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Game-theoretic study of the dynamics of tourism supply chains for package holidays under quantity competition

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This paper considers a tourism supply chain (TSC) for package holidays. Three sectors are included: a theme park, hotel and accommodation providers and tour operators. The different sectors are coordinated with each other, while enterprises within each compete in order to optimize their own objectives. This research studies the impacts of competitive and cooperative relationships between the enterprises on the dynamics of the TSC under quantity competition. Simultaneous non-cooperative games are used to model the competitive quantity decisions between enterprises in the same sector. A sequential game is established between the three sectors to coordinate tourist numbers. Sensitivity analyses are conducted to examine the dynamics of the supply chain in terms of several operating parameters, such as operating costs, sector size and product differentiation. Among the key findings are that member enterprises in one sector can benefit from intensified competition in a complementary sector in the same layer and that the upstream enterprises in the tourism supply chain prefer package holiday product differentiation strategies.

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Package holidays are becoming increasingly popular due to their cost advantage and convenience to tourists. Wang *et al* (1999) define package holidays as tourist programmes that purposefully consist of a variety of tourist activities, such as tourist attractions, accommodation, transportation, dining, shopping experiences, etc. Most of these activities can also be marketed as separate tourist products, but they are less attractive to individual tourists than packaged activities. These activities indeed form complex supply chains in tourism industries.

A tourism supply chain (TSC) includes the suppliers of all the goods and services that deliver tourism products to tourists (Tapper and Font, 2008). These suppliers can be configured in different layers or echelons according to their roles played in the supply chain for package holidays (see Figure 1). The downstream includes the tourists as end customers. Travel agents are retail branches of package holidays, dealing with tourists and tour operators. Travel agents and tour operators can be the same or separate business entities. Tour operators have direct/indirect influence on the volume of tourism and the choice of destinations and tourist facilities (Budeanu, 2005; Tapper and Font, 2008). The midstream of a TSC involves enterprises that directly provide tourist activities. Typical midstream business entities include theme parks, shopping centres, hotels, bars and restaurants, handicraft shops and transportation operators. Upstream enterprises provide raw materials and services to the enterprises located in the midstream of a TSC. It is important to note that a typical non-business player in a TSC is the local government, which facilitates public and private sector collaboration through policy interventions.

A TSC for package holidays operates through business-to-business relationships, and the individual supply chain agents optimize their short-term financial performance together with their long-term financial sustainability. TSC management aims to improve such performances by better business operations and decisions of each supplier and the supply chain as a whole.

The complexity of TSCs leads to significant difficulties in reaching an equilibrium state of all agents, or the TSC tends to switch between different equilibrium states. This paper considers a TSC involving three sectors. One sector includes multiple tour operators and each of them provides only one type of package holiday. The second sector includes hotel and accommodation providers. The third sector is a theme park, operating in the destination. Tour operators are responsible for packaging the holidays, which are sold at the appropriate prices. The price charged by the tour operator covers costs such as admission to the theme park and room rates paid to hotel and accommodation providers. Therefore, pricing is a key mechanism to achieve business competitiveness among business partners and to realize an individual firm's business objectives within the sustainability envelope set out by the local government.

Indeed, two phenomena of market competition can be observed in the Hong Kong tourism industry. The first phenomenon is associated with the Individual Visit Scheme (IVS), which has been implemented in many key cities of

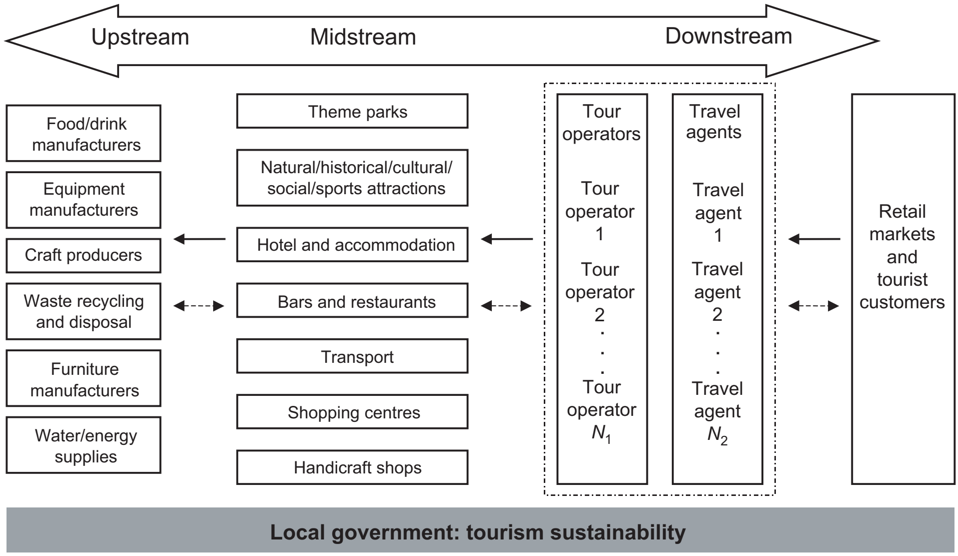

Figure 1. Tourism supply chain for package holidays.

mainland China since 2003. With the expansion of IVS, more and more mainland tourists are able to obtain their tour visas and travel easily to Hong Kong. Tour operators in Hong Kong responded to this opportunity of market expansion by adjusting the quantity of their product offerings in order to capture higher market shares. In the field of economics, this type of competition is typically described as Cournot or quantity competition.

The second phenomenon is related to the practices of some tour operators who reduce the retail prices of their products in order to increase their demand quantities. This pricing strategy has had profound impacts not only on other tour operators, but also on the enterprises of the other TSC sectors such as hotels, transportation operators and shopping centres. This competition through a 'price war' is typically described in economics as Bertrand competition.

