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Research Article

Evaluation of Breakthrough Technological Innovation Capability of Petroleum Equipment Manufacturing Enterprises Based on the CFPR-TIFNs Model

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"Internet + innovation" is a new emerging paradigm for breakthrough technological innovation, which is more complex than traditional scenarios because "Internet +" has completely overturned the acquisition of creativity and knowledge. This article aims to evaluate the breakthrough technological innovation capability (BTIC) of petroleum equipment manufacturing enterprises under the new paradigm of "Internet + innovation." This article constructs an index system that can reflect the characteristics of "breakthrough" and "Internet +" in five dimensions. Due to the difficulties of conducting quantitative measurements for the novel index system, a hybrid evaluation model based on a consistent fuzzy preference relationship (CFPR) and triangular intuitionistic fuzzy numbers (TIFNs) is put forward for the evaluation of BTIC. The main contribution of this article is to propose an index system and model for the evaluation of BTIC under the "Internet + innovation" paradigm, which is conducive to improving the quality of breakthrough technological innovation activities under more complex scenarios. The CFPR-TIFNs model can not only effectively calculate the BTIC of petroleum equipment manufacturing enterprises but also deeply analyze the influencing factors for their relatively weak technological innovation capability. This article provides a new methodology to solve problems in a more complex technological innovation system.

1. Introduction

Petroleum is a kind of nonrenewable fossil energy that is the driving source for the efficient operation of modern society and the raw material for the development of various industries. Petroleum accounts for a high proportion of the world's energy consumption mix. It is currently the main energy resource that countries all over the world compete for and the lifeblood of national economic development in many countries. The advancement and innovativeness of petroleum equipment are two of the important factors affecting the efficiency and output of petroleum development [1]. Petroleum equipment manufacturing enterprises are the creators of machinery and equipment for petroleum exploration and development; their innovation capability directly determines the value creation capability of their production equipment. For a long time, the overall level of Chinese petroleum equipment manufacturing enterprises has lagged behind the developed countries with problems such as lack of concentration of R&D funds, weak innovation capability, low conversion rates of scientific and technological achievements, poor information liquidity, and so on [2]. The continuous low oil price urgently requires Chinese petroleum equipment manufacturing enterprises to carry out the research, development, and application of new technologies to significantly reduce the cost. With the increase of the proved reserves of unconventional petroleum resources, Chinese petroleum equipment manufacturing enterprises have been engaged in the research and development of new petroleum equipment in line with the characteristics of Chinese unconventional oil reserves and geological conditions on the basis of conventional equipment manufacturing [3]. It can be seen that breakthrough technological innovation is a booster for the survival and development of petroleum equipment manufacturing enterprises in China.

At the same time, it is no longer suitable to only rely on Chinese petroleum equipment manufacturing enterprises for breakthrough technological innovation in order to meet the rapid changes in market demands [4], with the continuous shortening of the life cycle of petroleum equipment products. It is necessary to search for resources and talents for innovation in the world by breaking through space-time and geographical restrictions and to realize the deep integration of enterprises and the petroleum equipment manufacturing industry, depending on Internet information technology. The "Internet + innovation" paradigm, through the analysis and integration of big data on the Internet, can accelerate the pace of breakthrough technological innovation and enhance the core competitiveness of Chinese petroleum equipment manufacturing enterprises.

As we all know, the technological complexity composed of dynamic feedback, nonlinearity and unpredictability, self-organization, adaptability, and network characteristics, together with the characteristics of "breakthrough" and "Internet +," will inevitably bring complex challenges to breakthrough technological innovation. The complex challenges contain the nonlinear interaction among elements of innovation, the cooperation among innovation systems, the dynamic feedback of the innovation process, and the social network cooperation among innovation subjects. Therefore, the complex theory applies to explain breakthrough technological innovations and evaluate BTIC. At the same time, the complex characteristics determine that some indicators are difficult to measure quantitatively. Therefore, a new method and model should be established to evaluate BTIC.

How to objectively evaluate the BTIC of petroleum equipment manufacturing enterprises under the "Internet + innovation" paradigm can provide a good basis for petroleum equipment manufacturing enterprises to accurately grasp the current situation and potential of breakthrough technological innovation. Meanwhile, the petroleum equipment manufacturing enterprises can tap their own further innovation advantages and take measures to make up for their disadvantages. Therefore, this article intends to establish an evaluation index system and a model of BTIC based on consistent fuzzy preference relations (CFPR) and triangular intuitionistic fuzzy numbers (TIFNs), which are suitable for the characteristics of petroleum equipment manufacturing enterprises under the "Internet + innovation" paradigm and will provide support for the further improvement of BTIC in Chinese petroleum equipment manufacturing enterprises.

2. Theoretical Background

2.1. Petroleum Equipment Manufacturing and "Internet + Innovation". With the development of society and the continuous improvement of economic levels, petroleum plays an increasingly important role in the world. The development and utilization of petroleum cannot be separated from petroleum equipment [1]. As a national strategic industry that provides petroleum drilling equipment, improving manufacturing technology is not only beneficial to the industry but also beneficial to the whole industrial chain through knowledge spillover and technology diffusion. With the increasing emphasis on innovation, the environment, and production efficiency [2], the energy industry urgently needs support from the petroleum equipment industry. Under the guidance of the policy of promoting Chinese manufacturing power, it has brought new development opportunities for the sustainable development of petroleum equipment manufacturing [3]. Therefore, China must attach great importance to the innovative development strategy of the petroleum equipment manufacturing industry. With decreasing global oil and gas surface resources and the underground structure complex [4], there is an urgent need for innovation and development, continuous technological innovation, and technological progress in the petroleum equipment industry, which is related to the sustainable development of the entire petroleum industry.

Using the Internet as a medium, search engines and big data provide petroleum equipment manufacturing enterprises with accurate information and the information analysis needed for breakthrough technology innovation [5]. In the industrial field, the new mode of "Internet + industry" has greatly promoted the rapid development of industry towards a more digital and intelligent industry 4.0. The development of new-generation information technologies, such as big data, cloud computing, and the Internet of things, has triggered a new round of scientific and industrial revolutions around the world. This provides new ideas for the development of the manufacturing industry and the petroleum equipment manufacturing industry [6–8].

Pan and Zhang have preliminary explored the path of transformation and upgrading of the petroleum equipment manufacturing industry in the context of the "Internet +" [9, 10]. Zhang et al. proposed that with the support of the "Internet +" technology, the transformation and upgrading of the petroleum manufacturing industry can be accelerated through breakthrough technological innovation [11]. Through the close combination of information technology and the Internet platform, the production flexibility of the petroleum equipment manufacturing industry can be improved. Liu and Yi believed that the oil equipment manufacturing industry should actively embrace the "Internet +" era and play the roles of the government, enterprises, and clusters [12].

