Cooperative Service Contract for Tour-Guides Service Outsourcing Under Dual Principle-Agent

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Abstract
During tour-guides service outsourcing, tourists entrust travel agencies with tourism service, and travel agencies entrust tour-guides service providers with part of tourism service. Due to asymmetric information, tourists’ experience and satisfaction cannot achieve their expected targets. To solve it, cooperative service contracts are designed on tour-guides service outsourcing with a travel agency as dual principal-agent roles, and parameters of cooperative contracts and tourists’ revenue are analyzed by mathematical models and numerical simulation. Research results show that contracts with reward-penalty mechanism added to revenue sharing can effectively increase partners’ revenue and improve tourists’ satisfaction; but too high intensity of reward-penalty can only ensure revenue of tourists and travel agencies, which, however, damages revenue of service providers, failing to guarantee long-term cooperation during tour-guides service outsourcing.

Key words: Tour-guides Service Outsourcing, Dual Principal-agent, Cooperative Service, Outsourcing Contract, Reward-penalty Mechanism.

1. INTRODUCTION

During tour-guides service outsourcing, tourists entrust travel agencies as agents with tourism service, travel agencies as principals entrust tour-guides service providers to serve tourists with part of tourism service and travel agencies will provide tourists with other service such as transportation, accommodation and food, etc. So it is travel agencies and tour-guide service providers that serve tourists cooperatively and both parties’ behaviors are essential to whole tour-guides service outsourcing. However, participation behaviors of travel agencies are hard to be observed by tour-guides and tour-guides’ effort levels are hard to be observed by travel agencies. So moral hazards are likely to happen on both parties, which directly affect outsourcing system’s outputs and tourists’ utility. What’s worse is that two parties may shirk responsibilities by their own private information when they are exposed to customers’ complaints. Therefore, it is urgent to design reasonable incentive contracts with dual roles of travel agencies to solve the issue caused by bilateral asymmetric information in tour-guides service outsourcing.

Compared with the research field on IT service outsourcing, the research on tourism service outsourcing lags behind, what’s more, compared with the practice of service outsourcing, its relevant theoretical research has not yet formed a complete and clear theoretical framework. Fan defined the concept of tourism service outsourcing based on the element reconstruction of the value chain in service industry and the theory of service outsourcing (Fan, 2012). The tourism service outsourcing is the process reengineering of current tourism economic industry. It can solve the phenomenon of “scattered, small, weak, bad” tourism service industry in China to some extent, at the same time, it is also an important way to upgrade the tourism service industry and optimize the tourism resource. At present, researches on the tourism service outsourcing mainly focus on hotel business outsourcing. Lamminmaki proposed that it was the uncertainty and large demand that makes it suitable to adopt outsourcing in hotel industry (Lamminmaki, 2011). But Hiamey put forward that the core business of the hotel industry cannot be outsourced and positive results won’t always appear by the outsourcing (Hiamey, 2013). Leeman considered that good communication, tolerance, trust relationship and positive emotions between hotels and service providers was vital to maintain production, establish long-term cooperative partnership and corporate performance (Leeman, 2012). Wang put out the business model of service outsourcing to improve service industry combined with the characteristics of China’s tourism souvenirs industry (Wang, 2012). Yuan took tourism call centers as research objects and discussed the significance of the service outsourcing to enterprises’ competitiveness. The above literatures rarely mentioned tour-guides service outsourcing (Yuan, 2012). Xu suggested that building government-leading mechanism of tour-guide service outsourcing could effectively regulate the management of tour-guides and improve the service quality of tour-guides (Xu, 2013).
In the study of service outsourcing, scholars generally agree that in the process of service outsourcing service providers and service customers are required to cooperate and coordinate highly because the performance of service outsourcing will be influenced by behaviors of both parties. Elitzur believed that behaviors of any one of service customers and service providers would affect the other party's behaviors in the analysis of the bilateral moral hazards in information system outsourcing (Elitzur, 2012). Li argued that the participation of service customers could affect the revenue sharing mechanism of two parties and the effort level of the other party (Li, 2013). In addition, service customers’ participation behavior in the service outsourcing would also reduce production costs and improve productivity; what’s more, service providers’ effort level was positively related to the degree of service customers’ participation (Song, 2011). Song made a conclusion that participation behaviors of service customers could make research purpose more specific and innovation’s uncertainty lower according to the uncertainty characteristics of research and development (Song, 2013). If service customers and service providers could not observe the other parties’ behavior efforts, it was easier to bring about bilateral moral hazards due to asymmetric information during service outsourcing with service customer participation. Corbett studied the optimal linear revenue sharing contract in supply chain and if effort cost functions were more extensive, the optimal contract was still in the form of fixed payment plus variable parts (Corbett, 2005). Plambeck studied relational contracts between joint production enterprises with bilateral moral hazards (Plambeck, 2006). Zhou thought the whole revenue of supply chain was higher, and the information sharing was not always beneficial to supply chain’s coordination when there was asymmetric information between suppliers and retailers (Zhou, 2012). Bhattacharya believed that in contracts to cooperatively improve service quality between customer service centers and customer enterprises, the linear revenue sharing contract could achieve the system’s optimization when efforts of both parties could be observed (Bhattacharya, 2014). Zhang gave the adverse selection model on how to induce service providers to tell the truth by service customers (Zhang, 2013). In the supply chain joint promotion, both suppliers and sellers had strong incentives to take free ride under bilateral moral hazards. At this time, the reasonable distribution of revenue had important effect on the promotion active investment of cooperative parties(Meng, 2013). Dai considered that linear contract design should make service customers and service suppliers bear risks to some extent and share revenue, otherwise contracts could not achieve the optimization (Dai, 2014). If there was no substantial change in the production technology of service outsourcing, the optimal linear distribution ratio needn’t be changed. All of the above studies are based on the prerequisite that the efforts level of service providers cannot be observed. Zhang designed the optimal contracts on cooperative production in service outsourcing from the point of view of the private cost information without verification (Zhang, 2014).

