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Application of Intuitionistic Fuzzy DEMATEL Method for Analysis of the Cause and Impact of Health Tourism Factors

S. Piros[1], **P. Khamrot**[2], **N. Deetae**[3,*]

[1]*Department of Business Administration, Faculty of Management, Pibulsongkram Rajabhat University, Thailand*

[2]*Department of Mathematics, Faculty of Science and Agricultural Technology, Rajamangala University of Technology Lanna, Phitsanulok, Thailand*

[3]*Department of Statistics, Faculty of Science and Technology, Pibulsongkram Rajabhat University, Thailand*

[*]*Corresponding author:* natthinee@psru.ac.th

Abstract. This research presents the application of the Intuitionistic Fuzzy DEMATEL (IF-DEMATEL) method to analyze health tourism factors in Phitsanulok Province. The objective is to examine the cause-and-effect relationships among health tourism factors using the IF-DEMATEL method in order to identify the key factors that influence the success and sustainability of health tourism in the area. The results indicate that, in the Cause Influence Group, the most important factors are customer satisfaction (C1) and safety at the venue (C3), which directly affect the quality and overall experience of tourists. In the Effect Influence Group, the most significant factors are technological efficiency (C11) and financial performance (C7). Technology enhances convenience and service quality, while financial stability contributes to the long-term sustainability of tourism. The identified cause-and-effect relationships provide valuable insights for developing effective strategies, such as investing in technology alongside environmental management (C10) to strengthen competitiveness (C12) and attract both domestic and international tourists. The findings can be used at both the local and national levels as guidelines for policy formulation and the sustainable development of health tourism.

1. Introduction

Activities promoting the conservation-driven Thai economic system, under the supervision of the Ministry of Tourism and Sports, reported that travel into Thailand during the period 1 January–31 December 2024 reached 35.54 million international visitors. The Thai tourism sector continued the recovery momentum observed in 2023, generating approximately 1.67 trillion baht

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in revenue from 34 million tourists in that year [1]. The tourism industry has steadily moved forward following the global spread of the coronavirus pandemic beginning in 2019.

Thailand is widely recognized for its rich traditions and cultural identity, which reflect the uniqueness of Thai society. These cultural strengths enhance the value of natural resources and environmental conservation while reducing negative impacts on both local communities and international visitors traveling within the Asian region. However, the COVID-19 pandemic significantly affected the tourism sector, leading to substantial economic losses and a downturn in tourism-related industries. According to the national strategic development plan, tourism has been a major contributor to gross domestic product (GDP) since 2017. Thailand's tourism resources are abundant in natural attractions (nature tourism), cultural heritage sites (cultural tourism), and specialized tourism segments (specialty tourism). Currently, the tourism market has increasingly focused on health and wellness tourism. Between 2019 and 2021, despite the pandemic, Thailand maintained a strong position in the global health tourism market and was ranked 17th out of 46 countries. Thailand's "Thainess" identity—emphasizing traditional culture, hospitality, and medical expertise—has strengthened its competitiveness and contributed to positive visitor experiences.

Given these circumstances, health tourism has become an important driver of economic stability and development. Merdivenci and Karakaş [2] evaluated the performance of health tourism in Turkey using the fuzzy DEMATEL method to measure tourism efficiency. Their study highlights the importance of identifying key causal factors in order to enhance strategic decision-making. Service quality remains a central determinant of tourism outcomes [3–7], particularly in developing countries where health tourism presents significant growth opportunities [8, 9].