In the era of "Internet +," the petroleum equipment manufacturing industry can realize innovation-driven and intelligent upgrading through deep integration with information network technology. By using intelligent machines and information data, we can realize the high automation of the production line of the petroleum equipment manufacturing industry and the seamless connection between various production factors. Therefore, it can improve the production efficiency of petroleum equipment enterprises. Using flexible production technology to realize mass customization production and meet the personalized needs of users. Using information and numerical control technology, we can develop intelligent products and numerical control equipment and improve the market competitiveness of new products from enterprises.

2.2. Consistent Fuzzy Preference Relations (CFPR) and Triangular Intuitionistic Fuzzy Numbers (TIFNs). This article makes use of CFPR to determine the weights of indicators for the evaluation of BTIC. CFPR was put forward by Herrera-Viedma et al. to avoid misleading solutions during the process of decision-making [13]. Then, many scholars extended the theory and application of CFPR. Lin et al. introduced CRPR into the evaluation of knowledge sharing and knowledge acquisition [14, 15]. CFPR is implied to determine the weights of indicators with qualitative method. CFPR can improve the efficiency and reliability of weight determination because it can reduce pairwise comparison times absolutely. With the rules of Herrera-Viedma et al., CFPR can also maintain high consistency during the calculation process. Wang and Chang presented a model based on CFPR for forecasting the probability of successful knowledge management and solved the difficulty that indicators could not be measured quantitatively [16]. Wang and Chen applied CFPR to select partnerships for virtual enterprises. By comparative analysis, they considered that CFPR is an easy and practical approach for ranking alternatives [17].

Chang and Wang gave a description of the possibility of measuring the success of implementing advanced manufacturing technology. They demonstrated that CFPR has some advantages in dealing with complicated hierarchical, multiattribute decision-making problems [18].

Triangular intuitionistic fuzzy numbers (TIFNs) were raised by Shu for fault-tree analysis based on intuitionistic fuzzy sets [19, 20]. Li improved the theory of triangle intuitionistic fuzzy numbers by correcting some errors in the four arithmetic operations and creating a new ranking method for the MADM problem [21]. Wan et al. emphasized that TIFNs are useful for fuzzy preference information. The crisp weighted possibility means the Hamming distance and Euclidean distance are defined. A new triangular intuitionistic fuzzy weighted average operator is presented for decision-making [22]. Xu et al. developed an approach to aggregating decision data into intuitionistic triangular fuzzy numbers for heterogeneous MAGDM problems, which upgrades the application of TIFNs [23]. Wu et al. applied TIFNs to collect qualitative index information to evaluate the low-speed wind power site selection [24]. Hamzeh et al. employed TIFNs to improve time performance indicators in the risk assessment of EDM projects [25].

3. Index System of BTIC of Petroleum Equipment Manufacturing Enterprises Under "Internet + Innovation" Paradigm

The essence of "Internet + innovation" is the innovation mode of "Internet 4.0 + innovation 4.0," which means that petroleum equipment manufacturing enterprises make full use of internal innovation resources to carry out breakthrough technological innovation That widely uses Internet technology and new media technology to obtain new technology and knowledge needed for innovation in real time around the world. Different carriers of new technology and knowledge are added to the enterprise's breakthrough technological innovation in the form of virtual R&D team members, so as to achieve the enterprise's breakthrough technological innovation goals quickly.

3.1. Construction of Index System. At present, there is little academic research on BTICs of petroleum equipment manufacturing enterprises. The BTIC under the "Internet + innovation" paradigm refers to the comprehensive capability of petroleum equipment manufacturing enterprises to create new products and processes in a new sense for users and continuously commercialize them by analyzing the needs of potential users or the development trend of new technologies in the future. It mainly uses Internet technology to obtain creative knowledge from inside and outside and breaks away from the original technological track.

To build a scientific and reasonable evaluation index system for the BTIC of petroleum equipment manufacturing enterprises, this article mainly constructs and screens the evaluation index system for the BTIC of petroleum equipment manufacturing enterprises under the "Internet + innovation" paradigm from the following three aspects:

(1) Consulting the relevant literature on BTIC. For example, O'Connor et al. proposed that breakthrough innovation capabilities include discovery capability, incubation capability, and acceleration capability [26]. Peng et al. believed that the enterprise's breakthrough innovation capability includes six dimensions: breakthrough innovation tendency, breakthrough innovation resource investment capability, breakthrough innovation management capability, breakthrough product and process R&D capability, breakthrough product manufacturing capability, and breakthrough product marketing capability [27]. Wang proposed that breakthrough innovation capabilities include discovery capabilities, evaluation and screening capabilities, incubation capabilities, acceleration capabilities, and commercialization capabilities [28]. Zhu believed that breakthrough innovation capability can be measured in seven dimensions: decision-making, investment, R&D, management, production, marketing, and risk control [29]. Yang proposed that the BTIC mainly includes management, investment, R&D, marketing, and production [30]. Luo et al. believed that the BTIC of new small start-up technological enterprises includes the following six capabilities: fuzzy front-end creativity generation, research and development, pilot production, commercialization, and promotion of new technology standards [31, 32].

(2) Excavating the characteristics of breakthrough technological innovations in petroleum equipment manufacturing enterprises under the "Internet + innovation" paradigm. This article holds that the breakthrough technological innovations of petroleum equipment manufacturing enterprises based on the Internet the dual characteristics of "breakthrough" and "Internet +." The "breakthrough" feature indicates the novelty of creative ideas and the advancement of the functions of new technologies or products. The "Internet +" is mainly reflected in the networking, informatization, and platformization of the innovation process.

(3) Surveying some petroleum equipment enterprises. Taking advantage of the geographical advantages, the authors visited the Daqing oilfield equipment manufacturing group and its subordinate companies through communication with senior managers, middle managers, and grass-roots technical personnel. Therefore, the authors obtained the views of staff on the breakthrough technological innovation of petroleum equipment manufacturing enterprises under the "Internet + innovation" paradigm, which provided support for the construction of an evaluation index system for BTIC.

By sorting the abovementioned literature and the mining characteristics of breakthrough technological innovation of petroleum equipment manufacturing enterprises, the process model of breakthrough technological innovation is constructed, as shown in Figure 1. According to the stage division of the breakthrough technological innovation process of oil equipment manufacturing enterprises under the "Internet + innovation" paradigm, this article believes that BTIC includes five dimensions. They include the creative discovery capabilities of breakthrough new technologies, the creative screening capabilities of breakthrough new technologies, the research and development capabilities of breakthrough new technologies, the commercialization capabilities of breakthrough new technologies, and the ability to support breakthrough new technologies. The process of breakthrough technological innovation in Figure 1 shows that the five stages interact, and the combination of "Internet +" technology and organizational coordination is a necessary condition for the breakthrough technological innovation of petroleum equipment manufacturing enterprises.

