

Coordinating commission to hotels and online travel agencies

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Abstract

The purpose of this research is to find the optimal commission rate that the hotels pay the online travel agencies under cooperative decentralization. A Stackelberg game theory is utilized to model their decision making. The online travel agency who sets and provides a commission rate to the hotel acts as the leader; the hotel who decides the guest room rate is the follower. The results show that the optimal commission rate under cooperative decentralization is the ratio of the online travel agency unit cost to total unit cost. The sum of these two firms' profit will equal the profits under the centralized channel. Notably, even decentralization occurs if through coordination, it can still obtain the maximum profit the same as under centralization.

Keywords: hotel, online travel agency, commission rate, channel coordination

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Introduction

Previous studies on the interaction between hotels and online travel agencies have focused on hotel pricing strategies that are part of online distribution channels, hotel room allocation strategies, overselling strategies, dual-channel sales and demand uncertainty (Collins & Parsa, 2006; Guo & He, 2012; Kim *et al.*, 2009; Koide & Ishii, 2005; Lai & Ng, 2005; Liao *et al.*, 2019; Ling *et al.*, 2014; Tso & Law, 2005). Additional research regarding the rates of commission paid by hotels to the online travel agencies assume that such commission is exogenously attributed (Guo *et al.*, 2013; Liao *et al.*, 2019; Liao *et al.*, 2015). For example, Liao *et al.* (2015) examines the impact of different commission rates impacting online travel agency profitability. Whenever the commission rate is moderate, hotels and online travel agencies may obtain the highest profit levels. Therefore, online travel agencies and hotels can choose to negotiate an appropriate commission rate that is mutually beneficial. Although Liao *et al.* (2015) proves the existence of an optimal commission rate, their model considers the commission rate as an exogenous setting and substitutes different values into the profit function, which lacks generality. It should be noted that the above studies consider the commission rate to be an exogenous variable. Apart from the aforementioned literature, this paper regards the commission rate to be an endogenous variable determinant of the optimal commission rate.

Various prior studies (Guo *et al.*, 2013; Ling *et al.*, 2011; Ling *et al.*, 2014) have set the hotel as the “leader” in the theoretical Stackelberg game, and online travel agency as the “follower”. The hotels represented in the literature are typically large, international hotel chains possessing greater price negotiation rights when compared to online travel agencies. However, in the current study, the research objects are mainly small-to-medium-sized hotels or B&B operations, while the objects of online travel agencies are those with stronger price negotiation power. As such, this paper sets the online travel agency as the leader and the hotel as the follower similar to Liao *et al.* (2019).

The purpose of this paper is to examine the optimal commission rate determined by the online travel agency and the optimal hotel room rate determined by the hotel in order to maximize profits as part of a cooperative decentralized channel. The feature of this research is that the commission rate paid by the hotel to the online travel agencies is regarded as an endogenous decision variable to be solved, and a mutually beneficial hotel room rate is able to be solved simultaneously when based on negotiation.

Methodology

Considering a hotel supply chain, this research takes one dominant online travel agency and one small or medium-sized hotel as the research objects. It is given that the hotel cooperates exclusively with a specific online travel agency and that all rooms are handled by this entity for single-channel online sales. Thus, the hotel and online travel agency cooperate under an agency model. Following a Stackelberg game sequence, the online travel agency (leader) provides the hotel (follower) with a cooperation proposal, which presents a mutually beneficial commission rate. As a follower, the hotel responds by setting a reasonable room rate. The online travel agency charges a commission fee rp at the commission rate r for each room sold. The hotel responds by choosing a room rate p to maximize its profit. It is assumed that the quantity sold by a hotel $q(p)$ is a linear function of price p :

$$q(p) = a - bp \quad (1)$$

where a and b are both nonnegative, the scale parameter and price sensitivity coefficient of (1) respectively. Let c represent the unit cost of the entire channel, $c = c_h + c_o$. c_h is the unit production cost of hotel, c_o is the unit production cost of the online travel agency. Let π_o , π_h , and π_t represent the profit of the online travel agency, the hotel, and the entire hotel supply chain channel respectively, $\pi_t = \pi_h + \pi_o$.