The analysis of tourism components and their impacts on tourists can be framed within Decision-Making Theory, particularly under Multi-Criteria Decision Making (MCDM) problems [10]. Various MCDM approaches have been applied in tourism research. For example, Zopounidis et al. [11] employed the PROMETHEE II method to evaluate Mediterranean tourism performance. Wang et al. [12] applied the Fuzzy Delphi and Fuzzy Analytic Hierarchy Process methods to analyze tourism performance in Taiwan's coastal zone. Several researchers have also used MCDM techniques to assess health tourism performance [13, 14]. In particular, Merdivenci and Karakaş [2] utilized the DEMATEL (Decision-Making Trial and Evaluation Laboratory) method as an MCDM tool to analyze causal relationships affecting health tourism performance in Turkey. The DEMATEL approach is effective for identifying high-level causal structures and examining complex interrelationships among decision criteria. MCDM methods provide valuable insights into cause–effect relationships and the varying intensities of influencing factors [15–20]. Therefore, the DEMATEL method serves as a powerful analytical instrument for supporting strategic planning in health tourism.

Based on these considerations, the application of decision-making theories offers valuable direction for the tourism industry. By analyzing the causal relationships among health tourism factors, DEMATEL, as an MCDM method, can effectively demonstrate the determinants influencing health tourism performance and sustainability.

2. Research Methodology

This study aims to investigate the causal relationships and key determinants of health tourism development using the IF-DEMATEL approach. Based on a comprehensive review of the relevant literature [2–6, 8, 9], a set of critical factors influencing health tourism performance was identified. These factors were subsequently analyzed to determine their structural relationships and levels of influence within the system.

2.1. **Define the variables.** To conduct the IF-DEMATEL analysis, twelve key criteria (C1–C12) were defined based on theoretical foundations and empirical studies in the fields of tourism performance, health tourism development, and multi-criteria decision-making. Each criterion represents a significant dimension influencing the sustainability and competitiveness of health tourism in Phitsanulok Province.

C1 represents customer satisfaction: the quality level and assessment of the attitudes and behaviors of service recipients.

C2 represents innovation: the quantity and quality of innovative products and services related to health tourism.

C3 represents security: safety in health tourism destinations in Phitsanulok Province.

C4 represents tourism resources: the diversity of tourism resources in Phitsanulok Province.

C5 represents the social perspective: support from the government and private sectors in providing health tourism services.

C6 represents travel in tourism: This criterion represents the convenience of travel within the tourism system, including transportation infrastructure such as roads, buses, and other transit services.

C7 represents financial performance: financial liquidity related to health tourism in Phitsanulok Province.

C8 represents price: the total cost of health tourism in Phitsanulok Province.

C9 represents flexibility: health tourism destinations adapt to current situations.

C10 represents the environmental perspective. (Environmental Perspective) Pollution levels, cleanliness, and environmental management within Phitsanulok province.

C11 represents technology performance: the application of technology in conjunction with health tourism.

C12 represents competition: health tourism in Phitsanulok province is outstanding and can compete with other provinces.

2.2. **Data Collection.** For data collection, the researchers used questionnaires as the tool. Respondents were individuals involved in health tourism in the public and private sectors, as well as tourism operators. They held a bachelor's degree or higher and had at least 10 years of work experience in their current position or establishment. Cause and effect analysis was then conducted using the IF-DEMATAL method.

2.3. **Intuitionistic fuzzy DEMATEL (IF-DEMATEL).** The Dematel Integrative Method is the application of intuitionistic fuzzy sets (IF) to the determination of the causal components of Dematel [20]. The Dematel Integrative Method is one of the MCDM methods used for evaluating the causes, factors, or components of evaluation criteria where the data is not fixed and is ambiguous according to the concept of fuzzy sets [21]. The method has been applied in various fields, and it can be found that there are still researchers who have developed a form of the Dematel Integrative Method to suit the situation that has occurred and have created the IF-DEMATEL process, which is detailed as follows:

Definition 2.1. *Let X be a non-empty set. An intuitionistic fuzzy set (IFS) A in X is defined as*

$$A = \{(x, \mu_A(x), \nu_A(x)) \mid x \in X\}, \tag{2.1}$$

where $\mu_A : X \to [0,1]$ is the membership function and $\nu_A : X \to [0,1]$ is the non-membership function satisfying

$$0 \le \mu_A(x) + \nu_A(x) \le 1, \quad \forall x \in X.$$

3. Methodology

To analyze the causal relationships among health tourism factors, this study adopts the Intuitionistic Fuzzy DEMATEL (IF-DEMATEL) method. The DEMATEL technique is widely used to identify and visualize cause-effect structures in complex systems, while the intuitionistic fuzzy framework enhances the model by incorporating uncertainty, hesitation, and ambiguity in expert judgments.