In recent years, there were only a few literatures about dual principal-agent theory. Cao built an incentive model with multi-tasks based on dual principal-agent theory and made a quantitative analysis on the relationship among safety risk, safety work’s performance and governments’ rewards (Cao, 2011). Luo explored the effects of roles’ conflict of dual leadership in internal audit on internal activities through dual principal-agent theory (Luo, 2013). Ren solved the problem on food safety to some extent by motivating food business managers by salary contracts based on dual principal-agent model (Ren, 2014). Li used structural equation path to analyze function mechanism and effect of excessive investment by dual principal-agent (Li, 2014). Li took core members of farmers’ specialized cooperative as incentive objects and analyzed dual principal-agent relationship during the process of agricultural standardization popularization (Li, 2015). Presently, there is still no application of dual principal-agent theory to tour-guides service outsourcing.

To sum up, there are the following deficiencies in current researches: (1) as tourism service products are perishable and untouchable, it is obvious that the current outsourcing contracts on bilateral moral hazards are not applied to outsourcing practice of tour-guides service. (2) Among researches on bilateral moral hazards, most literatures only researched outsourcing contracts between service customers and single service supplier. Few literatures study effects of a third party such as consumers excluding service customers and service suppliers on the implementation of outsourcing contracts. In this paper, bilateral moral hazards during the cooperation of tour-guides service outsourcing with the participation of travel agencies are discussed considering tourists’ utilities. Assuming that service suppliers are risk aversion and that travel agencies and tourists are risk neutral, incentive contracts are designed with travel agencies with dual roles by dual principal-agent theory. The parameters of incentive contracts, the efforts level of travel agencies and service suppliers, tourists’ utilities and influencing factors on systems’ output are analyzed through models’ analysis and numerical simulation with bilateral moral hazards. The validity of incentive contracts on tour-guides service outsourcing is discussed in theory with bilateral moral hazards.

2. PROBLEM DESCRIPTION AND MODEL HYPOTHESIS

2.1. Problem Description

Currently, more and more travel agencies outsource tour-guides’ business to service suppliers, that is, travel agencies entrusted tourists’ service to service suppliers; Tourists prefer to choose the travel agency which brings higher tourism’s utility for them through good travel experience supported by service suppliers. So the
relationship among tourists, travel agencies and service suppliers are dual principal-agent, among which travel agencies are both principals and agents. This paper researches the service outsourcing system consisting of a travel agency, a service supplier and tourists. In the system, the system’s output is determined by collaborative service of the travel agency and the service supplier, and tourists’ utilities is determined by efforts level of the travel agency and the service supplier. During the cooperation between the travel agency and the service supplier, the private information of both parties is difficult to be observed by each other. So it is easy to lead to moral hazards in both parties, therefore, affect tourists’ utility and satisfaction. According to dual principal-agent theory, the best way for the travel agency is to provide the service supplier with a set of effectively incentive contracts, which optimizes tourism experience of tourists, at the same time, maximizes the service supplier’s utilities after satisfying the travel agency’s revenue.

The whole process of tour-guides service outsourcing could be divided into four stages : (1) the travel agency provides service outsourcing contracts with fixed salary and revenue sharing coefficient to the service supplier; (2) The service supplier adapts his service cost according to the contract supplied by the travel agency and decide whether to sign contracts; (3) if the service supplier accepts contracts, the travel agency and the service supplier maximize tourists’ utilities by their optimal efforts levels at the same time maximizing their expected utilities; (4) after finishing the cooperative production, the travel agency pays fees to the service supplier.

