retail price under a reselling mode. This implies that customers can benefit from OTA's CSR behavior. However, CSR cannot motivate the TSP to decrease his wholesale price because he cares about his own profit only. If they adopt a marketplace mode, the retail price would be unaffected by the CSR as the OTA has no pricing power. Similarly, Proposition 1(iii) reveals that OTA's CSR behavior would drive her to decrease the retail price in the reselling channel, but it does not affect the TSP's pricing decisions. This indicates that one firm's CSR behavior can influence its own pricing setting but not others'.

Proposition 2.

- (i) *In Mode R, CSR could increase the demand (i.e., $\partial d^{R*}/\partial\lambda > 0$).*
- (ii) *In Mode M, CSR does not affect the demand (i.e., $\partial d^{M*}/\partial\lambda = 0$).*
- (iii) *In Mode D, CSR could decrease the direct demand but increase the indirect demand*

(i.e., $\partial d_1^* / \partial \lambda < 0$; $\partial d_2^* / \partial \lambda > 0$).

Proposition 2 demonstrates how OTA's CSR behavior affects the market demands in the three selling modes. In Mode R, a higher CSR level would bring more consumers to the TSC, but it has no impact on demand in Mode M. This can be explained with Proposition 1, which indicates that a lower retail price in Mode R could attract more consumers but in Mode M, an unchanged retail price would leave the consumers' purchasing behaviors, thus the demand unchanged. Additionally, Proposition 2(iii) shows that the OTA would lower retail price to attract more consumers from the reselling channel as CSR increases. We also know from Proposition 1 that TSP does not change his pricing in any mode. In the dual selling mode, therefore, some consumers may switch to the OTA's reselling channel due to its relatively low retail price, decreasing the demand in the marketplace channel. In short, the CSR would indirectly affect the demand by directly changing the retail price.

Proposition 3.

- (i) *Mode D generates more demand than Mode R or M (i.e., $d^{D*} > d^{R*}$; $d^{D*} > d^{M*}$).*
- (ii) *CSR reduces the demand gap between Mode D and R (i.e., $\partial(d^{D*} - d^{R*}) / \partial \lambda < 0$).*
- (iii) *CSR enlarges the demand gap between Mode D and M (i.e., $\partial(d^{D*} - d^{M*}) / \partial \lambda > 0$).*

According to Proposition 3(i), OTA can use the dual selling mode to enlarge the market share. This would partly answer why some online platforms are willing to provide two online selling channels for the TSPs, even though new price competition will rise. Moreover, Proposition 3(ii)-(iii) show that as the CSR increases, the OTA with an existing reselling mode will be less motivated to open the other channel from the perspective of market share. By contrast, the OTA with an existing marketplace mode will be more motivated to do so.

5. Online selling mode selection

In this section, we first analyze the online selling mode preferences from the perspectives of the TSP, the OTA, the TSC, and the consumers by comparing the profits and utilities across the three online selling modes. Then, we will identify the equilibrium online sale mode.

5.1. Online selling mode preference analysis

We explore the online selling mode preferences by first comparing the TSP's profits and the utilities of OTA and TSC, as well as the consumer surplus between Mode M and R. The following Proposition 4 shows the selling mode preferences of the tourism stakeholders.

Proposition 4. *Comparing Modes M and R, we have the following properties:*

- (i) *For the TSP: when $0 < c \leq \min(\bar{c}_0, \bar{c}_1)$, if $0 < r \leq \bar{r}_1$, $\Pi_{TSP}^{M*} \geq \Pi_{TSP}^{R*}$; if $\bar{r}_1 < r \leq 1$, $\Pi_{TSP}^{M*} < \Pi_{TSP}^{R*}$. When $\bar{c}_1 < c \leq \bar{c}_0$, $\Pi_{TSP}^{M*} < \Pi_{TSP}^{R*}$.*
- (ii) *For the OTA: when $0 < r \leq \min(\bar{r}_2, 1)$, $\Pi_{OTA}^{M*} \leq \Pi_{OTA}^{R*}$. When $\max(0, \bar{r}_2) < r \leq 1$, $\Pi_{OTA}^{M*} > \Pi_{OTA}^{R*}$.*
- (iii) *For the TSC: when $0 < c \leq \min(\bar{c}_0, \bar{c}_2)$, $\Pi_{TSC}^{M*} \geq \Pi_{TSC}^{R*}$. When $\bar{c}_2 < c \leq \bar{c}_0$, $\Pi_{TSC}^{M*} < \Pi_{TSC}^{R*}$.*
- (iv) *For the consumers: when $0 < c \leq \min(\bar{c}_0, \bar{c}_3)$, $CS^{M*} \geq CS^{R*}$. When $\bar{c}_3 < c \leq \bar{c}_0$, $CS^{M*} < CS^{R*}$.*

where $\bar{c}_1 = \frac{2-\lambda-\sqrt{2-\lambda}}{2-\lambda}$, $\bar{c}_2 = \frac{4-\lambda^2-\sqrt{3}\sqrt{4-\lambda^2}}{4-\lambda^2}$, $\bar{c}_3 = \frac{1-\lambda}{2-\lambda}$, $\bar{r}_1 = \frac{1-4c+2c^2-\lambda(1-c)^2}{(1-c)^2(2-\lambda)}$, and $\bar{r}_2 = \frac{1-\lambda(1-c)^2(2-\lambda)}{2(1-c)^2(2-\lambda)}$.

Proposition 4(i) indicates that when the cost advantage c is relatively low, the TSP's selling mode preference would be affected by the profit-sharing rate r . Furthermore, if r is relatively low, the TSP prefers the marketplace mode to the reselling mode. On the contrary,

he would like to adopt Mode R under a higher r . Note that when c is high enough, the TSP always prefers the reselling mode. This is straightforward because a higher c would demotivate the TSP from running a marketplace. Proposition 4(ii) reveals that the profit-sharing rate significantly affects the OTA's online selling mode preference. In particular, a lower (higher) r would drive OTA to select Mode R (M). For the TSC and consumers, we find that the cost advantage plays an important role. Specifically, when c is sufficiently low, Mode M is better off. When c is relatively high, Mode R is propitious to consumers and the TSC. This implies that the TSP should pay attention to the cost advantage and the profit-sharing rate when choosing a selling mode. For the OTA, she just needs to consider the profit-sharing rate. As to the TSC and consumers, the selling mode preferences are largely influenced by the cost advantage.

In what follows, we compare the optimal profits and utilities in Mode D and Mode R to explore what factors affect the supply chain's selling mode decisions and how.