The proposed methodology consists of several systematic steps, including the construction of the intuitionistic fuzzy direct relation matrix, aggregation of expert evaluations, normalization, computation of the total relation matrix, and classification of criteria into cause and effect groups. The detailed procedures are presented as follows.

3.1. **Step 1: Construction of the Intuitionistic Fuzzy Direct Relation Matrix.** Let X be a nonempty set. An intuitionistic fuzzy set (IFS) A in X is defined as

$$A = \{(x, \mu_A(x), \nu_A(x)) \mid x \in X\}, \tag{3.1}$$

where $\mu_A(x)$ and $\nu_A(x)$ denote the membership and non-membership degrees, respectively, satisfying

$$0 \le \mu_A(x), \nu_A(x) \le 1, \quad 0 \le \mu_A(x) + \nu_A(x) \le 1.$$

The hesitation degree is defined as

$$\pi_A(x) = 1 - \mu_A(x) - \nu_A(x).$$

Consider an MCDM problem with n criteria $(c_1, c_2, \ldots, c_n)$ and l experts.

The influence relationships among criteria are expressed using linguistic variables represented by intuitionistic fuzzy numbers (IFNs), as shown in Table 1.

Table 1. Linguistic Variables of Influence

Linguistic Term	**IFN** (μ, ν, π)
No influence	$(0.00, 0.30, 0.70)$
Low influence	$(0.35, 0.25, 0.40)$
Moderate influence	$(0.60, 0.20, 0.20)$
High influence	$(0.85, 0.15, 0.00)$

The direct-relation matrix provided by the k-th expert is denoted as

$$A^{(k)} = [a_{ij}^{(k)}]_{n\times n}, \tag{3.2}$$

where

$$a_{ij}^{(k)} = (\mu_{ij}^{(k)}, \nu_{ij}^{(k)}, \pi_{ij}^{(k)})$$

represents the IF evaluation of the influence of criterion c_i on criterion c_j given by expert k.

The diagonal elements satisfy

$$a_{ii}^{(k)} = (0, 1, 0),$$

indicating that a criterion does not influence itself.

3.2. **Step 2: Determination of Experts' Priority Weights.** Since experts may have different levels of expertise, A relative importance weight is assigned to each expert.

The linguistic scale for expert importance is given in Table 2.

Table 2. Linguistic Variables for Experts' Importance

Linguistic Term	**IFN** (μ, ν, π)
Very important	$(0.90, 0.05, 0.05)$
Important	$(0.75, 0.20, 0.05)$
Moderate	$(0.50, 0.50, 0.00)$
Not important	$(0.25, 0.70, 0.05)$
Not very important	$(0.10, 0.85, 0.05)$

Let the IF weight of expert k be

$$\tilde{\lambda}_k = (\mu_k, \nu_k, \pi_k), \quad \mu_k + \nu_k + \pi_k = 1.$$

To obtain a crisp priority weight, a score function is used:

$$S(\tilde{\lambda}_k) = \mu_k + \pi_k\left(\frac{\mu_k}{\mu_k + \nu_k}\right). \tag{3.3}$$

The normalized weight of expert k is

$$\lambda_k = \frac{S(\tilde{\lambda}_k)}{\sum_{k=1}^{l} S(\tilde{\lambda}_k)}, \tag{3.4}$$

such that

$$\sum_{k=1}^{l} \lambda_k = 1.$$

3.3. **Step 3: Construction of the Weighted Aggregated Direct-Relation Matrix.** The individual direct-relation matrices provided by l experts are aggregated into a collective intuitionistic fuzzy direct-relation matrix using the Intuitionistic Fuzzy Weighted Averaging (IFWA) operator.

