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# Selection of Technological Innovation for Service-Orientated Enterprises

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**Abstract:** Technological innovation is a vital method for enterprises to remain sustainably competitive. Highlighting the emerging information technology such as cloud computing, big data, and Internet of Things (IOT) provides grounds for options of technological innovation for service-orientated enterprises, how could the service-orientated enterprises make appropriate and effective decisions? This paper constructs the evaluation criteria system of a technological innovation scheme selection based on the four-dimensional model of service innovation and uses the hybrid multi-criteria decision model (MCDM) to make systematic selection. That is, to analyze the relationship between every dimension and criteria based on Decision Making Trial and Evaluation Laboratory (DEMATEL) method, draw out the network diagram, calculate the weighted ratio of each indicator using the Analytic Network Process (ANP) method, and finally through integrating the modified VlseKriterijumska Optimizacija I Kompromisno Resenje (mVIKOR) method to order the enterprise innovation scheme. The result of this paper shows that Beacons technology is the best service innovation scheme, and the sequencing of each dimension's weight is the new service delivery system, new client interface, new service concept, and technology choice. It also, combining with the research conclusion, gives out advice on enterprises' technological innovation selection process.

**Keywords:** Technological innovation; service-orientated enterprises; service innovation; sustainable competitive; DEMATEL method; ANP method; mVIKOR method

## 1. Introduction

As a comprehensive industry, along with social and economic development, the service industry is not only an important driving force for economic growth, but also one of the main users of emerging Internet technology [1]. At present, emerging information technologies such as cloud computing, big data, and Internet of Things have derived a series of technological services related to the service-oriented enterprises and these services play an important role in the process of improving consumer mobility and accessibility, reducing users' risks, and improving service experiences [2–4]. For service-oriented enterprises, in light of the consumers' needs getting increasingly more critical and more professional and in order to maintain sustainable competitiveness in the market, they must force themselves to use innovative technology to continuously enhance innovative ability and innovative advantage [5–7]. However, under a complex business environment, each technological innovation is a double-edged sword: On the one hand, it provides the service-oriented enterprises the opportunities to profit from innovation, to upgrade its business roles, and to better prepare for meeting the consumers' needs. On the other hand, innovation may potentially alter the past traditional supply chain, undermining some of the immature business processes and adversely causing

expected losses to enterprises [8]. Hence, one major challenge that service-orientated enterprises have to face, especially when there is currently a lack of support to technological innovation scheme by comprehensive and effective evaluation methods and index systems for technology, is how to scientifically and rationally carry out the selection of technological innovation programs and innovate the experiences to attract more consumers.

The hybrid multi-criteria decision model based on DANP (DEMATEL-based ANP)-VIKOR method has been proved to be effective in solving multi-objective and multi-attribute decision-making problems. It is now widely used in fields of management and finance, including risk assessment [9], website quality improvement [10], tourism Policy assessment [11], brand marketing management [12], and stock selection [13]. The model could effectively improve the weights of the traditional analytic hierarchy process (AHP) method that is mainly applicable to the independent shortcomings of each dimension and criteria, better in line with the real-life situations where decision-making problems often display dependency or feedback relationship [14]. That is, to firstly use Decision Making Trial and Evaluation Laboratory (DEMATEL) to find out the relationship between the factors and draw the impact network diagram; then, to use Analytic Network Process (ANP) calculate the weight of each factor; and lastly, in order to overcome the problem that the technique for order of preference by similarity to ideal solution (TOPSIS) method cannot reflect the degree of proximity of the scheme and the positive and negative ideal solution, to use VlseKriterijuska Optimizacija I Komoromisno Resenje (VIKOR) to select the preferred schemes, fully considering the maximization of the utility of groups and minimization of self-pity [15]. Given the complexity of the selection process of the service-oriented enterprise's technological innovation program, which involves many influencing factors, such as technology, cost, employee, and so on; the selection of technological innovation should be considered a multiple criteria decision-making problem. In particular, these related variables are interdependent and interact with each other. Therefore, this paper attempts to adopt the hybrid multi-criteria decision model based on the DANP-VIKOR method to select the technical innovation scheme of the service-orientated enterprises.

## 2. Construction of Evaluation Criteria of Technical Innovation Scheme

The four-dimension model of service innovation proposed by Bilderbeek et al. integrates previous research results [16]. That is, the service innovation that consists of four dimensions: The service concept, the client interface, the service delivery system/organization, and technological options. The model comprehensively describes the implementation aspects of service innovation, and guides the actual development of innovative activities, with some referential significance to policy making and modern enterprises servicing [17]. At present, the application in the service industry focuses more on the overall macroscopic investigation of the four dimensions of the model, and lacks specific and detailed analysis of the quantitative subdivision indicators [18,19]. In view of the degree of reliance on technology, this paper chooses the four-dimensional model in service innovation as the evaluation framework and constructs the evaluation criteria system in light of the opinions of the experts and scholars within the service industry on selecting the technological innovation programs for service-orientated enterprises. The detailed illustrations are presented in the following.

### *2.1. New Service Concept*

The selection of new service concept is one of the most important aspects of innovative service development. When facing choices of selecting new service concepts, service-oriented enterprises need to answer some basic questions: Which types of products can retain existing customers and develop new customers? Which types of products do the competitors offer? How do we deliver the new services to our customers? It is clear that this new service concept is market-oriented, which depends on the consumers and the competitors [20]. This requires companies to continually identify existing and potential competing services, forming the enterprise's 'business intelligence' through understanding the concept of new services.

