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Service Reliability Diagnosis of Tourism Supply Chain

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Abstract. In order to promote the service level of tourism supply chain, the fault tree of tourism supply chain was compiled to diagnose the service reliability, which is based on questionnaire. Via giving the calculation methods of top event risk probability and bottom events risk equivalent and taking Pingyao ancient city as an empirical study, we have found out the key fault factors and offered the decision basis for the system service reliability management. Taking fault tree into service reliability of tourism supply chain is a new idea.

Introduction

In recent years, tourism has become one of the fastest-growing, most promising and largest emerging industries in the world [1]. In order to obtain high benefit and stable operation, tourism supply chain must be guaranteed by high reliability [2-4]. Reliability of tourism supply chain is the core of customer perception of tourism service quality. If maintenance of supply chain is a profit growth point of enterprises, the failure diagnosis of supply chain is the source of this point [5]. Hao LIU established the reliability evaluation index system [6]. Jing-zhi CHEN constructed the reliability evaluation index system from three dimensions of tourism supply chain operation quality standard requirements [7]. Yue-mei ZHANG and others combined fuzzy theory with fault tree to construct the reliability analysis model of tourism supply chain [8]. From the above relevant literature, we can see that the existing research is limited to the definition of tourism supply chain reliability, type differentiation and evaluation indicators, but the diagnosis of tourism supply chain service reliability is insufficient. This paper will discuss how to diagnose the high failure factors of tourism supply chain service by introducing the fault tree analysis method based on the analysis of system operation failure. In the tourism service system, there are many factors which may lead to the failure of tourism service and affect the reliability of the system. The diagnosis of the factors is an important problem to improve the reliability and operational efficiency of the tourism supply chain service.

Service Failure Analysis of Tourism Supply Chain

Leading tourism scholars Richard Tapper and Xavier Font, among others, believed that the tourism supply chain includes all the goods or service providers in the tourism product supply system used to meet the needs of tourists [9]. These enterprises work directly or indirectly with travel operators, retailers or suppliers providing accommodation only. In addition, the tourism supply chain also includes other suppliers of destination where tourists purchase goods or services directly. Tao CHEN, Jie LI summarized three kinds of tourism supply chain models, including the supply chain model dominated by travel agency, the theme park model with service industry as the main body, and the free travel supply chain model represented by e-commerce website [10]. No matter which mode, in the process of tourism supply chain operation, there are some factors that affect the reliability of the system leading to the failure of the system to meet the needs of customers duly and accurately. That can be considered that the system has a tourism service failure. According to the running environment of tourism supply chain, the system failure must be caused by each node fault in the supply chain. These node links include food, shelter, travel, shopping, entertainment and so on, and the "purchase, entertainment" two links are freely chosen by tourists in the destination, so, this paper mainly aimed at traffic, accommodation and tourism community these three modules, establishes a general fault model of service failure diagnosis in tourism supply chain (refer with figure 1).

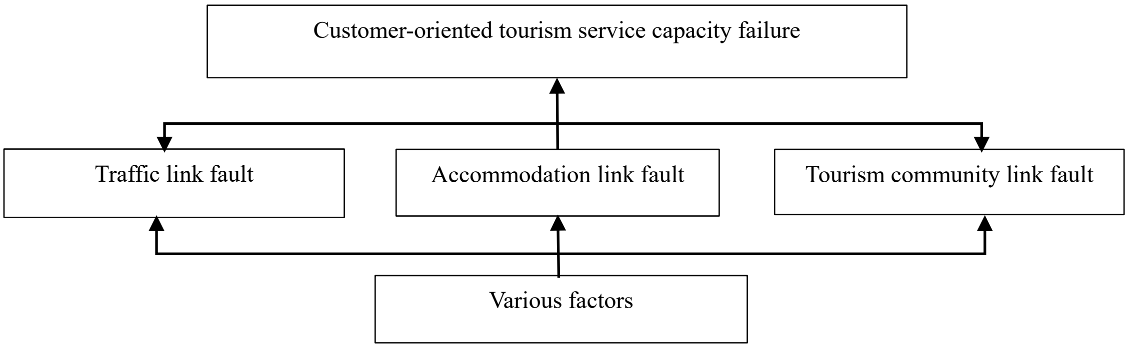

Fig. 1, Fault module diagram of tourism supply chain service

Fault Tree Model and Analysis of Service Reliability Diagnosis in Tourism Supply Chain