This research will discuss the first phenomenon of the IVS, with two major objectives. First, we analyse the competition relationships in both the tour operators' sector and the hotel and accommodation providers' sector; the coordination relationships between tour operators and the theme park and between tour operators and hotel and accommodation providers. Then, the impacts of some typical parameters such as operating cost, sector size and product differentiation on the enterprises involved in the TSC are discussed.

We employ game-theoretic models to examine the competition and cooperation among the enterprises involved in the TSC. Non-cooperative and cooperative games have been widely demonstrated in the literature on manufacturing supply chain management to study such issues as pricing (Lau and Lau, 2003), quantity discount (Wang, 2002; Viswanathan and Wang, 2003), advertising (Huang and Li, 2001; Jørgensen *et al*, 2001), quality (Wauthy, 1996; Banker *et al*, 1998) and configuration (Talluri and Baker, 2002). The game framework proposed in this paper includes two stages. The tour operators first play a non-cooperative simultaneous quantity competition game, noted as a Cournot game in short. The three sectors in the TSC then play a sequential game to coordinate the tourist quantities between the sectors.

The rest of the paper is organized as follows. In the next section, essential literature about TSCs and package holidays and the application of game theory is reviewed. The subsequent section defines the TSC problem used in this paper. We then develop quantity competition models for tour operators, hotel and accommodation providers and the theme park, and present the equilibrium results of these models. Next, the impacts of three types of parameters on the three sectors are analysed. Finally, we offer our general conclusions and recommendations for future work.

Literature review

The literature relevant to this study is reviewed in three groups. They are TSCs for package holidays, the application of game theory to general supply chain management and the application of game theory to tourism industries.

In general, the literature on TSCs is very limited. However, several schools of thought form the foundation for this research. Wang *et al* (1999) identify some key elements which constitute a package holiday. Tapper and Font (2008) describe the structure of TSCs for package holidays. Both Budeanu (2005) and Tepelus (2005) show the key roles that tour operators play in the TSC for package holidays. Some literature concentrates on the competitive strategies of theme parks (Braun and Soskin, 1999), oligopolistic hotel pricing (Baum and Mudambi, 1995) and government policies (Godfrey, 1998). Some studies have also focused on observing the relationships between tour operators and the destinations or hotels. For example, Carey *et al* (1997) study the influence of tour operators on the long-term sustainability of destinations. Later, Klemm and Parkinson (2001) show the impacts of tour operators' competitive strategies on the development of tourist destinations. Buhalis (2000) and Medina-Muñoz *et al* (2003) analyse the competitive and cooperative relationships between tour operators and hotels. Theuvsen (2004) concludes that coordination among enterprises could benefit the tourism industry. The above reviews have focused basically on the relationship between the two sectors respectively, not from the perspective of the entire TSC, though they have provided us with some useful insights to discuss the cooperative and competitive relationships between the enterprises involved in the TSC.

Significant efforts have been made to study the application of game theory to competition and cooperation among the enterprises involved in manufacturing supply chains. Talluri and Baker (2002) consider a three-level supply chain of suppliers, manufacturers and distributors and develop a hybrid mathematical programming approach to solve the game. Huang and Li (2001) use two non-cooperative games and one cooperative game to explore the role of vertical co-op advertising efficiency between a manufacturer and a retailer. Non-cooperative and cooperative games have been widely demonstrated in the literature for manufacturing supply chain management to study such issues as pricing (Lau and Lau, 2003), quantity discount (Wang, 2002; Viswanathan and Wang, 2003), advertising (Jørgensen *et al*, 2001) and quality (Wauthy, 1996;

Banker *et al*, 1998). Carr and Karmarkar (2005) show that a multi-echelon model including three sectors can be set up to observe the competitive and cooperative relationships in the supply chain. Methods used in these publications on manufacturing supply chains could be borrowed and extended to study the TSC, which also includes three sectors but provides non-perfect substitutable products.

Aguiló *et al* (2002) examine an oligopoly tourism market in which the tour operators have market power to fix a higher price without losing their market share. Candela and Cellini (2006) argue that differentiated oligopoly models could be used to study tourism development strategies. Taylor (1998) develops a model to evaluate strategic pricing behaviour in the UK package tour industry. Wie (2005) builds an *N*-person non-zero sum, non-cooperative dynamic game to investigate strategic capacity investment in the cruise line industry. García and Tugores (2006) apply a vertical differentiation duopoly model to explain the rationale of coexistence of both high- and low-tariff hotels. Previous studies that have used game theory in tourism research generally have been focused on single echelons instead of multiple layers of TSCs. In addition, tourism pricing strategies have not been studied adequately. This paper fills these gaps.

Tourism supply chain problem

We consider a TSC that provides package holidays as tourist products in a destination. It is assumed that there is one major theme park (TP), or a type of major attraction or event, in this tourist destination and all package holiday products include a trip to this park as a standard component. The theme park is operated independently and an entrance fee is charged for each trip. In addition to this TP, tour operators (TOs) are responsible for configuring their package holiday products to include other elements such as hotels and accommodation (HA). It should be noted that this paper does not distinguish between tour operators and travel agents. Each TO is assumed to provide and market only one type of package holiday, which includes a trip to the theme park and a one-night stay in a hotel. Therefore, this TSC includes four sectors or echelons, namely, one TP, multiple TOs, multiple HA providers and tourists as customers. In this value chain, a tourist books a package holiday through a TO at a given price. The price charged by the TO is shared by the other two echelons: the admission to the TP and fees paid to the HA.

This research is concerned with the competition and dynamics both within and between these three sectors of TP, HA and TO. Because of multiple enterprises within the TO and HA sectors, there are internal sector competitions, each aiming to optimize its own objective. On the other hand, the TO, TP and HA sectors complement each other in providing package holiday products. We are interested in identifying the equilibrium of this TSC. Changes in one sector or its members may induce a series of changes in the other sectors, which in turn will change the condition of the TSC equilibrium. Therefore, we are interested in studying the dynamic behaviour of the TSC equilibrium.