Let

$$a_{ij}^{(k)} = (\mu_{ij}^{(k)}, \nu_{ij}^{(k)}, \pi_{ij}^{(k)})$$

be the IF evaluation of expert k.

The aggregated IF value is defined as

$$x_{ij} = \left(1 - \prod_{k=1}^{l}(1-\mu_{ij}^{(k)})^{\lambda_k},\ \prod_{k=1}^{l}(\nu_{ij}^{(k)})^{\lambda_k}\right), \tag{3.5}$$

for $i, j \in \{1, 2, \ldots, n\}$, where λ_k denotes the normalized weight of expert k.

The hesitation degree is obtained by

$$\pi_{ij} = 1 - \mu_{ij} - \nu_{ij}.$$

Thus, the aggregated intuitionistic fuzzy direct-relation matrix is

$$\tilde{X} = [x_{ij}]_{n\times n}.$$

3.4. **Step 4: Normalization of the Direct-Relation Matrix.** To ensure that the sum of rows or columns does not exceed unity, the aggregated matrix is normalized.

First, a crisp transformation is applied using the score function:

$$p_{ij} = \frac{\mu_{ij} - \nu_{ij} + 1}{2}. \tag{3.6}$$

The scaling factor is defined as

$$m = \min\left\{\frac{1}{\max_i \sum_{j=1}^{n} p_{ij}},\ \frac{1}{\max_j \sum_{i=1}^{n} p_{ij}}\right\}. \tag{3.7}$$

The normalized direct-relation matrix is then obtained as

$$X = mP, \tag{3.8}$$

where $P = [p_{ij}]_{n\times n}$.

3.5. **Step 5: Construction of the Total Relation Matrix.** The total relation matrix captures both direct and indirect effects among criteria.

$$T = X(I - X)^{-1}, \tag{3.9}$$

where I is the identity matrix.

3.6. **Step 6: Prominence and Relation Analysis.** Let

$$T = [t_{ij}]_{n\times n}.$$

The row sums and column sums are computed as

$$R_i = \sum_{j=1}^{n} t_{ij}, \qquad D_j = \sum_{i=1}^{n} t_{ij}. \tag{3.10}$$

For each criterion i:

- Prominence: $R_i + D_i$
- Relation: $R_i - D_i$

If $R_i - D_i > 0$, the criterion belongs to the cause group.
If $R_i - D_i < 0$, the criterion belongs to the effect group.

3.7. **Step 7: Causal Diagram Construction.** The causal diagram is constructed by plotting $(R_i + D_i)$ on the horizontal axis and $(R_i - D_i)$ on the vertical axis.

This visualization provides insight into the prominence and the causal structure of the criteria within the decision system.

4. Results and Discussion

This section reports the results of the proposed IF-DEMATEL procedure for analyzing the causal relationships among the health tourism criteria.

4.1. **Expert prioritization and weights.** Three experts were invited to provide pairwise influence judgments. Based on the linguistic evaluation of expert importance (Tables 1-2), the normalized priority weights were obtained as $\lambda_1 = 0.35$, $\lambda_2 = 0.42$, and $\lambda_3 = 0.22$.

4.2. **Aggregated direct-relation assessment.** Using the IFWA aggregation operator, the individual intuitionistic fuzzy direct-relation matrices were fused into the aggregated direct-relation matrix (Table 3). Subsequently, the aggregated crisp matrix was obtained (Table 4). The summations of rows and columns of the aggregated crisp matrix are reported in Table 5.

Table 3. Aggregated direct relation matrix (IF values).