Fault Tree Structure for Service Reliability Diagnosis of Tourism Supply Chain

Fault tree analysis, FTA, refers to the most undesirable failure as the total goal of failure analysis called top event. All direct causes could lead to this failure are referred to as intermediate events; and the direct causes may lead to these intermediate events called bottom events, including components or human causes. With the corresponding representative symbols and logical gates, we can connect top, intermediate and bottom events into a graph looked as if an inverted tree rooted in the top event that is fault tree.

Aiming at the complex and abstract tourism supply chain problem, this paper deal with it concretely in FTA.As figure 1, customer-oriented tourism service capacity failure is top event in terms of T. The failure of any one of the three major modules, traffic, accommodation and tourism community, could cause the occurrence of T. "Logic or" is used to connect those modules and T. The intermediate events at every level lead to node failure are representative by A_i, B_i, C_i (refers with table 1).Bottom events are expressed by X_i, and connect them in "logic and". Description of bottom events refers to table 2.Above that, we can achieve fault tree (refer with figure 2).

Table 1, Intermediate events

Events	Meaning	Events	Meaning
A_1	Traffic failure	B_3	not arrive in time
A_2	Board and lodging failure	B_4	Personal security failure
A_3	Community failure	B_5	not check in time
B_1	Traffic prophase failure	B_6	tourism deviation failure
B_2	Transit failure	B_7	Financial failure

Table 2, Bottom events

Events	Meaning	Events	Meaning
X_1	Equipment failure	X_8	Lack of basic tourism knowledge
X_2	Personnel operation failure	X_9	Poor defense consciousness
X_3	Not detected in advance	X_{10}	Unsafe board and lodging
X_4	Environment mutation	X_{11}	Insufficient board and lodging units
X_5	Not match the truth	X_{12}	no plans
X_6	Responsible tour guide	X_{13}	Unreasonable charge
X_7	Poor health	X_{14}	Insufficient budget

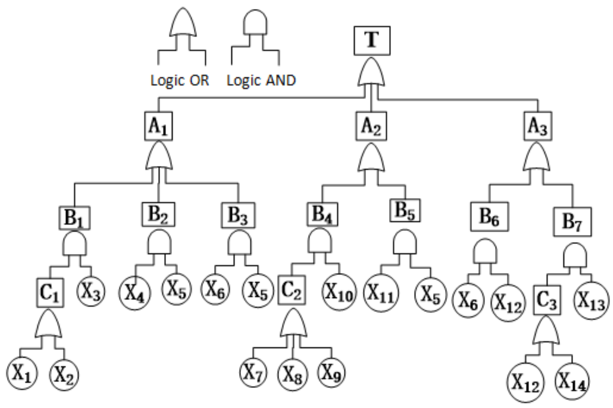

Fig. 2, Tourism supply chain fault tree

Structure Function Analysis of Fault Tree Top Events and Intermediate Events

According to figure 2, we can get the structure function of the intermediate events C_i ,B_i , A_i., refers with Eq.1

$$\begin{gathered} C_1 = X_1 + X_2 \quad C_2 = X_7 + X_8 + X_9 \quad C_3 = X_{12} + X_{14} \quad B_1 = C_1 \cdot X_3 \quad B_2 = X_4 \cdot X_5 \quad B_3 = X_6 \cdot X_5 \\ B_4 = C_2 \cdot X_{10} \quad B_5 = X_{11} \cdot X_5 \quad B_6 = X_6 \cdot X_{12} \quad B_7 = C_3 \cdot X_{13} \quad A_1 = B_1 + B_2 + B_3 \quad A_2 = B_4 + B_5 \quad A_3 = B_6 + B_7 \end{gathered} \tag{1}$$

