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Method of TFN-TOPSIS Based on Possibility Degree Relation Model and Its Application in the Patent Value Estimation of Self-Balancing Vehicles

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Abstract: With the advancement of technology and the development of intelligence, self-balancing scooters have gradually developed in the field of short-distance travel and have become a fashionable, popular and leisure means of transportation. In addition, both the export of self-balancing scooters and their safety are closely related to their core patents. Therefore, in order to promote the healthy development of the self-balancing automobile industry, this paper carries out the following research: First, we introduce the background of the self-balancing automobile patent and the research status of patent value evaluation at home and abroad. Then, considering the fuzziness of decision makers' thinking and the uncertainty of patent indicators, this paper extends the traditional TOPSIS method to the field of triangular fuzzy numbers (TFNs), and proposes a TFN-TOPSIS multi-criteria decision model based on the possibility degree relationship model. In addition, this study establishes a core patent value system using three aspects of technology, law and economy, and applies the TFN-TOPSIS model to the top 20 balanced car patents with the highest comprehensive evaluation to rank and analyze the measurement results. On this basis, this paper provides reference opinions for relevant industry personnel from the aspects of future product technology updates and patent layouts.

Keywords: possibility degree relation model; TFN-TOPSIS model; patent value estimating; multi-attribute decision-making

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1. Introduction

The electric intelligent balance car (hereinafter referred to as the balance car) is also called the somatosensory car, torsion car, etc. The market mainly includes two-wheeled and one-wheeled vehicles. Its working principle is based on "dynamic stability", using gyroscopes and acceleration sensors to detect changes in human posture, and using servo control systems to precisely drive motor movements to maintain the system balance. Electric self-balancing scooters have the advantages of green environmental protection, convenient control, and easy portability, so they are widely used for short-distance travel, leisure and entertainment, and other purposes. As they become more popular, the demand for self-balancing vehicles in China has been increasing year by year, from 1.93 million units in 2015 to 6.07 million units in 2022. In 2020, the total shipments of electric self-balancing scooters in the world will be 10.32 million units, of which 9.32 million units will be from China, accounting for approximately 90% of the total shipments. At present, China is the world's largest producer and exporter of self-balancing vehicles.

In fact, an American, Dean Kamen, was inspired by people's walking posture, and developed the world's first two-wheeled balance car, the "Segway", through gyroscope, motor and wheel simulation of dynamic stability in 2001; in 2008, the Segway balance car entered China and was highly sought after. Since then, some domestic companies have followed suit, developing and selling self-balancing scooters. After gaining a certain amount of profit in the domestic market, they rashly entered the foreign market, but were frequently obstructed by patent disputes and paid huge amounts of compensation for patent infringement. One of the most sensational cases was on 9 September 2014, when Ninebot and eight other Chinese self-balancing scooter companies were sued by Segway for allegedly infringing three invention patents and two design patents held by Segway. In April 2015, Ninebot received 80 million yuan in Series A financing from Xiaomi, Shunwei Capital, Sequoia Capital, Huashan Capital, etc., and fully acquired Segway, including more than 400 electric balance car patents under Segway's name. Since then, Ninebot has completely changed the status of passive responders and has become the boss of Segway. Using its more than 400 electric self-balancing vehicle patents, Ninebot has successfully fought back as a plaintiff, filing patent infringement lawsuits against US companies and Chinese companies, and driving competitors out of the self-balancing vehicle market.

As the main force in the production and export of self-balancing vehicles, China needs to continuously optimize and improve the quality of self-balancing vehicles, and carry out innovation and creation. At present, the patent database is used to search the patent applications for electric self-balancing vehicles, and the trend in patent applications for electric self-balancing vehicles is analyzed; this can provide a reference for the development of the industry.

From Figure 1, it can be seen that the number of patents for self-balancing vehicles in China is obviously more than that of foreign countries. However, among these domestic applications, approximately 2/3 of the patents are for utility models and appearance designs, while the patents applied for abroad are almost all concentrated in the field of invention patents. China should pay more attention to the research and development of self-balancing vehicles.

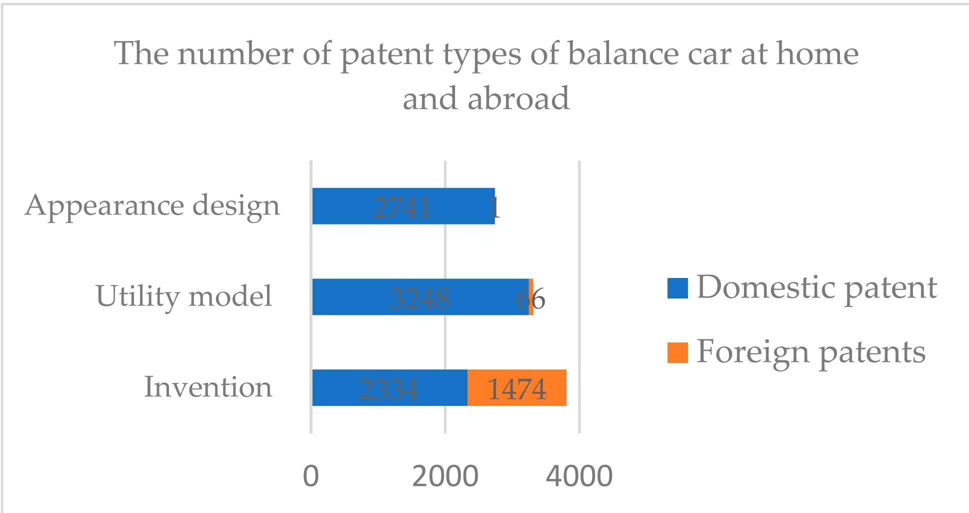

Figure 1. The number of patent types of balance vehicle at home and abroad [1].