2.2. Model Assumption

This paper constructs incentive contracts models with dual principal-agent roles played by the travel agency, in which ‘A’ represents the travel agency; ‘G’ represents the service supplier; ‘T’ represents tourists. The following are basic assumptions and parameters description.

1) Tour-guides’ service has the characteristics of untouchable and perishable, which leads to the efforts of the travel agency and tour-guides’ service provider difficult to observe and service results difficult to measure accurately during outsourcing. So the design of outsourcing contracts must be combined with the characteristics of tour-guides service. Niu considered the total amount of tourists in the tourism service chain which is composed of a travel agency and tour-guides as the system output, and that the output is positively related with the service ability and service effort of tour-guides (Niu, 2013). So, the total amount of tourists in the service outsourcing system can be represented as $Q = k_A e_A + k_G e_G + \varepsilon$, and $\varepsilon$ is the effect of uncertainty in tourism market, and $\varepsilon \sim N(0,\sigma^2)$, $\sigma^2$ indicates uncertainty of the tourism market. Therefore, the output of outsourcing system can be represented as $Q = \tau Q = \tau (k_A e_A + k_G e_G + \varepsilon)$, and $\tau > 0$ is the net average income of the travel agency obtained from tourists, in other words, $\tau$ is the average price of all tourism products purchased by tourists.

2) When the travel agency and the service provider cooperate in service outsourcing, their participation will bring costs for them, for example, their effort costs. The function on effort costs of the travel agency is $C_A(e_A,k_A) = c_A e_A^2 / 2k_A$, $e_A$ is the effort level of the travel agency, $k_A$ and $c_A$ are respectively the service ability and the coefficient on effort costs of the travel agency. In the same theory, the function on effort costs of the service provider is $C_G(e_G,k_G) = c_G e_G^2 / 2k_G$, in which $e_G$, $k_G$ and $c_G$ are respectively the effort level, service ability and the coefficient on effort costs of the service provider. The function on effort costs of travel agency and tour-guides service provider meets $\partial C_A(e_A,k_A)/\partial e_A > 0$, $\partial^2 C_A(e_A,k_A)/\partial e_A^2 > 0$, $\partial C_G(e_G,k_G)/\partial e_G > 0$ and $\partial^2 C_G(e_G,k_G)/\partial e_G^2 > 0$. That is to say, the cost function meets the law of increasing costs and increasing marginal cost.

3) Song proposed that because service customers and service providers share risk as an interest whole, the output of service outsourcing must be shared under bilateral moral hazards (Song, 2010). So the sharing mechanism on performance is used as the payment between the travel agency and the service provider, and the payment function is $\alpha + \beta Q$, in which $\alpha$ represents the fixed payment and $\beta$ represents the commission coefficient (it can be called incentive intensity) ($\alpha > 0, 0 < \beta < 1$).

4) Because the service provider is risk averse, the risk cost is represented as $\rho \beta^2 \sigma^2 / 2$, which $\rho$ indicates the degree of risk aversion of the service provider according to Arrow-Pratt. The larger the value is, the higher the degree of risk aversion will be.

5) According to the performance measurement in Luo, the service performance measurement of the service provider is represented as $x = e_G + \xi_G$, where $e_G$ represents the actual service performance of the service provider, $\xi_G$ represents the uncertainty of the service performance of the service provider, and $\xi_G \sim N(0,\delta^2)$, which $\delta^2$ is the observation error of the service performance (Luo, 2013).

6) In contracts, reward-penalty is applied to service performance of the service provider and reward-
penalty mechanism is set as \( Z_G = \gamma (X_G - s_0) = \gamma (e_G + \xi_G - s_0) \), where \( \gamma (\gamma > 0) \) is the reward-penalty coefficient, and \( s_0 \) is the service performance standard set by the travel agency. When \( e_G + \xi_G - s_0 > 0 \), the service provider will be given a reward by the travel agency, when \( e_G + \xi_G - s_0 < 0 \), the service provider will be given a penalty, when \( e_G + \xi_G - s_0 = 0 \), it means that the service provider just meets the standard set by the travel agency, and the travel agency will not give reward or penalty to the service provider.

7) Tourists’ utility is composed of \( v \) as basic utility of package tour (\( v \) is the same to all tourists in Song), \( Y_t \) as tourists’ experience, and \( C_t \) as the cost of purchasing package tour. \( Y_t \) depends on service ability and efforts level of the travel agency and the service provider, represented as \( Y_t = \theta (k_s e_s + k G e_G) \), where \( \theta \) as the coefficient means tourists’ preference (Song, 2009).