Proposition 5. *Comparing Modes D and R, we have the following properties:*

- (i) *For the TSP: when $c \leq \min(\bar{c}_4, \bar{c}_0)$, if $r \leq \bar{r}_3$, $\Pi_{TSP}^D \geq \Pi_{TSP}^R$; if $r > \bar{r}_3$, $\Pi_{TSP}^D < \Pi_{TSP}^R$. When $\bar{c}_4 < c \leq \bar{c}_0$ and $\theta \geq \bar{\theta}_1$, if $r \geq \bar{r}_3$, $\Pi_{TSP}^D \leq \Pi_{TSP}^R$; if $r < \bar{r}_3$, $\Pi_{TSP}^D > \Pi_{TSP}^R$. When $\bar{c}_4 < c \leq \bar{c}_0$, if $\theta < \bar{\theta}_1$, $\Pi_{TSP}^D < \Pi_{TSP}^R$.*
- (ii) *For the OTA: when $\theta \leq \bar{\theta}_2$, if $r \leq \bar{r}_4$, $\Pi_{OTA}^D \leq \Pi_{OTA}^R$; if $r > \bar{r}_4$, $\Pi_{OTA}^D > \Pi_{OTA}^R$. When $\theta > \bar{\theta}_2$, $\Pi_{OTA}^D > \Pi_{OTA}^R$.*
- (iii) *For the TSC: when $c \leq \min(\bar{c}_2, \bar{c}_0)$, $\Pi_{TSC}^D \geq \Pi_{TSC}^R$. When $\bar{c}_2 < c \leq \bar{c}_0$, if $\theta \leq \bar{\theta}_3$, $\Pi_{TSC}^D \leq \Pi_{TSC}^R$; if $\theta > \bar{\theta}_3$, $\Pi_{TSC}^D > \Pi_{TSC}^R$.*
- (iv) *For the consumers: when $c \leq \min(\bar{c}_5, \bar{c}_0)$, $CS^{D*} \geq CS^{R*}$. When $\bar{c}_5 < c \leq \bar{c}_0$, if $\theta \leq \bar{\theta}_4$, $CS^{D*} \leq CS^{R*}$; if $\theta > \bar{\theta}_4$, $CS^{D*} > CS^{R*}$.*

where $\bar{c}_4 = \frac{\lambda - 2 + \sqrt{3 - 2\lambda}}{\lambda - 1}$, $\bar{c}_5 = \frac{4 - 4\lambda + \lambda^2 - \sqrt{7 - 8\lambda + 2\lambda^2}}{3 - 4\lambda + \lambda^2}$, $\bar{r}_3 =$

$$\frac{1 - 4c + 2c^2 - \theta(1 - 4c + c^2) - \lambda(1 - c)^2(1 - \theta)}{(1 - c)^2(1 - \theta)(2 - \lambda)}, \quad \bar{r}_4 = \frac{1 - \theta(1 + c^2) - \lambda(1 - c)^2(2 - \lambda)(1 - \theta)}{2(1 - c)^2(1 - \theta)(2 - \lambda)}, \quad \bar{\theta}_1 =$$

$$\frac{4c - 2c^2 - 1 + \lambda(1 - c)^2}{4c - c^2 - 1 + \lambda(1 - c)^2}, \quad \bar{\theta}_2 = \frac{1 - \lambda(1 - c)^2(2 - \lambda)}{1 + c^2 - \lambda(1 - c)^2(2 - \lambda)}, \quad \bar{\theta}_3 = \frac{8c - 4c^2 - 1 + \lambda^2(1 - c)^2}{8c - c^2 - 1 + \lambda^2(1 - c)^2}, \quad \text{and} \quad \bar{\theta}_4 =$$

$$\frac{3 - 8c + 4c^2 + \lambda(1 - c)^2(\lambda - 4)}{3 - 8c + 3c^2 + \lambda(1 - c)^2(\lambda - 4)}.$$

Proposition 5(i) demonstrates that the TSP's selling mode preference is influenced jointly by the cost advantage c , the profit-sharing rate r and the consumers' channel acceptance θ . In particular, when c is relatively low, a lower (higher) r would motivate the TSP to choose the dual selling mode (reselling mode). In this case, the consumers' channel acceptance has no obvious effect. However, when the cost advantage is high enough, θ also plays an important role. More specifically, when θ is high enough, the profit-sharing rate r also matters. Contrarily, r has no palpable impact on the TSP's selling mode preference and Mode R is always good for TSP. From Proposition 5(ii), we can see that the consumers' channel acceptance and the profit-sharing rate are crucial factors for the OTA. Specifically, when both θ and r are relatively low, the OTA prefers Mode R. When θ is low but r is high, or θ is high enough, the OTA prefers Mode D. From the viewpoint of the TSC, c and θ jointly affect its selling mode preference. When the cost advantage is sufficiently low, the TSC prefers to select Mode D. More importantly, only when the cost advantage is high enough can the consumers' channel acceptance make a difference. For the consumers, when c is very low, they always prefer the dual selling mode. When c is relatively high, a lower consumers' channel acceptance would enhance the consumers' preference for the reselling mode, and vice versa.

Now we continue to compare the optimal outcomes in Mode D and Mode M to investigate when the dual selling mode or the marketplace mode is better.

Proposition 6. *For the TSP, the OTA, the TSC, and the consumers, Mode D is always*

superior to Mode M (i.e., $\Pi_{TSP}^{D*} > \Pi_{TSP}^{M*}$, $\Pi_{OTA}^{D*} > \Pi_{OTA}^{M*}$, $\Pi_{TSC}^{D*} > \Pi_{TSC}^{M*}$, and $CS^{D*} > CS^{M*}$).

This proposition shows that the dual selling mode is always better than the marketplace mode. There are two possible reasons. On the one hand, in the pure marketplace mode, only the TSP makes the pricing decision. This may lead to a monopolistic price, which would hurt consumers. Introducing the reselling channel will result in price competition, thus benefiting the consumers. On the other hand, the TSP is less efficient than the OTA. Hence, introducing the reselling channel can reduce the average selling cost. Note that Proposition 4 demonstrates that the pure marketplace mode may be better than the pure reselling mode. That is because no OTA's second adding price could reduce the double marginalization effect (Huang et al., 2018). However, in this case, the benefit generated by the dual selling mode would be more evident because a part of the advantage from no second adding price is still retained in addition to the unit cost reduction effect. As a result, for a TSC with an existing marketplace channel, it should add the reselling channel. This is beneficial not only for the TSC but also for its members.

5.2. Online selling mode equilibrium analysis

Thus far, we have analyzed the selling mode preferences of the entire TSC and its members, as well as the consumers without considering other members' selling mode preferences. However, only when the selling mode preferences of supply chain members are identical can the selling mode be an equilibrium sale mode. In the following part, we focus on exploring the online selling mode equilibrium. We will discuss two possible scenarios depending on if a dual selling mode exists. In business practice, some online platforms (e.g., Travelocity, Kuoni, Expedia) have not conducted a dual selling mode while some OTAs have run one (e.g., Ctrip, Fliggy). In fact, Ctrip and Fliggy were pure platform agents in the early stage of their development and they have introduced the dual selling mode in recent years.

Accordingly, when the OTA does not offer a dual selling mode, the chain members will choose either marketplace mode or reselling mode. When the dual selling mode is also optional, they could select the optimal selling mode among the three online selling modes.

Scenario 1: only pure selling modes available. In the following analysis, we consider the scenario in which there are only pure selling modes to choose. Namely, the supply chain members choose between Mode R and Model M. As done before, we first analyze the selling mode equilibrium from the perspectives of the TSP and the OTA.

