OPEN ACCESS
EURASIA Journal of Mathematics Science and Technology Education
ISSN: 1305-8223 (online) 1305-8215 (print)
2017 13(8):5985-5996
DOI: 10.12973/eurasia.2017.01046a

The Dynamic Games of Visitor Education with Incentive Mechanism

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Received 23 March 2017 ▪ Revised 14 July 2017 ▪ Accepted 30 July 2017

ABSTRACT

The two-stage dynamic game of visitor education with incentive mechanism is proposed in this paper to study how to raise the effect of the visitor education and how to inspirit the visitors to take part in visitor education programme. In the first stage of the game, the park's managers should choose proper strategies including positive and negative incentives for visitors. They should choose the optimal inspiriting measures and strengths to encourage the visitors to take part in the education intervention programme. In the second stage of the game, the visitors can decide whether they take part in the visitor education and obey the park's rules to reduce their unwanted behaviors or not. There are negative utilities for the visitors when they Obey rules of the park and reduce their unwanted behaviors. And the negative utilities function of the visitors is strict concave. The park can induce the visitors to obey the rules and reduce their unwanted behaviors by visitor education intervention programme. The cost of facilities maintenance and nature resource recovering fee, cleaning fee and so on can be saved by reducing visitors' unwanted behaviors. The cost saving of the park is the return of developing visitor education programme. The return function is convex. The law of diminishing returns is satisfied. And the return growth rate declines gradually when the visitors' efforts to reduce their unwanted behaviors increase. The Nash Equilibrium solution of the game shows that the park should set up effective and creative incentive mechanism according to the visitor's negative utilities, the expectation of visitors' satisfaction and visitors' sensitivity to inspiriting measures. The incentive mechanisms reflecting multi-benefit demands, common-benefits and joint-responsibilities can inspirit the visitors to participate in the visitor education interventions actively and reduce the negative impacts in tourism destinations.

Keywords: visitor education, incentive mechanism, dynamic games

INTRODUCTION

The domestic tourists reached about 3.26 billion in China. And the outbound tourists exceed 9.81 million (China National Tourism Administration, 2014). As a result, tourism industry with this huge number of tourists stimulates

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State of the literature

- The increasingly serious negative tourism impacts with fast expanding visitation have been found in many tourism destinations since 1950s.
- Facing the undesirable tourism impacts, many scholars and park managers proposed different strategies to reduce the impacts.
- Visitor education has been widely touted as the most appropriate approach for managing recreation in wilderness. However, many scholars found that the visitor education programme still draws resistance from visitors because there are no enough motivations for the visitors to take part in education intervention activities.

Contribution of this paper to the literature

- The key of the present research lies in its contribution to the literature with the incentive mechanism of visitor education to induce the visitors take part in the education intervening programme actively.
- According to the study, there are negative utilities to obey the rules of the park and reduce the unwanted behaviors. Meanwhile, the park can get positive return by reducing visitors' unwanted behaviors. Therefore, visitor education incentive mechanism should reflect the characters of multi-interest demand, interest-sharing, joint-responsibility.
- The result of the study shows that the park should set up effective and creative incentive mechanism according to the visitor's negative utilities, the visitors' expectation of satisfaction, visitors' sensitivity to inspiriting measures. And the cost of the visitor education can be cut down by high efficient education techniques, creative education measures and volunteer services.

China domestic demand. Meanwhile, this huge number of tourist also puts tremendous pressures and brings obvious negative nature resource and social impacts on the tourism destination. On the one hand, the nature resource impacts are growing in intensity. 22% of nature protection areas are damaged by tourism activities.11% of nature tourism resources are degraded in China. On the other hand, the social impacts in tourism destination appear repeatedly. There are many dramatic conflicts between tourists and guides, tourists and scene spots managers, tourists and residences, tourists themselves in recent years (Wen S. W. & Wu Z. W., 2009).It is common to observe unwanted behaviors such as speaking loudly in public places, scratching some Chinese characters in landmarks of the tourism areas and dumping garbage optionally (Dongping Wei, Shouwen Wen, 2014). The abrasive behaviors of tourists also ruined the Chinese global images recently. For example, the caution signs designed for Chinese tourists including "be quite", "No spitting", etc. written in Chinese characters appear in many tourism destinations of France, Germany, Japan, Thailand, Singapore and so on. These cautions signs show that Chinese tourists' abrasive behaviors are disgusting in these countries. The abrasive behaviors of Chinese tourists also arouse the public resentment in domestic and abroad.