The declaration of other parameters: \( \Pi_G \), \( \Pi_A \), and \( \Pi_t \) represent expected revenues of the service provider, the travel agency and tourists respectively. \( \Pi_G \) represents reservation revenue of the service provider, and if the revenue during outsourcing is less than \( \Pi_G \), the service provider will refuse to sign contracts with the travel agency; \( \Pi_t \) is reservation revenue of the travel agency.

3. INCENTIVE CONTRACT MODEL FOR SERVICE OUTSOURCING WITHOUT REWARD-PENALTY MECHANISM

To the service provider, the certainty equivalent revenue is actual income minus risk cost and effort cost.

\[
\Pi_G = \alpha + \beta \tau (k_s e_s + k G e_G) - \frac{c G e_G^2}{2k_G} - \frac{1}{2} \rho \beta^2 \sigma^2
\]  

(1)

The shared revenue of the travel agency is \((1-\beta)Q = (1-\beta)(k_s e_s + k G e_G)\), and the revenue function of the travel agency is its shared revenue minus effort cost and fixed salary paid to the service provider, that is,

\[
\Pi_A = (1-\beta)\tau (k_s e_s + k G e_G) - \frac{c A e_A^2}{2k_A} - \alpha
\]  

(2)

The "tourists" considered in this paper is a tourist group in a service period and not a single individual. Because tourists are studied as a whole in the paper, tourists’ cost for purchasing during the travelling is that the total tourists \( q \) multiplies the net average revenue of the travel agency that obtained from per tourist. So tourists’ cost can be represented as \( C_t = \tau q = \tau (k_s e_s + k G e_G) \). Then the revenue function of tourists is

\[
\Pi_t = Y_t - C_t = v + \theta (k_s e_s + k G e_G) - \tau (k_s e_s + k G e_G)
\]  

(3)

When the travel agency maximizes its own revenue, it is also restrained by the service provider’s and its individual rational constraints (IR: Individual rationality) and incentive compatibility constraints (IC: Incentive Compatibility). So, the principal-agent relationship among the travel agency, the service provider and tourists can be described the following linear programming model P1.

\[
P1: \max \Pi_t = v + \theta (k_s e_s + k G e_G) - \tau (k_s e_s + k G e_G)
\]  

(4)

\[s.t.\]

\[
(\text{IC}_G) e_G \in \arg \max \alpha + \beta \tau (k_s e_s + k G e_G) - \frac{c G e_G^2}{2k_G} - \frac{1}{2} \rho \beta^2 \sigma^2
\]  

(5)

\[
(\text{IC}_A) e_s \in \arg \max (1-\beta)\tau (k_s e_s + k G e_G) - \frac{c A e_A^2}{2k_A} - \alpha
\]  

(6)

\[
(\text{IR}_G) \alpha + \beta \tau (k_s e_s + k G e_G) - \frac{c G e_G^2}{2k_G} - \frac{1}{2} \rho \beta^2 \sigma^2 \geq \Pi_G
\]  

(7)

\[
(\text{IR}_A) (1-\beta)\tau (k_s e_s + k G e_G) - \frac{c A e_A^2}{2k_A} - \alpha \geq \Pi_t
\]  

(8)

Formula (4) as the objective function is tourists’ revenue; formula (5) and formula (6) are the incentive compatibility constraint of the service provider and the travel agency respectively; Formula (7) and formula (8) are the participation restrictions of the service provider and the travel agency.

Through solving the linear programming model P1, the following conclusions can be drawn.
**Proposition 1:** The optimal effort levels of the service provider and the travel agency without reward-penalty mechanism are:

\[ e_G^* = \beta \tau k_G^2 / c_G \]

\[ e_A^* = (1-\beta) \tau k_A^2 / c_A \]  

The optimal revenue sharing coefficient of the above incentive model is:

\[ \beta^* = \frac{c_A \tau^2 k_A^3}{c_A \tau^2 k_A^3 + c_G \tau^2 k_G^3 + c_A c_G \rho \sigma^2} \]  

**4. INCENTIVE CONTRACT MODEL FOR SERVICE OUTSOURCING WITH REWARD-PENALTY MECHANISM**

As the designer of service outsourcing contracts, the travel agency takes a leading role in the process of outsourcing. As participation behaviors of the travel agency and effort levels of the service provider are not easy to be observed by each other and the output of the service outsourcing system is difficult to judge who play a more important role, the service provider may take a free ride. To solve this, the travel agency can determine the service performance of the service provider by questionnaire surveys, and set a reward-penalty mechanism for service performance. According to Hypothesis 5, the function for the service performance measurement of the service provider could be set as: \( x = e_G + \xi_a \). In Hypothesis 6, the rewards-penalty mechanism is: \( Z_G = \gamma (X_G - s_0) = \gamma (e_G + \xi_a - s_0) \); if \( e_G + \xi_a - s_0 > 0 \), the travel agency will give the service provider a reward; if \( e_G + \xi_a - s_0 < 0 \), the service provider will be given a penalty; if \( e_G + \xi_a - s_0 = 0 \), it means that the service provider just meets the service performance standards, therefore, the service provider won’t be given any rewards and penalty.