Proposition 7. *For the TSP and the OTA,*

- (i) *When $c \leq \min(\bar{c}_0, \bar{c}_2)$ and $\bar{r}_2 \leq r \leq \bar{r}_1$, Mode M is the equilibrium sale mode.*
- (ii) *When $\bar{c}_2 < c \leq \min(\bar{c}_0, \bar{c}_1)$ and $\bar{r}_1 \leq r \leq \bar{r}_2$, Mode R is the equilibrium sale mode.*
- (iii) *When $\bar{c}_1 < c \leq \bar{c}_0$ and $r \leq \bar{r}_2$, Mode R is the equilibrium sale mode.*

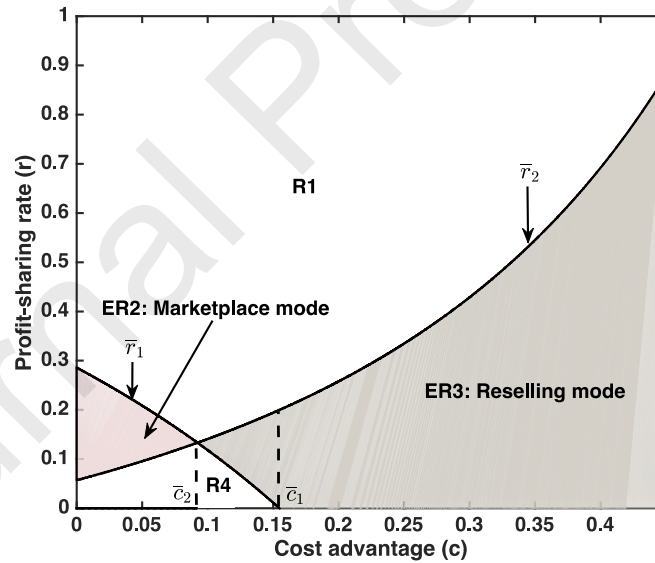


Fig. 1. Equilibrium regions for TSP and OTA under scenario 1.

Proposition 7 shows there are equilibrium sale modes for both supply chain members. Fig. 1 illustrates the results, which can help the readers understand. Furthermore, we find that when the cost advantage c is sufficiently low, Mode M would be the equilibrium sale mode as long as the two members agree on a moderate profit-sharing rate (see Fig. 1(ER2)). When the cost advantage is moderate or high, the reselling mode would be the possible equilibrium

(see Fig. 1(ER3)). In these settings, in order to have a stable sale mode, TSP and OTA should set a moderate profit-sharing rate when c is moderate. When c is high enough, they just need to care about the upper bound of profit-sharing rate and set a not too high one to make sure that each participant can benefit more from Mode R. To sum up, the TSC members should focus on the cost advantage and the profit-sharing rate when choosing the online selling mode.

We next concentrate on analyzing the selling mode equilibrium from the perspectives of the TSC and consumers. The results are summarized in the following proposition.

Proposition 8. *For the TSC and consumers, when $0 < c \leq \min(\bar{c}_0, \bar{c}_2)$, Mode M is the equilibrium sale mode while Mode R is the equilibrium when $\bar{c}_3 \leq c < \bar{c}_0$.*

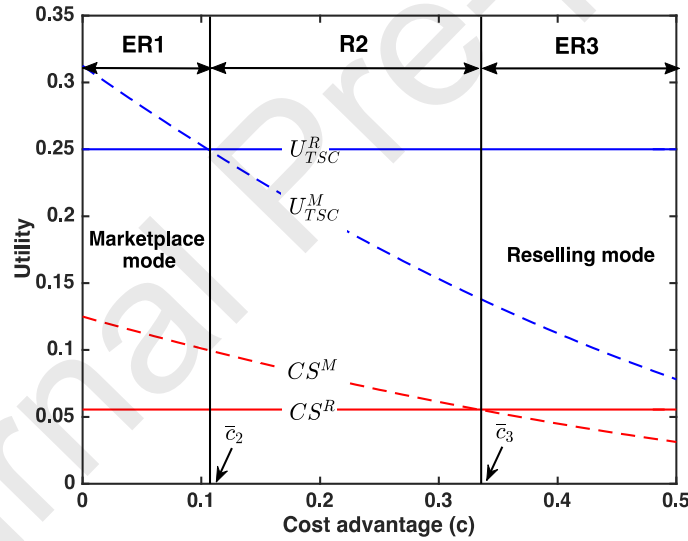


Fig. 2. Equilibrium regions for the TSC and consumers under scenario 1.

Fig. 2 illustrates our results. Proposition 8 reveals that when only pure selling modes are available, if the TSP is sufficiently efficient (lower c), the marketplace mode is the equilibrium sale mode (see Fig. 2(ER1)). In this region, both the TSC and consumers can obtain more revenues from the marketplace mode. Conversely, the reselling mode is the equilibrium under a relatively high cost advantage (see Fig. 2(ER3)). This implies that in this case, the Mode R benefits the TSC and consumers more than Mode M. Additionally, we can

see from the region R2 that when the cost advantage is moderate, the TSC prefers the reselling mode while the consumers are more likely to choose the marketplace mode.

Scenario 2: both pure and dual selling modes available. In this situation, there are two pure selling modes and one dual selling mode available. From Proposition 6, we know that Mode D always dominates Mode M for all stakeholders. Put differently, the marketplace mode would never be the equilibrium. Therefore, we hereafter investigate when the reselling mode or the dual selling mode is the equilibrium.

Proposition 9. *For the TSP and the OTA,*

- (i) *When $c \leq \bar{c}_6$, if $\theta \leq \bar{\theta}_2$ and $\bar{r}_4 \leq r \leq \bar{r}_3$, Mode D is the equilibrium sale mode; if $\theta > \bar{\theta}_2$ and $r \leq \bar{r}_3$, Mode D is the equilibrium sale mode.*
- (ii) *When $\bar{c}_6 < c \leq \bar{c}_4$, if $\theta \leq \bar{\theta}_3$ and $\bar{r}_3 \leq r \leq \bar{r}_4$, Mode R is the equilibrium sale mode; if $\bar{\theta}_3 < \theta \leq \bar{\theta}_2$ and $\bar{r}_4 \leq r \leq \bar{r}_3$, Mode D is the equilibrium sale mode; if $\bar{\theta}_2 < \theta$ and $r \leq \bar{r}_3$, Mode D is the equilibrium sale mode.*
- (iii) *When $\bar{c}_4 < c \leq \bar{c}_0$, if $\theta \leq \bar{\theta}_1$ and $r \leq \bar{r}_4$, Mode R is the equilibrium sale mode; if $\bar{\theta}_1 < \theta \leq \bar{\theta}_3$ and $\bar{r}_3 \leq r \leq \bar{r}_4$, Mode R is the equilibrium sale mode; if $\bar{\theta}_3 < \theta \leq \bar{\theta}_2$ and $\bar{r}_4 \leq r \leq \bar{r}_3$, Mode D is the equilibrium sale mode; if $\bar{\theta}_2 < \theta$ and $r \leq \bar{r}_3$, the equilibrium sale mode is Mode D.*

where $\bar{c}_6 = \frac{4 - \lambda^2 - \sqrt{3}\sqrt{5 - 2\lambda^2}}{1 - \lambda^2}$.