LITERATURES REVIEWING

Early in 1970s, western countries like Unite States and Australia also found the undesirable impacts on the tourism destination with fast expanding visitation (Peterson G. L. & Lime D. W, 2014; Shouwen, Wen, 2011; Wei D., Wen S., Chen Y., et al. 2013).These impacts can lead to unacceptable changes in resource or social conditions (Vagias W. M., Powell R. B., Moore D. D., 2014 ; Shouwen Wen, Donping Wei, 2014; Wen S. W., Xu F. F., Wen Z. W., et al. 2014) Facing the increasingly serious negative tourism impacts, many scholars proposed different strategies including isolation of sensitive areas, construction of boardwalks, visitor education and monitoring programmes to reduce the impacts(Wen S. W., 2008 ; Li H. G., Cai J., 2005; Ballantyne R., Packer J., Hughes K., 2009). The national education program of Leave No Trace was developed in 1990 by the United States Forest Service in conjunction with the National Outdoor Leadership School (NOLS) (Marion J. L., Reid S. E., 2007). The similar Leave No Trace programme has already been implemented in many other western countries (Wenshou Wen, 2008) Docutte, J. E. and Cole D. N. presented that visitor education has been widely touted as the most appropriate approach for managing recreation in wilderness (Rutko E. A., Gillespie J., 2013). Visitor education is also more easily to win the supports of visitors.

In fact, visitor education programme is an indirect management strategy including giving visitors choosing right, no antagonism between visitors and managers, intervening in the visitors' behaviors previously (educations, communications, explanations, persuasions). However, the visitor education programme still draws resistance from visitors because there are no enough motivations for the visitors to take part in education intervention activities. Adam Smith proposed that every individual is "economy man". He also proposed that rational self-interest and competition can lead to economic prosperity. Adam Smith wrote in The Wealth of Nations that "every individual generally, indeed, neither intends to promote the public interest, nor knows how much he is promoting it (Adam Smith, 2003). By pursuing his own interest, he frequently promotes that of the society more effectually than when he really intends to promote it." Stimulating the individual's self-interest is incentive mechanism such as "Carrot and Stick" approach (Andreoni, J., 2003). The "carrot and stick" approach (also "carrot or stick approach" (Jin, Y., 2009)) is an idiom that refers to a policy of offering a combination of rewards and punishment to induce behavior.

In this case, government and other external stakeholders are external force to push the visitor education programme. The effect of inducing visitors to participate in visitor education programme by external force is limited. And the laws and regulations cannot push the visitor education programme develop smoothly because they cannot inspire visitors' initiative and enthusiasm in the education programme. Hence, it is necessary to take proper measures to set up a visitor education incentive mechanism reflecting multi-interest demand, interest-sharing, joint-responsibility. Inducing the visitors take part in the education intervening programme actively with the effective incentive mechanism, the visitor education can develop significantly and sustainably.

A lot of references mainly focus on the visitor educational message contents (Doan, T. M., 2000; Marion, J. L., 1995), message delivery approaches (Weiler, B & Ham, S. H, 2002; Zhang W, Li N., 2007) and so on. However, there is no related research to study how to inspire visitors participating in education intervening programme actively. The incentive mechanism of visitor education is a brand-new subject. It is valuable to study how to set up an effective visitor education incentive mechanism by dynamic game theory. It is expected that the incentive mechanism can induce or change the visitors' behaviors to intended optimal targets. And the maximum profit of visitor education can be obtained with minimum education cost.

DEFINITIONS AND NOTATIONS

The park receives a lot of visitors at the same time. For simplifying and retaining the general meaning of the problem, it is necessary to assume that there are two represented visitors entering the park at the same time and the park managers try to intervene in their behaviors by visitor education programme. It is necessary to define the incentive measures, the benefit of park and utility functions of visitors firstly.

The incentive measures mainly include positive inspiriting and negative inspiriting measures. The positive inspiriting measures mainly include praising, encouraging and rewarding. For example, the park managers can give Scene Clubcard Points to the visitors who take part in visitor education programme actively. Scene Clubcard is a way of saying thanks to visitors. Collect Clubcard Points on the visitor education programme and the park will send the visitors tickets or other Clubcard Vouchers to say thanks. And consulting the law of Salaries Tax & Personal Assessment in Hongkong, visitor education programme can try to include a pilot scheme such as deduction of visitors' education cost. Salaries Tax & Personal Assessment specified that Hongkong residents may claim deductions for expenses of self-education provided that the prescribed conditions are satisfied. Under salaries tax, Hongkong residents can claim a deduction for expenses of self-education (SEE) (including tuition and the related examination fees) paid for a prescribed course of education. A prescribed course of education is extended to cover training or development course not only provided but also recognized or accredited by the Vocational Training Council or related Training Authority in Honkong. Visitor education programme may be covered by prescribed course of education. And then visitors can claim deductions for expenses of visitor education when visitors gain enough scene Clubcard Points. The cost of positive inspiriting measures is denoted as w_h. The negative inspiriting measures mainly include criticizing, warning, punishment and so on. The cost of these inspiriting measures is denoted as w_l. The positive and negative inspiriting measures should satisfy $w_h > w_l \geq 0$.