First, the selection of a new service concept should be consistent with corporate innovation or sustainable development strategy, as strategy is fundamental and the most effective internal driving force for business innovation. It is not only a long-term sustainable business plan for the enterprise itself, but also a basic guideline for various activities undertaken in the enterprises [21]. Incorporating innovation or sustainability with the corporate strategy is a fundamental approach for service-oriented enterprises to gain competitive advantage and safeguard their corporate image. Secondly, the corporate consumers' needs and competitors' status often determine the innovation process [22] and understanding consumers' needs and competitors enhances the probability of businesses being able to meet consumers' needs [23]. Service-oriented enterprises need to motivate themselves to continually identify and address the consumers' needs, to ensure there is sufficient knowledge to understand which innovative service concepts could lead to effective market segmentation and accurate targeting location and hence deliver better values to customers [24]. In addition, the choice of new service concept would also be influenced by government decisions as the service-oriented enterprises innovation development obviously requires government involvement at the national level and the government controls a large number of policy instruments that focus on different categories of innovation [25]. The specific government-support innovative policies and measures and boosting entrepreneurial information on the macroeconomic environment could effectively enhance the enterprise's innovation investment and future innovation willingness. For the service enterprises, the choice of new service concept should, as much as possible, be consistent with the government-supported direction, and thus benefits from the government financial support, consulting services, skills development projects, and research and development programs [7]. Based on that, this paper extracts indicators including 'corporate strategy', 'consumer demand', 'competitive pressure', and 'government support' under the concept of new service.

### *2.2. New Client Interface*

The new client interface, as a new communication way between service providers and customers, plays an important role in service innovation. In particular, IT-based interface can be applied to marketing, transaction, information processing, customized services and post-sales services and many other areas. Enterprises could also further collect the information on actual consumers' and potential consumer' needs through technology including databases and data mining. Therefore, when designing new interfaces, enterprises usually need to consider the following factors: How do we communicate with customers? How do our competitors do? How to let customers act as 'co-producers' in innovation? Correctly addressing the above questions is also the foundation and prerequisite for tourism enterprises to establish a good customer interface in the process of service innovation.

As the most direct contact point for consumers to perceive the corporate image, the new client interface has its design directly influencing the delivery of innovative services and the establishment of a positive corporate image [26]. Therefore, when evaluating new customers in this study, this study refers to scholars' widely accepted technology acceptance model [27], which was proposed to explain and predict the degree of acceptance of information systems and information technologies by consumers. Among all, perceived ease of use and perceived usefulness are two main determining factors of users' acceptance of using new technologies and service-oriented enterprises when designing new client interfaces must fully integrate the usability and usefulness of the system to enhance the user experience and improve the degree of satisfaction. In addition, the new client interface emphasizes the importance of customers acting as 'co-producers' in innovation, as customer involvement as a factor of production is a significant source of improving efficiency in service processes [28], and emerging information technologies could accelerate the process. Based on that, in the context of new client interface, the indicators of 'corporate image', 'ease of use', 'usefulness', and 'customer engagement' are proposed.

### *2.3. New Service Delivery System*

The new service delivery system is closely linked with the new client interface. The new client interface emphasizes the way employees communicate with customers while the new service delivery system highlights the internal organization arrangement, that is how to ensure correct delivery of innovative services work through reasonable organization, coordination and management. On one hand, it involves how companies delegate powers to employees to enable them to finish their work and deliver innovative services; on the other hand, companies need to consider how to make room for innovation through designing new organizational structure and training employees.

Compared with the manufacturing industry, the service industry is more likely to be affected by employee efficiency, skills, and experiences [29]. The human and organizational factors are also crucial to the innovation in the service-oriented enterprises. Human factors include the education level of employees, creativity, risk-taking ability, and especially employee training, which was proved to have a positive impact on service-orientated enterprises' innovation activities [30–32]. Hence, the service delivery system of the service-oriented enterprises concludes the employee-related factors as 'employee readiness'. In addition, since most of the technological innovation programs introduced by service-oriented enterprises are tangible products and require supports from hardware devices, and staff training and hardware devices are inseparable from the enterprises' overall implementation capability and expected costs. For reference, Kelly and Storey [33] and Lee et al. [34] research on service criteria system introduced three criteria, including 'hardware equipment', 'expected cost', and 'ability to implement'.

### *2.4. Technology Selection*

Technology selection is an option in the four-dimensional model of service innovation, but for service-oriented enterprises, the selection process of technological innovation programs is largely inseparable from the technical dimension and enterprises should consider how to make better choices of technology that fit the current business process.

According to theory of technology-organization-environment (TOE) put forward on the basis of relevant comprehensive innovation theories, factors influencing the organization's adoption of technological innovation could be summarized as technical factors, organizational factors and environmental factors [35]. The technical factor mainly refers to the use of internal and external information technology by enterprises and potentially adoptable technology, which contains some special features of technology, such as complexity and compatibility; this requires service-oriented enterprises when selecting technology, must take into account the degree of difficulty for a business in developing or acquiring the key technologies needed for innovation and the compatibility of the technology itself to the business processes, cultures, and values. In addition, Lee et al. also introduced the technical dimension to evaluate the concept of new services while emphasizing its dependence on technology, which in other words is its reliance on key technologies and service innovation [26]. Based on that, this paper selects three indicators of 'dependence', 'complexity', and 'compatibility', which eventually form the evaluation criteria system on selection of technological innovation programs for service-oriented enterprises in this research. The detailed description of each criteria is shown in Table 1.

**Table 1.** Service-oriented technology innovation program selection evaluation criteria.

| Dimension | Criteria | Criteria Description | References |
| --- | --- | --- | --- |
| New service concept ($D_1$) | Corporate strategy ($C_1$) | Degree of service innovation in consistent with corporate innovation or sustainability strategy. | [21] |
| | Consumer needs ($C_2$) | Degree of consumers' needs for service innovation. | [22] |
| | Competitive pressures ($C_3$) | Pressures on firms driven by external competition to choose service innovation. | [23,24] |
| | Government support ($C_4$) | The extent to which service innovation is supported by government laws and regulations. | [25] |
| New client interface ($D_2$) | Corporate image ($C_5$) | Positive Impact of new client interface in service innovation on corporate image. | [26] |
| | Ease of use ($C_6$) | Perceived ease of use of new client interfaces in service innovation. | [27] |
| | Usefulness ($C_7$) | The perceived usefulness of new client interface on service innovation. | [27] |
| | Customer engagement ($C_8$) | Degree of interaction of customer engagement and service innovation in new client interface | [28] |
| New service delivery system ($D_3$) | Staff preparation ($C_9$) | Staff preparation on skills and experience for service innovation. | [30,31] |
| | Implementation capability ($C_{10}$) | The ability of enterprises to implement service innovation. | [33,34] |
| | Expected cost ($C_{11}$) | Expected cost and maintenance expenses for enterprise service innovation. | [33,34] |
| | Hardware facilities ($C_{12}$) | The availability of hardware facilities for enterprise service innovation. | [33,34] |
| Technology selection ($D_4$) | Technology dependence ($C_{13}$) | Degree of dependency on technology for enterprise service innovation. | [26] |
| | Technical complexity ($C_{14}$) | Difficulties in acquiring key technology needed for Service Innovation. | [26] |
| | Technology compatibility ($C_{15}$) | Compatibility of technology selection for Service Innovations with business process, culture and values. | [26] |