According to Proposition 9(i), when the cost advantage is fairly low only the dual selling mode would be the potential equilibrium. Further, when the consumers' channel acceptance is relatively low, the supply chain members should set a moderate profit-sharing rate. Also, profit-sharing rate cannot be set too high under a higher θ to reach the equilibrium Mode D (see Fig. 3(a)). From Proposition 9(ii)-(iii), Mode R or Mode D would be the potential equilibrium when the cost advantage is moderate or high. Specifically, when

θ is relatively low ($\theta \leq \bar{\theta}_3$), Mode R would be the possible equilibrium sale mode (see Fig. 3(ER5)-(ER9)). When c is sufficiently high, the TSC members should set a not too high (or a moderate) profit-sharing rate under a sufficiently low (or moderate) θ so that both would adopt Mode R (see Fig. 3(c)). When θ is relatively high ($\theta > \bar{\theta}_3$), Mode D would be the potential equilibrium sale mode. In contrast to the case ($\theta < \bar{\theta}_3$), when the consumers' channel acceptance is very high ($\theta > \bar{\theta}_2$), the participants just need to consider the upper boundary of the profit-sharing rate. When θ is moderate ($\bar{\theta}_3 < \theta < \bar{\theta}_2$), they should set a moderate one. As a summary, when the dual selling mode is optional, the chain members should pay more attention to the consumers' channel acceptance and the profit-sharing rate, as well as the cost advantage, unless c is so low. In this case, Mode D may be the only equilibrium regardless of the θ value.

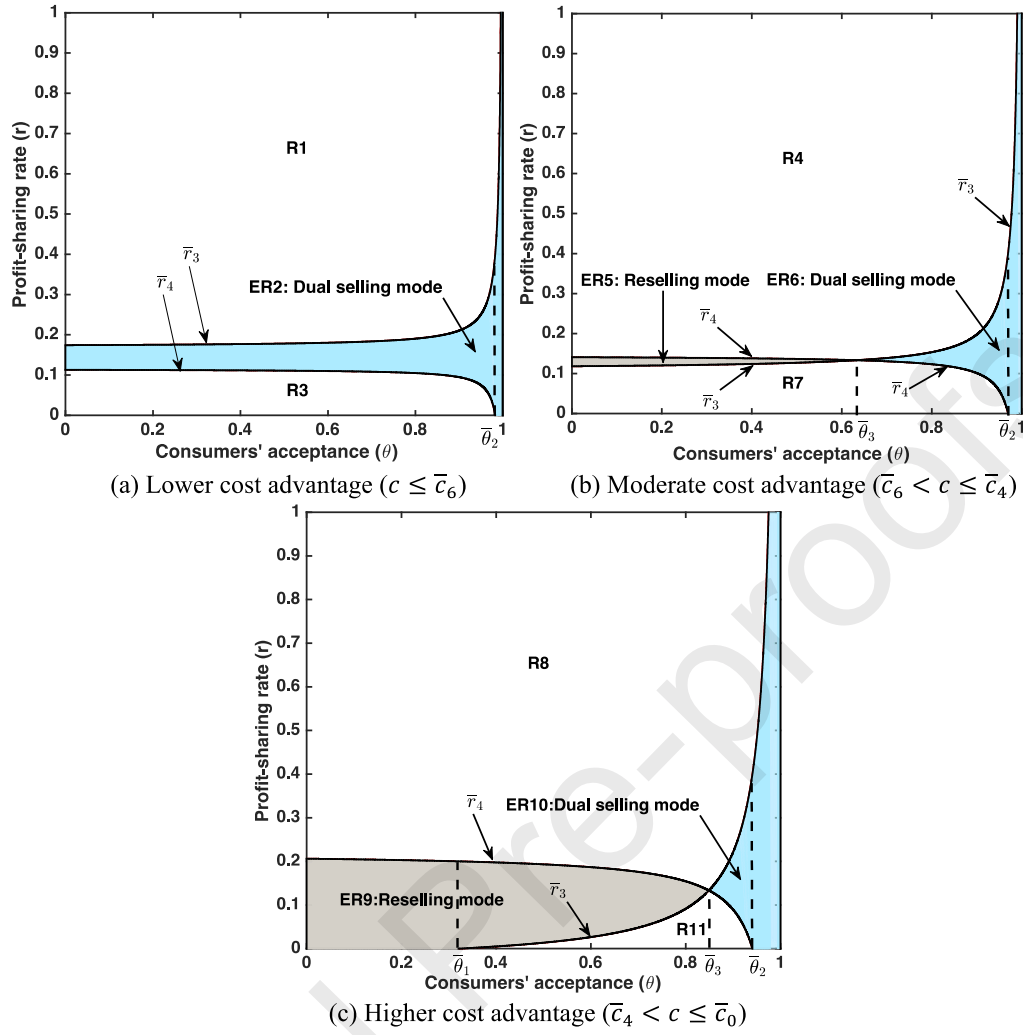


Fig. 3. Equilibrium regions for TSP and OTA under scenario 2.

Proposition 10. For the TSC and consumers, when $c \leq \min(\bar{c}_2, \bar{c}_0)$ or $\bar{c}_2 < c \leq \min(\bar{c}_5, \bar{c}_0)$ & $\theta \geq \bar{\theta}_3$ Mode D is the equilibrium sale mode; when $\bar{c}_5 < c \leq \bar{c}_0$ & $\theta \leq \bar{\theta}_4$ Mode R is the equilibrium.

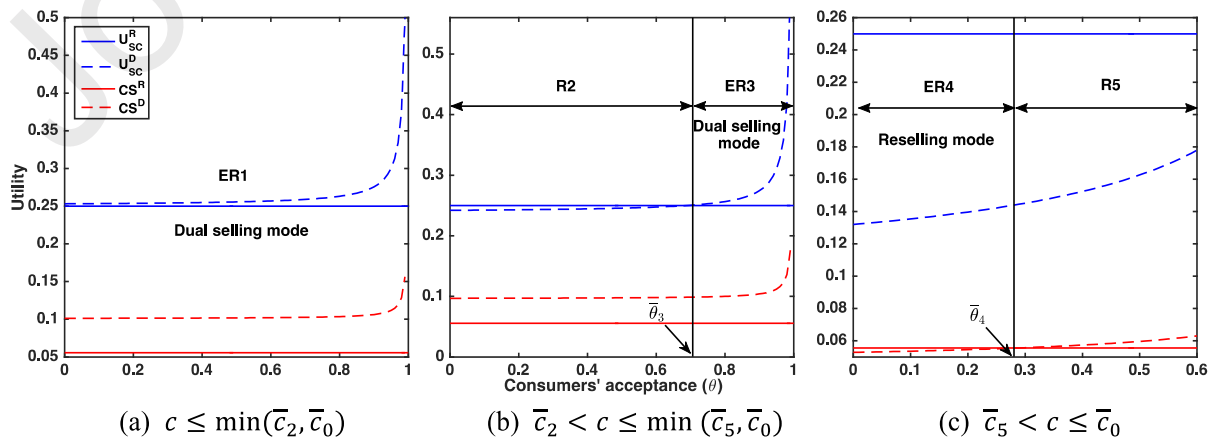


Fig. 4. Equilibrium regions for the whole TSC and consumers under scenario 2.