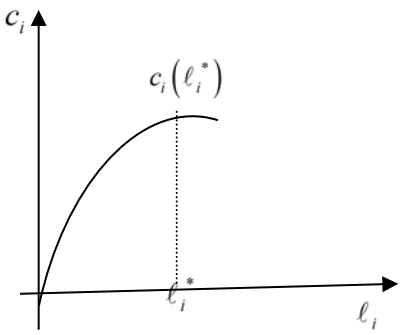

Figure 1. The cost saving of the park due to visitor behavior intervention

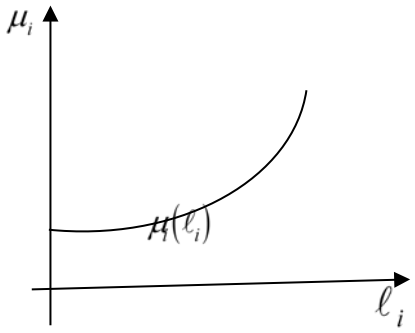

Figure 2. The negative utility of visitor due to visitor behaviours intervention

Visitor i takes part in visitor education programme. The park can get positive benefit when visitors reduce their unwanted behaviors. For example, the cost of facilities maintenance and nature resource recovering fee and cleaning fee can be saved by reducing visitors' unwanted behaviors such as scratching some Chinese characters in landmarks of the tourism areas and dumping garbage optionally. The cost saving can be considered as positive benefit of park. Then the benefit of park can be calculated as following

$$y_i = c_i(\ell_i) + \varepsilon_i, i = 1,2 \tag{1}$$

where ε_i is stochastic intervening factor and it's probability distribution is $f(\varepsilon)$. And It's expectation is $E(\varepsilon_i) = 0$. And ℓ_i is the visitor i's efforts or wills to reduce unwanted behaviors $c_i(\ell_i)$ is the cost saving when visitor i reduce his unwanted behaviors. Different unwanted behaviors bring different degradation of tourism areas. For example, some Chinese tourists like scratching some Chinese characters in landmarks of the tourism areas. And some tourists like deflowering in the tourism areas. Some tourists often dump garbage optionally. These unwanted behaviors bring different degradation of tourism areas. In other words, the cost saving of the park $c_i(\ell_i)$ is determined by what kind of visitor i's unwanted behaviors and visitor i's efforts or wills to reduce his unwanted behaviors. $c_i(\ell_i)$ is a convex function because $c_i'(\ell_i) > 0, c_i(\ell_i)'' < 0$. $c_i(\ell_i)$ should satisfy the law of diminishing returns and its growth rate declines gradually when ℓ_i increases. As shown in **Figure 1**, the cost saving of the park is higher when the visitor i's efforts to reduce his unwanted behaviors is higher. But the growth rate of the cost saving is getting smaller and there is a maximum point $c_i(\ell_i^*)$.

There is negative utility for some visitors when they reduce unwanted behaviors. For example, the carrying garbage time increases because of the prohibition of littering. Then the visitors' satisfaction decreases when they feel inconvenience. The negative utility of visitor i is determined by his efforts or wills to reduce unwanted behaviors. The negative utility function of visitor i is denoted as $\mu_i(\ell_i)$. $\mu_i(\ell_i)$ is concave function and satisfy $\mu_i'(\ell_i) > 0$ and $\mu_i''(\ell_i) > 0$. **Figure 2** shows that the negative utility of visitor i is getting higher when his effort to reduce unwanted behaviors is higher. And the increase rate of negative utility of visitor i is getting higher as shown in **Figure 2**.

