FUZZY AHP ANALYSIS OF INTERNET OF THINGS IN TOURISM INDUSTRY

Nguyen Quang Vinh

University of Labor and Social Affairs, Hanoi, Vietnam

ABSTRACT

With the impacts of the industrial revolution 4.0, the tourism industry faces the opportunity to innovate the development model. In this situation, Vietnam tourism will have a revolutionary development, creating outstanding personalized customer service. The objective of this study is to indentify the key success factor for IoT application in tourism companies by integrating fuzzy theory and analytical hierarchy process (FAHP). Following the steps of FAHP methods, the study finds that the critical success factors for IoT application in tourism companies have developed, including technology, organization, environment, and Customer Security. The result also indicated the importance of Technology infrastructure, IT Human resources, Government policy, and Information privacy in IoT applications in tourism companies. Discussion, conclusion, limitations, and suggestions for future research are also presented.

KEYWORDS

Internet of Things, Fuzzy AHP, Tourism industry, Vietnam

1. INTRODUCTION

The Internet of Things (IoT) is an achievement of the information technology era with the emergence of the internet. Scientists believe IoT with artificial intelligence will help people get things done more brilliantly and efficiently [1]. It can be demonstrated by the impact of IoT on the tourism industry's development, including the management of tourism businesses, the provision of tourism services, and the connection between supply and demand for tourism. Travel companies also need to use this technology to understand visitor needs as a data discovery and retrieval channel to build future intelligent strategies for the entire value chain of tourism. However, the tourism industry is also known as a service industry provided to tourists through duty transfer officers[2]. Service quality is often judged on the waiter's attitude, skill, and grace. These job characteristics of the tourism industry cannot be replaced by science and technology. In recent years, many countries are still trying to find IoT application opportunities in various fields, such as healthcare, education, transportation, home appliances, factories, and a smart city. Scholars believe that a critical element to the growth of IoT is application innovation, known as Generation 2.0 Innovation, which focuses on user experience. The next generation will face a society where knowledge is everywhere [1].

While many methods have been proposed to calculate and synthesize weights to rank factors. The fuzzy weighting of each criterion is suggested by [3] and is specified in several studies, such as [4] and [5][6]. Therefore, this study aims to applied the FAHP to identify critical success factors in IoTadoption by tourism companies.The rest of this paper is organized as follows. Part 2 briefly the IoT literature review and the critical success factors for IoT adoption. Section 3 presents the method to identify essential factors. Section 4 presents the empirical and discussion results.

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Finally, the conclusions with theoretical and managerial contributions and the limitation and further research are presented in Section 5.

2. LITERATURE REVIEW

2.1. Internet of Things

The concept of IoT emerged decades ago. IoT is a scenario of a world where each object and person is provided with its identifier, and all can transmit and exchange information and data over a single network without needing to be connected to direct human-to-human or human-to-computer interaction[7].Kim et al. [8] state that: "the common interface for the IoT platform consists of a four-layer architecture based on two common interface diagrams with its data flow when connecting to the device and the service layer." In simple terms, IoT is all devices that can connect. Devices can be smartphones, heaters, computers, dishwashers, washing machines, coffee machines, and many other appliances. All devices and objects in a house can be harmoniously connected to create a smart home in which every human thought and action can be recorded and understood[9]. Most prominent is the ability to communicate and understand each other between all devices in the IoT system.

2.2. Internet of Things in Tourism Industry

The tourism industry includes many stakeholders and impacts the global economy. Personalized travel and customer experiences in the travel industry are top of the list regarding IoT innovations. As[2]indicates that IoT adoption is only possible if the local infrastructure allows the deployment of devices that provide the information and data needed to make real-time decisions and the information that helps with simulations to predict future situations. [11] in the study of smart tourist destinations, have proposed five components, including Personal Control; Seamless Travel; Smart Energy Saving; Location Information, and Maintenance and Repairs. IoT technology will change the business model [12]. In this regard, this technology will allow airlines to save time and effort by improving the quality of baggage handling on flights and facilitating the check-in process with many passengers [13]. The virtual assistant-assisted interface helps guests visit by interacting with them and enhancing their stay experience. A sensible sensor with AI can suggest recipes with available items to kitchen staff. In addition, hotels can also use IoT for eco-friendly management activities in hotels, including waste recycling and reuse, energy saving, tree feeding, and maintenance[13]