The structure function of the top events obtained from (1), refers with Eq.2:

$$\begin{aligned} T &= A_1 + A_2 + A_3 = B_1 + B_2 + B_3 + B_4 + B_5 + B_6 + B_7 = C_1X_3 + X_4X_5 + X_6X_5 + C_2X_{10} + X_{11}X_5 + X_6X_{12} + C_3X_{13} \\ &= (X_1 + X_2)X_3 + X_4X_5 + X_6X_5 + (X_7 + X_8 + X_9)X_{10} + X_{11}X_5 + X_6X_{12} + (X_{12} + X_{14})X_{13} \\ &= X_1X_3 + X_2X_3 + X_4X_5 + X_6X_5 + X_7X_{10} + X_8X_{10} + X_9X_{10} + X_{11}X_5 + X_6X_{12} + X_{12}X_{13} + X_{14}X_{13} \end{aligned} \tag{2}$$

Importance Analysis of Bottom Events in Fault Tree

The fault tree model directly shows the causality between the top event and the underlying factors. In this paper, the uplink method is used to solve the minimum cut set. The top event is expressed as the sum of the bottom events product, in which all the product terms are the minimum cut set of the fault tree, in which each minimum cut set represents a failure mode of the tourism supply chain. If there is at least one bottom event will not occur, the top event will not occur. So finding the minimum cut set is significant to reduce the potential faults and weak links of tourism supply chain service system. In figure 2, the minimum cut set of the tourism supply chain is solved. According to equation (2),there are 11minimumcut sets of the fault tree, which are represented by U_i(i=1,2……11).They are respectively U_1={X_4, X_5}, U_2={X_6, X_5}, U_3={X_{11}, X_5}, U_4={X_6, X_{12}}, U_5={X_1, X_3}, U_6={X_2, X_3}, U_7={X_7, X_{10}}, U_8={X_8, X_{10}}, U_9={X_9, X_{10}}, U_{10}={X_{12}, X_{13}}, U_{11}={X_{14}, X_{13}}.

From the bottom events in each minimum cut set, the criteria for defining the influence level after the occurrence of events are as follows: occur 3 times is serious, twice is general ,and once is slight. It can be seen that serious ones are X_5, X_{10}. General ones are X_6, X_{12}, X_3, X_{13}. The slight ones are: X_4, X_{11}, X_1, X_2, X_7, X_8, X_9.

Calculation of Risk Equivalent of Bottom Events in Fault Tree

The risk of each event has two basic characteristics, one is the possibility of the occurrence of the risk expressed by the probability; one is the loss caused by the occurrence of the risk. Therefore, the bottom event risk equivalent I in the fault tree is equal to the occurrence probability of the bottom event fault multiplied by the level of influence after the fault occurs (refers with Eq.3).

$$I = \omega \cdot P \tag{3}$$

An Empirical Study: A Case Study of Ping-yao Ancient City in Shan-xi Province

Pingyao ancient city, located in Shanxi Province, is one of the ancient counties in our country that has successfully declared the world cultural heritage by the whole ancient city. According to the Pingyao County Tourism Department, the county received 430100 tourists from February 16 to February 21, 2018, an increase of 37.54 percent over the same period last year. With the increasing businesses, in order to improve the service quality of supply chain and reduce the risk, the fault diagnosis of tourism supply chain is very important.

Results

In order to understand the potential weak factors that lead to the tourism risk in Pinyao, we have published a questionnaire, targeting people with Pingyao travel experience. In this paper, the probability of occurrence of fault tree bottom events in Pingyao tourism supply chain is investigated, 197 valid questionnaires are collected, and the statistical data are shown in table 3.In the table, X_i (i=1, 2……14) is bottom event, P_i (i=1, 2……14) is the probability of occurrence.

Table 3, Failure rate of various bottom events in Pingyao tourism

X_i	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}	X_{14}
P_i	0.03	0.01	0.05	0.03	0.05	0.09	0.04	0.04	0.03	0.05	0.01	0.06	0.04	0.01

Probability Analysis of Top Events and Intermediate Events

From equation (2) and table 3, the probability of failure of intermediate events can be obtained (refer with table 4). We can see that the tourism community fault module is more prone to community failure than traffic and accommodation module, which is also math the truth.