When the travel agency maximizes his own revenue, it is also restrained by rational constraint (IR) and incentive compatibility constraint (IC). The principal-agent relationship among the travel agency, the service provider and tourists can be described as the following linear programming model P2.

\[ P2: \max_{e_G, e_A} \Pi_t = \nu + \theta (k_x e_A + k_o e_o) - \tau (k_x e_A + k_o e_o) \]  

s.t.

\[ (IC_G) e_o \in \arg \max \alpha + \beta \tau (k_x e_A + k_o e_o) + \gamma (e_G - s_0) - c_G e_G^2 / 2k_G - \frac{1}{2} \rho \beta^2 \sigma^2 - \frac{1}{2} \rho \gamma^2 \sigma^2 \]  

\[ (IC_A) e_A \in \arg \max (1-\beta) \tau (k_x e_A + k_o e_o) - c_A e_A^2 / 2k_A - \gamma (e_G - s_0) - \alpha \]  

\[ (IR_G) \alpha + \beta \tau (k_x e_A + k_o e_o) - c_G e_G^2 / 2k_G + \gamma (e_G - s_0) - c_A e_A^2 / 2k_A - \frac{1}{2} \rho \beta^2 \sigma^2 - \frac{1}{2} \rho \gamma^2 \sigma^2 \geq \Pi_o \]  

\[ (IR_A) (1-\beta) \tau (k_x e_A + k_o e_o) - c_A e_A^2 / 2k_A - \gamma (e_G - s_0) - \alpha \geq \Pi_o \]

Formula (12) set tourists’ revenue’s maximization as the objective function; formula (13) and formula (14) represent incentive compatibility constraints of the service provider and the travel agency respectively; formula (15) and (16) represent participate constraints of the service provider and the travel agency respectively.

Through solving the linear programming model P2, the following conclusions can be drawn.

**Proposition 2:** The optimal effort levels of the service provider and travel agency with reward-penalty mechanism are:

\[ e_G^* = (\beta \tau k_G^2 + \gamma k_G) / c_G \]  

\[ e_A^* = (1-\beta) \tau k_A^2 / c_A \]  

The optimal coefficients on revenue sharing and reward-penalty of the above incentive model are:

\[ \beta^* = \frac{c_A \tau^2 k_A^3 - c_G \tau^2 k_G^3}{c_A \tau^2 k_A^3 + c_G \tau^2 k_G^3 + c_A c_G \rho \sigma^2} \]  

\[ \gamma^* = \frac{(1-\beta) \tau k_A^2}{k_G + c_G \rho \sigma^2} \]
5. COMPARATIVE ANALYSES OF TWO INCENTIVE CONTRACTS

5.1. Analysis of Intensity Coefficient of Reward-penalty

**Theorem 1:** The coefficient of reward-penalty will decrease with the increase of the coefficient of revenue sharing, the observation error on service performance of the service provider by the travel agency and the risk aversion of the service provider. What’s more, the coefficient of rewards-penalty will increase with the increase of the uncertainty degree of tourism market and the average price of tourism products.

**Proof:** Take the partial derivative of $\gamma$ to $\beta$ and get $\partial \gamma^*/\partial \beta < 0$; take the partial derivative of $\gamma$ to $\delta$ and get $\partial \gamma^*/\partial \delta < 0$.

According formula (19) and (20), the reward-penalty intensity coefficient can be furtherly described as:

$$
\gamma^* = \frac{\tau^1 k_0^2 k_4^3 + c_4 \tau k_0^2 \rho \sigma^2}{\tau^2 k_0 k_4^3 + c_4 k_0 \rho \sigma^2 + \rho \delta^2 (c_4 \tau^2 k_0^3 + c_4 k_0^3 + c_4 c_0 \rho \sigma^2)}
$$

(21)

According to formula (21), take the partial derivative of $\gamma^*$ to $\sigma^2$, $\rho$ and $\tau$ respectively and get $\partial \gamma^*/\partial \sigma^2 > 0$, $\partial \gamma^*/\partial \rho < 0$ and $\partial \gamma^*/\partial \tau > 0$.