## 3. Hybrid Multi-Criteria Decision Model

The analysis process of the hybrid multi-criteria decision model based on the DANP-mVIKOR method is as follows: after determining the evaluation criteria, the original data obtained from the DEMATEL survey is analyzed, and the comprehensive matrix $T$ based on each dimension and criteria is obtained. Based on that, the influencing network diagram could be drawn and the unweighted supermatrix $W$, the weighted supermatrix $W^{\alpha}$, and limit supermatrix $W^{*}$ could be calculated based on comprehensive matrix $T$ using the ANP method. The weight of each evaluation criteria could be obtained and VIKOR method could be employed to choose a preferred plan [11].

### *3.1. DANP Method*

The DANP method consists of DEMATEL and ANP, with the DEMATEL method being used to understand the causal relationship of complex things through the hierarchical structure [36]. As a general form of AHP, the ANP method could effectively tackle the problem of interdependence and feedback between dimensional indicators. To apply the ANP method, an initial direct influence matrix A is constructed first with the help from industrial experts or university scholars. The DEMATEL survey scored by experts or scholars in a particular field can be translated directly into an initial direct influence matrix, and surveyors could use 0 (no impact), 1 (low impact), 2 (medium impact), 3 (high impact), and 4 (Very high impact) to score on the paired comparison of dimensional indicators. Then, A standardized direct influence matrix D and a comprehensive influential matrix T are calculated in the next step. An unweighted supermatrix $W$ is later created to obtain weighted supermatrix $W^{\alpha}$. The multiples matrix is multiplied by itself until the results converge and remain stable, and then get the weight of each evaluation criteria.

### *3.2. mVIKOR Method*

The VIKOR approach was proposed using the concept of compromise to resolve the multi-program ordering of mutually competing issues among evaluation criteria [37]. The method ranks the degree of proximity of each solution to the ideal solution. The closer a solution is to the ideal solution, the better the solution. On the contrary, the closer to the negative solution, the worse the solution is. In order to avoid the situation where the scores of a certain criterion are not ideal among all the alternatives, Hu et. al. [9] improved the mVIKOR method by introducing a wider range from 0 (representing the worst) to 10 (representing the best) in the questionnaire. The modified mVIKOR method can be used to solve real life business problems. This method first needs to confirm the positive ideal solution and negative ideal solution. In the following step, the average of group utility $S_k$ and the biggest regret $Q_k$ are calculated. The comprehensive ranking $R_k$ is obtained through formulas. Lastly, the improvement methods for each alternative is proposed according to the rankings of $S_k$, $Q_k$, and $R_k$ provided by the evaluation object.

The specific formulas of the DANP-mVIKOR method could be found in the literature [11,12].

## 4. Case Analysis

Tourism is a typical representative of the service industry and this study decided to choose tourism enterprises to introduce the selection process of its technological innovation programs in detail. Tourism enterprises A, in response to the China National Tourism Administration's propose of construction of smart tourist attractions, launched the "smart scenic" construction projects combined with the "Internet +" era of the latest technology. Currently, there are three sets of service innovation options to choose from, they are: (1) Smart wristband, a wearable device with built-in Bluetooth and RFID chip [38], that has the functions of scenic spot tickets, hotel room keys, points accumulation and online payments; (2) Scenic Smart Application, which provide visitors with supports including scenic navigation, tour guide, shopping guide and other guidance information; and (3) Beacons technology, which aims to display relevant information on the tourist's equipment at the right time and the right place, and is applicable to the queue management of the theme parks [39]. Next, this study will select from the three sets of technological innovations using the DANP-mVIKOR method.

### *4.1. Data Collection*

The data collection of this study is divided into two parts. The first part is to invite 13 experts and scholars in the field of tourism to fill in the DEMATEL survey, of which, 6 are tourism scholars and 7 are medium and top-level tourism enterprises managers who have many years of experience in the travel industry. As the DEMATEL survey is sampled by experts and scholars, the focus of the method is not on the sample size distribution, but on the consistency of the opinions by the experts and scholars [40]. Therefore, we need to measure the degree of inconsistency of the surveys. It could be seen from notes in Table 2 that the inconsistency rate of 13 experts and scholars is 2.30%, which is less than 5% (reliability is 97.70%, which is higher than 95%). It indicates that the survey has a significant reliability.