For simplicity, we assume that the TSC is an oligopoly under full information

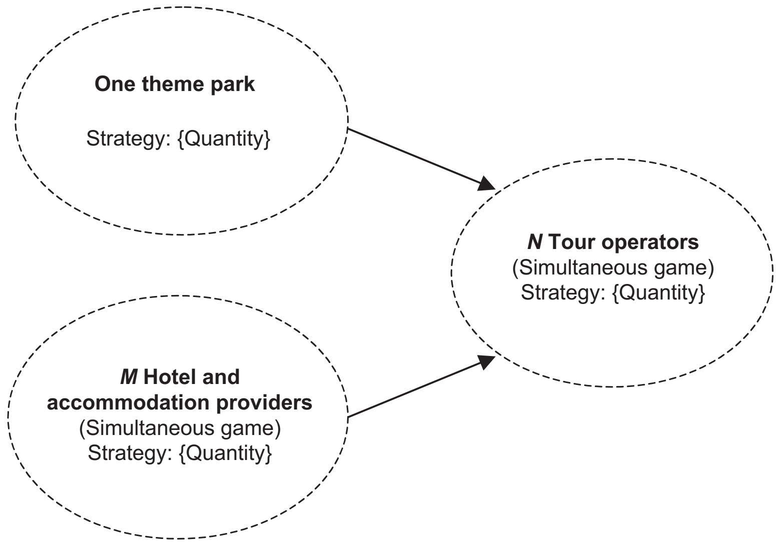

Figure 2. Tourism supply chain game structure.

condition, like the market defined by Candela and Cellini (2006). This oligopoly TSC model involves only one theme park. The number (N) of tour operators is limited. When $N = 1$, we have a case of monopoly. Therefore, we focus on considering the case where $N \geq 2$. The package holiday products are assumed to be imperfect substitutions due to other optional activities such as different hotels and/or transport used in the products. We further assume that the TOs work in the same region where tourists can compare and choose their products freely and the tourists and TOs have perfect information about the products. Chung (2000) states that hotels with the same star ratings tend to set their room rates at a comparable level in order to maximize their revenues. This observation is taken in this study as an assumption that all M ($M \geq 2$) HA providers have the same level of cost to play a classic oligopoly quantity competition game.

This paper employs the Cournot model to address the above TSC problem. The TOs and HA providers take quantity strategies to play a simultaneous non-cooperative game, respectively. Then the three sectors in the TSC play a sequential game (see Figure 2).

Game model and solution

There are N TOs and M HA providers in the TSC, indexed by $1 \ldots N$ and $1 \ldots M$. The prices per unit of TO^j, HA^j and TP are p_1^j, p_2 and p, respectively. The unit costs of TO^j, HA^j and TP are c_1^j, c_2 and c, respectively. The tourist quantities of TO^j, HA^j and TP are q_1^j, q_2^j and Q, respectively. All tourists taking a package holiday must visit the theme park and stay one night in a hotel, so

$$Q = \sum_{j=1}^{N} q_1^j = \sum_{j=1}^{M} q_2^j \tag{1}$$

We use the backward method to model this problem and achieve the solutions.

Model for tour operators

Following a common practice in game-theoretic supply chain models such as Carr and Karmarkar (2005), we assume a linear inverse demand function for TO^j under quantity competition:

$$p_1^j = \alpha - \beta q_1^j - \gamma \sum_{i \neq 1} q_1^i \tag{2}$$

The ratio γ/β captures the degree of substitution of package holidays. When $\gamma = 0$, this means that the products are independent. $\gamma = \beta$ indicates that the products are perfect substitutes. In this paper, the natural restrictions on the demand parameters are

$$\alpha > \bar{c}_1 + c_2 + c \text{ and } 0 < \gamma < \beta \ (\bar{c}_1 = \frac{1}{N}\sum_{j=1}^{N} c_1^j).$$

The profit function for TO^j is

$$\pi_1^j = q_1^j(p_1^j - p - p_2 - c_1^j).$$

so TO^j determines tourist quantity as

$$q_1^j = \frac{\alpha - c_1^j - p - p_2}{2\beta} - \frac{\gamma}{2\beta}\sum_{i \neq j} q_1^i \tag{3}$$

Solving (3) leads to the following Cournot equilibrium for TO^j:

$$q_1^j = \frac{\alpha - c_1^j - p - p_2}{2\beta - \gamma} - \frac{\gamma N(\alpha - \bar{c}_1 - p - p_2)}{(2\beta - \gamma)[2\beta + \gamma(N - 1)]} \tag{4}$$

$$Q = \frac{N(\alpha - \bar{c}_1 - p - \mathrm{p}_2)}{2\beta + \gamma(N - 1)} \tag{5}$$

Please refer to Appendix 1 for the derivation of (4).

Model for hotel and accommodation providers

The price for each HA provider from (5) is

$$p_2 = \alpha - \bar{c}_1 - p - \frac{Q[2\beta + \gamma(N - 1)]}{N} \tag{6}$$

The profit function for each HA provider is

$$\pi_2^j = q_2^j(p_2 - c_2).$$

So HA^j defines tourist quantity as

$$q_2^j = \frac{N(\alpha - \bar{c}_1 - p - c_2)}{2[2\beta + \gamma(N-1)]} - \frac{\sum_{i \neq j} q_2^i}{2} \tag{7}$$

A system of M independent linear equations has a symmetric solution, so each HA provider determines tourist quantity as

$$q_2 = \frac{N(\alpha - \bar{c}_1 - c_2 - p)}{(M+1)[2\beta + \gamma(N-1)]} \tag{8}$$

Model for theme parks

The price for TP from (5) is

$$p = \alpha - \bar{c}_1 - p_2 - \frac{Q[2\beta + \gamma(N-1)]}{N} \tag{9}$$

The profit function of TP is

$$\pi = Q(p - c)$$

so TP selects tourist quantity as

$$Q = \frac{N(\alpha - \bar{c}_1 - c - p_2)}{2[2\beta + \gamma(N-1)]} \tag{10}$$

Impact analyses

In the game model, the equilibrium results of prices, tourist quantities and profits for TOs, HA providers and the TP are shown in Table 1.