Fig. 4 helps illustrate our points. Proposition 10 unveils how the cost advantage and consumers' channel acceptance affect the equilibrium sale mode. When the cost advantage is sufficiently low, the dual selling mode is always the equilibrium mode (see Fig. 4(a)). When it is moderate, if the consumers' channel acceptance is high enough, Mode D is also the equilibrium (see Fig. 4(b)). When it is sufficiently high and the consumers' channel acceptance is relatively low, the reselling mode is the equilibrium (see Fig. 4(c)). However, there is no equilibrium when both c and θ are sufficiently high. More specifically, when $\bar{c}_5 < c \leq \bar{c}_0$ and $\theta > \bar{\theta}_4$ the TSC would like to adopt Mode R but the consumers prefer Mode D. Hence, when the TSP's online sale efficiency is moderate or high, the TSC should adopt the Mode D to achieve a win-win situation, whereas Mode R is best when the TSP's online selling efficiency is sufficiently low and the consumers have lower acceptance for the reselling channel.

6. Numerical studies and sensitivity analysis

In this section, we conduct numerical examples and sensitivity analysis to illustrate how the CSR and consumers' channel acceptance affect the optimal decisions, profits, and utilities of supply chain members, as well as consumer surplus. As this is the first study on online selling mode and pricing decisions in the tourism industry, we set the parameters' values based on our previous assumptions and the studies of Guo et al. (2013) and Long and Shi (2017). The basic parameter setting is: $c = 0.05, \theta = 0.5, r = 0.5, \lambda = 0.5$. We will change the values of λ and θ given other parameters, respectively.

6.1. Effect analysis of CSR

In this subsection, we conduct numerical studies to illustrate the effects of CSR. We let λ vary over $[0, 1]$ with the step length of 0.05. Figs. 5 and 6 depict these results.

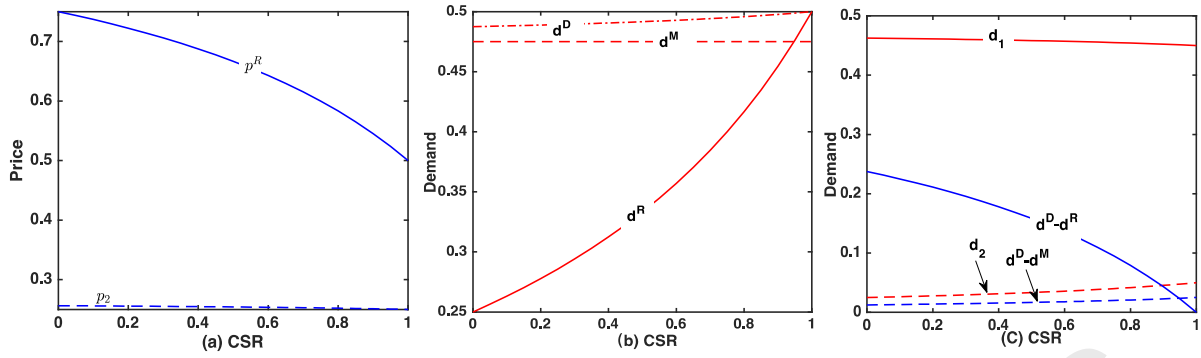


Fig. 5. The effects of CSR on prices and demands.

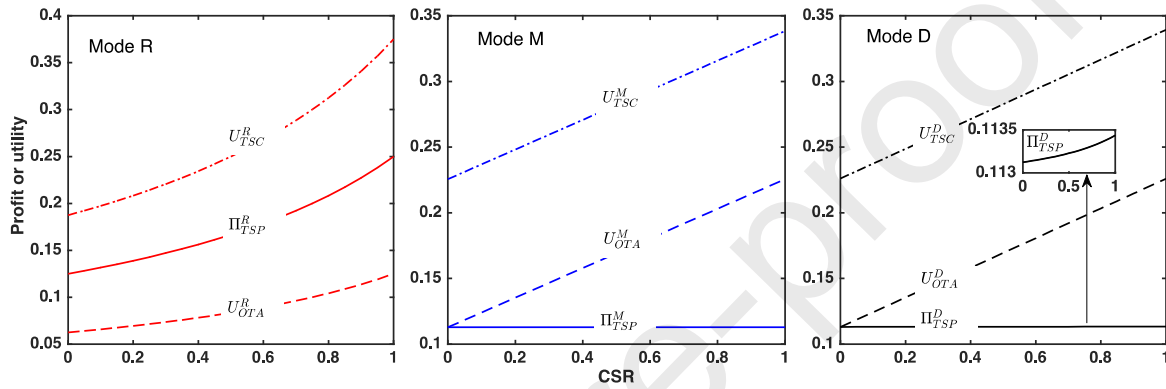


Fig. 6. The effects of CSR on profits and utilities.

From Fig. 5, we can observe that the retail price in reselling mode or the indirect retail price in dual selling mode is negatively related to CSR. Also, the demand in the reselling mode or the indirect demand in the dual selling mode is positively correlated to CSR. On the other hand, the direct demand is negatively related to CSR and the demand in marketplace mode is independent of CSR. Moreover, the total demand of dual selling mode is always larger than that in the other two pure online selling modes and the demand gap between Mode D and Mode R (M) decreases (increases) in CSR. These numerical results are consistent with the results shown in Propositions 1-3.

Based on Fig. 6, in the reselling or dual selling mode, it can be seen that OTA's CSR behavior always benefits supply chain members. However, in the marketplace mode, a higher CSR can increase OTA's utility but has no effect on TSP's, thereby resulting in the utility enhancement of the entire TSC. This is because the OTA has no pricing right so that her CSR has no impact on the TSP. Finally, this result indicates that when a firm takes CSR into

consideration, it may benefit not only himself but also other stakeholders such as consumers, business partners, and the whole supply chain.

6.2. Effect analysis of consumers' channel acceptance

Now we investigate the impacts of consumers' channel acceptance on the prices, demands, profits and the total utilities of the TSC and its members, as well as the consumer surplus. We vary θ from 0 to 1 and plot the results in Figs. 7 and 8. Note that θ is relevant for the dual selling mode.

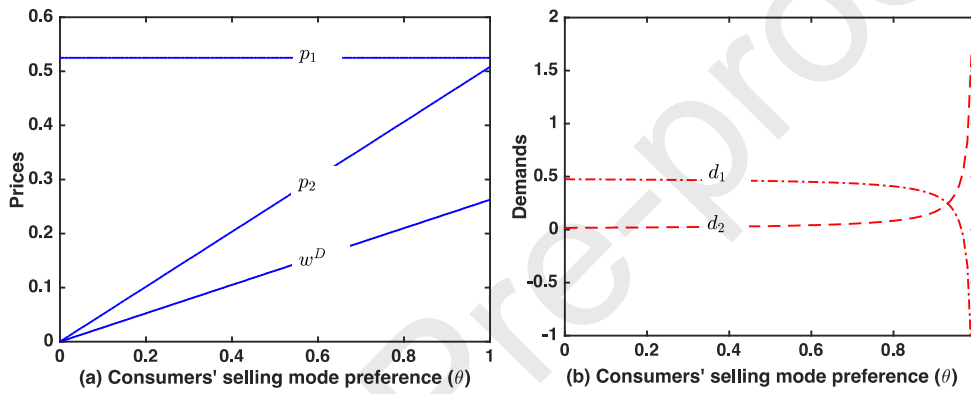


Fig. 7. The effects of θ on prices and demands.