**Table 2.** Initial direct influence matrix A.

| | $C_1$ | $C_2$ | $C_3$ | $C_4$ | $C_5$ | $C_6$ | $C_7$ | $C_8$ | $C_9$ | $C_{10}$ | $C_{11}$ | $C_{12}$ | $C_{13}$ | $C_{14}$ | $C_{15}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $C_1$ | 0.000 | 2.833 | 3.500 | 2.667 | 4.000 | 2.000 | 2.667 | 3.000 | 3.333 | 3.500 | 3.167 | 3.833 | 2.333 | 2.333 | 3.083 |
| $C_2$ | 3.833 | 0.000 | 3.500 | 2.667 | 2.833 | 3.500 | 3.833 | 3.667 | 2.667 | 3.000 | 3.000 | 2.833 | 2.500 | 2.333 | 2.917 |
| $C_3$ | 3.667 | 2.500 | 0.000 | 2.333 | 3.667 | 2.833 | 3.000 | 1.833 | 2.833 | 3.000 | 2.167 | 3.167 | 2.333 | 2.333 | 2.667 |
| $C_4$ | 3.833 | 3.333 | 3.167 | 0.000 | 2.833 | 1.833 | 1.667 | 1.500 | 2.167 | 2.500 | 2.833 | 3.500 | 2.167 | 2.167 | 3.167 |
| $C_5$ | 3.667 | 3.000 | 3.167 | 3.333 | 0.000 | 2.167 | 1.833 | 3.167 | 2.500 | 2.500 | 2.500 | 2.333 | 1.833 | 1.667 | 1.833 |
| $C_6$ | 2.083 | 3.500 | 3.167 | 1.667 | 3.167 | 0.000 | 3.750 | 3.833 | 3.833 | 2.833 | 3.667 | 2.333 | 3.667 | 3.833 | 3.000 |
| $C_7$ | 2.667 | 3.833 | 3.333 | 2.000 | 3.500 | 3.667 | 0.000 | 3.667 | 3.500 | 3.000 | 3.167 | 2.500 | 3.667 | 3.167 | 3.833 |
| $C_8$ | 2.500 | 3.667 | 3.333 | 1.333 | 3.167 | 3.167 | 3.000 | 0.000 | 2.333 | 2.333 | 2.167 | 1.833 | 2.000 | 2.000 | 2.167 |
| $C_9$ | 3.833 | 2.667 | 3.500 | 2.167 | 3.833 | 3.833 | 3.167 | 2.333 | 0.000 | 3.333 | 3.500 | 3.667 | 3.167 | 3.333 | 3.500 |
| $C_{10}$ | 2.833 | 2.667 | 3.167 | 1.833 | 3.333 | 2.333 | 2.500 | 2.667 | 3.500 | 0.000 | 2.167 | 2.000 | 1.667 | 1.667 | 3.167 |
| $C_{11}$ | 3.500 | 2.500 | 3.333 | 1.667 | 3.667 | 3.500 | 3.167 | 2.500 | 3.833 | 2.833 | 0.000 | 3.667 | 3.167 | 3.500 | 3.667 |
| $C_{12}$ | 3.333 | 2.167 | 3.500 | 1.833 | 2.167 | 3.167 | 3.000 | 2.000 | 3.667 | 3.333 | 3.667 | 0.000 | 2.667 | 3.167 | 2.833 |
| $C_{13}$ | 3.167 | 2.000 | 3.000 | 2.000 | 2.333 | 3.667 | 3.167 | 2.333 | 3.833 | 3.000 | 3.500 | 3.500 | 0.000 | 3.833 | 3.833 |
| $C_{14}$ | 2.833 | 1.833 | 3.000 | 1.833 | 2.167 | 3.833 | 2.833 | 2.833 | 3.833 | 3.667 | 3.583 | 4.000 | 3.833 | 0.000 | 4.000 |
| $C_{15}$ | 3.167 | 2.167 | 3.000 | 1.500 | 2.333 | 2.500 | 2.833 | 2.167 | 2.833 | 3.667 | 3.167 | 3.667 | 3.667 | 3.833 | 0.000 |

Note: Inconsistency rate = $\frac{1}{n(n-1)} \sum_{i=1}^{n} \sum_{j=1}^{n} \frac{\left| a_{ij}^{s} - a_{ij}^{s-1} \right|}{a_{ij}^{s}} \times 100\% = 2.30\% < 5\%$, consistency rate = $1 - 2.30\% = 97.70\%$, where $s = 13$ denotes the number of experts, $a_{ij}^{s}$ denotes the average influence of criterion $i$ on criterion $j$; $n$ denotes number of criterion.

The second part of the data collection was conducted in March 2017 by inviting 25 experts and scholars who are familiar with tourism enterprises A (15 of whom are senior managers of the scenic area and 10 are university scholars in the tourism field) to score. The survey used 11 scales, varying from 0 (very poor) to 10 (very good) to suggest a scoring condition of an indicator. There are 22 effective surveys, excluding 3 incomplete surveys.

### *4.2. Build the Relationship between the Network Diagram Based on DEMATEL Method*

The purpose of the DEMATEL method is to analyze the interrelationship among 15 indicators of technological innovation programs in tourism enterprises. Firstly, it is to calculate the mean value to get the 15 × 15 initial direct influence matrix A (see Table 2) based on the surveyed data of 13 experts and scholars, then use the equation to obtain a standardized direct influence matrix T; thirdly, calculate the indicators and dimensions of the comprehensive influential matrix $T_C$ and $T_D$ (see Tables 3 and 4); finally, sum each row and column of the comprehensive influential matrix (see Table 5) and draw the impact network diagram of each dimension and criterion (see Figure 1).