We find that both the number of TOs and the entrance cost of TOs are limited.

Proof. Due to

$$q_1^j = \frac{M(\alpha - \bar{c}_1 - c_2 - c)}{(2M+1)[2\beta + \gamma(N-1)]} + \frac{\bar{c}_1 - c_1^j}{2\beta - \gamma} > 0,$$

it is easy to get

$$\frac{M(\alpha - \bar{c}_1 - c_2 - c)}{(2M+1)[2\beta + \gamma(N-1)]} > \frac{c_1^j - \bar{c}_1}{2\beta - \gamma}.$$

If $c_1^j \leq \bar{c}$, whatever N is ($N \geq 2$), the above inequality is correct.

If $c_1^j > \bar{c}$, the above inequality could be written as

$$2\beta + \gamma(N-1) < \frac{M(\alpha - \bar{c}_1 - c_2 - c)(2\beta - \gamma)}{(2M+1)(c_1^j - \bar{c}_1)}.$$

Table 1. Equilibrium results for the game model.

TO	$p_1^j = \frac{[(3M+2)\beta+(M+1)(N-1)\gamma]\alpha+[\beta+\gamma(N-1)]M(\bar{c}_1+c_2+c)}{(2M+1)[2\beta+\gamma(N-1)]} + \frac{(\beta-\gamma)(c_1^j-\bar{c}_1)}{2\beta-\gamma}$	(11)
	$q_1^j = \frac{M(\alpha-\bar{c}_1-c_2-c)}{(2M+1)[2\beta+\gamma(N-1)]} + \frac{\bar{c}_1-c_1^j}{2\beta-\gamma}$	(12)
	$\pi_1^j = \beta\{\frac{M(\alpha-\bar{c}_1-c_2-c)}{(2M+1)[2\beta+\gamma(N-1)]} + \frac{\bar{c}_1-c_1^j}{2\beta-\gamma}\}^2 = \beta(q_1^j)^2$	(13)
HA	$p_2 = \frac{\alpha-\bar{c}_1-c+2Mc_2}{2M+1}$	(14)
	$q_2 = \frac{N(\alpha-\bar{c}_1-c_2-c)}{(2M+1)[2\beta+\gamma(N-1)]}$	(15)
	$\pi_2 = \frac{N(\alpha-\bar{c}_1-c_2-c)^2}{(2M+1)^2[2\beta+\gamma(N-1)]}$	(16)
TP	$p = \frac{M(\alpha-\bar{c}_1-c_2)+(M+1)c}{2M+1}$	(17)
	$Q = \frac{MN(\alpha-\bar{c}_1-c_2-c)}{(2M+1)[2\beta+\gamma(N-1)]}$	(18)
	$\pi = \frac{M^2N(\alpha-\bar{c}_1-c_2-c)^2}{(2M+1)^2[2\beta+\gamma(N-1)]}$	(19)

Note: Please refer to Appendix 2 for the derivation of (11)–(19).

Because

$$f\ \frac{M(\alpha - \bar{c}_1 - c_2 - c)(2\beta - \gamma)}{(2M + 1)(c_1^j - \bar{c}_1)}$$

has inverse change with c_1^j, so

$$N < \frac{2\beta - \gamma}{\gamma}[\frac{M(\alpha - \bar{c}_1 - c_2 - c)}{(2M + 1)\theta} - 1] ,$$

in which $\theta = \max(c_1^j) - \bar{c}_1$.

Due to

$$N \geq 2, \frac{2\beta - \gamma}{\gamma}[\frac{M(\alpha - \bar{c}_1 - c_2 - c)}{(2M + 1)\theta} - 1] ,$$

must be larger than 2. It could be written as

$$\theta < \frac{M(\alpha - \bar{c}_1 - c_2 - c)(2\beta - \gamma)}{(2M + 1)(2\beta + \gamma)} .$$

Therefore, the cost of TOs must be less than

$$\frac{M(\alpha - \bar{c}_1 - c_2 - c)(2\beta - \gamma)}{(2M + 1)(2\beta + \gamma)} + \bar{c}_1 .$$

Based on the above conditions, we can obtain the propositions as follows.

Proposition 1: Under the quantity competition, the effects of a small change in the operating cost of TO^j on the equilibrium price, quantity and profit of each entity in the TSC are shown in Table 2 and the effects of a small change in the operating cost of HA providers or the cost of the TP on the equilibrium price, quantity and profit are shown in Table 3 (+ denotes an increasing trend, and – denotes a decreasing trend).

This proposition shows that when the operating cost of a firm in the TSC decreases, it is able to reduce its product/service price. As a result, it can attract more tourists and thus improve its profit. Those TOs whose costs are lower than the average cost ($c_1^j < \bar{c}_1$) enjoy their cost advantages and attract more customers and higher profits; those TOs whose costs are higher than the average cost ($c_1^j > \bar{c}_1$) must set higher product prices in order to remain profitable, resulting in a loss of customers and profits. If a TO is able to reduce its operating cost, this reduction will attract more tourists and higher profits from its competitors in the same sector. In contrast, enterprises of a complementing sector in the same layer are also able to enjoy benefits from this cost reduction. Another observation is that when the downstream enterprises reduce their costs, the prices, number of tourists and profits of the upstream enterprises demonstrate increasing trends. This finding is important in the sense that downstream enterprises should reduce their operating costs as much as possible to encourage the upstream operators to attract more tourists, which benefits the downstream enterprises. In contrast, if the cost of the upstream enterprise decreases, downstream enterprises are able to reduce their prices in order to attract more tourists and still improve their benefits.