	C1	C2	C3	⋯	C11	C12
C1	(0.000,0.000)	(0.666,0.160)	(0.182,0.238)	⋯	(0.196,0.0.243)	(0.360,0.200)
C2	(0.523,0.523)	(0.000,0.000)	(0.123,0.250)	⋯	(0.251,0.231)	(0.170,0.250)
C3	(0.406,0.406)	(0.285,0.216)	(0.000,0.000)	⋯	(0.504,0.194)	(0.251,0.231)
C4	(0.360,0.360)	(0.285,0.216)	(0.360,0.200)	⋯	(0.469,0.188)	(0.182,0.238)
C5	(0.251,0.251)	(0.285,0.216)	(0.360,0.200)	⋯	(0.360,0.200)	(0.172,0.253)
C6	(0.268,0.268)	(0.285,0.216)	(0.146,0.260)	⋯	(0.182,0.238)	(0.196,0.243)
C7	(0.210,0.210)	(0.285,0.216)	(0.313,0.210)	⋯	(0.473,0.000)	(0.360,0.200)
C8	(0.293,0.293)	(0.136,0.257)	(0.313,0.210)	⋯	(0.000,0.300)	(0.523,0.181)
C9	(0.251,0.251)	(0.136,0.257)	(0.360,0.200)	⋯	(0.360,0.200)	(0.172,0.253)
C10	(0.313,0.313)	(0.182,0.238)	(0.210,0.237)	⋯	(0.285,0.216)	(0.360,0.200)
C11	(0.172,0.172)	(0.285,0.216)	(0.073,0.270)	⋯	(0.000,0.000)	(0.313,0.210)
C12	(0.360,0.360)	(0.073,0.270)	(0.285,0.216)	⋯	(0.360,0.200)	(0.000,0.000)

Table 4. Aggregated crisp matrix.

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12
C1	0.000	0.209	-0.012	0.027	0.005	-0.011	0.017	-0.017	0.092	0.012	-0.010	0.045
C2	0.121	0.000	-0.024	0.045	-0.045	0.045	-0.024	0.045	-0.041	0.136	0.005	-0.017
C3	0.062	0.017	0.000	-0.029	0.045	-0.033	0.045	-0.022	0.019	0.011	0.108	0.005
C4	0.045	0.017	0.045	0.000	-0.006	0.045	-0.033	0.045	-0.012	-0.006	0.092	-0.012
C5	0.005	0.017	0.045	0.045	0.000	0.017	0.019	0.005	0.045	0.017	0.045	-0.017
C6	0.012	0.017	-0.023	0.183	0.045	0.000	-0.006	0.045	-0.033	0.019	-0.012	-0.010
C7	-0.006	0.017	0.027	0.005	0.045	0.045	0.000	0.017	0.045	0.005	0.112	0.045
C8	0.019	-0.024	0.027	-0.022	0.019	-0.002	0.121	0.000	0.017	0.045	-0.045	0.121
C9	0.005	-0.024	0.045	-0.032	0.045	-0.023	0.168	0.045	0.000	0.017	0.045	-0.017
C10	0.027	-0.012	-0.006	-0.033	0.072	0.045	0.101	0.045	0.017	0.000	0.017	0.045
C11	-0.017	0.017	-0.034	0.005	-0.029	0.045	-0.041	0.045	0.017	0.017	0.000	0.027
C12	0.045	-0.034	0.017	-0.011	0.005	-0.017	0.017	0.027	0.005	0.121	0.045	0.000

Table 5. Summation of row and column.

Criteria	Summation of row	Summation of column
C1	0.357	0.317
C2	0.246	0.218
C3	0.227	0.107
C4	0.220	0.182
C5	0.242	0.199
C6	0.236	0.155
C7	0.356	0.384
C8	0.275	0.279
C9	0.273	0.170
C10	0.318	0.393
C11	0.051	0.402
C12	0.220	0.214
Maximum	**0.356**	**0.402**

4.3. **Normalization and total relation matrix.** Following the normalization procedure, the normalized direct-relation matrix X was obtained (Table 6). The total relation matrix T, which captures both direct and indirect influences among criteria, was computed using $T = X(I - X)^{-1}$ and is presented in Table 7.