According to the abovementioned five dimensions, combined with the literature reviews and the characteristics of breakthrough technological innovation under the "Internet + innovation" paradigm, this article designs 5 primary indicators and 25 secondary indicators. It uses the five scales to design a questionnaire to conduct a sampling survey of petroleum equipment manufacturing enterprises in China. The authors distributed 186 questionnaires through the Internet and interviews and recovered 171 questionnaires, for a recovery rate of 91.94%. There were 165 valid questionnaires, with an effective rate of 96.49%. Based on the statistical analysis of the survey data, four secondary indicators with scores below 4.2 were removed, and 21 secondary indicators were finally identified, as shown in Table 1.

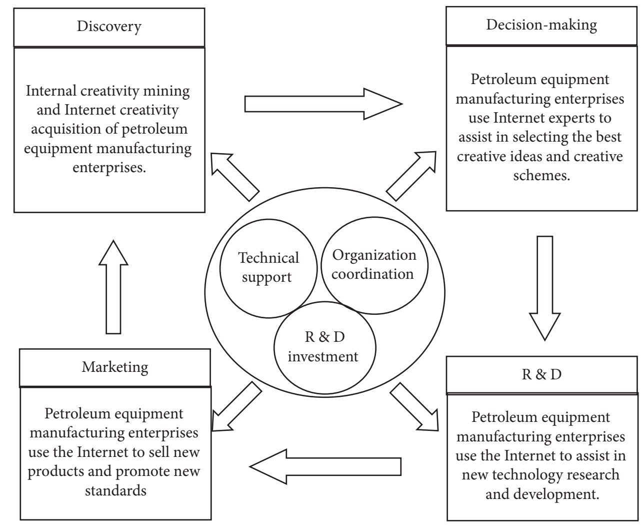

Figure 1: Breakthrough technology innovation process of petroleum equipment manufacturing enterprises.

3.2. Interpretation of Index System

(1) Creativity discovery capability. This indicator mainly reveals whether petroleum equipment manufacturing enterprises can fully tap Internet-related creative ideas on the basis of mining internal creative ideas accurately. The demand of some leading users on the Internet and the judgment on the potential development trend of technology can provide reference and support for the breakthrough technological innovation of petroleum equipment manufacturing enterprises to a certain extent. Therefore, the breakthrough technological innovation of petroleum equipment manufacturing enterprises needs to tap the creative ideas of the Internet deeply. This indicator mainly includes 4 secondary indicators: the acquisition capability of an Internet creative idea, the mining capability of an internal creative idea, the refining capability of breakthrough technical ideas, and defining breakthrough new technology capabilities.

(2) Creativity screening capability. This indicator mainly reflects whether the petroleum equipment manufacturing enterprises can give full play to the best breakthrough technology innovation assisted by Internet experts. The implementation of the "Internet +" strategy can help petroleum equipment manufacturing enterprises search for top experts in the field around the world. These experts help enterprises make decisions on creative ideas to ensure that the creative ideas and schemes are very forward-looking. This indicator mainly includes 3 secondary indicators: the adaptability of the innovative

Table 1: Index system for BTIC of petroleum equipment manufacturing enterprises.

Order number	Primary index	Secondary index
1	Creativity discovery capability of breakthrough new technologies	1.1. Acquisition capability of Internet creative idea 1.2. Mining capability of internal creative idea 1.3. Refining capability of breakthrough technical ideas 1.4. Defining capability of breakthrough new technology
2	Creativity screening capability of breakthrough new technologies	2.1. Adaptability of innovative screening system for breakthrough new technologies 2.2. Internet experts' ability to express views in real time and accurately 2.3. Experts' ability to judge the future market expectation of new technologies
3	Research and development capability of breakthrough new technologies	3.1. Capability of Internet to acquire knowledge required for innovation 3.2. Capital investment capability for breakthrough new technology R&D 3.3 Internal investment capability of breakthrough new technology R&D personnel 3.4. Participating capability of remote personnel for breakthrough new technology R&D 3.5. Promoting capability of function leapfrog for breakthrough new technologies 3.6. Capability to obtain invention patents for breakthrough new technologies
4	Commercialization capability of breakthrough new technologies	4.1. Internet promotion of new technologies or products 4.2. Capability of new products to meet the needs of leading users 4.3. Market development capability of new Internet products 4.4. Development capability of potential users of new products 4.5. Real-time production and supply capability of new products
5	Support capability of breakthrough new technologies	5.1. Docking capability of open space platform based on Internet 5.2. Real-time information transmission capability based on Internet 5.3. Supporting capability of internet-based information technology

screening system for breakthrough new technologies; Internet experts' ability to express views in real time and accurately; and experts' ability to judge the future market expectations of new technologies.

(3) Research and development capabilities. This indicator mainly reflects whether the petroleum equipment manufacturing enterprises can give full play to the ability of Internet experts to assist in the research and development of breakthrough new technologies and whether they can transform creative ideas into new technologies/products or not. Research and development of breakthrough new technology is the key link in breakthrough technology innovation for petroleum equipment manufacturing enterprises. It is necessary to find relevant experts to solve innovation problems on Internet platforms to shorten the innovation time and reduce risks. This indicator mainly includes 6 secondary indicators: the capability of the Internet to acquire the knowledge required for innovation, the capital investment capability for R&D, the internal investment capability of R&D personnel, the participating capability of remote personnel for R&D, the promoting capability of function leapfrogging and the capability to obtain invention patents.

(4) Commercialization capability. This indicator mainly implies whether petroleum equipment manufacturing enterprises can effectively use the Internet to assist in the mass production of new technologies/products and gradually achieve commercialization. Bringing breakthrough new technologies/products to the market starts with meeting the needs of leading users. These can be promoted through their own publicity and spontaneous diffusion of leading users. Finally, the commercialization of new products can be realized. This indicator mainly includes 5 secondary indicators: Internet promotion of new technologies or products; the capability of new products to meet the needs of leading users; market development capability of new

Internet products; development capability of potential users of new products; and real-time production and supply capability of new products.

(5) Supporting capability. This indicator mainly reflects whether the petroleum equipment manufacturing enterprises can provide the necessary support for breakthrough technological innovation from a technical perspective. Under the "Internet + innovation" paradigm, petroleum equipment manufacturing enterprises need to use the Internet to obtain the scarce resources that are necessary for innovation, such as knowledge, talent, and equipment. These need the support of advanced information and communication technology, social media, and other technologies. This indicator mainly includes 3 secondary indicators: the docking capability of an open-space platform based on the Internet, the real-time information transmission capability based on the Internet, and the support capability of internet-based information technology.

3.3. Analyzing the Characteristics of Index System. Under the "Internet + innovation" paradigm, the breakthrough technological innovation of the petroleum equipment manufacturing enterprises has the characteristics of "breakthrough" and "Internet +." Therefore, the evaluation index system of breakthrough technological innovation capability of petroleum equipment manufacturing enterprises reflects the characteristics of "breakthrough" and "Internet +" well.