2.3. The Critical Success Factors for IoT Adoption

There have been many studies on the factors leading to success in applying science and technology in enterprises, the earliest of which is the technology, organization, and environment (TOE) model [14]. Besides the TOE model, the technology acceptance model (TAM) and the "Diffusion of innovation" model (DOI) are also widely used in research related to technological innovation [9]. However, TAM is limited consideration of environmental conditions in technology change due to different technical viewpoints [15]. In summary, the TOE framework is broader, contains organizational factors, and is relevant to this study. In addition to the TOE framework, some of the most significant barriers to IoT adoption are privacy and security concerns, such as resistance to attacks, data authentication, control access and privacy of customers in various activities, such as personal operations, business processes, transportation, and protection of information [9]. The literature review collected research variables and indicators that can be used to explore the factors influencing IoT adoption in the tourism industry. This paper uses the TOE framework and adds a customer security variable. Therefore, the

framework includes four variables technology, organization, environment, and customer security (TOEC) which are the four aspects of this research framework. These dimensions and criteria are listed in Table 1.

Table 1. Dimensions and criteria

Main variable	Sub variable	Operation definition	Source
Technology	Technology infrastructure	The technology infrastructure includes hardware and software components to support an enterprise's application of IoT	[9]
	Connectivity	IoT integration means bringing together new IoT devices, IoT data, IoT platforms, and IoT applications in an end-to-end deployment landscape.	[9]
	Smart tourism application	Provide innovative travel services such as web, mobile services, and cloud computing	Author develops
Organization	IT Human resource	A human resource is a person in the company's workforce, whether part-time, full-time, freelance, or contract employees.	[9]
	Top management support	Support from top managers in IoT application such as: CEO, Management board or seniors managers.	[9]
	Organisational readiness	The willingness of organizations indicated the IoT application.	[9]
Environment	Government policy	The declaration of government in planning and intention concerning the IoT	[9]
	Supporting industry	Supporting industries manufacture production parts and tooling to apply the IoT	[9]
	Competitive pressure	Competitive pressure is when a company typically faces pressure due to its competitor's IoT application.	[9]
Customer securities	Information privacy	A highly desirable consideration from customers when adapting IoT technologies or products	[1]
	Authorization	A function that allows authorized users to look up the best-defined data in the database when they need.	[1]
	Data management	A user filter mechanical feature for document access, operation, and control.	[1]

3. METHOD

This study applied the FAHP method, the expert's rating are represented by fuzzy trianggular number. The fuzzy matrix is shown as form:

$$\tilde{A} = \left(\tilde{a}_{ij}\right)_{n\times n} = \begin{bmatrix} (1,1,1) & (l_{12},m_{12},u_{12}) & \dots & (l_{1n},m_{1n},u_{1n}) \\ (l_{21},m_{21},u_{21}) & (1,1,1) & \dots & (l_{2n},m_{2n},u_{2n}) \\ \vdots & \vdots & \vdots & \vdots \\ (l_{n1},m_{n1},u_{n1}) & (l_{n2},m_{n2},u_{n2}) & \dots & (1,1,1) \end{bmatrix}$$

Where $\tilde{a}_{ij} = \left(l_{ij},m_{ij},u_{ij}\right)$ và $\tilde{a}_{ij}^{-1} = \left(1/u_{ij}, 1/m_{ij}, 1/l_{ij}\right)$ với $i, j = 1, \dots, n$ và $i \neq j$. (1)

To determine each criterion's fuzzy mean and fuzzy weight, this research applies the suggestion of Hsieh et al. (2004):

$$\tilde{r}_i = (\tilde{a}_{i1} \otimes \ldots \otimes \tilde{a}_{ij} \otimes \ldots . \otimes \tilde{a}_{in})^{1/n} \quad (2)$$

$$\tilde{w}_i = \tilde{r}_i \otimes [\tilde{r}_i \oplus \ldots \oplus \tilde{r}_i \oplus \ldots \oplus \tilde{r}_i)^{-1} \quad (3)$$

Defuzzification: Converting fuzzy weights to nonfuzzy values This defuzzification method is performed by finding the center of area (COA) values to find the variables' weights criteria through the Best nonfuzzy performance (BNP) index:

$$BNP = \frac{[(U_{wi} - L_{wi}) + (M_{Wi} - L_{wi})}{3} + L_{wi} \quad (4)$$

To determine the incompatibility ratio, it needs to defuzzify the comparison matrix and obtain the incompatibility ratio as a simple AHP. If the value of the consistency ratio, CR < 0.1, is acceptable. To perform the pairwise comparison between fuzzy parameters, the linguistic variable is defined corresponding to the evaluation levels according to the following Table 2