According to theorem 1, when there is high revenue sharing to the service provider, the travel agency will increase the coefficient of reward-penalty to maintain his utility; when there is big error on service performance of the service provider which will harm the revenue of the service provider and the outsourcing cooperation, the travel agency should reduce the coefficient of reward-penalty to maintain the revenue of outsourcing parties; if the risk aversion is high to the service provider, the high coefficient of reward-penalty will bring more insecurity to the service provider and restrain his work enthusiasm; if the price of tourism products is increasing, the travel agency should increase the coefficient of reward-penalty to achieve tourists’ satisfaction.

5.2. Performance Sharing Coefficient Analysis

**Theorem 2:** No matter whether there is a reward-penalty, the revenue sharing coefficient is a decreasing function on the risk aversion of the service provider, an increasing function on the uncertainty of tourism market and the observation error on service performance of the service provider. When there is a reward-penalty, the revenue sharing coefficient will decrease to maintain the revenue of the travel agency and is a decreasing function on the coefficient of reward-penalty. The gap between the revenue sharing coefficients with and without reward-penalty will increase with increasing reward-penalty coefficient. The coefficient of revenue sharing is an increasing function on the average price of tourism products without reward-penalty and is a decreasing function on the average price of tourism products with reward-penalty.

**Proof:** Combine formula (19) and (20), the revenue sharing coefficient with reward-penalty can be represented as:

$$
\beta^* = \frac{c_4 \tau k_0^2}{\tau^2 k_0 k_4^3 + c_4 k_0 \rho \sigma^2 + \rho \delta^2 (c_4 \tau^2 k_0^3 + c_4 k_0^3 + c_4 c_0 \rho \sigma^2)}
$$

(22)

Based on (11) and (22), take the partial derivatives of $\beta^*$ and $\beta^{**}$ to $\rho$, then get $\partial \beta^*/\partial \rho < 0$ and $\partial \beta^{**}/\partial \rho < 0$. Take the partial derivatives of $\beta^*$ and $\beta^{**}$ to $\sigma^2$ and get $\partial \beta^*/\partial \sigma^2 > 0$ and $\partial \beta^{**}/\partial \sigma^2 > 0$ respectively. Take the partial derivatives of $\beta^*$ on $\delta^2$, and get $\partial \beta^*/\partial \delta^2 > 0$. Take the partial derivatives of $\beta^*$ and $\beta^{**}$ on $\tau$, and get $\partial \beta^*/\partial \tau > 0$ and $\partial \beta^{**}/\partial \tau < 0$.

Take the partial derivative of $\beta^{**}$ on $\gamma$ according the function (20), and get $\partial \beta^{**}/\partial \gamma < 0$. Combine formula (11) and formula (20), and the difference between $\beta^*$ and $\beta^{**}$ can be represented as

$$
\Delta \beta = \beta^* - \beta^{**} = \frac{c_4 \tau k_0^2}{c_4 \tau^2 k_0^3 + c_4 k_0^3 + c_4 c_0 \rho \sigma^2} > 0.
$$

Take the partial derivatives of $\Delta \beta$ on $\gamma$, and get

$$
\partial (\Delta \beta)/\partial \gamma = \partial \left(\beta^* - \beta^{**}\right)/\partial \gamma > 0.
$$

According to the theorem 2, it is a necessary and effective way for the travel agency to increase the revenue sharing coefficient to incentive the service provider’s responsibility and service efforts because the uncertainty of tourism market brings risks and restrains work enthusiasm of the service provider. If the risk aversion is high for the service provider, he will get low revenue sharing as he cannot bear outside risk and inner responsibility. If there is a reward-penalty, to save his revenue, the travel agency is sure to convert part of
revenue sharing coefficient into the reward-penalty to the service provider. That is to say, the reward-penalty and revenue sharing mechanism are complementary.

5.3. Analysis of Optimal Effort Level

(1) Effort level of service provider

**Theorem 3:** No matter whether there is a reward-penalty, the effort level of service provider is an increasing function on revenue sharing coefficients and a decreasing function of his own risk aversion and uncertainty of tourism market. If there is a reward-penalty, the effort level of the service provider is lower than that without a reward-penalty and will decrease with increasing coefficient of reward-penalty. In addition, if the observation error of the travel agency to the service provider is increasing, the effort level of the service provider will decrease.