(1) Reflecting the characteristics of "breakthrough." Under the "Internet + innovation" paradigm, the index system of BTIC of the petroleum equipment manufacturing enterprises reflects the "breakthrough" feature. This feature is mainly expressed by four primary indicators and secondary indicators, namely, creativity discovery capability, creativity screening capability, research and development capability, and commercialization capability. For example, indicators such as refining the capability of breakthrough technological ideas, defining the capability of breakthrough new technology, promoting the function of leapfrogging capability, the capability of new products to meet the needs of leading users, and the market development capability of new Internet products better reflect the characteristics of "breakthrough".

(2) Reflecting the characteristics of "Internet +." Under the "Internet + innovation" paradigm, the evaluation index system of BTIC first indicates the characteristics of "Internet +." The characteristics mainly include the acquisition capability of Internet creative ideas, Internet experts' ability to express views in real time and accurately, the capability of the Internet to acquire the knowledge required for innovation, the participating capability of remote personnel for breakthrough new technology R&D, Internet promotion of new technologies or products, the docking capability of open space platforms based on the Internet, real-time information transmission capability based on the Internet, and the supporting capability of internet-based information technology.

4. Evaluation Model and Process

Under the "Internet + innovation" paradigm, it is difficult for petroleum equipment manufacturing enterprises to quantify the evaluation indicators of BTIC. This article mainly utilizes language variables for evaluation. Then, we combine CFPR and TIFNs to establish a hybrid model and conduct a series of quantitative analyses. The evaluation process of BTIC based on CFPR-TIFNs is shown in Figure 2.

4.1. Step 1. Defining triangular intuitionistic fuzzy numbers and linguistic variables

Experts apply TIFNs and language variables to measure the secondary indicators of BTIC of petroleum equipment manufacturing enterprises under the "Internet + innovation" paradigm. Therefore, we should first define TIFNs and corresponding language variables in this article.

(1) Defining triangular intuitionistic fuzzy numbers - Scholars put forward the concept of TIFNs on the basis of fuzzy sets and intuitionistic sets [33–35]. A triangular intuitionistic fuzzy number is indicated as $\tilde{a} = ((a, b, c); \mu_{\tilde{a}}, \nu_{\tilde{a}})$. It is an intuitionistic fuzzy number on the set of real numbers R. Its membership function is given by the following formula:

$$\mu_{\tilde{a}}(x) = \begin{cases} \dfrac{x-a}{b-a}\mu_{\tilde{a}}, & a \le x < b, \\ \mu_{\tilde{a}}, & x = b, \\ \dfrac{c-x}{c-b}\mu_{\tilde{a}}, & b < x \le c, \\ 0 & x < a \text{ or } x > c. \end{cases} \quad (1)$$

The nonmembership function is given by the following formula:

$$\nu_{\tilde{a}}(x) = \begin{cases} \dfrac{(b-x)+(x-a)\nu_{\tilde{a}}}{b-a}\mu_{\tilde{a}}, & a \le x < b, \\ \nu_{\tilde{a}}, & x = b, \\ \dfrac{(x-b)+(c-x)\nu_{\tilde{a}}}{c-b}, & b < x \le c, \\ 0 & x < a \text{ or } x > c, \end{cases} \quad (2)$$

where $\mu_{\tilde{a}}$ represents the maximum membership of the decision-maker whose judgment value belongs to the triangular fuzzy number (a, b, c). $\nu_{\tilde{a}}$ refers to the

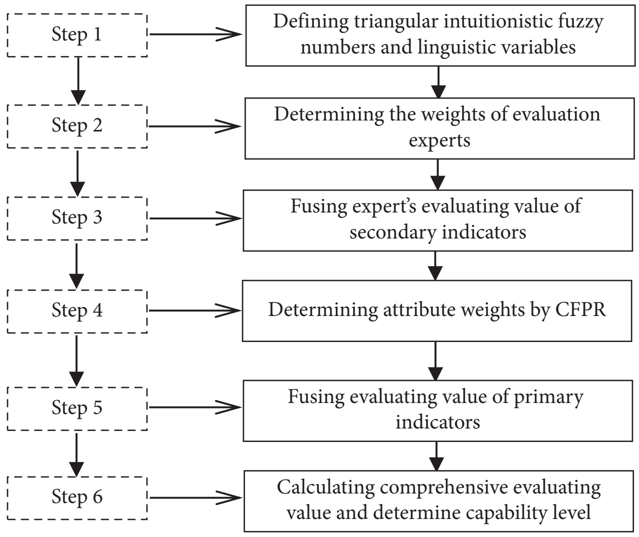

Figure 2: Evaluation process of BTIC of petroleum equipment manufacturing enterprises.

minimum membership degree of the decision-maker whose judgment value does not belong to the triangular fuzzy number (a, b, c). Also, $0 \le \mu_{\tilde{a}} \le 1, 0 \le \nu_{\tilde{a}} \le 1, 0 \le \mu_{\tilde{a}} + \nu_{\tilde{a}} \le 1$. $\pi_{\tilde{a}}(x) = 1 - \mu_{\tilde{a}}(x) - \nu_{\tilde{a}}(x)$ indicates the degree of hesitation of the decision-maker's judgment, that is, the degree of uncertainty. The smaller is $\pi_{\tilde{a}}(x)$, the higher affirmation degree of the decision-maker's judgment.

(2) Defining the operating rules of a triangular intuitionistic fuzzy number Let there be two triangular intuitionistic fuzzy numbers $\tilde{a}_1 = ((a_1, b_1, c_1); \mu_{\tilde{a}_1}, \nu_{\tilde{a}_1})$ and $\tilde{a}_2 = ((a_2, b_2, c_2); \mu_{\tilde{a}_2}, \nu_{\tilde{a}_2})$, there are

$$\tilde{a}_1 + \tilde{a}_2 = \left((a_1 + a_2, b_1 + b_2, c_1 + c_2); 1 - \left(1 - \mu_{\tilde{a}_1}\right)\left(1 - \mu_{\tilde{a}_2}\right), \left(1 - \mu_{\tilde{a}_1}\right)\left(1 - \mu_{\tilde{a}_2}\right) - \left(1 - \left(\mu_{\tilde{a}_1} + \nu_{\tilde{a}_1}\right)\right)\left(1 - \left(\mu_{\tilde{a}_2} + \nu_{\tilde{a}_2}\right)\right)\right)\Big),$$
$$\lambda\tilde{a} = \begin{cases} (\lambda a_1, \lambda b_1, \lambda c_1) 1 - \left(1 - \mu_{\tilde{a}_1}\right)^{\lambda}, \\ \left(1 - \mu_{\tilde{a}_1}\right)^{\lambda} - \left(1 - \left(\mu_{\tilde{a}_1} + \nu_{\tilde{a}_1}\right)\right)^{\lambda}, \quad \lambda \ge 0, \\ (\lambda c_1, \lambda b_1, \lambda a_1); 1 - \left(1 - \mu_{\tilde{a}_1}\right)^{\lambda}, \\ \left(1 - \mu_{\tilde{a}_1}\right)^{\lambda} - \left(1 - \left(\mu_{\tilde{a}_1} + \nu_{\tilde{a}_1}\right)\right)\Big)^{\lambda}, \lambda < 0. \end{cases} \tag{3}$$