To solve the decision-making problem of the centralized hotel supply chain, first consider the sub-problems of the online travel agency and hotel, and then sum them up as an aggregate whole. The profit function of the hotel is represented by the following equation:

$$\pi_h = [(1-r)p - c_h]q(p)$$

Substituting the $q(p)$ equation (1) into the profit function of the hotel, it is re-written as:

$$\pi_h = [(1-r)p - c_h] (a - bp) \quad (2)$$

The profit function of the online travel agency is expressed as follows:

$$\pi_o = (rp - c_o) (a - bp) \quad (3)$$

Summing equations (2) and (3), there is only one optimization problem of decision variable p :

$$\begin{aligned} \max_p \pi_t &= \pi_h + \pi_o \\ &= (p-c)(a - bp) \end{aligned} \quad (4)$$

Differentiating (4) with respect to p and setting to zero, the optimal hotel room rate is derived:

$$\frac{\partial \pi_t}{\partial p} = a - 2bp + bc = 0$$

The optimal room rate p^* can be obtained as:

$$p^* = \frac{a}{2b} + \frac{c}{2} \quad (5)$$

Substituting equation (5) into (4), it is possible to have the maximization profit of centralized hotel supply chain, as follows:

$$\begin{aligned} \pi_t^* &= (p^* - c) (a - bp^*) \\ &= \left(\frac{a + bc}{2b} - c \right) \left[a - b \left(\frac{a + bc}{2b} \right) \right] \\ &= \frac{(a - bc)^2}{4b} \end{aligned} \quad (6)$$

Before solving the optimal commission rate and price for cooperative decentralization, it is necessary to solve them for non-cooperative decentralization. Each firm is to maximize its profit in non-cooperative decentralized scenario. The profit maximized decision of the hotel can be derived from equation (2) as follows:

$$\frac{\partial \pi_h}{\partial p} = a(1-r) - 2b(1-r)p + bc_h = 0$$

The optimal room rate, denoted as $p_d^*(r)$, is a function of commission rate r :

$$p_d^*(r) = \frac{a}{2b} + \frac{c_h}{2(1-r)} \quad (7)$$

Proposition 1. In non-cooperative decentralized scenario, the guest room rate of hotel is optimal and unique.

Proof. The second order partial derivative of π_h in (2) is shown as follows:

$$\frac{\partial^2 \pi_h}{\partial p^2} = -2b(1-r) < 0$$

Therefore, $p_d^*(r)$ is optimal and unique.

Differing from the position of non-cooperative decentralization, the online travel agency can induce the hotel to set the optimum guest room rate that can maximize a channel-wide profit scheme by adopting the optimal commission rate under the cooperative decentralization. According to previous literature, maximized profit occurs at the point of centralization (Liao *et al.*, 2019; Ling *et al.*, 2014; Guo *et al.*, 2013). For example, let the optimal price of non-cooperative decentralization become equal to the optimal price of centralization:

$$p_d^*(r) = p^*$$

$$\frac{a}{2b} + \frac{c_h}{2(1-r)} = \frac{a}{2b} + \frac{c}{2}$$

that is,

Solving the equation above obtains the optimal commission rate for the cooperative decentralized channel by producing:

$$r_c^* = \frac{c_o}{c} \quad (8)$$

Proposition 2. The optimal commission rate for cooperative decentralization is equal to the ratio of online travel agency cost to the total cost of the entire channel. Thus, the optimal guest room price for cooperative decentralization is equal to the optimal centralized price. Such price and commission-rate settings generate the maximized channel-wide profit in the same manner as that of centralization.

Proof

Substituting equation (8) $r_c^* = c_o/c$ into (7), there exists:

$$\begin{aligned}
 p_d^*(r) &= \frac{a}{2b} + \frac{c_h}{2(1 - \frac{c_o}{c})} \\
 &= \frac{a}{2b} + \frac{c}{2}
 \end{aligned} \tag{9}$$

The result is the same as that of equation (5), that is:

$$p_d^*(r) = p^*$$

The optimal guest room price for cooperative decentralization is equal to the optimal centralized price. Then it is possible to prove that the optimum room price and commission rate settings under cooperative decentralization will generate the maximized channel-wide profit in the same way as centralization.

Substituting equation (8) $r_c^* = c_o/c$ and (7) $p_d^*(r) = \frac{a}{2b} + \frac{c}{2}$ into (2) and (3), there is:

$$\pi_h^c = (1 - r_c^*) \pi_t^* \tag{10}$$

$$\pi_o^c = r_c^* \pi_t^* \tag{11}$$

Proof

See Appendix.

The profit of a hotel and an online travel agency under the auspices of cooperative decentralization is equal to the ratio of their respective cost to the total cost multiplied by the total profit of the centralization. Summing up (10) and (11), there is:

$$\pi_h^c + \pi_o^c = \pi_t^* \tag{12}$$

The above equation indicates that the sum of profit for the hotel and the online travel agency is equal to the profit of centralization. Whenever the commission rate of cooperative decentralization is equal to the ratio of the online travel agency cost to the total cost for the entire channel and the hotel room price is equal to the optimal hotel room price of centralized channel, the sum of profit for the hotel and the online travel agency equal to the profit of centralization. Therefore, the commission rate and hotel room rate are optimal.