Proposition 2: Under the quantity competition, the effects of changing the number of TOs or the number of HA providers on the equilibrium price, quantity and profit of each entity are shown in Table 4.

Table 2. Effects of cost reduction of tour operator *j* under the game model.

c_1^j	p_1^j		q_1^j	π_1^j	q_1^i	π_1^i
	−		+	+	−	−
−	p_2	q_2	π_2	p	Q	π
	+	+	+	+	+	+

Note: Please refer to Appendix 3 for the drivation of the results and note that $i \neq j$ in Table 2.

Table 3. Effects of cost reduction of HA providers or TP under the game model.

c_2	p_1^j	q_1^j	π_1^j	p_2	q_2	π_2	P	Q	π
−	−	+	+	−	+	+	+	+	+
c	p_1^j	q_1^j	π_1^j	p_2	q_2	π_2	P	Q	π
−	−	+	+	+	+	+	−	+	+

Note: Please refer to Appendix 4 for the derivation of the results.

Table 4. Effects of change in the size of the TO or HA provider sector under the game model.

N	p_1^j			q_1^j			π_1^j		
+	−			−			−		
M	p_1^j	q_1^j	π_1^j	p_2	q_2	π_2	P	Q	π
+	−	+	+	−	−	−	+	+	+

Note: Please refer to Appendix 5 for the derivation of the results.

This proposition shows that when a new competitor enters the market, the prices, tourist quantities and profits of the other enterprises in this sector are affected negatively. The prices, tourist quantities and profits of the enterprises in the other sector of the same layer will increase, benefiting from competition within the other sector. For example, the entrance of a new HA provider into the market will bring more customers and profits for the TP. Meanwhile, the downstream enterprises are able to reduce their prices so as to attract more tourists and achieve higher profits once new HA providers enter the market.

Table 5. Effects of substitution degree of TO under the game model.

γ	q_2	π_2	Q	π
–	+	+	+	+
$\gamma(c_1^j \geq \bar{c}_1)$	p_1^j		q_1^j	π_1^i
–	+		+	+

Note: Please refer to Appendix 6 for the derivation of the results.

Proposition 3: Under the quantity competition, assuming β to be invariable, the effects of the substitution degree (γ/β) on the equilibrium price, quantity and profit of each entity are shown in Table 5.

The substitution degree of products/services provided by TOs defines the differentiability between their package holidays. The lower the substitution degree is, the higher the differentiability is. This proposition shows that the upstream enterprises such as the TP and HA providers are able to attract more tourists and improve their profits if package holiday products provided in the TSC are highly differentiated. The TOs whose costs are higher than the average cost are said to be inefficient. At the downstream of the TSC, the inefficient TOs could set higher prices once their products are more differentiated from other package holiday products, as well as attracting more tourists and improving their profitability.

Conclusions and implications

This paper discussed the competition and dynamics of a TSC providing package holidays. Simultaneous non-cooperative games were used to model the quantity decisions between the enterprises in the same sector (for example, tour operators and hotels). A sequential game was established between the three sectors (that is, theme park, hotels and tour operators) to coordinate tourist numbers. Equilibrium solutions of these games were derived for price, quantity and profit decisions. Sensitivity analyses were conducted in order to achieve useful findings and observations.

This study has several useful and important managerial implications. Some of them are summarized as follows:

(1) When a firm in the TSC is able to reduce its operating cost, this firm should be able to lower its product price to attract additional tourists from its competitors in the same sector, and thus improve its profitability. The firms of the other sector in the same layer could also benefit from the reduced costs of their partners in the complementing sector by increasing their product prices and sharing more tourists and profits. In addition, the upstream (downstream) enterprises could also gain more tourists and profits if the downstream (upstream) enterprises are able to reduce their costs.

(2) If a new competitor enters the market, the decision makers of the other firms in the same sector are forced to reduce their product prices. But the other sector in the same layer will get more tourists and profits, benefiting from intensified competition in its complementing sector. Meanwhile, downstream enterprises are also able to reduce their product prices and gain more tourists and profits.
(3) When the degree of substitution between TOs decreases, those inefficient TOs whose costs are higher than the average cost are forced to increase their product prices in order to retain their profits. The upstream enterprises benefit from the differentiability between package holidays, attracting more tourists and achieving higher profits.

However, this study also has a few limitations and needs further investigation. For example, HA providers are assumed to form a hotel chain and offer accommodation at a unified cost level due to their internal competition. In reality, package holiday products may use hotels of different grades. For instance, high-end luxurious packages would use 4- or 5-star hotels. The consideration of such differentiated hotels would require new game-theoretic models with considerable additional complexity.

Another limitation of this study is that we examine the competition dynamics through sensitivity analysis assuming that changes of operating parameters in the TSC are small enough that they will not lead to changes of equilibria. It may be more appropriate to incorporate parameters and even variables (for example, advertisement, quantity discount, health alerts and seasonal holidays) that affect the dynamics in the game models for theoretical analysis.

Besides, this study has assumed that individual enterprises in the same sector in the TSC are of similar status, without any dominance. In reality, some TOs are much more aggressive and comprehensive than others and they may enjoy so-called first-move advantages resulting from their dominance in corresponding sectors. It will be necessary to extend the study in the leader–follower game models.

Finally, only one theme park is considered in our study. A tourist destination is very likely to have more than one theme park that compete and possibly cooperate with each other. Therefore, the competition and coordination in the theme park sector should also be considered in multistage game models.

References

Aguiló, E., Alegre, J., and Sard, M. (2002), 'Analysis of package holiday prices in the Balearic Islands', Working Paper 2002, University of Balearic Islands, Palma de Mallorca.

Banker, R.D., Khosla, I., and Sinha, K.K. (1998), 'Quality and competition', *Management Science*, Vol 44, No 9, pp 1179–1192.

Baum, T., and Mudambi, R. (1995), 'An empirical analysis of oligopolistic hotel pricing', *Annals of Tourism Research*, Vol 22, No 3, pp 501–516.