(3) Calculating weighted arithmetic average operator of triangular intuitionistic fuzzy numbers Let there be n triangular intuitionistic fuzzy numbers $\tilde{a}_j = ((a_j, b_j, c_j); \mu_{\tilde{a}_j}, \nu_{\tilde{a}_j})$, $j = 1, 2, \ldots, n$. The weight vector is $w = (w_1, w_2, \ldots, w_n)$, and w_j ($j = 1, 2, \ldots, n$) is the weight of the jth triangular intuitionistic fuzzy number. $w_j \in [0, 1]$, and $\sum_{j=1}^{n} w_j = 1$. Then, the weighted arithmetic average operator of n triangular intuitionistic fuzzy numbers is

$$\text{TIFN} - \text{WAIA}\left(\tilde{a}_1, \tilde{a}_2, \ldots \tilde{a}_n\right) = \left(\left(\sum_{j=1}^{n} w_j a_j, \sum_{j=1}^{n} w_j b_j, \sum_{j=1}^{n} w_j c_j\right); 1 - \prod_{j=1}^{n}\left(1 - \mu_{\tilde{a}_1}\right)^{w_j}, \prod_{j=1}^{n}\left(1 - \mu_{\tilde{a}_1}\right)^{w_j} - \prod_{j=1}^{n} 1 - \left(\mu_{\tilde{a}_1} + \vartheta_{\tilde{a}_1}\right)^{w_j}\right). \tag{4}$$

(4) Defining linguistic variables and a triangular intuitionistic fuzzy number

This article applies [0, 10] to determine the language variables and the corresponding triangular intuitionistic fuzzy numbers for the evaluation of BTIC of petroleum equipment manufacturing enterprises under the "Internet + innovation" paradigm, as shown in Table 2. Experts evaluate the secondary indicators of BTIC of enterprises according to $(a, b, c; \mu_{\tilde{a}}, v_{\tilde{a}})$. We define $\mu_{\tilde{a}} = 1$, $v_{\tilde{a}} = 0$.

4.2. Step 2. Determining the weights of evaluation experts

The organizers of the evaluation of BTIC by petroleum equipment manufacturing enterprises determine the weights of the evaluation experts. The first part of the questionnaire for investigating the weights of the index system mainly involves the basic information of experts, including their work field, working years, professional knowledge and skills, the experience of participating in relevant petroleum equipment technology innovation, etc.

Based on the contents provided by the experts who participate in the evaluation, the organizers determine the weights of the evaluation experts. Where $w = (w_1, w_2, \ldots, w_n)$ represent the weights of n experts. $w_j \in [0, 1]$, and $\sum_{j=1}^{n} w_j = 1$. When the weights of n experts are equal, that is, $w_j = 1/n$.

4.3. Step 3. Fusing expert's evaluating value of secondary indicator

There are n experts participating in the evaluation. The triangular intuitionistic fuzzy number corresponding to the evaluation value of the language variables is $\tilde{x}_{ij}^{k}, k = 1.2, \ldots, n$, $\tilde{x}_{ij}^{k} = ((a_{ij}^{k}, b_{ij}^{k}, c_{ij}^{k}); \mu_{\tilde{x}_{ij}^{k}}, v_{\tilde{x}_{ij}^{k}})$. Where the k-th expert is responsible for the j-th secondary indicator under the i-th primary indicator. Let the weight of the k-th expert be w_k. This article is based on the weighted arithmetic average operator of the triangular intuitionistic fuzzy number $\text{TIFN} - \text{WAIA}(\tilde{a}_1, \tilde{a}_2, \ldots, \tilde{a}_n)$. It can be obtained that the fused triangular intuitionistic fuzzy number of the j-th secondary indicator under the i-th primary indicator is $\tilde{x}_{ij}$. Then, there is

$$\tilde{x}_{ij} = \text{TIFN} - \text{WAIA}_{w_k}\left(\tilde{x}_{ij}^{1}, \tilde{x}_{ij}^{2}, \ldots, \tilde{x}_{ij}^{n}\right). \quad (5)$$

4.4. Step 4. Determining the indicators' weights by CFPR

This article applies CFPR to determine the indicators' weights [17, 36–38]. CFPR is a simple method to avoid inconsistencies in the traditional pairwise judgment matrix comparison. The steps for determining the indicators' weights by CFPR are as follows:

(1) Indicator set is $X = \{x_1, x_2, \ldots, x_n\}$, and its corresponding complementary preference relation $A = (a_{ij})$, where $a_{ij} \in [1/9, 9]$. The corresponding fuzzy preference relation $P = (p_{ij})$, where $p_{ij} \in [0, 1]$. Therefore, $P = g(A)$, that is

$$p_{ij} = g\left(a_{ij}\right) = \frac{1}{2}\left(1 + \log_9\left(a_{ij}\right)\right), \quad (6)$$

where g can be appropriately converted according to the actual situation of the study, which is called the conversion function.

(2) For the fuzzy preference relation $P = (p_{ij})$, there is

$$p_{ij} + p_{jk} + p_{ki} = \frac{3}{2} \quad \forall i < j < k. \quad (7)$$

(3) For the fuzzy preference relation $P = (p_{ij})$, there is

$$p_{i(i+1)} + p_{(i+1)(i+2)} + \cdots + p_{(j-1)j} + p_{ji} = \frac{j-i+1}{2}, \quad \forall i < j. \quad (8)$$

If p_{ij} obtained after calculation is not in [0, 1] but in [−a, 1 + a] (a > 0). Therefore, under the condition of maintaining complementarity and additive consistency, it can be transformed into [0, 1] through the conversion function. The steps are as follows:

① Calculating preference set B

$$\begin{aligned} B &= \left\{p_{ij}, i < j \wedge p_{ij} \notin \left\{p_{12}, p_{23}, \ldots, p_{(n-1)n}\right\}\right\}, \\ p_{ji} &= \frac{j-i+1}{2} - p_{i(i+1)} - p_{(i+1)(i+2)} - \cdots - p_{(j-1)j}. \end{aligned} \quad (9)$$

② Calculating k value

$$\begin{aligned} k &= \left|\min\left\{B \cup \left\{p_{12}, p_{23}, \ldots, p_{(n-1)n}\right\}\right\}\right|, \\ P &= \left\{p_{12}, p_{23}, \ldots, p_{(n-1)n}\right\} \cup B \cup \left\{1 - p_{12}, 1 - p_{23}, \ldots, 1 - p_{(n-1)n}\right\} \cup -B. \end{aligned} \quad (10)$$

Table 2: Language variables and corresponding triangular intuitionistic fuzzy numbers.