Fig. 7 shows the effects of consumers' channel acceptance on the prices and demands in Mode D. It can be seen that the direct retail price is unaffected by θ . However, the wholesale price or the indirect retail price increases in θ . That is to say, the more consumers prefer the reselling channel, the higher price the supply chain is inclined to set to extract more consumer surplus. This can also be understood from the demand perspective as the direct demand decreases with the increase of θ . The opposite is true for the indirect demand. Therefore, a higher consumers' channel acceptance would drive more consumers to the reselling channel. Note that θ should be not too high. Otherwise, nobody wants to purchase from the marketplace channel due to the resulted negative utility.

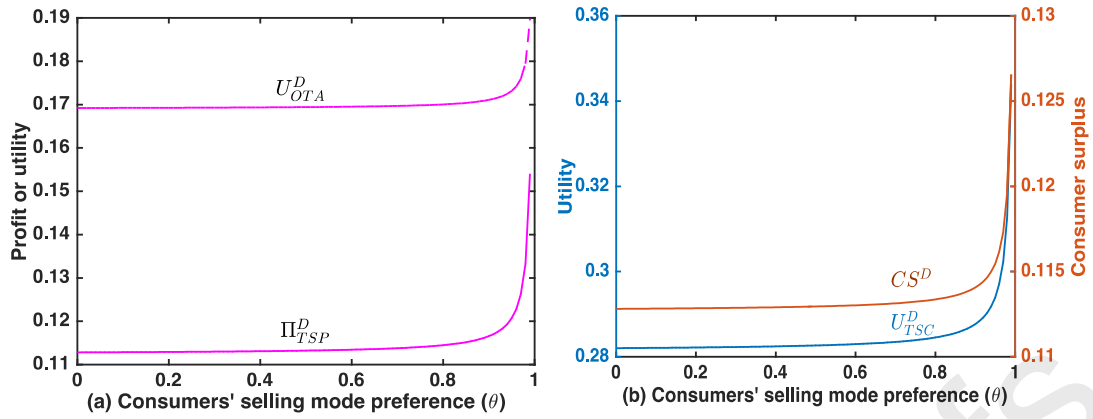


Fig. 8. The effects of θ on profit, utility and consumer surplus in Mode D.

We can obtain management implications from Fig. 8, which shows that the TSP's profit, the utilities of the OTA and the TSC, and the consumer surplus in the dual selling mode all increase in the consumers' channel acceptance. This means that a higher θ always benefits the TSC and its members and consumers in the dual selling mode. Accordingly, tourism firms planning to adopt Mode D should aim to reduce the levels of attractiveness between the reselling and the marketplace channels.

7. Conclusions

With the rapid development of online marketing platforms, various types of online selling modes have been implemented in business practice. In this paper, we investigate the selling mode choice and pricing decisions of an O2O tourism supply chain comprised of a tourism service provider and an online travel agency having a corporate social responsibility. Motivated by business practice, we study three sale models, namely, the pure reselling mode, the pure marketplace mode, and the dual selling mode. Our main research results and managerial insights can be summarized as follows.

First, our findings reveal when an online selling mode is best from different perspectives. For the TSP and the OTA, it suggests that when there are only two pure selling modes to choose, they should consider the OTA's cost advantage and profit-sharing rate. In this case, when the cost advantage is sufficiently low, they should set a moderate profit-sharing rate to

achieve win-win outcomes using the marketplace mode. When the cost advantage is moderate, the reselling mode would be the equilibrium as long as the profit-sharing rate is also moderate. However, when the cost advantage is high enough, they should set a relatively low profit-sharing rate. With the availability of the dual selling mode, things become more complicated. In general, when the cost advantage is very low the dual selling mode is the only possible equilibrium. However, when it is moderate or high, either the reselling mode or the dual selling mode may be the equilibrium. Furthermore, if the consumers' channel acceptance for the reselling channel is relatively low and the profit-sharing rate is moderate and/or not too high, Mode R would be the equilibrium. Otherwise, Mode D would be the equilibrium. From the perspective of the TSC and consumers, we find that only the cost advantage can affect the selling mode choices when only pure selling modes are available. If the dual selling mode is also possible, both the cost advantage and consumers' channel acceptance could influence their choices. In this scenario, the marketplace mode would never be the equilibrium. These results can provide theoretical managerial insights for tourism firms to make the right sale mode decision.

Second, our research findings can help the TSC members make better pricing decisions. Our analysis shows that OTA's CSR behavior would affect the optimal pricing, thereby impacting the market demands. Furthermore, the OTA, if endowed with pricing power, should reduce the retail prices in any selling mode with an increase of λ . However, the OTA's CSR behavior will not influence the TSP's pricing in all three modes. This implies that one firm's CSR behavior may not extend to others through prices. However, in the dual selling mode, CSR behavior would attract more consumers to the reselling channel, which would reduce the TSP's marketplace channel demand. Moreover, the consumers' channel acceptance also plays an important role in pricing. Specifically, in the dual selling mode, the wholesale and retail prices in the reselling channel increase as θ increases. More

importantly, higher λ and θ would create more total utility. The associated managerial insight is that tourism firms reduce the difference of the attractiveness between the reselling and marketplace channels. For example, the offline service providers could provide the same service level for two channels instead of differentiated services or provide the reselling channel with product authorization certificate to reduce the discount utility, i.e., improving the consumers' channel acceptance for the reselling channel. These measures can lead to more total utility in the dual selling mode.

There are several potential directions for future research. Firstly, in this paper, we focus on the optimal choice of online selling modes without considering the offline channel or the TSP's own online channel. Hence, future research can investigate the possibility of offline competitive travel agency or TSP's own sale website. In addition, in this study, we assume that the TSC sells only one type of product in two different online selling channels. It would be an interesting research direction to study the case with multiple product types and multiple tourism service providers.

Acknowledgments

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Appendices

Appendix A. Proofs of optimal solutions

In Mode R, we first solve the optimal pricing response of OTA by backward induction. Taking the second-order derivative of U_{OTA}^R with respect to p^R leads to $\frac{d^2 U_{OTA}^R}{d(p^R)^2} = \lambda - 2 < 0$. This means the optimization problem of OTA has an optimal solution, which can be solved by the first-order condition $1 - 2p + w - (1 - p)\lambda = 0$ resulting in $p^R = \frac{1 + w - \lambda}{2 - \lambda}$. Plugging this best price response into the problem of TSP and taking the second-order derivative of Π_{TSP}^R with respect to w^R , we can have $\frac{d^2 \Pi_{TSP}^R}{d(w^R)^2} = \frac{-2}{2 - \lambda} < 0$, which also indicates the TSP can get his optimal solution by the first-order condition $\frac{1 - 2w}{2 - \lambda} = 0$, resulting in $w^{R*} = \frac{1}{2}$. Then we take w^{R*} back into the best response of OTA to get the optimal sale price as $p^{R*} = \frac{3 - 2\lambda}{2(2 - \lambda)}$. Afterwards, we take the optimal solutions w^{R*} and p^{R*} into the demand and profit functions of TSP and utility functions of OTA and the whole supply chain resulting in the optimal demands and profits and utilities of supply chain members.