**Table 3.** The comprehensive influential matrix $T_C$ of criterion.

| | $C_1$ | $C_2$ | $C_3$ | $C_4$ | $C_5$ | $C_6$ | $C_7$ | $C_8$ | $C_9$ | $C_{10}$ | $C_{11}$ | $C_{12}$ | $C_{13}$ | $C_{14}$ | $C_{15}$ | ***r*** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $C_1$ | 0.574 | 0.553 | 0.654 | 0.434 | 0.635 | 0.581 | 0.576 | 0.546 | 0.641 | 0.618 | 0.605 | 0.625 | 0.547 | 0.553 | 0.619 | 8.761 |
| $C_2$ | 0.664 | 0.509 | 0.669 | 0.443 | 0.627 | 0.624 | 0.613 | 0.573 | 0.643 | 0.622 | 0.616 | 0.620 | 0.564 | 0.567 | 0.631 | 8.982 |
| $C_3$ | 0.600 | 0.507 | 0.535 | 0.397 | 0.583 | 0.553 | 0.540 | 0.485 | 0.585 | 0.564 | 0.543 | 0.568 | 0.507 | 0.513 | 0.566 | 8.045 |
| $C_4$ | 0.582 | 0.502 | 0.577 | 0.333 | 0.545 | 0.512 | 0.494 | 0.458 | 0.549 | 0.533 | 0.534 | 0.555 | 0.484 | 0.490 | 0.554 | 7.704 |
| $C_5$ | 0.560 | 0.482 | 0.559 | 0.389 | 0.470 | 0.501 | 0.480 | 0.476 | 0.536 | 0.515 | 0.510 | 0.513 | 0.460 | 0.462 | 0.510 | 7.423 |
| $C_6$ | 0.651 | 0.597 | 0.683 | 0.436 | 0.652 | 0.574 | 0.631 | 0.594 | 0.686 | 0.639 | 0.649 | 0.630 | 0.605 | 0.615 | 0.653 | 9.296 |
| $C_7$ | 0.675 | 0.614 | 0.699 | 0.451 | 0.670 | 0.659 | 0.566 | 0.601 | 0.692 | 0.654 | 0.651 | 0.645 | 0.616 | 0.613 | 0.681 | 9.496 |
| $C_8$ | 0.535 | 0.494 | 0.560 | 0.349 | 0.533 | 0.520 | 0.503 | 0.412 | 0.532 | 0.510 | 0.502 | 0.501 | 0.464 | 0.469 | 0.515 | 7.398 |
| $C_9$ | 0.702 | 0.595 | 0.706 | 0.458 | 0.681 | 0.666 | 0.634 | 0.579 | 0.626 | 0.665 | 0.662 | 0.673 | 0.610 | 0.620 | 0.679 | 9.555 |
| $C_{10}$ | 0.547 | 0.477 | 0.561 | 0.361 | 0.541 | 0.507 | 0.496 | 0.469 | 0.559 | 0.466 | 0.506 | 0.509 | 0.460 | 0.466 | 0.538 | 7.464 |
| $C_{11}$ | 0.680 | 0.578 | 0.688 | 0.438 | 0.663 | 0.645 | 0.620 | 0.569 | 0.688 | 0.641 | 0.577 | 0.658 | 0.597 | 0.610 | 0.667 | 9.320 |
| $C_{12}$ | 0.627 | 0.528 | 0.640 | 0.407 | 0.587 | 0.592 | 0.572 | 0.516 | 0.636 | 0.603 | 0.603 | 0.536 | 0.544 | 0.560 | 0.603 | 8.553 |
| $C_{13}$ | 0.659 | 0.555 | 0.666 | 0.433 | 0.623 | 0.635 | 0.607 | 0.553 | 0.674 | 0.630 | 0.634 | 0.641 | 0.520 | 0.605 | 0.657 | 9.095 |
| $C_{14}$ | 0.662 | 0.561 | 0.676 | 0.436 | 0.629 | 0.648 | 0.610 | 0.570 | 0.684 | 0.652 | 0.645 | 0.660 | 0.606 | 0.536 | 0.670 | 9.246 |
| $C_{15}$ | 0.622 | 0.526 | 0.629 | 0.400 | 0.587 | 0.578 | 0.567 | 0.518 | 0.618 | 0.608 | 0.593 | 0.609 | 0.561 | 0.571 | 0.544 | 8.530 |
| ***c*** | 9.339 | 8.078 | 9.502 | 6.165 | 9.026 | 8.795 | 8.509 | 7.919 | 9.351 | 8.920 | 8.831 | 8.943 | 8.144 | 8.251 | 9.087 | - |

**Table 4.** The comprehensive influential matrix $T_D$ of dimensions.

| | $D_1$ | $D_2$ | $D_3$ | $D_4$ | $r$ |
|---|---|---|---|---|---|
| $D_1$ | 1.087 | 1.630 | 1.645 | 1.196 | 5.558 |
| $D_2$ | 1.228 | 1.254 | 1.541 | 1.156 | 5.180 |
| $D_3$ | 1.000 | 1.197 | 1.041 | 0.929 | 4.167 |
| $D_4$ | 1.216 | 1.553 | 1.576 | 0.977 | 5.321 |
| $c$ | 4.530 | 5.634 | 5.803 | 4.258 | - |

**Table 5.** Sum each row and column of the comprehensive influential matrix.

| **Dimension/Criteria** | $r$ | $c$ | $r+c$ | $r-c$ |
|---|---|---|---|---|
| New service concept ($D_1$) | 5.558 | 4.530 | 10.088 | 1.027 |
| Corporate strategy ($C_1$) | 8.761 | 9.339 | 18.100 | −0.578 |
| Consumer needs ($C_2$) | 8.982 | 8.078 | 17.060 | 0.904 |
| Competitive pressures ($C_3$) | 8.045 | 9.502 | 17.547 | −1.456 |
| Government support ($C_4$) | 7.704 | 6.165 | 13.869 | 1.540 |
| New client interface ($D_2$) | 5.180 | 5.634 | 10.813 | −0.454 |
| Corporate image ($C_5$) | 7.423 | 9.026 | 16.449 | −1.603 |
| Ease of use ($C_6$) | 9.296 | 8.795 | 18.091 | 0.501 |
| Usefulness ($C_7$) | 9.486 | 8.509 | 17.995 | 0.978 |
| Customer engagement ($C_8$) | 7.398 | 7.919 | 15.317 | −0.521 |
| New service delivery system ($D_3$) | 4.167 | 5.803 | 9.969 | −1.636 |
| Staff preparation ($C_9$) | 9.555 | 9.351 | 18.906 | 0.204 |
| Implementation capability ($C_{10}$) | 7.464 | 8.920 | 16.384 | −1.456 |
| Expected cost ($C_{11}$) | 9.320 | 8.831 | 18.150 | 0.489 |
| Hardware facilities ($C_{12}$) | 8.553 | 8.943 | 17.496 | −0.390 |
| Technology selection ($D_4$) | 5.321 | 4.258 | 9.578 | 1.063 |
| Technology dependence ($C_{13}$) | 9.095 | 8.144 | 17.239 | 0.951 |
| Technical complexity ($C_{14}$) | 9.246 | 8.251 | 17.497 | 0.994 |
| Technology compatibility ($C_{15}$) | 8.530 | 9.087 | 17.618 | −0.557 |