Braun, B.M., and Soskin, M.D. (1999), 'Theme park competitive strategies', *Annals of Tourism Research*, Vol 26, No 2, pp 438–442.

Budeanu, A. (2005), 'Impacts and responsibilities for sustainable tourism: a tour operator's perspective', *Journal of Cleaner Production*, Vol 13, No 2, pp 89–97.

Buhalis, D. (2000), 'Relationships in the distribution channel of tourism: conflicts between hoteliers and tour operators in the Mediterranean region', *International Journal of Hospitality and Tourism Administration*, Vol 1, No 1, pp 113–139.

Candela, G., and Cellini, R. (2006), 'Investment in tourism market: a dynamic model of differentiated oligopoly', *Environmental and Resource Economics*, Vol 35, No 1, pp 41–58.

Carey, S., Gountas, Y., and Gilbert, D. (1997), 'Tour operators and destination sustainability', *Tourism Management*, Vol 18, No 7, pp 425–431.

Carr, S.M., and Karmarkar, U.S. (2005), 'Competition in multi-echelon assembly supply chains', *Management Science*, Vol 51, No 1, pp 45–59.

Chung, K.Y. (2000), 'Hotel room rate pricing strategy for market share in oligopolistic competition: eight-year longitudinal study of super deluxe hotels in Seoul', *Tourism Management*, Vol 21, No 2, pp 135–145.

García, D., and Tugores, M. (2006), 'Optimal choice of quality in hotel services', *Annals of Tourism Research*, Vol 33, No 2, pp 456–469.

Godfrey, K.B. (1998), 'Attitudes towards "sustainable tourism" in the UK: a view from local government', *Tourism Management*, Vol 19, No 3, pp 213–224.

Huang, Z., and Li, S.X. (2001), 'Co-op advertising models in manufacturer–retailer supply chains: a game theory approach', *European Journal of Operational Research*, Vol 135, No 3, pp 527–544.

Jørgensen, S., Taboubi, S., and Zaccour, G. (2001), 'Cooperative advertising in a marketing channel', *Journal of Optimization Theory and Applications*, Vol 110, No 1, pp 145–158.

Klemm, M., and Parkinson, L. (2001), 'UK tour operator strategies: causes and consequences', *International Journal of Tourism Research*, Vol 3, No 5, pp 367–375.

Lau, A.H.L., and Lau, H.S. (2003), 'Effects of a demand-curve's shape on the optimal solutions of a multi-echelon inventory/pricing model', *European Journal of Operational Research*, Vol 147, No 3, pp 530–548.

Medina-Muñoz, R.D., Medina-Muñoz, D.R., and García-Falcón, J.M. (2003), 'Understanding European tour operators' control on accommodation companies: an empirical evidence', *Tourism Management*, Vol 24, No 2, pp 135–147.

Talluri, S., and Baker, R.C. (2002), 'A multi-phase mathematical programming approach for effective supply chain design', *European Journal of Operational Research*, Vol 141, No 3, pp 544–558.

Tapper, R., and Font, X. (2008), 'Tourism supply chains' (http://www.leedsmet.ac.uk/lsif/the/Tourism_Supply_Chains.pdf, accessed 3 January 2008).

Taylor, P. (1998), 'Mixed strategy pricing behavior in the UK package tour industry', *International Journal of the Economics of Business*, Vol 5, No 1, pp 29–46.

Tepelus, C.M. (2005), 'Aiming for sustainability in the tour operating business', *Journal of Cleaner Production*, Vol 13, No 2, pp 99–107.

Theuvsen, L. (2004), 'Vertical integration in the European package tour business', *Annals of Tourism Research*, Vol 31, No 2, pp 475–478.

Viswanathan, S., and Wang, Q. (2003), 'Discount pricing decisions in distribution channels with price-sensitive demand', *European Journal of Operational Research*, Vol 149, No 3, pp 571–587.

Wang, K.C., Hsieh, A.T., and Huan, T.C. (1999), 'Critical service features in group package tour: an exploratory research', *Tourism Management*, Vol 21, No 2, pp 177–189.

Wang, Q. (2002), 'Determination of suppliers' optimal quantity discount schedules with heterogeneous buyers', *Naval Research Logistics*, Vol 49, No 1, pp 46–59.

Wauthy, X. (1996), 'Quality choice in models of vertical differentiation', *The Journal of Industrial Economics*, Vol XLIV, No 3, pp 345–353.

Wie, B.W. (2005), 'A dynamic game model of strategic capacity investment in the cruise line industry', *Tourism Management*, Vol 26, No 2, pp 203–217.

Appendix 1

Derivation of the equilibrium quantity for TO^j under the Cournot model

From (3), we get

$$\begin{bmatrix} 2\beta & \gamma & \dots & \gamma \\ \gamma & 2\beta & \dots & \gamma \\ \vdots & \vdots & \ddots & \vdots \\ \gamma & \gamma & \dots & 2\beta \end{bmatrix} \begin{bmatrix} q_1^1 \\ q_1^2 \\ \vdots \\ q_1^N \end{bmatrix} = \begin{bmatrix} \alpha - c_1^1 - p - p_2 \\ \alpha - c_1^2 - p - p_2 \\ \vdots \\ \alpha - c_1^N - p - p_2 \end{bmatrix} \tag{A1}$$

Let us define

$$S = \begin{bmatrix} 2\beta & \gamma & \dots & \gamma \\ \gamma & 2\beta & \dots & \gamma \\ \vdots & \vdots & \ddots & \vdots \\ \gamma & \gamma & \dots & 2\beta \end{bmatrix} = (2\beta - \gamma) \begin{bmatrix} 1 & 0 & \dots & 0 \\ 0 & 1 & \dots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \dots & 1 \end{bmatrix} + \gamma \begin{bmatrix} 1 & 1 & \dots & 1 \\ 1 & 1 & \dots & 1 \\ \vdots & \vdots & \ddots & \vdots \\ 1 & 1 & \dots & 1 \end{bmatrix}$$

and

$$(aI_n + b1_n)\left(\frac{1}{a} I_n - \frac{b}{a(a+nb)} 1_n\right) = I_n + \frac{b}{a} 1_n - \frac{ab}{a(a+nb)} 1_n - \frac{nb^2}{a(a+nb)} 1_n = I_n \tag{A2}$$