The proofs of the other two modes are similar to the pure reselling mode, so we omit the specific certification process to save space but provide the optimal solution existence conditions here. In Mode M, we have $\frac{d^2 \Pi_{TSP}^M}{d(p^M)^2} = -2(1 - r) < 0$. In Mode D, we can have the Hessian matrix as shown Eq. (A.1), which implies that the optimization problem of the supply chain has optimal solutions.

$$H = \begin{vmatrix} \frac{-2}{(1 - \theta)\theta(2 - \lambda)} & \frac{2(1 - r)}{(1 - \theta)(2 - \lambda)} \\ \frac{2(1 - r)}{(1 - \theta)(2 - \lambda)} & \frac{2(1 - r)[\theta(1 + r - \lambda) + \lambda - 2]}{(1 - \theta)(2 - \lambda)} \end{vmatrix} = \frac{4(1 - r)}{(1 - \theta)\theta(2 - \lambda)} > 0 \quad (A.1)$$

Appendix B. Proofs of Propositions

Proofs of Propositions 1-2. Taking the first derivatives of prices and demands with respect

to parameter λ resulting in $\frac{\partial p^{R*}}{\partial \lambda} = \frac{-1}{2(2-\lambda)^2} < 0$; $\frac{\partial p_2}{\partial \lambda} = \frac{-c\theta}{2(2-\lambda)^2} < 0$; $\frac{\partial d^{R*}}{\partial \lambda} = \frac{2}{(4-2\lambda)^2} > 0$; $\frac{\partial d_1^{D*}}{\partial \lambda} = \frac{-c\theta}{2(1-\theta)(2-\lambda)^2} < 0$; $\frac{\partial d_2^{D*}}{\partial \lambda} = \frac{c(2-2\theta)}{(4-4\theta-2\lambda+2\theta\lambda)^2} > 0$. The proofs are completed.

Proof of Proposition 3. Comparing the demands among the three models, we can obtain

$$d^{D*} - d^{R*} = \frac{(1-c)(1-\lambda)}{2(2-\lambda)} > 0 \quad \text{and} \quad d^{D*} - d^{M*} = \frac{c}{4-2\lambda} > 0. \quad \text{Based on these comparison}$$

results, it can be further deduced that $\frac{\partial(d^{D*} - d^{R*})}{\partial \lambda} = \frac{-1+c}{2(2-\lambda)^2} < 0$ and $\frac{\partial(d^{D*} - d^{M*})}{\partial \lambda} = \frac{2c}{(4-2\lambda)^2} > 0$.

Proof of Proposition 4. Comparing the profits of TSP in Models M and R, we have the following expression.

$$\Pi_{TSP}^{M*} - \Pi_{TSP}^{R*} = \frac{1 - 2c(1-r)(2-\lambda) + c^2(1-r)(2-\lambda) - r(2-\lambda) - \lambda}{4(2-\lambda)} \quad (\text{B.1})$$

We set $f(r) = 1 - 2c(1-r)(2-\lambda) + c^2(1-r)(2-\lambda) - r(2-\lambda) - \lambda$. Furthermore, we can find that when $f(r) \geq 0$, then $\Pi_{TSP}^{M*} \geq \Pi_{TSP}^{R*}$. Hence, solving the equation $f(r) = 0$, we can have: $\bar{r}_1 = \frac{1-4c+2c^2-\lambda(1-c)^2}{(1-c)^2(2-\lambda)}$. We further define $g_1(c) = 1 - 4c + 2c^2 - \lambda(1-c)^2$.

From the \bar{r}_1 , we can derive that when $g_1(c) \geq 0$, then $\bar{r}_1 \geq 0$, otherwise $\bar{r}_1 < 0$. Therefore, we solve the $g_1(c) = 0$ to get two roots $\bar{c}_1 = \frac{2-\lambda-\sqrt{2-\lambda}}{2-\lambda}$ and $\bar{c}_1' = \frac{2-\lambda+\sqrt{2-\lambda}}{2-\lambda} > 1$ (deleted). To sum up, we derive that when $c \leq \bar{c}_1$, then $\bar{r}_1 \geq 0$ while $\bar{r}_1 < 0$ when $c > \bar{c}_1$.

Based on this, we further find that given $c \leq \bar{c}_1$: when $r \leq \bar{r}_1$, then $\Pi_{TSP}^{M*} \geq \Pi_{TSP}^{R*}$, otherwise $\Pi_{TSP}^{M*} < \Pi_{TSP}^{R*}$. Similarly, we can prove the other results and we just provide the expressions as follows.

$$U_{OTA}^{M*} - U_{OTA}^{R*} = \frac{2(1-c)^2r(2-\lambda) + \lambda(1-c)^2(2-\lambda) - 1}{8(2-\lambda)} \quad (\text{B.2})$$

$$U_{SC}^{M*} - U_{SC}^{R*} = \frac{1-\lambda^2-(2-c)c(4-\lambda^2)}{8(2-\lambda)} \quad (\text{B.3})$$

$$CS^{M*} - CS^{R*} = \frac{3-(2-c)c(2-\lambda)^2-4\lambda+\lambda^2}{8(2-\lambda)^2} \quad (\text{B.4})$$

By solving the equation $\Pi_{OTA}^{M*} - \Pi_{OTA}^{R*} = 0$, $\Pi_{SC}^{M*} - \Pi_{SC}^{R*} = 0$ and $CS^{M*} - CS^{R*} = 0$, we can obtain the thresholds as $\bar{r}_2 = \frac{1 - \lambda(1 - c)^2(2 - \lambda)}{2(1 - c)^2(2 - \lambda)}$, $\bar{c}_2 = \frac{4 - \lambda^2 - \sqrt{3}\sqrt{4 - \lambda^2}}{4 - \lambda^2}$ and $\bar{c}_3 = \frac{1 - \lambda}{2 - \lambda}$.

Proof of Proposition 5. Comparing the profits and utilities of TSP, OTA, and SC in Mode D and Mode R, we have the following expressions.

$$\Pi_{TSP}^{D*} - \Pi_{TSP}^{R*} = \frac{(1 - \theta)[1 - r(2 - \lambda) - \lambda] - 2c(1 - r)(1 - \theta)(2 - \lambda) + c^2\{2 - \theta + (1 - \theta)[(2 - \lambda)r - \lambda]\}}{4(1 - \theta)(2 - \lambda)} \quad (B.5)$$

$$U_{OTA}^{D*} - U_{OTA}^{R*} = \frac{2(1 - c)^2[r(1 - \theta)(2 - \lambda) + \lambda(1 - \lambda)] - 1 + \theta[(1 + c^2)(1 - \lambda)^2 + 2c(2 - \lambda)\lambda]}{8(1 - \theta)(2 - \lambda)} \quad (B.6)$$

$$U_{SC}^{D*} - U_{SC}^{R*} = \frac{(1 - \theta)[(1 - \lambda^2) - 2c(4 - \lambda^2)] + c^2[4 - \lambda^2 - \theta(1 - \lambda^2)]}{8(1 - \theta)(2 - \lambda)} \quad (B.7)$$

$$CS^{D*} - CS^{R*} = \frac{(1 - \theta)[2c(2 - \lambda)^2 - (3 - 4\lambda + \lambda^2)] + c^2[\theta(3 - 4\lambda + \lambda^2) - (2 - \lambda)^2]}{-8(1 - \theta)(2 - \lambda)^2} \quad (B.8)$$