4.4. **Prominence and cause–effect analysis.** Let R_i and D_i denote the row-sum and column-sum of T, respectively. The prominence $(R_i + D_i)$ reflects the overall importance of criterion i, while the relation $(R_i - D_i)$ identifies its net causal role. The computed values are summarized in Table 8.

Table 6. Normalized direct relation matrix.

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12
C1	0.000	0.519	-0.029	0.067	0.012	-0.026	0.042	-0.041	0.228	0.030	-0.025	0.111
C2	0.300	0.000	-0.059	0.111	-0.112	0.111	-0.059	0.111	-0.102	0.338	0.012	-0.041
C3	0.154	0.042	0.000	-0.073	0.111	-0.082	0.111	-0.054	0.047	0.027	0.269	0.012
C4	0.111	0.042	0.111	0.000	-0.015	0.111	-0.082	0.111	-0.029	-0.015	0.230	-0.029
C5	0.012	0.042	0.111	0.111	0.000	0.042	0.047	0.012	0.111	0.042	0.111	-0.043
C6	0.030	0.042	-0.058	0.455	0.111	0.000	-0.015	0.111	-0.082	0.047	-0.029	-0.025
C7	-0.015	0.042	0.067	0.012	0.111	0.111	0.000	0.042	0.111	0.012	0.279	0.111
C8	0.047	-0.059	0.067	-0.054	0.047	-0.006	0.300	0.000	0.042	0.111	-0.112	0.300
C9	0.012	-0.059	0.111	-0.080	0.111	-0.058	0.419	0.111	0.000	0.042	0.111	-0.043
C10	0.067	-0.029	-0.015	-0.082	0.179	0.111	0.252	0.111	0.042	0.000	0.042	0.111
C11	-0.043	0.042	-0.084	0.012	-0.073	0.111	-0.102	0.111	0.042	0.042	0.000	0.067
C12	0.111	-0.084	0.042	-0.026	0.012	-0.041	0.042	0.067	0.012	0.300	0.111	0.000

Table 7. Total relation matrix.

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12
C1	0.260	0.631	-0.004	0.155	0.079	0.116	0.255	0.162	0.276	0.361	0.139	0.218
C2	0.441	0.212	-0.058	0.214	-0.005	0.222	0.117	0.246	-0.002	0.501	0.071	0.134
C3	0.200	0.151	-0.002	-0.050	0.137	-0.005	0.195	0.035	0.140	0.145	0.351	0.090
C4	0.195	0.148	0.090	0.077	0.005	0.157	-0.019	0.185	0.011	0.100	0.251	0.062
C5	0.091	0.104	0.135	0.150	0.061	0.108	0.158	0.110	0.160	0.130	0.243	0.030
C6	0.156	0.141	-0.001	0.522	0.128	0.103	0.019	0.217	-0.049	0.144	0.088	0.054
C7	0.067	0.080	0.093	0.088	0.181	0.189	0.145	0.181	0.176	0.169	0.408	0.211
C8	0.123	-0.014	0.142	-0.057	0.203	0.057	0.522	0.108	0.185	0.288	0.145	0.432
C9	0.036	-0.020	0.168	-0.078	0.228	0.029	0.578	0.196	0.138	0.136	0.335	0.111
C10	0.135	0.043	0.054	0.011	0.297	0.194	0.440	0.233	0.167	0.166	0.235	0.254
C11	-0.014	0.012	-0.075	0.046	-0.043	0.120	-0.031	0.153	0.026	0.098	-0.023	0.112
C12	0.152	-0.017	0.069	-0.044	0.131	0.030	0.248	0.158	0.127	0.386	0.228	0.141

Table 8. Summations of row and column and causal classification.