In order to clearly presenting the dynamic game in the next three sections, it is necessary to introduce the key definitions and notations of variables firstly.

w_h : The cost of positive inspiriting measures
w_l : The cost of negative inspiriting measures
ε_i : The stochastic intervening factor
ℓ_i : The visitor i's efforts or wills to reduce unwanted behaviors
$c_i(\ell_i)$: The cost saving of the park when visitor i reduces his unwanted behaviors
$\mu_i(\ell_i)$: The negative utility function of visitor i when he reduces his unwanted behaviors
S^m : The strategies set of the park including inspiriting measures and strength

S_i^n : The strategies set of visitor i's efforts and wills to reduce his unwanted behaviors
α_i: The visitor i's sensitivity to inspiriting measures
U_i : The utility function of visitor i
$R(S^m, S_i^n, S_j^n)$: The return function of park developing visitor education programme
$u_i(w)$: The satisfaction increment of visitor i when he gets the reward
λ^* : The rewards coefficient of the park
β^* : The ratio of the marginal cost and marginal return of visitor education
y_i : The cost saving by reducing visitors i's unwanted behaviors
u_0 : Visitor i's satisfaction when he is enjoying the scene without any visitor education
a : The ticket price of the park

RESEARCH METHODS

In fact, visitor education intervening programme is a typical complete information two stage multi-players dynamic game with incentive mechanism. The park is the manager and teacher of visitor education programme. The park managers can choose positive or negative inspiriting measures according to the visitors' behaviors. And they can also decide the rewarding measures and strengths when visitors take part in the visitor education programme. The park managers choosing the inspiriting measures including w_h and w_l for visitors is the first stage of the dynamic game with incentive mechanism. After the represented visitors learn the inspiriting measures of park managers, they may choose whether participate the visitors' education programme, obey the rules of the park and reduce their unwanted behavior or not. This is the second stage of the dynamic game with incentive mechanism. The two stage multi-players dynamic game with incentive mechanism can be described as following

$$G\left(S^m, S_i^n, R\left(S^m, S_i^n, S_j^n\right), U_i\left(S^m, S_i^n, S_j^n\right)\right) \tag{2}$$

where $S^m = \{x \in R_+^m\}$, $S_i^n = \{\ell_i \in R_+^n\}$. S^m is the strategies set of the park including inspiriting measures and strength. S_i^n is the strategies set of visitor i's efforts and wills to reduce his unwanted behaviors. $U_i\left(S^m, S_i^n, S_j^n\right), i = 1, 2$ is the utility function of visitor i. $R\left(S^m, S_i^n, S_j^n\right)$ is the return function of park developing visitor education programme.

In the first stage of the dynamic game with incentive mechanism, the park should choose the proper visitor intervening measure and inspiriting strategies in S^m. And the visitor i and j should choose their optimal strategies according to the park's inspiriting measures. Hence, the dynamic game of visitor education with incentive mechanism is the optimal problem as following

$$\begin{gathered} \max\left\{R(S^m, S_i^n, S_j^n), U_i\left(S^m, S_i^n, S_j^n\right), i = 1, 2;\ j = 1, 2\right\} \\ s.t.\ S^m = \{x \in R_+^m\}, S_i^n = \{\ell_i \in R_+^n\}\ i = 1, 2 \end{gathered} \tag{3}$$

The utility function of visitor i can be denoted as following

$$U_i(w, \ell_i) = \left(u_0 + u_i(w) - \mu_i(\ell_i)\right)a \tag{4}$$

where u_0 is visitor i's satisfaction when he is enjoying the scene without any visitor education problem. $u_i(w)$ is the satisfaction increment of visitor i when he gets the reward by participating the visitor education programme. $\mu_i(\ell_i)$ is negative utility because of reducing his unwanted behaviors. a is the ticket price of the park. The ticket should be priced in reasonable range, otherwise the utility of visitors will be very low.

Visitor i's psychological perception to inspiriting measures can be described as following

$$u_i(w) = \alpha_i w + \gamma \tag{4'}$$

where α_i is visitor i's sensitivity to inspiriting measures. Bigger α_i means that visitor i is more sensitive to inspiriting measures. The effect of inspiriting measures is better when α_i is bigger. $u_i(w)$ is the visitor i's utility function when the park applies inspiriting measures on him.

The park's visitor education programme return function can be described as following

$$R(w_i, y_i) = \sum_{i=1}^{n} (a + y_i - \hat{c}(\ell_i) - c_0 - w_i) \tag{5}$$

where c_0 is the fixed unit cost of the park when there is not any visitor education programme. And y_i is the cost saving by reducing visitors' unwanted behaviors. $\hat{c}(\ell_i)$ is the cost of inspiriting measures.

RESULTS

The Backwards Induction is the best method to explore the Nash Equilibrium Solution of the two stage Dynamic Game of visitor education with incentive mechanism $G\left(S^m, S_i^n, R(S^m, S_i^n, S_j^n), U_i(S^m, S_i^n, S_j^n)\right)$ (Wang K. L., Wang S., 2010; Osborne, 2008).

The park claims that the visitors who participate the visitor education programme, obey the park's rules and reduce their unwanted behaviors actively will get the positive rewards w_h. And the park threatens that the visitors don't participate the visitor education programme, disobey the park's rules and have many unwanted behaviors will get the negative rewards w_l such as punishments. The visitors should participate in the game once they enter the park. But they can choose whether participate in the visitor education and reduce their unwanted behaviors according to w_h, w_l and their own utilities.