Table 4, Failure rate of immediate events

X_i	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}	X_{14}
$I(x_i)$	0.03	0.01	0.10	0.03	0.15	0.18	0.04	0.04	0.03	0.15	0.01	0.12	0.08	0.02

According to formula (3), the failure rate of top event is as follows:

$$P(T) = P(A_1) + P(A_2) + P(A_3) = 0.0219$$

According to the risk matrix in reference [11], the failure probability of tourism supply chain system in this example is 0.0219, between 10^{-3}and10^{-2}, so the risk level is 4, that is, the probability of expected failure is in the middle and high risk area. The system needs to be maintained in time.

Measurement of Risk Equivalent of Bottom Event in Fault Tree

Based on formula (3), the risk equivalent of bottom event is calculated (refer with table 5)

Table 5, Risk equivalent of various bottom events

Events	C_1	C_2	C_3	B_1	B_2	B_3	B_4	B_5	B_6	B_7	A_1	A_2	A_3
Failure rate	0.04	0.11	0.07	0.0012	0.002	0.0045	0.0055	0.0005	0.0054	0.0028	0.0077	0.0060	0.0082

Results Analysis and Countermeasures

From table 5, we can see that there are some differences in the degree of the risk of the different bottom events. According to the risk equivalent, the bottom events can be classified into three categories: class A is 0.18-0.12,B is between 0.10-0.04 and C is 0.03-0.01.That is, class A is X_6, X_{10}, X_5, X_{12},class B is X_3, X_{13}, X_7, X_8,class C is X_1, X_4, X_9, X_{14}, X_2, X_{11}.In the reliability management of the system, there should be a focus on differentiated management.

The fault event in category A is the key factor in the fault management, which is decided by two reasons: more times of occurrence in minimum cut set and higher failure rate. Such as tour guide irresponsible, unsafe accommodation, not match the truth, no plans. In terms of tour guide, as one of the world cultural heritage sites and a national 5A scenic spot, Pingyao needs more eligible Tour guides to publicizing the essence of its history and culture. So, while ensuring the related practicing ability of tour guides, we should also strengthen training so that they can provide targeted services with various situation, and strengthen supervision on the phenomenon of “indifference and perfunctory”. In the aspect of accommodation, it is directly related to personal safety. Travel agencies may, according to their own economic strength, annex some of the weaker small and medium-sized enterprises to achieve horizontal expansion, and then enter into strategic alliances for catering and accommodation through mergers, transfer of franchise rights, or signing of contacts. With regard to the truth match, we should try our best to ensure the authenticity of the propaganda content and meet the needs of tourists for “seeking knowledge and truth”. For the cultural heritage sites represented by Pingyao, it is also necessary to strengthen the “sensitivity” and “comprehensibility” of tourism activities and take cultural heritage as the support to achieve psychological satisfaction. Finally, tourists themselves should make plans in advance, get the corresponding knowledge, travel planning and capital budget.

Class B events are secondary important factors, including early detection, unreasonable charges, poor health and lack of basic tourism knowledge. Class C events are general factors, such as equipment failure, environmental mutation, poor defense awareness, insufficient budget, personnel operation trouble and insufficient ability of board and lodging units. Every failure event in class B or C shouldn‟t be ignored; even one screw can cause the whole system to break down.

Summary

In this paper, the fault tree of tourism supply chain is compiled. Aiming at the problem that it is difficult to quantify the service reliability of tourism supply chain at present, the calculation method of the probability of the top event of the fault tree is given by solving the minimum cut set and the intermediate events. Finally, taking Pingyao ancient city as an example, the reliability of tourism supply chain is analyzed quantitatively, the risk equivalent of bottom event is obtained, and the countermeasures are given. In this paper, the risk influence level of the fault factors quantified by the number of occurrence of the bottom events in the minimum cut set, which makes up for the deficiency of the quantitative management and helps to find out the key fault factors in the system.

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