Table 2. Linguistic variable

Numerical rating	Linguistic variable	TFN
1	Equally important	(1,1,1)
2	Intermediate value between 1 and 3	(1,2,3)
3	Essentially important	(2,3,4)
4	Intermediate value between 3 and 5	(3,4,5)
5	Strongly important	(4,5,6)
6	Intermediate value between 5 and 7	(5,6,7)
7	Very strongly important	(6,7,8)
8	Intermediate value between 7 and 9	(7,8,9)
9	Extremely important	(8,9,10)

Fourteen experts were selected to participate in the survey, including IT professionals, tourism business executives, and university lecturers. Out of the returned responses, four questionnaires had inappropriate answers. Table 3 presents information of the experts:

Table 3. Information of the experts

No.	Position	Experience	Education	Organization
1	Vice-president	15	Doctor	University
2	IT Lecturer	18	Doctor	University
3	Head of IT Department	15	Doctor	University
4	IT Specialist	10	Doctor	Research Institute
5	IT Specialist	10	Doctor	Research Institute
6	Manager	10	Master	Tourism business
7	Manager	15	Master	Tourism business
8	Sales manager	9	Master	Tourism business
9	Head of Marketing	15	Master	Tourism business
10	Project Manager	10	Master	Tourism business

4. RESULT AND DISCUSSION

4.1. AHP Results

Through the steps of FAHP analysis, fuzzy mean (r), weight ($\tilde{w}$), and BNP values are obtained.

The ranking of indicators related to technology is shown in Table 4, organizational in Table 5, environmental in Table 6, customer securities in Table 7, and finally, the main factors leading to success in IoT application of tourism enterprises are shown in Table 8.

Table 4. Technology indicators ranking

	r	W*	BNP	Ranking
Technology infrastructure	(1.22, 1.37, 1.47)	(0.36, 0.44, 0.52)	0.44	1
Connectivity	(0.86, 0.95, 1.05)	(0.25, 0.31, 0.37)	0.31	2
Smart tourism application	(0.72, 0.77, 0.86)	(0.21, 0.25, 0.31)	0.26	3

*CR < 0.1

Table 4 shows the indicators' r, w, and BNP values in the model of priority for Technology indicators. The result shows that Technology infrastructure is ranked as the first importance in technology factors (BNP =0.44). The second factor is Connectivity (0.31), and the last ranking is Smart tourism application (BNP = 0.26). The *CR < 0.1 indicates the acceptable consistency ratio suggested by Saaty (1980).

Table 5. Organizational indicators ranking

	r	W*	BNP	Ranking
IT Human resource	(1.29, 1.56, 1.75)	(0.36, 0.49, 0.65)	0.50	1
Top management support	(0.72, 0.83, 0.96)	(0.20, 0.26, 0.35)	0.27	2
Organizational readiness	(0.69, 0.77, 0.92)	(0.19, 0.24, 0.34)	0.26	3

*CR < 0.1

Table 5 shows the indicators' r, w, and BNP values in the model of priority for organisational indicators. The result shows that IT human resource is ranked as the first importance in organisational factors (BNP =0.5). The second factor is Top management support (0.27), and the last ranking is Organisational readiness (BNP = 0.26). The *CR < 0.1 indicates the acceptable consistency ratio suggested by Saaty (1980).

Table 6. Environment indicators ranking

	r	W*	BNP	Ranking
Government policy	(1.27, 1.38, 1.46)	(0.38, 0.45, 0.51)	0.45	1
Supporting industry	(0.75, 0.83, 0.90)	(0.22, 0.27, 0.32)	0.27	3
Competitive pressure	(0.82, 0.88, 0.98)	(0.25, 0.29, 0.34)	0.29	2

*CR < 0.1

Table 6shows the indicators' r, w, and BNP values in the model of priority for Environment indicators. The result shows that Government policy is ranked as the first importance in Environment factors (BNP =0.45). The second factor isCompetitive pressure (0.29), and the last ranking is Supporting industry (BNP = 0.27). The *CR < 0.1 indicates the acceptable consistency ratio suggested by Saaty (1980).

Table 7. Customer securities indicators ranking

	r	W*	BNP	Ranking
Information privacy	(1.30, 1.60, 1.83)	(0.34, 0.49, 0.68)	0.51	1
Authorization	(0.86, 1.04, 1.25)	(0.23, 0.32, 0.46)	0.34	2
Data management	(0.52, 0.60, 0.74)	(0.14, 0.19, 0.28)	0.20	3

*CR < 0.1

Table 7 shows the indicators' r, w, and BNP values in the model of priority for Environment indicators. The result shows that Information privacy is ranked as the first importance inCustomer securities factors(BNP =0.51). The second factor Authorization (0.34), and the last ranking is Data management (BNP = 0.20). The *CR < 0.1 indicates the acceptable consistency ratio suggested by Saaty (1980).