Language variables	Triangular intuitionistic fuzzy numbers
Very weak (VW)	(0, 0, 2.5; 1, 0)
Weak (W)	(0, 2.5, 5; 1, 0)
Medium (M)	(2.5, 5, 7.5; 1, 0)
Strong (S)	(5, 7.5, 10; 1, 0)
Very strong (VS)	(7.5, 10, 10; 1, 0)

We can get the conversion function as follows:

$$f\colon [-a, 1+a] \longrightarrow [0,1], f(x) = \frac{x+a}{1+2a}, \quad a<0. \tag{11}$$

③Checking standardized values We check the calculated p_{ij}^k value whether in [0, 1]. If p_{ij}^k is not in [0, 1], we should transform p_{ij}^k into [0, 1], according to the transformation function (11). We comprehensively consider the judgments of various experts and take their mean value as the basis, namely,

$$p_{ij} = \frac{1}{m}\sum_{k=1}^{m} p_{ij}^k. \tag{12}$$

④Calculating indicators' weights

Based on the fuzzy preference relation matrix $P = (p_{ij})$, the average preference degree of indicators at all levels is calculated by

$$s_i = \frac{1}{n}\sum_{j=1}^{n} p_{ij}. \tag{13}$$

Then, the weight of each indicator is

$$w_i = \frac{s_i}{\sum_{i=1}^{n} s_i}. \tag{14}$$

4.5. Step 5. Fusing evaluating value of primary indicator

According to step 3, the TIFNs of the j-th secondary indicator under the i-th primary indicator are obtained according to step 3, that is $\tilde{x}_{ij} = \text{TIFN} - \text{WAIA}_{w_k}(\tilde{x}_{ij}^1, \tilde{x}_{ij}^2, \ldots, \tilde{x}_{ij}^n)$. Let $\tilde{x}_i$ be the TIFNs of the i-th primary indicator. According to CFPR in Step 4, the weight vector of each secondary indicator under the primary indicator is determined as w_{ij} ($j = 1.2,\ldots,n$). Then, it is

$$\tilde{x}_i = \text{TIFN} - \text{WAIA}_{w_{ij}}(\tilde{x}_{i1}, \tilde{x}_{i2}, \ldots, \tilde{x}_{in}). \tag{15}$$

After the calculation, we get the weighted arithmetic trigonometric intuitionistic fuzzy numbers of all primary indicators.

4.6. Step 6. Calculating the comprehensive evaluation value and determining the capability level

According to the weight w_i ($i = 1.2,\ldots,n$) of each primary index calculated in step 4 and the triangular intuitionistic fuzzy number $\tilde{x}_i$ of the primary index calculated in step 3, we can calculate the comprehensive triangular intuitionistic fuzzy number of an enterprise, as shown in the following formula:

$$\tilde{x} = ((a,b,c); \mu_{\tilde{x}}, \nu_{\tilde{x}}) = \text{TIFN} - \text{WAIA}_{w_i}(\tilde{x}_1, \tilde{x}_2, \ldots, \tilde{x}_n). \tag{16}$$

Then, according to the following formula, we calculate the Hamming distance [39] between $\tilde{x}$ and the triangular intuitionistic fuzzy number corresponding to the five language variables in Table 2:

$$d(\tilde{a}_1, \tilde{a}_2) = \frac{1}{6}\Big[\big|(1+u_{\tilde{a}_1} - \nu_{\tilde{a}_1})a_1 - (1+u_{\tilde{a}_2} - \nu_{\tilde{a}_2})a_2\big| + \big|(1+u_{\tilde{a}_1} - \nu_{\tilde{a}_1})b_1 - (1+u_{\tilde{a}_2} - \nu_{\tilde{a}_2})b_2\big| + \big|(1+u_{\tilde{a}_1} - \nu_{\tilde{a}_1})c_1 - (1+u_{\tilde{a}_2} - \nu_{\tilde{a}_2})c_2\big|\Big]. \tag{17}$$

According to the principle of maximum closeness (the shorter the distance, the better), we determine the level of BTIC and the trust degree of the level.

5. Case Analysis

This article selects a breakthrough technological innovation case of an equipment manufacturing enterprise in Daqing Oilfield, China, to elaborate on the specific application process of the index system and evaluation model constructed in this article. The enterprise actively responded to the "going out" strategy of Daqing Oilfield, carried out breakthrough new technology research and development for the special needs of exploration and development in a region in the Middle East, and achieved phased results. To grasp the breakthrough technological innovation capability of the enterprise accurately, the enterprise employed five experts in this field to measure and evaluate the BTIC of the enterprise according to the index system and measurement method constructed in this article. The specific processes are as follows.

5.1. Step 1. Evaluating secondary indicators

Experts evaluated the 21 secondary indicators based on the language variables in Table 2, and the evaluating results are shown in Table 3.

5.2. Step 2. Determining the weights of evaluation experts

The organizers of this petroleum equipment manufacturing enterprise are responsible for organizing the

Table 3: Expert's evaluation of secondary indicators.