Numerical analysis

To verify the analytic results in the current study, the parameters a , b , c_h , c_o are assumed to be 100, 0.5, 80 and 20 respectively. Substituting the above data into Equation (5), (8), (6), (2) and (3), we can obtain the optimal guest room rate 150, optimal commission rate 0.2, maximized profit of centralization 1250, hotel's profit 1000 and OTA's profit 250. Table 1 shows that the sum of hotel's and OTA's profit 1250 under cooperative decentralization, which is the same as that of centralization. The results in Therefore, The numerical results from the analytic solutions listed in Table 1 confirm the theoretical derivation of Proposition 2 and Equation (10), (11) and (12).

Table 1. Numerical results from the analytic solutions

Optimal parameter	Centralization	Cooperative decentralization
Guest room rate	150	150
Commission rate	----	0.2
Hotel's profit	----	1000
OTA's profit	----	250
Total profit	1250	1250

Conclusion

This study discusses a mutually beneficial commission rate coordination between hotels and online travel agencies. Differing from the previous studies (Guo *et al.*, 2013; Liao *et al.*, 2019; Liao *et al.*, 2015), this paper assumes that the commission rate is not a constant, but it is to be considered as an important decision variable for the online travel agency. It derives the optimum commission rate paid by the hotelier to the online travel agency along with the corresponding optimum hotel room rate. The optimal commission rate under cooperative decentralization is the ratio of the online travel agency unit cost to unit cost of the entire channel; so, the optimal guest room rate is equal to the one under centralization. If the hotel and the online travel agency are able to be coordinated with one another, the online travel agency will provide the optimal commission rate to the hotel and the hotel responds with the most appropriate pricing. The sum of these two firms' profit will equal the profits under the centralized channel. Notably, even decentralization occurs if through coordination, it can still obtain the maximum profit the same as under centralization.

Appendix

Proof of Proposition 3.

Substituting (8) and (9) into (3), π_o is replaced by π_o^c , there is:

$$\begin{aligned}
 \pi_o^c &= (rp - c_o)(a - bp) \\
 &= \left[\frac{c_o}{c} \left(\frac{a}{2b} + \frac{c}{2} \right) - c_o \right] \left[a - b \left(\frac{a}{2b} + \frac{c}{2} \right) \right] \\
 &= \left(\frac{ac_o}{2bc} - \frac{c_o}{2} \right) \left(\frac{a}{2} - \frac{bc}{2} \right) \\
 &= \frac{a^2c_o}{4bc} - \frac{ac_o}{4} - \frac{ac_o}{4} + \frac{bcc_o}{4} \\
 &= \frac{a^2c_o - 2abcc_o + b^2c^2c_o}{4bc} = \frac{c_o(a - bc)^2}{4bc} \\
 &= \frac{c_o}{c} \frac{(a - bc)^2}{4b} \\
 &= r_c^* \pi_t
 \end{aligned}$$

Similarly, substituting (8) and (9) into (2), π_h is replaced by π_h^c , there is:

$$\begin{aligned}
 \pi_h^c &= [(1 - r)p - c_h](a - bp) \\
 &= \left[\left(1 - \frac{c_o}{c} \right) \left(\frac{a}{2b} + \frac{c}{2} \right) - c_h \right] \left[a - b \left(\frac{a}{2b} + \frac{c}{2} \right) \right] \\
 &= \left[\frac{c_h}{c} \left(\frac{a}{2b} + \frac{c}{2} \right) - c_h \right] \left[a - b \left(\frac{a}{2b} + \frac{c}{2} \right) \right]
 \end{aligned}$$

$$\begin{aligned}
&= \left(\frac{ac_h}{2bc} - \frac{c_o}{2} \right) \left(\frac{a}{2} - \frac{bc}{2} \right) \\
&= \frac{a^2c_h}{4bc} - \frac{ac_h}{4} - \frac{ac_h}{4} + \frac{bcc_h}{4} \\
&= \frac{a^2c_h - 2abcc_h + b^2c^2c_o}{4bc} = \frac{c_h(a-bc)^2}{4bc} \\
&= \frac{c_h}{c} \frac{(a-bc)^2}{4b} \\
&= \left(1 - \frac{c_o}{c} \right) \pi_t \\
&= (1-r_c) \pi_t
\end{aligned}$$

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