The Visitors' Optimal Strategies

The two represented visitors choose their own optimal strategies (ℓ_1^*, ℓ_2^*) when the game gains the Nash Equilibrium state. If the two visitors are risk neutral, then the Nash Equilibrium strategies of visitor i is obtained when he chooses a proper strategy ℓ_i to obtain the maximum expectation utility. For any visitor i, his optimal ℓ_i^* should satisfy the following optimization problem

$$\begin{aligned} &\max_{\ell_{i\geq 0}} \left[P_{w_h} U_i(w_h, \ell_i) + P_{w_l} U_i(w_1, \ell_i)\right] \\ &= \max_{\ell_{i\geq 0}} \left[U_i(w_h, \ell_i) P\left(y_i(\ell_i^*) > y_j(\ell_j^*)\right) + P\left(y_i(\ell_i^*) \leq y_j(\ell_j^*)\right) U_i(w_i, \ell_i)\right] \\ &= \max_{\ell_{i\geq 0}} \left[a\big(u(w_h) - u(w_l)\big) P\left(y_i(\ell_i^*) > y_j(\ell_j^*)\right) + a(u_0 + u(w_l) - \mu_i(\ell_i))\right] \end{aligned} \tag{6}$$

where $i = 1, 2$. The first order condition of the maximization problem of Eq. (4) is obtained by following

$$\big(u(w_h) - u(w_l)\big) \frac{\partial P\left(y_i(\ell_i^*) \geq y_i(\ell_j^*)\right)}{\partial \ell_i} = \mu_i'(\ell_i^*) \tag{7}$$

Eq. (7) shows that the maximization of Eq. (6) is obtained when the visitor i's positive utility by park's rewards equals to the negative utility by his efforts to reduce his unwanted behaviors. According to Bayesian law and condition probability formula (Huang B. B., Wang X. J., Gui F. L., Zhang X. X., 2011), the following equation can be obtained.

$$\begin{aligned} P\left(y_i(\ell_i^*) > y_i(\ell_j^*)\right) &= P\left(\varepsilon_i > c_i(\ell_j^*) + \varepsilon_j - c_i(\ell_i^*)\right) \\ &= \int_{\varepsilon_j} P\big(\varepsilon_i > c_j(\ell_j^*) + \varepsilon_j - c_i(\ell_i^*) | \varepsilon_j\big) f(\varepsilon_j) d\varepsilon_j \\ &= \int_{\varepsilon_j} \left(1 - F\left(c_j(\ell_j^*) + \varepsilon_j - c_i(\ell_i^*)\right)\right) f(\varepsilon_j) d\varepsilon_j \end{aligned} \tag{8}$$

Substituting Eq. (8) into Eq. (7), the following equation can be obtained

$$\big(u(w_h) - u(w_l)\big) c_i'(\ell_i^*) \int_{\varepsilon_j} \left(f(\ell_j^*) + \varepsilon_j - c_i(\ell_i^*)\right) f(\varepsilon_j) d\varepsilon_j = \mu_i'(\ell_i^*) \tag{9}$$

Transforming Eq. (9) into following equation

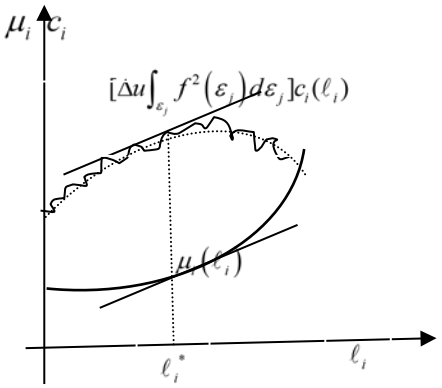

Figure 3. The optimizing visitor i s' efforts to reduce his unwanted behaviors with incentive mechanism

$$\frac{\mu_i'(\ell_i^*)}{c_i'(\ell_i^*)} = (u(w_h) - u(w_l)) \int_{\varepsilon_j} \left(f\left(c_j(\ell_j^*) + \varepsilon_j - c_i(\ell_i^*)\right)\right) f(\varepsilon_j)d\varepsilon_j \tag{10}$$

The two represented visitors are homogenous because their habits, risk preference and mental state are coincident. They are self-interest individuals. Hence, it is reasonable to assume that their performances to inspiriting measures are coincident. In other words, they choose the same efforts to reduce their unwanted behaviors with the same inspiriting measures. It can be described as $\ell_i^* = \ell_j^*$. For example, they will reduce the times of unwanted behaviors such as littering optionally or scratching Chinese characters in landmarks of the tourism areas.