Criteria	R	D	$R+D$	$R-D$	**Group**
C1	2.650	1.841	4.491	0.809	Cause
C2	2.093	1.471	3.563	0.622	Cause
C3	1.387	0.612	1.999	0.775	Cause
C4	1.261	1.033	2.294	0.228	Cause
C5	1.477	1.401	2.878	0.076	Cause
C6	1.522	1.319	2.841	0.202	Cause
C7	1.986	2.627	4.614	-0.641	Effect
C8	2.133	1.982	4.116	0.151	Cause
C9	1.857	1.355	3.212	0.502	Cause
C10	2.230	2.623	4.853	-0.394	Effect
C11	0.381	2.470	2.851	-2.089	Effect
C12	1.609	1.850	3.458	-0.241	Effect

Based on the sign of $(R_i - D_i)$, criteria were divided into two groups: (i) *cause group* with $(R_i - D_i) > 0$, and (ii) *effect group* with $(R_i - D_i) < 0$. The ranking results for the cause and effect groups are provided in Table 9.

Table 9. Ranking of cause and effect groups.

Cause	Rank	Effect	Rank
C1	1	C11	1
C3	2	C7	2
C2	3	C10	3
C9	4	C12	4
C4	5		
C6	6		
C8	7		
C5	8		

4.5. **Causal diagram.** The causal diagram was constructed by plotting each criterion using coordinates $\left(R_i + D_i, R_i - D_i\right)$ (Figure 1), which provides an interpretable visualization of prominence and causal structure in the health tourism decision system.

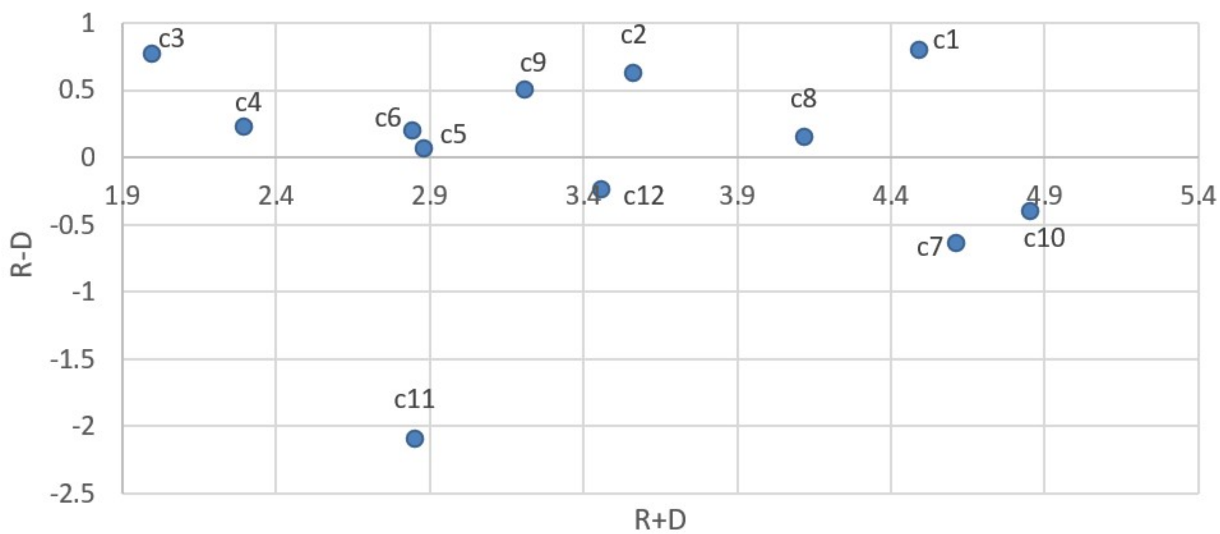

Figure 1. Cause-effect diagram.

From the IF-DEMATEL analysis, the factors are classified into two groups: the Cause Influence Group and the Effect Influence Group. The Cause Influence Group, ranked by the degree of influence, consists of C1, C3, C2, C9, C4, C6, C8, and C5. The Effect Influence Group, ranked by influence, consists of C11, C7, C10, and C12, respectively, as presented in Table 9.