From Equation (A2), we obtain the inverse of matrix S as follows:

$$S^{-1} = \frac{1}{2\beta - \gamma} \begin{bmatrix} 1 & 0 & \dots & 0 \\ 0 & 1 & \dots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \dots & 1 \end{bmatrix} - \frac{\gamma}{(2\beta - \gamma)(2\beta - \gamma + \gamma N)} \begin{bmatrix} 1 & 1 & \dots & 1 \\ 1 & 1 & \dots & 1 \\ \vdots & \vdots & \ddots & \vdots \\ 1 & 1 & \dots & 1 \end{bmatrix}$$

Let us define

$$u = \frac{1}{2\beta - \gamma}$$

and

$$v = \frac{\gamma}{(2\beta - \gamma)(2\beta - \gamma + \gamma N)}$$

Multiplying both sides of (A1) by S^{-1}, we obtain

$$\begin{bmatrix} q_1^1 \\ q_1^2 \\ \cdot \\ \cdot \\ \cdot \\ q_1^N \end{bmatrix} = \begin{bmatrix} u-v & -v & \cdots & -v \\ -v & u-v & \cdots & -v \\ \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot \\ -v & -v & \cdots & u-v \end{bmatrix} \begin{bmatrix} \alpha-c_1^1-p-p_2 \\ \alpha-c_1^2-p-p_2 \\ \cdot \\ \cdot \\ \cdot \\ \alpha-c_1^N-p-p_2 \end{bmatrix}$$

Therefore, the equilibrium quantity for TO^j is as follows

$$q^j_1 = \frac{\alpha-c_1^j-p-p_2}{2\beta-\gamma} - \frac{\gamma N(\alpha-\bar{c}_1-p-p_2)}{(2\beta-\gamma)[2\beta+\gamma(N-1)]}$$

Appendix 2

Derivation of the equilibrium prices under the Cournot model

Substituting (8) into (6) to get the equilibrium price for each HA provider

$$p_2 = \frac{\alpha-\bar{c}_1-p+Mc_2}{M+1} \tag{A3}$$

Substituting (10) into (9) to get the price for TP

$$p = \frac{\alpha-\bar{c}_1-p_2+c}{2} \tag{A4}$$

Solving simultaneous Equations (A3) and (A4) to get

$$p = \frac{M(\alpha-\bar{c}_1-c_2)+(M+1)c}{2M+1} \tag{A5}$$

$$p_2 = \frac{\alpha-\bar{c}_1-c+2Mc_2}{2M+1} \tag{A6}$$

Substituting (A4) and (A5) into Equations (2)–(10) to obtain (11)–(19).

Appendix 3

The effects of cost reduction of TO^j under the Cournot model

In the Cournot model, the derivatives with respect to the cost of TO^j are:

$$\frac{\partial p_1^j}{\partial c_1^j} = \frac{M[\beta+\gamma(N-1)]}{N(2M+1)[2\beta+\gamma(N-1)]} + \frac{(N-1)(\beta-\gamma)}{N(2\beta-\gamma)} > 0$$

$$\frac{\partial q_1^j}{\partial c_1^j} = -\frac{M}{N(2M+1)[2\beta+\gamma(N-1)]} - \frac{(N-1)}{N(2\beta-\gamma)} < 0$$

$$\frac{\partial \pi_1^j}{\partial c_1^j} = 2\beta q_1^j \frac{\partial q_1^j}{\partial c_1^j} < 0$$

$$\frac{\partial q_1^i}{\partial c_1^j} = \frac{(M+1)(2\beta-\gamma)+N(2M+1)\gamma}{N(2M+1)[2\beta-\gamma][2\beta+\gamma(N-1)]} > 0, \text{ all } i \neq j$$

$$\frac{\partial \pi_1^i}{\partial c_1^j} = 2\beta q_1^i \frac{\partial q_1^i}{\partial c_1^j} > 0, \text{ all } i \neq j$$

$$\frac{\partial p_2}{\partial c_1^j} = -\frac{1}{N(2M+1)} < 0$$

$$\frac{\partial p}{\partial c_1^j} = -\frac{M}{N(2M+1)} < 0$$

$$\frac{\partial q_2}{\partial c_1^j} = -\frac{1}{(2M+1)[2\beta+\gamma(N-1)]} < 0$$

$$\frac{\partial Q}{\partial c_1^j} = M\frac{\partial q_2}{\partial c_1^j} < 0$$

$$\frac{\partial \pi_2}{\partial c_1^j} = -\frac{2(\alpha-\bar{c}_1-c_2-c)}{(2M+1)^2[2\beta+\gamma(N-1)]} < 0$$

$$\frac{\partial \pi}{\partial c_1^j} = M^2\frac{\partial \pi_2}{\partial c_1^j} < 0$$

Appendix 4

The effects of cost reduction of the HA providers or the TP under the Cournot model