Secondary indicators	Expert 1 0.25	Expert 2 0.2	Expert 3 0.2	Expert 4 0.15	Expert 5 0.2
1.1	(5, 7.5, 10; 0.9, 0.1)	(0, 2.5, 5; 0.7, 0.3)	(5, 7.5, 10; 0.85, 0.12)	(5, 7.5, 10; 0.9, 0.04)	(0, 2.5, 5; 0.75, 0.25)
1.2	(5, 7.5, 10; 0.85, 0.12)	(7.5, 10, 10; 0.7, 0.3)	(5, 7.5, 10; 0.8, 0.2)	(7.5, 10, 10; 0.69, 0.3)	(5, 7.5, 10; 0.65, 0.25)
1.3	(5, 7.5, 10; 0.75, 0.2)	(7.5, 10, 10; 0.85, 0.1)	(5, 7.5, 10; 0.95, 0.01)	(2.5, 5, 7.5; 0.9, 0.04)	(5, 7.5, 10; 0.85, 0.1)
1.4	(7.5, 10, 10; 0.6, 0.3)	(7.5, 10, 10; 0.8, 0.15)	(7.5, 10, 10; 0.75, 0.25)	(2.5, 5, 7.5; 0.75, 0.2)	(7.5, 10, 10; 0.9, 0.1)
2.1	(5, 7.5, 10; 0.85, 0.12)	(7.5, 10, 10; 0.7, 0.3)	(5, 7.5, 10; 0.85, 0.15)	(7.5, 10, 10; 0.7, 0.25)	(5, 7.5, 10; 0.8, 0.2)
2.2	(0, 2.5, 5; 0.9, 0.1)	(2.5, 5, 7.5; 0.75, 0.2)	(5, 7.5, 10; 0.95, 0.01)	(2.5, 5, 7.5; 0.9, 0.04)	(5, 7.5, 10; 0.75, 0.2)
2.3	(7.5, 10, 10; 0.85, 0.15)	(7.5, 10, 10; 0.8, 0.15)	(7.5, 10, 10; 0.75, 0.25)	(2.5, 5, 7.5; 0.75, 0.2)	(7.5, 10, 10; 0.95, 0.03)
3.1	(5, 7.5, 10; 0.85, 0.12)	(5, 7.5, 10; 0.75, 0.2)	(5, 7.5, 10; 0.85, 0.1)	(7.5, 10, 10; 0.7, 0.3)	(5, 7.5, 10; 0.75, 0.25)
3.2	(5, 7.5, 10; 0.85, 0.12)	(7.5, 10, 10; 0.85, 0.1)	(5, 7.5, 10; 0.95, 0.01)	(2.5, 5, 7.5; 0.9, 0.04)	(5, 7.5, 10; 0.85, 0.15)
3.3	(7.5, 10, 10; 0.6, 0.3)	(7.5, 10, 10; 0.8, 0.15)	(7.5, 10, 10; 0.75, 0.25)	(2.5, 5, 7.5; 0.75, 0.2)	(7.5, 10, 10; 0.95, 0.05)
3.4	(5, 7.5, 10; 0.85, 0.12)	(7.5, 10, 10; 0.7, 0.3)	(5, 7.5, 10; 0.85, 0.15)	(7.5, 10, 10; 0.7, 0.25)	(2.5, 5, 7.5; 0.75, 0.2)
3.5	(7.5, 10, 10; 0.7, 0.3)	(7.5, 10, 10; 0.8, 0.15)	(5, 7.5, 10; 0.9, 0.1)	(7.5, 10, 10; 0.8, 0.2)	(7.5, 10, 10; 0.9, 0.1)
3.6	(7.5, 10, 10; 0.85, 0.15)	(7.5, 10, 10; 0.8, 0.15)	(7.5, 10, 10; 0.75, 0.25)	(2.5, 5, 7.5; 0.75, 0.2)	(7.5, 10, 10; 0.75, 0.25)
4.1	(5, 7.5, 10; 0.8, 0.12)	(2.5, 5, 7.5; 0.9, 0.1)	(0, 2.5, 5; 0.6, 0.3)	(0, 2.5, 5; 0.85, 0.1)	(5, 7.5, 10; 0.65, 0.25)
4.2	(5, 7.5, 10; 0.8, 0.15)	(7.5, 10, 10; 0.85, 0.1)	(5, 7.5, 10; 0.95, 0.01)	(2.5, 5, 7.5; 0.9, 0.04)	(5, 7.5, 10; 0.85, 0.1)
4.3	(0, 2.5, 5; 0.8, 0.1)	(2.5, 5, 7.5; 0.8, 0.2)	(2.5, 5, 7.5; 0.85, 0.1)	(2.5, 5, 7.5; 0.75, 0.2)	(7.5, 10, 10; 0.9, 0.1)
4.4	(5, 7.5, 10; 0.85, 0.12)	(2.5, 5, 7.5; 0.9, 0.1)	(5, 7.5, 10; 0.85, 0.15)	(2.5, 5, 7.5; 0.8, 0.1)	(5, 7.5, 10; 0.8, 0.1)
4.5	(0, 2.5, 5; 0.95, 0.05)	(2.5, 5, 7.5; 0.75, 0.2)	(5, 7.5, 10; 0.95, 0.01)	(2.5, 5, 7.5; 0.9, 0.04)	(5, 7.5, 10; 0.75, 0.25)
5.1	(2.5, 5, 7.5; 0.8, 0.2)	(2.5, 5, 7.5; 0.8, 0.2)	(2.5, 5, 7.5; 0.85, 0.1)	(2.5, 5, 7.5; 0.75, 0.2)	(7.5, 10, 10; 0.9, 0.1)
5.2	(5, 7.5, 10; 0.85, 0.12)	(2.5, 5, 7.5; 0.9, 0.1)	(5, 7.5, 10; 0.85, 0.15)	(2.5, 5, 7.5; 0.85, 0.1)	(5, 7.5, 10; 0.8, 0.1)
5.3	(5, 7.5, 10; 0.85, 0.12)	(0, 2.5, 5; 0.8, 0.2)	(5, 7.5, 10; 0.95, 0.01)	(2.5, 5, 7.5; 0.9, 0.1)	(5, 7.5, 10; 0.85, 0.1)

evaluation of BTIC and determining the weights of five experts according to their relevant information provided in questionnaires; the results are shown in Table 3.

5.3. Step 3. Integrating the experts' evaluation of secondary indicators

According to formula (5), the experts' evaluating values of secondary indicators are fused, and the calculating results are shown in Table 4.

5.4. Step 4. Determining the indicators' weights by CFPR

The five experts compared and scored the five primary and secondary indicators using the 1–9 scale. Through Formulas (6)–(14), the weights of the primary and secondary indicators of the enterprise's BTIC are calculated. The calculation results are shown in Table 4.

5.5. Step 5. Calculating the value of the weighted fusion primary indicator

According to the triangle intuitionistic fuzzy evaluating value and the weighted fusion secondary indicators in Table 4, the triangle intuitionistic fuzzy number evaluating the value of each primary indicator is obtained through the weighted fusion of formula (15). The calculation results are listed in Table 5.

5.6. Step 6. Calculating the comprehensive evaluation value and determining the capability level

According to the evaluation value and the weighted fusion primary indicator in Table 5, the comprehensive triangular intuitionistic fuzzy evaluating value of the enterprise's BTIC $\tilde{x}_i = (4.8, 7.3, 9.0; 0.87, 0.11)$ is obtained by the weighted fusion formula (16). Also, the Hamming distance between $\tilde{x}_i$ and 5 language variables in Table 2 is calculated according to Formula (17). The calculation results are shown in Table 6.

According to the Hamming distance in Table 6 and the principle of maximum closeness, the BTIC of the petroleum equipment manufacturing enterprise belongs to the "Medium" level, and the reliability is 0.85. It can be seen from Table 6 that the BTIC of the petroleum equipment manufacturing enterprise is still far from the "very strong" level. This is mainly because the enterprise is in the initial stages of carrying out breakthrough technological innovation and has not formed a unique innovation advantage.

According to the evaluation value of the triangular intuitionistic fuzzy number after the fusion of the primary indicators in Table 5, the petroleum equipment manufacturing enterprise has a strong R&D capability for breakthrough new technology. While its commercialization capability and innovation support capability for breakthrough new technology are relatively weak.

From the evaluation results, it can be seen that the enterprise has initially formed a medium BTIC based on "Internet +" and has mastered the skills of using the Internet to acquire creativity, knowledge, and talent. Although the enterprise's innovation platform has been connected with various social media and external innovation platforms, there are still some flaws. For example, the breakpoint of information transmission sometimes occurs when virtual scientific research team members conduct online real-time communication. It has affected the effective utilization of Internet innovation resources to some extent. At the same time, the petroleum equipment manufacturing enterprise is

Table 4: Experts' values and indicators' weights of fusion secondary indicators.