4.6. **Cause Influence Group.** The Cause Influence Group includes factors that drive changes within the system. Among these, customer satisfaction, service quality level, attitude assessment, and service recipient behavior (C1) are identified as key determinants. Customer satisfaction is considered a major factor influencing the success of health tourism because it is directly related to the experiences and perceptions that tourists gain from service utilization. This factor encompasses evaluations of service quality, perceived value for money, customer attitudes toward staff and service providers, and post-service behaviors such as repeat visits and recommendations to others. Enhancing customer satisfaction requires an integrated approach, including staff training, facility improvement, and systematic collection of customer feedback to support continuous service development. Consistent with the findings of Kieanwatana et al. (2018) [22], foreign tourists' decisions to travel to Thailand are strongly influenced by prior travel experiences and information received from previous visits. High levels of satisfaction encourage repeat visitation and positive word-of-mouth promotion. The second most influential causal factor is safety in health tourism destinations in Phitsanulok Province (C3). Safety plays a crucial role in tourists' decision-making processes, particularly in health tourism, where services are directly related to healthcare and well-being. Key safety considerations include environmental cleanliness, quality control of food and water, accident prevention within service areas, and accessibility to medical or emergency services when necessary. Ensuring safety may involve compliance with certified standards, implementation of monitoring technologies such as CCTV systems and alarm devices, and clear communication of safety information to customers. Many countries have positioned tourism safety as a strategic strength to attract international visitors. Similarly, Kupkitaphun and Bunjongmanee (2019) [23] emphasized that adequate facilities and infrastructure are critical factors influencing European tourists' decisions in health tourism contexts.

Overall, C1 (customer satisfaction) and C3 (safety) are structurally interconnected. A deficiency in safety measures can significantly reduce customer satisfaction. Therefore, improvements in these factors must be implemented in an integrated manner to build trust, credibility, and confidence among tourists, particularly those seeking specialized health services.

4.7. **Effect Influence Group.** The Effect Influence Group consists of factors that represent outcomes resulting from causal interactions within the system. Technological efficiency and the integration of technology in health tourism services (C11) enhance the tourism experience through tools such as online booking systems, digital health applications, and smart service management platforms, thereby increasing convenience and accessibility. This aligns with the findings of Kaewsanga et al. (2020) [24], who demonstrated that social media promotion and digital content presentation play a vital role in stimulating tourist interest and strengthening destination credibility. Financial performance and liquidity in the health tourism sector (C7) reflect the economic sustainability of tourism operations. Effective cost and revenue management directly influence service quality, infrastructure development, and the ability to secure government or private sector support, such as funding and tax incentives. Strong financial performance enhances long-term competitiveness and stability. Environmental management factors (C10), including pollution control, cleanliness, and sustainable environmental practices, contribute significantly to destination image and attractiveness. Effective environmental management improves public perception and supports long-term sustainability.

Competitive advantage factors (C12) reflect the unique characteristics of health tourism in Phitsanulok Province compared to other regions. Differentiation strategies may include high-quality local health services (hospitals, spas, rehabilitation centers), integration of traditional and modern medicine, and promotion of distinctive cultural identity. Developing these unique strengths enhances provincial competitiveness in both domestic and international health tourism markets.

4.8. **Integrated Cause–Effect Relationships.** Overall, causal factors drive the outcomes observed in the effect group. For example, improvements in technological efficiency (C11) can enhance customer satisfaction (C1) and strengthen safety management (C3), ultimately leading to improved financial performance (C7). Conversely, weak financial performance (C7) may reduce the capacity to invest in technological development (C11) or environmental improvements (C10), demonstrating reciprocal interactions within the system. Therefore, integrated management of both causal and effect factors is essential to achieve balanced and sustainable development. Enhancing technological efficiency (C11) should align with environmental management strategies (C10) to improve customer satisfaction (C1) and safety (C3) in health tourism destinations. Coordinated strategic planning across these dimensions will support long-term competitiveness and sustainability in the health tourism sector of Phitsanulok Province.

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