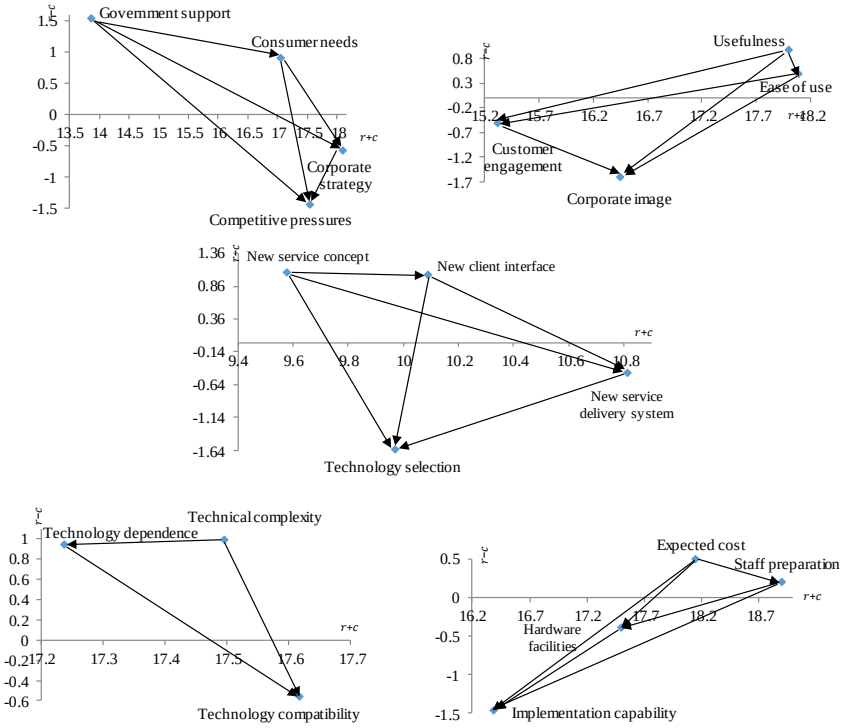


**Figure 1.** The impact network diagram of each dimension and criterion.

The impact network diagram that is drawn based on each dimension and criterion of the DEMATEL method helps us to understand the mutual influential relationship among the criterion of various dimensions in the technological innovation program of tourism enterprises. Figure 1 shows that the new service concept has the highest degree of cause, which could affect the new client interface, new service delivery system, and technology selection, and is judged as the key criteria. The new service delivery system has the highest degree of centrality and the strongest influential relationship and is judged as important indicators. Technology selection has the lowest degree of cause and is affected by the other three dimensions. The mutual relationships between these dimensions can help business managers to make better decisions, that is, in order to make the right choice of technology, managers should give priority to each program's new service concept, considering whether it matches the service innovation, then design and improve the new client interface, and build up the communication platform between business and users, and finally do a good job in the new service delivery system. As for subdivision indicators under the dimensions, Figure 1 shows that in the new service concept dimension, government support has the highest degree of cause, affecting the consumer demands, corporate strategy, and competitive pressures and is judged as a key indicator. Corporate strategy has the highest degree of centrality and the strongest total influential relationship and its competitive pressure is affected by the other three indicators. Therefore, to reduce the competitive pressures, priority can be given to improving the government support, followed by consumer demands and corporate strategy. In the new client interface dimension, usefulness has the highest degree, affecting ease of use, customer engagement, and corporate image. Ease of use has the highest degree of centrality. In order to improve the corporate image through the new client interface, the criterion can be improved through the following order: Usefulness, ease of use, and customer engagement. In the new service delivery system dimension, the expected cost has the highest degree of cause, affecting staff preparation, hardware facilities, and implementation capability. Employee preparation has the highest degree of centrality. In order to improve the implementation capability of new service delivery system, it is preferable to start with the expected cost, followed by staff preparation, and hardware facilities. In the technical selection dimension, technical complexity has the highest degree of cause, affecting the technical dependence and technical compatibility. Technical compatibility has the highest degree of cause and the strongest total influential relationship. In order to improve the technical compatibility of technical selection, priority should be given to improving technical complexity.

### *4.3. Calculation of Criteria Weights Based on ANP Method*

After obtaining the mutual influential relationship between each dimension and criteria using the DEMATEL method, we could use the ANP method to obtain the dimensions of service innovation programs for tourism companies and the weight of each criterion. Firstly, the comprehensive influence matrix $T_D$ and $T_C$ of dimension and criteria are standardized by equations and the resulting standardized matrix could be transposed to the unweighted supermatrix $W$. Next we use the unweighted supermatrix $W$ to multiply by the standardized dimensional comprehensive influence matrix to obtain the weighted supermatrix $W^{\alpha}$ (see Table 6). Finally, we use matrix $W^{\alpha}$ itself to do the power operation, until the results converge to a stable state. Table 7 shows the final result.

The results obtained by the DANP method are shown in Tables 7 and 8. In the selection of technological innovation programs, experts think that the new service delivery system is the most important, with a value of 0.283, and followed by the new client interface, new service concept, and technology. This is mainly due to the fact that when travelling, tourists are mostly closely exposed to front desk services, such as the attitudes of staff in the scenic spots and the related hardware devices. The new service concepts and technology selection are nevertheless hidden in the back desk of enterprises. For tourism innovation activities, technological innovation, and development process is important, but what is more important is to transfer the innovation products to the tourists. In the new service concept dimension, experts believe that the competitive pressure is the most important indicator,

followed by corporate strategy, consumer demands, and government support. This is largely due to the uniqueness of tourism resources owned by tourism enterprises and where tourist visits are taken for granted by the enterprises, who thus lack the motivation and needs to initiate the innovation. As there is an increasing number of tourist attractions, especially when companies face fierce competition in the theme park market, the external competitive pressure forces tourism enterprises to develop new service concept for service innovation. In the new client interface dimension, corporate image is the most important indicator, followed by ease of use, usefulness, and customer engagement, respectively, as the ultimate goal of the new service delivery is to make it easier for customers to use and help them actively participate through a friendly new client interface, so as to establish a positive image for tourism enterprises. In the dimension of new service delivery system, the weight of each indicator has an order of: Staff preparation, hardware facilities, implementation capability, and expected cost. This is mainly because service industries are more easily affected by efficiency of the employees and their skills and experience, and the implementation capability and hardware facilities are also affected by the staff. We could only ensure timely and effective delivery of innovative services to tourists in the technology selection dimension only when the staff are fully prepared through the relevant training. In the technology selection dimension, technical compatibility has the highest weight, followed by technical complexity and technical dependency, respectively. This is because technical compatibility mainly emphasizes that the technological choices of service innovation need to match the business processes, cultures, and values of the enterprise. We could only ensure a successful implementation only when new technologies are fully absorbed and utilized.