In the Cournot model, the derivatives with respect to the cost of the HA or the cost of TP are:

$$\frac{\partial p_1^j}{\partial c_2} = \frac{\partial p_1^j}{\partial c} = \frac{M[\beta+\gamma(N-1)]}{(2M+1)[2\beta+\gamma(N-1)]} > 0$$

$$\frac{\partial q_1^j}{\partial c_2} = \frac{\partial q_1^j}{\partial c} = -\frac{M}{(2M+1)[2\beta+\gamma(N-1)]} < 0$$

$$\frac{\partial \pi_1^j}{\partial c_2} = 2\beta q_1^j \frac{\partial q_1^j}{\partial c_2} < 0$$

$$\frac{\partial \pi_1^j}{\partial c} = 2\beta q_1^j \frac{\partial q_1^j}{\partial c} < 0$$

$$\frac{\partial p_2}{\partial c_2} = \frac{2M}{2M+1} > 0$$

$$\frac{\partial p_2}{\partial c} = -\frac{1}{2M+1} < 0$$

$$\frac{\partial q_2}{\partial c_2} = \frac{\partial q_2}{\partial c} = -\frac{N}{(2M+1)[2\beta+\gamma(N-1)]} < 0$$

$$\frac{\partial \pi_2}{\partial c_2} = \frac{\partial \pi_2}{\partial c} = -\frac{2N(\alpha-\bar{c}_1-c_2-c)}{(2M+1)^2[2\beta+\gamma(N-1)]} < 0$$

$$\frac{\partial p}{\partial c_2} = -\frac{M}{2M+1} < 0$$

$$\frac{\partial p}{\partial c} = \frac{M+1}{2M+1} > 0$$

$$\frac{\partial Q}{\partial c_2} = \frac{\partial Q}{\partial c} = M\frac{\partial q_2}{\partial c_2} < 0$$

$$\frac{\partial \pi}{\partial c_2} = \frac{\partial \pi}{\partial c} = M^2 \frac{\partial \pi_2}{\partial c_2} < 0$$

Appendix 5

The effects of change in the size of the TO or HA sector under the Cournot model

In the Cournot model, assuming that N and M are continuous, the derivatives with respect to N and M are:

$$\frac{\partial p_1^j}{\partial N} = -\frac{\beta\gamma M(\alpha - \bar{c}_1 - c_2 - c)}{(2M+1)[2\beta+\gamma(N-1)]^2} < 0$$

$$\frac{\partial q_1^j}{\partial N} = -\frac{\gamma M(\alpha - \bar{c}_1 - c_2 - c)}{(2M+1)[2\beta+\gamma(N-1)]^2} < 0$$

$$\frac{\partial \pi_1^j}{\partial N} = 2\beta q_1^j \frac{\partial q_1^j}{\partial N} < 0$$

$$\frac{\partial p_1^j}{\partial M} = -\frac{[\beta+\gamma(N-1)](\alpha - \bar{c}_1 - c_2 - c)}{(2M+1)^2[2\beta+\gamma(N-1)]} < 0$$

$$\frac{\partial q_1^j}{\partial M} = \frac{(\alpha - \bar{c}_1 - c_2 - c)}{(2M+1)^2[2\beta+\gamma(N-1)]} > 0$$

$$\frac{\partial \pi_1^j}{\partial M} = 2\beta q_1^j \frac{\partial q_1^j}{\partial M} > 0$$

$$\frac{\partial p_2}{\partial M} = -\frac{2(\alpha - \bar{c}_1 - c_2 - c)}{(2M+1)^2} < 0$$

$$\frac{\partial q_2}{\partial M} = -\frac{2N(\alpha - \bar{c}_1 - c_2 - c)}{(2M+1)^2[2\beta+\gamma(N-1)]} < 0$$

$$\frac{\partial \pi_2}{\partial M} = -\frac{4N(\alpha - \bar{c}_1 - c_2 - c)^2}{(2M+1)^3[2\beta+\gamma(N-1)]} < 0$$

$$\frac{\partial p}{\partial M} = \frac{(\alpha - \bar{c}_1 - c_2 - c)}{(2M+1)^2} > 0$$

$$\frac{\partial Q}{\partial M} = \frac{N(\alpha - \bar{c}_1 - c_2 - c)}{(2M+1)^2[2\beta + \gamma(N-1)]} > 0$$

$$\frac{\partial \pi}{\partial M} = \frac{2MN(\alpha - \bar{c}_1 - c_2 - c)^2}{(2M+1)^3[2\beta + \gamma(N-1)]} > 0$$

Appendix 6

The effects of the degree of substitution between TOs under the Cournot model

In the Cournot model, the derivatives with respect to γ are:

$$\frac{\partial q_2}{\partial \gamma} = -\frac{N(N-1)(\alpha - \bar{c}_1 - c_2 - c)}{(2M+1)[2\beta + \gamma(N-1)]^2} < 0$$

$$\frac{\partial \pi_2}{\partial \gamma} = \left(\frac{(\alpha - \bar{c}_1 - c_2 - c)}{2M+1}\right) \frac{\partial q_2}{\partial \gamma} < 0$$

$$\frac{\partial Q}{\partial \gamma} = M\frac{\partial q_2}{\partial \gamma} < 0$$

$$\frac{\partial \pi}{\partial \gamma} = \left[\frac{M^2(\alpha - \bar{c}_1 - c_2 - c)}{2M+1}\right] \frac{\partial q_2}{\partial \gamma} < 0$$

$$\frac{\partial p_1^j}{\partial \gamma} = -\frac{M(N-1)\beta(\alpha - \bar{c}_1 - c_2 - c)}{(2M+1)[2\beta + \gamma(N-1)]^2} + \frac{\beta(\bar{c}_1 - c_1^j)}{(2\beta - \gamma)^2}$$

$$\frac{\partial q_1^j}{\partial \gamma} = -\frac{M(N-1)(\alpha - \bar{c}_1 - c_2 - c)}{(2M+1)[2\beta + \gamma(N-1)]^2} + \frac{\bar{c}_1 - c_1^j}{(2\beta - \gamma)^2}$$

$$\frac{\partial \pi_1^j}{\partial \gamma} = 2\beta q_1^j \frac{\partial q_1^j}{\partial \gamma}$$

The following observations can be made:

if $c_1^j \geq \bar{c}_1$, then $\frac{\partial q_1^j}{\partial \gamma} < 0$, $\frac{\partial q_1^j}{\partial \gamma} < 0$, $\frac{\partial \pi_1^j}{\partial \gamma} < 0$.