By solving $\Pi_{TSP}^{D*} - \Pi_{TSP}^{R*} = 0$, we can obtain the corresponding thresholds as $\bar{r}_3 = \frac{1 - 4c + 2c^2 - \theta(1 - 4c + c^2) - \lambda(1 - c)^2(1 - \theta)}{(1 - c)^2(1 - \theta)(2 - \lambda)}$, $\bar{\theta}_1 = \frac{4c - 2c^2 - 1 + \lambda(1 - c)^2}{4c - c^2 - 1 + \lambda(1 - c)^2}$ and $\bar{c}_4 = \frac{\lambda - 2 + \sqrt{3 - 2\lambda}}{\lambda - 1}$. Solving the

equation $\Pi_{OTA}^{D*} - \Pi_{OTA}^{R*} = 0$ results in $\bar{r}_4 = \frac{1 - \theta(1 + c^2) - \lambda(1 - c)^2(2 - \lambda)(1 - \theta)}{2(1 - c)^2(1 - \theta)(2 - \lambda)}$ and $\bar{\theta}_2 =$

$\frac{1 - \lambda(1 - c)^2(2 - \lambda)}{1 + c^2 - \lambda(1 - c)^2(2 - \lambda)}$. According to Eq. (B.7), we can derive the key thresholds as $\bar{\theta}_3 =$

$\frac{8c - 4c^2 - 1 + \lambda^2(1 - c)^2}{8c - c^2 - 1 + \lambda^2(1 - c)^2}$. From Eq. (B.8), we have $\bar{\theta}_4 = \frac{3 - 8c + 4c^2 + \lambda(1 - c)^2(\lambda - 4)}{3 - 8c + 3c^2 + \lambda(1 - c)^2(\lambda - 4)}$ and $\bar{c}_5 =$

$\frac{4 - 4\lambda + \lambda^2 - \sqrt{7 - 8\lambda + 2\lambda^2}}{3 - 4\lambda + \lambda^2}$.

Proof of Proposition 6. Comparing the profits and utilities of TSP, OTA, and SC in Mode D and Mode M, we have the following expressions, which can directly prove this proposition.

$$\Pi_{TSP}^{D*} - \Pi_{TSP}^{M*} = \frac{c^2\theta}{4(1 - \theta)(2 - \lambda)} > 0 \quad (B.9)$$

$$U_{OTA}^{D*} - U_{OTA}^{M*} = \frac{c^2\theta}{8(1 - \theta)(2 - \lambda)} > 0 \quad (B.10)$$

$$U_{SC}^{D*} - U_{SC}^{M*} = \frac{3c^2\theta}{8(1 - \theta)(2 - \lambda)} > 0 \quad (B.11)$$

$$CS^{D*} - CS^{M*} = \frac{c^2\theta}{8(1 - \theta)(2 - \lambda)^2} > 0 \quad (B.12)$$

Proof of Proposition 7. According to Proposition 4(1)-(2), we should make sure that the two

chain members choose the same selling mode. Namely, we only need to find the common parameters areas that they prefer the same marketing mode. We compare the thresholds resulting in $\bar{r}_1 - \bar{r}_2 = \frac{1 - \lambda^2 - c(4 - \lambda^2)(2 - c)}{2(1 - c)^2(2 - \lambda)}$. We set $g_2(c) = 1 - \lambda^2 - c(4 - \lambda^2)(2 - c)$ and solve the equation $g_2(c) = 0$ leading to two roots $\bar{c}_2 = \frac{4 - \lambda^2 - \sqrt{3}\sqrt{4 - \lambda^2}}{4 - \lambda^2}$ and $\bar{c}_2' = \frac{4 - \lambda^2 + \sqrt{3}\sqrt{4 - \lambda^2}}{4 - \lambda^2} > 1$ (deleted). Furthermore, we can deduce that when $c < \bar{c}_2$, then $\bar{r}_1 > \bar{r}_2$ while $c > \bar{c}_2$, then $\bar{r}_1 < \bar{r}_2$. According to this, we can find the common regions, which are summarized in Proposition 7.

Proof of Proposition 8. Similar to the proofs of Proposition 7, comparing the thresholds results in $\bar{r}_4 - \bar{r}_3 = \frac{(1 - \theta)[(1 - \lambda^2) - 2c(4 - \lambda^2)] + c^2[4 - \lambda^2 - \theta(1 - \lambda^2)]}{2(1 - c)^2(1 - \theta)(2 - \lambda)}$. Solving $\bar{r}_4 - \bar{r}_3 = 0$, we can obtain the threshold $\bar{\theta}_3 = \frac{8c - 4c^2 - 1 + \lambda^2(1 - c)^2}{8c - c^2 - 1 + \lambda^2(1 - c)^2} = 1 - \frac{3c^2}{8c - c^2 - 1 + \lambda^2(1 - c)^2}$. We here omit the other similar solving processes to save pace and just present the thresholds as follows.

$$\bar{\theta}_3 - \bar{\theta}_2 = \frac{2(1 - c)^2 c^2 (2 - 3\lambda + \lambda^2)}{[(1 - \lambda)^2 + c^2(1 - \lambda)^2 + 2c(2 - \lambda)\lambda][1 - \lambda^2 - 2c(4 - \lambda^2) + c^2(1 - \lambda^2)]} \quad (\text{B.13})$$

$$\bar{\theta}_1 - \bar{\theta}_3 = \frac{-(1 - c)^2 c^2 (2 - 3\lambda + \lambda^2)}{[(c^2 + 1)(1 - \lambda) + 2c(2 - \lambda)][(c^2 + 1)(1 - \lambda^2) - 2c(4 - \lambda^2)]} \quad (\text{B.14})$$

We define $g_3(c) = 1 - \lambda^2 - 2c(4 - \lambda^2) + c^2(1 - \lambda^2)$ and solve $g_3(c) = 0$ leading to $\bar{c}_6 = \frac{4 - \lambda^2 - \sqrt{3}\sqrt{5 - 2\lambda^2}}{1 - \lambda^2}$ and $\bar{c}_6' = \frac{4 - \lambda^2 + \sqrt{3}\sqrt{5 - 2\lambda^2}}{1 - \lambda^2} > 1$ (deleted). Solving the $(c^2 + 1)(1 - \lambda^2) - 2c(4 - \lambda^2) = 0$, we can get the threshold \bar{c}_4 . When $\bar{c}_6 < c < \bar{c}_4$, we can derive $\bar{\theta}_3 < \bar{\theta}_2$. When $\bar{c}_4 < c < \bar{c}_0$, we have $\bar{\theta}_1 < \bar{\theta}_3 < \bar{\theta}_2$. Furthermore, we can obtain the Proposition 8 by finding the common regions.

The proofs of Propositions 9 and 10 are similar to Propositions 4 and 5 and we find out the same regions to obtain our results.

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Conflict of Interest

Title: Online selling mode choice and pricing in an O2O tourism supply chain considering corporate social responsibility

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Declarations of interest: none

Highlights:

- Pricing policies of the TSP and OTA under different online selling modes
- Impact of CSR on optimal prices and demands
- Effects of some system factors on profit, utility and consumer surplus
- Suggestions to tourism firms on how to make an online selling mode choice