In addition, the cost saving by reducing visits' unwanted behaviors because the represented visitors are homogenous. Hence, $c_j(\ell_j^*) = c_i(\ell_j^*)$. Eq. (10) can be simplified as following

$$\frac{\mu_i'(\ell_i^*)}{c_i'(\ell_i^*)} = (u(w_h) - u(w_l)) \int_{\varepsilon_j} f^2(\varepsilon_j)d\varepsilon_j \tag{11}$$

The visitor i's positive utility $u_i(w)$ by rewards w, the negative utility $\mu_i(\ell_i)$ and the distribution $f(\varepsilon)$ are determined specifically, then the visitor i's optimal efforts can be obtained by Eq. (11). $\Delta u = u(w_h) - u(w_l)$ is the utility discrepancy between high reward and low rewards to visitor i. Then $\mu_i'(\ell_i^*) = \left[\Delta u \int_{\varepsilon_j} f^2(\varepsilon_j)d\varepsilon_j\right] c_i'(\ell_i^*)$. $\mu_i'(\ell_i^*)$ is the marginal negative utilities function of the visitor i. $c_i'(\ell_i^*)$ is the marginal cost saving function of the park. $\left[\Delta u \int_{\varepsilon_j} f^2(\varepsilon_j)d\varepsilon_j\right]$ is uncertainty of the utility discrepancy between high reward and low rewards as shown in **Figure 3**. $\left[\Delta u \int_{\varepsilon_j} f^2(\varepsilon_j)d\varepsilon_j\right] c_i'(\ell_i^*)$ is the marginal cost saving function of the park with uncertainty factors. **Figure 3** shows that the maximization of Eq. (6) is obtained when the visitor i's marginal negative utility by his efforts to reduce his unwanted behaviors should equal to the marginal cost saving function of the park with uncertainty factors.

Eq. (11) shows that there are negative utilities when the visitors reduce their unwanted behaviors. $\mu_i'(\ell_i^*) > 0$ shows that the visitor i's negative utilities are growing when ℓ_i is growing. In the views of the park, $\mu_i'(\ell_i^*) > 0$ shows that the visitor i's negative utilities create positive return for it because the cost of facilities maintenance can be saved by reducing visitors' unwanted behaviors. Hence, the park should give some positive rewards to the visitors who are take part in visitor education programme in order to promote the visitor education developing well. The rewards coefficient of the park is defined as $\lambda^* = \frac{\mu_i'(\ell_i^*)}{c_i'(\ell_i^*)}$. λ^* is getting bigger when the cost saving of the park by reducing visitors' unwanted behaviors is growing.

The Optimal Inspiriting Strategies of the Park

In the first stage of the dynamic game, the park should choose an inspiriting measure to make sure that the visitor would like to take part in visitor education programme. In that case, the input of visitor education programme can get positive return.

The two represented visitors are homogenous in the game $G\left(S^m, S_i^n, R\left(S^m, S_i^n, S_j^n\right), U_i\left(S^m, S_i^n, S_j^n\right)\right)$ and their strategies are almost the same. Hence, the represented visitor i *and* j*'s* probabilities of getting high reward is the same. Then $P_{w_h} = P_{w_l} = 1/2$. It is reasonable to assume that the two represented visitors hope to have fun in the park. The visitors' expectation of satisfaction is denoted as $\hat{u}_0$. Then the visitors would like to enter the park and take part in the visitor education programme when $\mathrm{E}\left(U_i(w, \ell_i^*)\right) \geq \hat{u}_0$.

$$P_{w_h} U_i(w_h, \ell_i^*) + P_{w_l} U_i(w_l, \ell_i^*) \geq a\hat{u}_0 \tag{12}$$

The following equation can be obtained by substituting Eq. (12) into Eq. (4)

$$\left(u_0 + \frac{1}{2}u(w_h) + \frac{1}{2}u(w_l) - \mu_i(\ell_i^*)\right)a \geq a\hat{u}_0 \tag{13}$$

Eq. (13) can be defined as "the participation constrain". It is the base condition of visitors to take part in the visitor education programme. The park will follow the participation constrain as far as possible in order to get the maximum return. Then we can get the following equation

$$\left(u_0 + \frac{1}{2}u_i(w_h) + \frac{1}{2}u_i(w_l) - \mu_i(\ell_i^*)\right) = \hat{u}_0 \tag{14}$$