**Table 6.** The weighted supermatrix $W^{\alpha}$.

| | $C_1$ | $C_2$ | $C_3$ | $C_4$ | $C_5$ | $C_6$ | $C_7$ | $C_8$ | $C_9$ | $C_{10}$ | $C_{11}$ | $C_{12}$ | $C_{13}$ | $C_{14}$ | $C_{15}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $C_1$ | 0.051 | 0.057 | 0.058 | 0.057 | 0.067 | 0.065 | 0.066 | 0.065 | 0.068 | 0.067 | 0.068 | 0.068 | 0.065 | 0.065 | 0.065 |
| $C_2$ | 0.049 | 0.044 | 0.049 | 0.049 | 0.057 | 0.060 | 0.060 | 0.060 | 0.058 | 0.059 | 0.058 | 0.058 | 0.055 | 0.055 | 0.055 |
| $C_3$ | 0.058 | 0.057 | 0.051 | 0.057 | 0.067 | 0.068 | 0.068 | 0.069 | 0.069 | 0.069 | 0.069 | 0.070 | 0.066 | 0.066 | 0.066 |
| $C_4$ | 0.038 | 0.038 | 0.038 | 0.033 | 0.046 | 0.044 | 0.044 | 0.043 | 0.045 | 0.045 | 0.044 | 0.044 | 0.043 | 0.043 | 0.042 |
| $C_5$ | 0.080 | 0.075 | 0.079 | 0.080 | 0.059 | 0.064 | 0.065 | 0.066 | 0.076 | 0.077 | 0.076 | 0.074 | 0.075 | 0.075 | 0.076 |
| $C_6$ | 0.073 | 0.075 | 0.075 | 0.075 | 0.063 | 0.057 | 0.064 | 0.064 | 0.075 | 0.072 | 0.074 | 0.075 | 0.077 | 0.077 | 0.075 |
| $C_7$ | 0.072 | 0.074 | 0.073 | 0.072 | 0.060 | 0.062 | 0.055 | 0.062 | 0.071 | 0.071 | 0.071 | 0.072 | 0.073 | 0.072 | 0.074 |
| $C_8$ | 0.069 | 0.069 | 0.066 | 0.067 | 0.060 | 0.059 | 0.058 | 0.051 | 0.065 | 0.067 | 0.065 | 0.065 | 0.067 | 0.068 | 0.067 |
| $C_9$ | 0.076 | 0.076 | 0.077 | 0.075 | 0.077 | 0.078 | 0.078 | 0.077 | 0.060 | 0.068 | 0.067 | 0.067 | 0.077 | 0.077 | 0.075 |
| $C_{10}$ | 0.073 | 0.074 | 0.074 | 0.073 | 0.074 | 0.073 | 0.074 | 0.074 | 0.063 | 0.057 | 0.062 | 0.063 | 0.072 | 0.073 | 0.074 |
| $C_{11}$ | 0.072 | 0.073 | 0.071 | 0.073 | 0.073 | 0.074 | 0.073 | 0.073 | 0.063 | 0.062 | 0.056 | 0.063 | 0.073 | 0.072 | 0.072 |
| $C_{12}$ | 0.074 | 0.073 | 0.074 | 0.076 | 0.074 | 0.072 | 0.073 | 0.073 | 0.064 | 0.062 | 0.064 | 0.056 | 0.074 | 0.074 | 0.074 |
| $C_{13}$ | 0.068 | 0.069 | 0.069 | 0.068 | 0.072 | 0.072 | 0.072 | 0.071 | 0.071 | 0.070 | 0.071 | 0.071 | 0.054 | 0.061 | 0.061 |
| $C_{14}$ | 0.069 | 0.069 | 0.070 | 0.069 | 0.072 | 0.073 | 0.072 | 0.072 | 0.072 | 0.071 | 0.073 | 0.073 | 0.062 | 0.054 | 0.063 |
| $C_{15}$ | 0.078 | 0.077 | 0.077 | 0.078 | 0.079 | 0.078 | 0.080 | 0.079 | 0.079 | 0.082 | 0.079 | 0.079 | 0.068 | 0.068 | 0.060 |

**Table 7.** The weight of each evaluation criteria.

| | $C_1$ | $C_2$ | $C_3$ | $C_4$ | $C_5$ | $C_6$ | $C_7$ | $C_8$ | $C_9$ | $C_{10}$ | $C_{11}$ | $C_{12}$ | $C_{13}$ | $C_{14}$ | $C_{15}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| weights | 0.051 | 0.057 | 0.058 | 0.057 | 0.067 | 0.065 | 0.066 | 0.065 | 0.068 | 0.067 | 0.068 | 0.068 | 0.065 | 0.065 | 0.065 |