Table 8. Key success factors to IoT application ranking

	r	W*	BNP	Ranking
Technology	(1.36, 1.53, 1.66)	(0.26, 0.34, 0.42)	0.34	2
Organization	(1.54, 1.84, 2.12)	(0.30, 0.40, 0.54)	0.41	1
Environment	(0.51, 0.59, 0.67)	(0.10, 0.13, 0.17)	0.13	4
Customer Securities	(0.53, 0.61, 0.74)	(0.10, 0.13, 0.19)	0.14	3

*CR < 0.1

Table 8 shows the indicators' r, w, and BNP values in the model of priority for key **success** factors to IoT application. The result shows that Organization factoris ranked as the first importance inIoT application model (BNP =0.41). The second factor is technology (0.34), the third factor is customer securities, and the last ranking factor is environment (BNP = 0.20). The *CR < 0.1 indicates the acceptable consistency ratio suggested by Saaty (1980).

4.2. Discussion

From the research result, the key success factors to IoT application in tourism companies' model have developed from the TEO model with four factors including Technology, Organization, Environment, and Customer Securities. This study confirmed the previous papers conducted by applying the TEO model in analyzing the IoT application enterprises, such as [9],[16], and [17]. However, this study fills the gap in the TEO model by adding the factor of Customer Securities so-called TEOC model. The result also indicated the importance of Technology infrastructure, IT Human resources, Government policy, and Information privacy in IoT applications in tourism companies. [1] and [9]have shown the ranking factor related to IoT applications. However, their studies only show the cause-effect diagram.

5. CONCLUSION

5.1. Theorical Implication

This study prioritizes critical success factors for IoT applications in tourism companies. While previous studies use the TEO and TAM modelsis lacking the critical success factors for IoT application in tourism companies based on expert opinions. Furthermore, although the Fuzzy and

AHP have been used extensively in tourism research, they have yet to be combined to evaluate the critical success factors of IoT applications in tourism companies. This study contributes to the construction of specific critical success factors for IoT applications in tourism companies from the perspective of tourism and IT experts. The results indicate specific key factors and classify them into four main factors. Technology: technology infrastructure, connectivity, and smart tourism application (adding by author). Organizational: IT Human resources, top management support, and organizational readiness. Environmental: government policy, supporting industry, and competitive pressure. Moreover, the authors added factors, Customer securities: Information privacy, Authorization, and Data management. In this study, Customer security ranked as the third critical success factor for IoT applications in tourism companies.

5.2. Managerial Implication

The following recommendations are proposed for the tourism industry to enhance its IoT adoption. 1) FAHP method is a valuable method for ranking the Key success factors in IoT applications and insightful decisions making. 2) organization and technology are two main factors that companies should focus resources on to achieve higher efficiency in IoT applications. 3) The high-ranking indicator in the model of IoT application include Technology infrastructure, IT Human resources, and Information privacy, which companies need to improve. And 4) There are two indicators, Information privacy and Authorization of Customer Securities factor, which have high priority to get the customer confidence and satisfaction with the service provided by companies.

5.3. Limitation

Despite the specific findings, this study encountered some limitations in finding relevant literature, owing to limited access to data systems. In addition, through the application of FAHP methods to evaluate prioritisation, only four dimension and twelve indicators, without an in-depth analysis of the indicators or the influence of each indicator on the other indicators. Another limitation of this study is that the survey was only conducted with 10 experts. Therefore, further studies should conduct research using a more comprehensive database to provide a more in-depth analysis with more dimensions. The proposed properties in this research need more specific indicators and surveys with more experts, as well as other empirical research methods.

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AUTHOR

Nguyen Quang Vinh is a lecturer in the Faculty of Business Administration of the University of Labour and Social Affairs, Vietnam. He received his Ph.D. in Business from Fengchia University, Taiwan, in 2013. His academic research mainly focuses on the areas of Tourism, such as marketing, human resource, and tourist behavior. His research often adapts quantitative methods, such as fuzzy analytic hierarchy process (fuzzy AHP), fuzzy multiple criteria decision-making (fuzzy MCDM), structure equation model (SEM), and some other statistical methods to analyze research data collected from questionnaires and interviews