The following equation can be simplified by Eq.(14)

$$u(w_h) + u(w_l) = 2\hat{u}_0 + 2\mu_i(\ell_i^*) - 2u_0 \tag{15}$$

Because the two represented visitors are homogenous, their sensitivity to inspiriting measures are the same $\alpha_i = \alpha_j = \alpha$. Then Eq. (15) can be transformed to the following equation.

$$w_h + w_l = \frac{2}{\alpha}\hat{u}_0 + \frac{2}{\alpha}\mu_i(\ell_i) - \frac{2u_0 - 2\gamma}{\alpha} \tag{16}$$

The two represented visitors choose the same efforts to reduce their unwanted behaviors when the participation constrained is satisfied. Hence, the park's return function of visitor education programme can be calculated as following

$$R(w, y) = \sum_{i=1}^{n} R(w_i, y_i) = 2a - 2c_0 + 2c_i(\ell_i^*) + \varepsilon_i + \varepsilon_j - 2\hat{c}(\ell_i^*) - w_h - w_1 \tag{17}$$

Then the expectation return of the park can be calculated as following

$$\mathrm{E}\left(R(w, y)\right) = \mathrm{E}\left(\sum_{i=1}^{n} R(w_i, y_i)\right) = 2a - 2c_0 + 2c_i(\ell_i^*) - 2\hat{c}(\ell_i^*) - w_h - w_1 \tag{18}$$

The park should choose the optimal strategies w_h and w_l in order to maximize the expectation return.

$$\max_{w_h, w_l} \mathrm{E}(R(w, y)) = \max_{w_h, w_l}(2a - 2c_0 + 2c_i(\ell_i^*) - 2\hat{c}(\ell_i^*) - w_h - w_l) \tag{19}$$

s.t. $(w_h, w_l) \in S^2 = \{x \in R_+^2\}$.

Substituting Eq. (16) into Eq. (19), the maximization problem (19) can be transformed as following

$$\max_{\ell_i^*}\left\{2a - 2c_0 + 2c_i(\ell_i^*) - 2\hat{c}(\ell_i^*) - \left(\frac{2}{\alpha}\hat{u}_0 + \frac{2}{\alpha}\mu_i(\ell_i^*) - \frac{u_0 - 2\gamma}{\alpha}\right)\right\} \tag{20}$$

s.t $\ell_i^* \in S^1 = \{x \in R_+^1\}$.

The first order condition of Eq. (20) can be obtained as following

$$\alpha\left(c_i'(\ell_i^*) - \hat{c}'(\ell_i^*)\right) = \mu_i'(\ell_i^*) \tag{21}$$

$$\alpha\left(c_i(\ell_i^*) - \hat{c}(\ell_i^*)\right)' = \mu_i'(\ell_i^*) \tag{22}$$

Defined $\hat{R}(\ell_i^*) = c_i(\ell_i^*) - \hat{c}(\ell_i^*)$ as the parks' cost saving or the return function when visitor i reduces his unwanted behaviors. $\hat{c}(\ell_i^*)$ is the unit cost of the visitor education. Eq. (22) shows that the park should choose the optimal inspiriting strategies to make sure that the marginal utilities of the visitor i is the α times of marginal return of the park.

Substituting Eq. (21) into Eq. (11), the following equation can be obtained

$$\left(u(w_h) - u(w_l)\right) = \frac{(1-\beta^*)}{\int_{\varepsilon_j} f^2(\varepsilon_j) d\varepsilon_j} \tag{23}$$

where $\beta^* = \frac{\hat{c}(\ell_i^*)}{c_i'(\ell_i^*)}$. β^* is the ratio of the marginal cost and marginal return of visitor education. It means that marginal return ratio of the park. The visitor education effect can be denoted as β^*. β^* is bigger when the visitor education effect is worse. And β^* is smaller when the visitor education effect is better. The visitor education effect β^* is related with the visitor education techniques or measures. The park should use high efficiency and low cost visitor education techniques or measures. For example, the volunteer should be involved in the visitor education programme. And modern digital technique should be applied in the visitor education programme to cut down the human resource cost.

Recalling the definition of the rewards coefficient of the park λ^*,it is easy to find that $\lambda^* = 1 - \beta^*$. The rewards coefficient shows that the park's return by reducing visitors' unwanted behaviors should be redistributed to visitors. For example, the positive inspiriting measures including praising, encouraging and rewarding is adopted to feed back to the visitors who are take part in visitor education programme. In that case, the visitor education progromme can run smoothly and sustainably.

The feedback strength λ^* is related with the return of the park. β^* is smaller when the effect of the visitor education is better. And then the rewards coefficient λ^* is bigger and the feedback strength should be stronger. However, the feedback strength is uncertain because the return of the park is uncertain The uncertainty of the feedback strength λ^* is described by $\int_{\varepsilon_j} f^2(\varepsilon_j)\, d\varepsilon_j$.