Order number	Primary indicator (weight)	Secondary indicator (weight)	Evaluation values of fusion secondary indicators
1	Creativity discovery capability of breakthrough new technologies (0.209)	1.1. Acquisition capability of Internet creative idea (0.255)	(3.0, 5.5, 8.0; 0.84, 0.16)
		1.2. Mining capability of Internal creative idea (0.246)	(5.9, 8.4, 10; 0.76, 0.24)
		1.3. Refining capability of breakthrough technical ideas (0.256)	(5.1, 7.6, 9.6; 0.87, 0.08)
		1.4. Defining breakthrough new technology capabilities (0.243)	(6.8, 9.3, 9.6; 0.78, 0.22)
2	Creativity screening capability of breakthrough new technologies (0.192)	2.1. Adaptability of innovative screening system for breakthrough new technologies (0.317)	(5.9, 8.4, 10; 0.8, 0.2)
		2.2. Internet experts' ability to express views in real time and accurately (0.349)	(2.9, 5.4, 7.9; 0.87, 0.13)
		2.3. Experts' ability to judge the future market expectation of new technologies (0.334)	(6.8, 9.3, 9.6; 0.85, 0.15)
3	Research and development capability of breakthrough new technologies (0.211)	3.1. Capability of Internet to acquire knowledge required for innovation (0.132)	(5.4, 7.9, 10; 0.8, 0.2)
		3.2. Capital investment capability for breakthrough new technology R&D (0.113)	(5.1, 7.6, 9.6; 0.89, 0.11)
		3.3. Internal investment capability of breakthrough new technology R&D personnel (0.135)	(6.8, 9.3, 9.6; 0.81, 0.19)
		3.4. Participating capability of remote personnel for breakthrough new technology R&D (0.197)	(5.4, 7.9, 9.5; 0.79, 0.21)
		3.5. Promoting capability of function leapfrog for breakthrough new technologies (0.217)	(7.0, 9.5, 10; 0.83, 0.17)
		3.6. Capability to obtain invention patents for breakthrough new technologies (0.206)	(6.8, 9.3, 9.6; 0.79, 0.21)
4	Commercialization capability of breakthrough new technologies (0.196)	4.1. Internet promotion of new technologies or products (0.219)	(2.8, 5.3, 7.8; 0.79, 0.21)
		4.2. Capability of new products to meet the needs of leading users (0.216)	(5.1, 7.6, 9.6; 0.88, 0.07)
		4.3. Market development capability of new Internet products (0.218)	(2.9, 5.4, 7.4; 0.83, 0.17)
		4.4. Development capability of potential users of new products (0.174)	(4.1, 6.6, 9.1; 0.85, 0.15)
		4.5. Real—time production and supply capability of new products (0.173)	(2.9, 5.4, 7.9; 0.89, 0.11)
5	Support capability of breakthrough new technologies (0.192)	5.1. Docking capability of open space platform based on Internet (0.367)	(3.5, 6.0, 8.0; 0.83, 0.17)
		5.2. Real-time information transmission capability based on Internet (0.329)	(4.1, 6.6, 9.1; 0.85, 0.15)
		5.3. Supporting capability of Internet-based information technology (0.304)	(3.6, 6.1, 8.6; 0.88, 0.12)

Table 5: Evaluating value of weighted fusion triangle intuitionistic fuzzy number of primary indicators.

Order number	Primary indicator (weight)	Evaluation value of primary indicator after fusion
1	Creativity discovery capability of breakthrough new technologies (0.209)	(5.2, 7.7, 9.3; 0.82, 0.14)
2	Creativity screening capability of breakthrough new technologies (0.192)	(5.1, 7.6, 9.1; 0.84, 0.16)
3	Research and development capability of breakthrough new technologies (0.211)	(6.2, 8.7, 9.7; 0.82, 0.15)
4	Commercialization capability of breakthrough new technologies (0.196)	(3.6, 6.1, 8.3; 0.85, 0.15)
5	Supporting capability of breakthrough new technologies (0.192)	(3.7, 6.2, 8.6; 0.86, 0.12)

in the primary stage of changing from offline sales to online publicity of new product sales, and the publicity and sales methods need to be further improved.

Therefore, the petroleum equipment manufacturing enterprise should further strengthen the construction of the "Internet + innovation" paradigm on the basis of existing

Table 6: The Hamming distance between $\tilde{x}_i$ and the 5 language variables in Table 2.

Order number	Calculation object	Distance	Shortest distance	$\mu_{\tilde{a}}$	$\nu_{\tilde{a}}$
1	Distance between $\tilde{x}_i$ and VW	5.356			
2	Distance between $\tilde{x}_i$ and W	3.689			
3	Distance between $\tilde{x}_i$ and M	1.189	1.189	0.85	0.12
4	Distance between $\tilde{x}_i$ and S	1.311			
5	Distance between $\tilde{x}_i$ and VS	2.977			

capacity accumulation. It can realize a good connection with external innovation platforms and improve the acquisition of internet-based creative knowledge. It can also improve the absorption and application of external knowledge and talents based on the Internet, improve the efficiency and effect of Internet experts and scholars participating in breakthrough technological innovation, and innovate the ways and channels of online sales of new products. Thus, these can improve the BTIC of petroleum equipment manufacturing enterprises under the "Internet + innovation" paradigm.

6. Conclusion

"Internet + innovation" is a new innovation paradigm around the world that embodies a new innovation concept and has great development potential. The "Internet + innovation" paradigm makes the concepts, processes, and measurements more complex than traditional ones. Complex theory and methodology are adaptive for describing and evaluating BTIC for petroleum equipment manufacturing enterprises. The " Belt and Road" strategy provides a good opportunity for Chinese petroleum equipment manufacturing enterprises to expand their foreign businesses through breakthrough technological innovation. The evaluation index system of BTIC constructed in this article implies the characteristics of "breakthrough" and "Internet +" of breakthrough technological innovation in petroleum equipment manufacturing enterprises. Compared to the AHP-TIFNs model, the CFPR-TIFNs model based on triangular intuitionistic fuzzy numbers (TIFNs) and consistent fuzzy preference relationships (CFPR) described in this article can greatly reduce the time of pairwise comparisons of weights determined by methods such as AHP/ANP, and maintain high consistency. For example, there are 5 primary indicators and 21 secondary indicators in this study, and if the experts determine the weights of all indicators by AHP, they should conduct 47 pairwise comparisons, compared to only 20 times by CFPR. Compared to AHP/ANP, CFPR can maintain high consistency by reducing the number of pairwise comparisons. TIFNs embody the different viewpoints, experiences, and knowledge of each expert by entrusting different weights. TIFNs can not only give the evaluation value of language variables intuitively but also give the trust degree of the evaluation value of language variables by way of $\mu_{\tilde{a}}$ and $\nu_{\tilde{a}}$. Therefore, the results of this study can provide effective support for Chinese petroleum equipment manufacturing enterprises to accurately judge their own breakthrough technological innovation capability in the "Internet +" era.

Data Availability

The data used to support the findings of this study are included within the article.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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