**Table 8.** The performance evaluation of the case study using mVIKOR.

| Dimension/Criteria | Local Weight | Global Weight | Smart Wristband | | App | | Beacon | |
|---|---|---|---|---|---|---|---|---|
| | | | Performance | Gap | Performance | Gap | Performance | Gap |
| New service concept ($D_1$) | 0.227 | | 6.795 | 0.320 | 6.932 | 0.307 | 7.568 | 0.243 |
| Corporate strategy ($C_1$) | 0.282 | 0.064 | 6.864 | 0.314 | 6.727 | 0.327 | 7.591 | 0.241 |
| Consumer needs ($C_2$) | 0.244 | 0.055 | 8.000 | 0.200 | 7.682 | 0.232 | 7.545 | 0.245 |
| Competitive pressures ($C_3$) | 0.287 | 0.065 | 5.727 | 0.427 | 6.591 | 0.341 | 7.864 | 0.214 |
| Government support ($C_4$) | 0.187 | 0.042 | 6.591 | 0.341 | 6.727 | 0.327 | 7.273 | 0.273 |
| New client interface ($D_2$) | 0.277 | | 7.852 | 0.215 | 7.284 | 0.272 | 7.432 | 0.257 |
| Corporate image ($C_5$) | 0.263 | 0.073 | 8.000 | 0.200 | 7.273 | 0.273 | 7.455 | 0.255 |

**Table 8.** *Cont.*

| Dimension/Criteria | Local Weight | Global Weight | Smart Wristband | | App | | Beacon | |
|---|---|---|---|---|---|---|---|---|
| | | | Performance | Gap | Performance | Gap | Performance | Gap |
| Ease of use ($C_6$) | 0.257 | 0.071 | 7.409 | 0.259 | 7.727 | 0.227 | 7.864 | 0.214 |
| Usefulness ($C_7$) | 0.249 | 0.069 | 7.864 | 0.214 | 7.273 | 0.273 | 7.409 | 0.259 |
| Customer engagement ($C_8$) | 0.231 | 0.064 | 8.136 | 0.186 | 6.864 | 0.314 | 7.000 | 0.300 |
| New service delivery system ($D_3$) | 0.283 | | 5.352 | 0.465 | 6.989 | 0.301 | 7.591 | 0.241 |
| Staff preparation ($C_9$) | 0.260 | 0.074 | 5.591 | 0.441 | 6.909 | 0.309 | 7.727 | 0.227 |
| Implementation capability ($C_{10}$) | 0.247 | 0.070 | 5.273 | 0.473 | 7.318 | 0.268 | 7.727 | 0.227 |
| Expected cost ($C_{11}$) | 0.245 | 0.069 | 5.136 | 0.486 | 6.727 | 0.327 | 7.318 | 0.268 |
| Hardware facilities ($C_{12}$) | 0.248 | 0.070 | 5.409 | 0.459 | 7.000 | 0.300 | 7.591 | 0.241 |
| Technology selection ($D_4$) | 0.213 | | 6.561 | 0.344 | 7.273 | 0.273 | 7.576 | 0.242 |
| Technology dependence ($C_{13}$) | 0.320 | 0.068 | 5.864 | 0.414 | 7.545 | 0.245 | 7.727 | 0.227 |
| Technical complexity ($C_{14}$) | 0.324 | 0.069 | 5.818 | 0.418 | 7.545 | 0.245 | 8.000 | 0.200 |
| Technology compatibility ($C_{15}$) | 0.356 | 0.076 | 8.000 | 0.200 | 6.727 | 0.327 | 7.000 | 0.300 |
| *S* | | | 0.336 | | 0.288 | | 0.245 | |
| *Q* | | | 0.486 | | 0.341 | | 0.300 | |
| *R* | | | 0.411(3) | | 0.315(2) | | 0.273(1) | |

### *4.4. mVIKOR-Based Program Ranking*

After obtaining the weight of the influencing factors of the technological innovation program using the DANP method, the mVIKOR method is used to rank the technological innovation programs of the tourism enterprises. The final result is shown in Table 8, which shows: Beacons Technology > Scenic Smart App > Smart Wristband, which indicates that experts and scholars believe that the Solution Three Beacons technology is the best option, with *R* equal to 0.273 ($v$ = 0.5). Smart Application for scenic spots in Solution Two and Wrist strap in Solution One rank in the following. The VIKOR method can also find out the gap between the specific indicators and the ideal status for each program. From Table 8, in the Beacons technology solution, technical complexity is the closest to the ideal state, which means the key technologies of Beacons technology for tourism enterprises are relatively easy. With the solution, customer engagement and technical compatibility shall be considered to improve. In the scenic smart application solution, the ease of use is closest to the ideal state, while the competitive pressure is the furthest from the ideal. In the solution of wristband, customer engagement is the closest to the ideal state, and the expected cost is the farthest to the ideal state, which is in need of prioritized improvement.

## 5. Conclusions

Based on the four-dimensional model of service innovation, this paper constructs the evaluation criteria system of service innovation selection for service-orientated enterprises. Firstly, it uses DEMATEL to find out the mutual influential relationship between each dimension criteria and draw the diagram of influence network. Then, it uses ANP method to calculate the weight of each criterion. Finally, it combined with the mVIKOR method and chose from three options of technological innovation in tourism enterprises. Conclusions are stated in the following.

(1) From the results of DANP, we can see that in the service innovation four-dimensional model, the weights of each dimension have an order of: New service delivery system, new client interface, new service concept, and technology choice. The new service concept has the highest degree of cause, new service delivery system has the highest degree of centrality and technical selection has the lowest degree of cause. Among all the evaluation indicators, technology compatibility has the highest weight, followed by staff preparation and corporate image. Government support has the lowest weight. This indicates that service enterprises, when selecting technological innovation program, need to prioritize technology, people and corporate image in order to secure a successful implementation of the technological innovation program.

(2) According to the results of the mVIKOR method, experts think that developing Beacons Technology is currently the best technological innovation scheme.

There are some research drawbacks in this paper. Firstly, there were limited numbers of expert samples collected in the data collection process, which to some extent could affect the accuracy of scoring on the programmes. Sample size could be increased in future studies to ensure the stability and accuracy of the research results. Secondly, the evaluation criteria system of technological innovation scheme selection is based on literature opinions and expert interviews. Future studies could try to adopt quantitative research methods, such as reliability tests or longitudinal studies, to further enhance the overall reliability of the evaluation indicator system. Lastly, this research case study takes the tourism enterprises as an example. Future studies could further extend the research by analyzing other industries or enterprises, in order to enhance the external validity and universal applicability of the research results.

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