**Proof:** Take the partial derivatives of \( e^*_G \) on \( \beta \) according to formula (9) and get \( \frac{\partial e^*_G}{\partial \beta} > 0 \). Combined formula (17) and (20), take the partial derivatives of \( e^{**}_G \) on \( \beta \) and get
\[
\frac{\partial e^{**}_G}{\partial \beta} = \frac{\tau k_G^2}{c_G} - \frac{\tau k_G^3}{c_G (k_G + c_G \rho \delta^2)} > 0
\]
Combined formula (17) and (20), take the partial derivatives of \( e^{**}_G \) on \( \gamma \) and get
\[
\frac{\partial e^{**}_G}{\partial \gamma} = \frac{\tau k_G^2}{c_G} - \frac{c_G k_G + c_G \rho \delta^2}{c_G} < 0
\]
Combine formula (9), formula (11), formula (17) and formula (19) and get formula (23) and (24).

\[
e^*_G = \frac{c_G \rho \delta^2 + \tau k_G^3 + c_G \rho \sigma^2 + \tau k_G^3 + c_G \tau k_G^3 \rho \sigma^2}{c_G [\tau k_G^3 + c_G \rho \delta^2 + \tau k_G^3 + c_G \rho \sigma^2]}
\]
\[
e^{**}_G = \frac{c_G \rho \delta^2 + \tau k_G^3 + c_G \rho \sigma^2 + \tau k_G^3 + c_G \tau k_G^3 \rho \sigma^2}{c_G [\tau k_G^3 + c_G \rho \delta^2 + \tau k_G^3 + c_G \rho \sigma^2]}
\]
According to formula (23) and (24), take the partial derivatives of \( e^*_G \) and \( e^{**}_G \) on \( \rho \) and \( \sigma^2 \) respectively and get \( \frac{\partial e^*_G}{\partial \rho} < 0, \frac{\partial e^*_G}{\partial \sigma^2} < 0, \frac{\partial e^{**}_G}{\partial \rho} < 0, \frac{\partial e^{**}_G}{\partial \sigma^2} < 0 \). According to formula (24), take the partial derivatives of \( e^{**}_G \) on \( \delta^2 \) and get \( \frac{\partial e^{**}_G}{\partial \delta^2} < 0 \).

According to theorem 3, the revenue sharing is an effective and active incentive mechanism to the service provider. If there is a reward-penalty, the effort level of the service provider supringly decreases and is a decreasing function on the coefficient of reward-penalty, which means the reward-penalty cannot play an active role to motivate the service provider’s work for the travel agency.

(2) Effort level of travel agency

**Theorem 4:** The effort level of the travel agency will improve obviously with a reward-penalty and is an increasing function on the coefficient of reward-penalty and the uncertainty of tourism market. The effort level of the travel agency is a decreasing function on the revenue sharing’s coefficient, the risk aversion of the service provider and the observation error of the travel agency to the service provider.

**Proof:** According to formula (10) and (18), take the partial derivatives of \( e^*_A \) on \( \beta \) and get \( \frac{\partial e^*_A}{\partial \beta} > 0 \) and \( \frac{\partial e^*_A}{\partial \beta} < 0 \). Combined the conclusion \( \beta^* > \beta^{**} \) in theorem 2, it can get \( e^*_A - e^*_A = (\beta^* - \beta^{**}) \tau k_G^2 / c_A > 0 \).

Combine formula (18) and (20) and get
\[
e^{**}_A = \frac{\gamma \tau k_G^2 (k_G + c_G \rho \delta^2)}{c_A \tau k_G^2}
\]
Then take the partial derivative of \( e^{**}_A \) on \( \gamma \) and get \( \frac{\partial e^{**}_A}{\partial \gamma} > 0 \).

Combine formula (18) and (19) and get the following formula.
\[
e^{**}_A = \frac{\tau k_G^2 + c_A \tau k_G^2 \rho \sigma^2 + \rho \delta^2 (c_A \tau k_G^2 + c_A \tau k_G^2 \rho \sigma^2)}{c_A \tau k_G^2 + c_A \tau k_G^2 \rho \sigma^2 + \rho \delta^2 (c_A \tau k_G^2 + c_A \tau k_G^2 \rho \sigma^2)}
\]
Take the partial derivatives of \( e^{**}_A \) on \( \sigma^2, \rho \) and \( \delta^2 \) respectively, and get \( \frac{\partial e^{**}_A}{\partial \sigma^2} > 0, \frac{\partial e^{**}_A}{\partial \rho} < 0 \) and \( \frac{\partial e^{**}_A}{\partial \delta^2} < 0 \).
Based on the theorem 4, after adding a reward-penalty, the revenue sharing of the service provider will be less, but the revenue sharing of the travel agency will higher instead. Combined theorem 1 and 2, the revenue sharing coefficient of the service provider will decrease with the increasing revenue sharing, at the same time means the travel agency gets the potential incentives although the travel agency sets the reward-penalty mechanism to the service provider. While the uncertainty of tourism market increases, the effort level of the service provider decreases. So to maintain the outsourcing output the travel agency has to improve his effort level. However, when the travel agency cooperates with the service provider with low risk aversion, his work enthusiasm will be affected by the partner, so his effort level will decrease.