Substituting $u(w) = \alpha w + \gamma$ into Eq. (23), the following equation can be obtained

$$w_h - w_l = \frac{1}{\alpha}\frac{(1-\beta^*)}{\int_{\varepsilon_j} f^2(\varepsilon_j) d\varepsilon_j} \tag{24}$$

Eq. (24) shows that the discrepancy of high and low rewards (w_h and w_l) should be smaller when the visitors' sensitivity to inspiriting measures α is bigger.

When the two represented visitors are homogenous, the optimal strategies of the parks can be obtained by the Eq. (24) and Eq. (16) as following

$$w_h^* = \frac{1}{\alpha}\hat{u}_0 + \frac{1}{\alpha}\mu_i(\ell_i^*) - \frac{u_0 - \gamma}{\alpha} + \frac{1}{2\alpha}\frac{(1-\beta^*)}{\int_{\varepsilon_j} f^2(\varepsilon_j) d\varepsilon_j} \tag{25}$$

$$w_l^* = \frac{1}{\alpha}\hat{u}_0 + \frac{1}{\alpha}\mu_i(\ell_i^*) - \frac{u_0 - \gamma}{\alpha} - \frac{1}{2\alpha}\frac{(1-\beta^*)}{\int_{\varepsilon_j} f^2(\varepsilon_j) d\varepsilon_j} \tag{26}$$

The Nash Equilibrium solution of the dynamic game of visitor education game $G\left(S^m, S_i^n, R(S^m, S_i^n, S_i^n), U_i(S^m, S_i^n, S_i^n)\right)$ includes the optimal strategies of the park (w_h^*, w_1^*) in the first stage and the optimal strategies of the visitors $\left(\ell_i^*, \ell_j^*\right)$ in second stage.

The Nash Equilibrium solution of the game shows that the park should set up effective and creative incentive mechanism according to the visitor's negative utilities, the visitors' expectation of satisfaction, visitors' sensitivity to inspiriting measures. And the high efficient education techniques, creative education measures and volunteer services can be induced to reduce the cost of the visitor education.

DISCUSSION AND CONCLUSIONS

The two-stage dynamic game of visitor education $G\left(S^m, S_i^n, R(S^m, S_i^n, S_i^n), U_i(S^m, S_i^n, S_i^n)\right)$ is set up to study how to raise the effect of the visitor education and how to inspirit the visitors to take part in visitor education programme in this paper. The following important conclusion can be obtained by the game and it's Nash Equilibrium solution.

1) In the view of the visitors, there are negative utilities to obey the rules of the park and reduce the unwanted behaviors. The negative utilities are concave function. The negative utilities are bigger when the efforts of visitors' to reduce the unwanted behaviors are bigger. And the increase rate of negative utilities grows gradually.
2) The park can induce the visitors to obey the rules and reduce their unwanted behaviors by visitor education programme. The cost of facilities maintenance and nature resource recovering fee and cleaning fee can be saved by reducing visitors' unwanted behaviors. The cost saving of the park is the return of developing visitor education programme. The return function is a convex function and satisfies the law of diminishing returns and its growth rate declines gradually when the visitors' efforts to reduce their unwanted behaviors increase.
3) In order to make visitor education running effectively with low cost, the park should set up effective and creative incentive mechanism according to the visitor's negative utilities, the visitors' expectation of satisfaction, visitors' sensitivity to inspiriting measures. And the cost of the visitor education can be cut down when the park adopt high efficient education techniques, creative education measures and volunteer services.
4) The park can get positive return by reducing visitors' unwanted behaviors. The return should be redistributed to visitors by proper measures. The inspiriting measures are feed backs to the visitors who are take part in visitor education programme. The effective inspiriting measures can make visitor education progromme run smoothly and sustainably.

The research is based on assumptions of two represented visitors, the homogenous visitors and the linear visitors' psychological perception. However, these assumptions are not necessary. In fact, these assumptions can be neglected in order to study the high efficient visitor education programme further.

ACKNOWLEDGEMENTS

This work is supported by Project funded by China Postdoctoral Science Foundation (184877), Social Science Foundation of Guangdong（Grant No. GD16XYJ27, Key Resheach topic of Shenzhen Polytechnic (Grant No. 601722k35007), and Philosophical and Social Science Project of Shenzhen (Grant No. 135C008) , Natural Science Funds of Shenzhen Science and Technology Innovation Commission (JCYJ20160527172144272) and Shenzhen Education Science Project (No. ybfz16017).The authors would like to thank the editor and an anonymous referee for their helpful comments on the manuscript.

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