5.4 Analysis of Tourists’ Revenue

Under dual principal-agent relationship, tourists’ revenue directly depends on effort level of the travel agency and the service provider. And according to above conclusions, the effort levels directly depend on coefficients of revenue sharing and reward-penalty. So tourists’ revenue is affected indirectly by coefficients of revenue sharing and reward-penalty.

According to formula (1), (9) and (10), tourists’ revenue without reward-penalty on revenue sharing can be represented as formula (27); According to formula (1), (17) and (18), tourists’ revenue with reward-penalty on revenue sharing can be represented as formula (28); According to formula (28) and (20), tourists’ revenue on reward-penalty coefficients can be represented as formula (29).

\[
\Pi_T = v + \frac{\tau k_1^G (1 - \beta)(\theta - \tau)}{c_\alpha} + \frac{\beta \tau k_2^G (\theta - \tau)}{c_G}
\]

\[
\Pi_T' = v + \frac{\tau k_1^G (1 - \beta)(\theta - \tau)}{c_\alpha} + \frac{\beta \tau k_2^G (\theta - \tau)}{c_G} + \frac{\tau k_3^G (1 - \beta)(\theta - \tau)}{c_G(k_1^G + c_G \rho \delta^2)}
\]

\[
\Pi_T'' = v + \frac{\tau k_1^G (\theta - \tau)}{c_\alpha} + \frac{\tau k_2^G (\theta - \tau)\gamma}{c_G} + \frac{\tau k_3^G (\theta - \tau)(k_1^G + c_G \rho \delta^2)\gamma}{c_G} - \frac{(\theta - \tau)(k_1^G + c_G \rho \delta^2)\gamma}{c_G}
\]

In order to show the relationship between tourists’ revenue and revenue sharing coefficient or between tourists’ revenue and reward-penalty coefficient visually, numerical simulation is carried out with given specific parameters value.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>(c_G)</th>
<th>(c_\alpha)</th>
<th>(k_G)</th>
<th>(k_\alpha)</th>
<th>(\tau)</th>
<th>(\delta^2)</th>
<th>(\gamma)</th>
<th>(\theta)</th>
<th>(v)</th>
<th>(\beta)</th>
<th>(\gamma)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value</td>
<td>0.3</td>
<td>0.4</td>
<td>1.2</td>
<td>1.3</td>
<td>1.0</td>
<td>4.0</td>
<td>1.2</td>
<td>1.5</td>
<td>2.0</td>
<td>0.1,0.2...1.0</td>
<td>0.1,...0.0</td>
</tr>
</tbody>
</table>

![Figure 1. tourists’ revenue on \(\beta\)](image1.png)

![Figure 2. tourists’ revenue on \(\gamma\)](image2.png)

According to figure 1, tourists’ revenue increases slowly with increasing revenue sharing coefficient. Combined theorem 3, the effort level of the service provider is sure to increase with increasing revenue sharing coefficient. As the service provider provides higher tourism experience for tourists actively, so the tourists’ revenue increases. But tourists’ revenue increases slowly with the increasing revenue sharing because the effort level of the travel agency is affected by the revenue sharing. Tourists’ revenue with a reward-penalty is always bigger than that without a reward-penalty and decreases with increasing revenue sharing coefficient.

From Figure 2, tourists’ revenue always increases with the increasing reward-penalty. According to theorem 3, when the coefficient of reward-penalty increases, the effort level of the service provider decreases and tourists’ revenue doesn’t decrease. It is because the revenue sharing of the travel agency increases with increasing reward-penalty coefficient, which motivates work enthusiasm of the travel agency and makes the
travel agency plays a more important role in outsourcing system. However, to make outsource successful, the travel agency should set reward-penalty guarantee his revenue, because the reward-penalty can guarantee tourists’ tourism experience and maintain the outsourcing system continuous and stable.

6. CONCLUSION

The paper studies the dual principal-agent outsource among tourists, the travel agency and the service provider, among which the travel agency is a principal to the service provider and an agent to tourists. The incentive contract models of cooperative service are constructed with and without reward-penalty and the contracts’ parameters and tourists’ revenue are also studied. Through models analysis and numerical simulation, the reward-penalty in incentive contracts can effectively improve tourists’ revenue and tourists’ satisfaction. In addition, reasonable revenue sharing and reward-penalty coefficients are important to outsourcing systems.

The study can guide the design for outsourcing contracts and provide some suggestions for improving tourists’ satisfaction. But the interactive influence between service ability and effort level is ignored for simplifying computation. In reality, service ability and effort level are not linear relation on tourists’ quantity. In the future research, the interactive influence will be studied.

Acknowledgements

The paper is funded by National Natural Science Foundation of China(71201053) ,Outstanding Youth Project of Hunan Education Department(15B070) and National Social Science Foundation of China (13CJY007).

REFERENCES