In the current patent market, high-value patents only account for approximately 10% of the total number of patents, but their total value accounts for more than 80% of the total patent value. Therefore, it is vital to screen out the core patents of the balance car, and the patent values needs to be evaluated before that. The US intellectual property consulting firm CHI and the US National Science Foundation (NSF) jointly developed the world's first patent indicator evaluation system [2], which is used to evaluate the comprehensive strength of the intellectual property rights of companies or countries and regions; based on this indicator system, the value of a company's intangible assets can be evaluated. The CHI patent evaluation uses the following seven indicators: the number of patents, the average number of patent citations, the current impact indicator, the technical strength (the number of patents × the current impact indicator), the technology life cycle, the scientific relevance and the scientific strength (the number of patents × scientific relevance). On the basis of the CHI patent evaluation indicators, researchers have conducted much research on the patent value evaluation indicator system, which can be summarized into two research lines:

one focus is on the influencing factors and the mechanism of the patent value. A large number of studies have shown that the variables that affect the value of patents mainly include the following: patent life cycle [3], patent protection scope [4], patent creativity [5], patent substitutability, patent R&D investment [6], patentee characteristics [7], etc. The above studies analyze the influence mechanisms of various variables on the patent value for the single and multivariable variables that affect patent value, but do not establish a specific patent value evaluation model with multivariate variables as evaluation indicators. Another direction is the patent value evaluation indicator and model. The basic idea is to build a patent value evaluation indicator system starting from the four major factors that affect the patent value: technology, market, competition and law. The evaluation model calculation method mainly adopts the expert scoring method, the hierarchical method, the decision tree method and the fuzzy comprehensive evaluation method. X.L. Wan and X.Z. Zhu constructed a patent evaluation indicator system from the perspectives of technology, the market and rights [8], including a total of 17 evaluation indicators, and established an evaluation model by using the hierarchical method and fuzzy comprehensive theory. X. Zhang et al. constructed a patent literature value evaluation model from the technical, legal and economic perspectives of patents to identify core patents [9]. T.Y. Luo built a core patent identification indicator system, and also used the expert scoring method to determine the weight of each indicator to identify the core patents in the field of wind power generation control [10].

In 2012, the "Patent Value Analysis Indicator System Operation Manual" was jointly published by the State Intellectual Property Office and China Technology Exchange; it became the main reference material for domestic scholars to evaluate patent value. The manual focuses on the legal value, technical value and economic value of patents. It establishes patent value analysis indicators, including a total of 18 evaluation indicators, and calculates the patent value degree (0–100) through the expert scoring method [11,12].

With the deepening of research on multi-attribute decision-making methods, the precise number can no longer meet the decision needs of decision makers; thus, scholars have begun to expand the research on TFNs and linguistic values. For example, Zhang et al. revised the unbalanced language term sets in Herrera, and developed two optimization models to deal with multi-attribute decision-making problems with multi-granularity unbalanced language information [13,14]; Li et al. conducted research on personalized individual semantics in the context of multi-attribute decision-making, which can provide decision makers with personalized digital scales of language terms [15]. At the same time, many new methods have emerged, such as fuzzy EDAS [16,17], ARAS [18], MARCOS [19], MABAC [20], CoCoSo [21], characteristic object method (COMET) [22], and the ideal solution stable preference ranking (SPOTIS) method [23–25]. It is undeniable that these methods expand the research of multi-attribute decision-making methods, but there are also some shortcomings. For instance, the COMET method requires more information than traditional MCDM methods (such as TOPSIS), and the collection of information is often difficult; the traditional MARCOS method cannot meet the requirements related to dealing with the uncertainty that exists in decision attributes. In order to avoid these defects, this paper proposes the TFN-TOPSIS model, based on the possibility degree relationship, and introduces the possibility degree model to determine the weight; this can better deal with fuzzy information and ensure a certain degree of objectivity.

The TOPSIS method is widely used in comprehensive risk and decision-making evaluation research in various fields, some of which is also used in financial risk research; this method is more used in comprehensive risk evaluation. Bathrinath (2019) used the AHP-TOPSIS method to study the risks existing in the production process of the Indian textile industry, and found that the reasons for the high incidence of accidents were lighting, ventilation, noise and the importance of workers to risks [26]. Mohamed (2019) used the TOPSIS-CRITIC model to evaluate the supply chain risk of China's telecommunications companies. The evaluation system includes 36 indicators in 7 aspects of finance, supply, environment, operation, control, planning and information technology. The results show that financial risk is the most important factor [27]. Salehi (2020) used the entropy weight TOPSIS method to evaluate the risk management system of the petrochemical industry, and found that management capacity and human factors have the greatest impact on the risk management system [28]. In addition to comprehensive risk assessment, another application area of the entropy weight TOPSIS method is comprehensive effect assessment. Lam (2019) used the entropy weight TOPSIS method to evaluate the operating performance of Malaysian construction companies. In his model, indicators related to profitability are important influencing factors, and earnings per share is the most important decision-making standard [29]. Alireza (2018) and others used the entropy weight TOPSIS method to evaluate the quality of groundwater in Azerbaijan. They believed that the entropy weight TOPSIS method can improve the evaluation of groundwater quality [30].

Considering the subjectivity of decision makers and the availability of information, this paper evaluates the patent value of balanced vehicles by the TFN-TOPSIS method, based on the possibility degree relation model. This not only considers the fuzziness of human judgment, but can also fully mine the information provided by the original data, which has good objectivity and scientificity. Firstly, we introduce the relevant background of self-balancing automobile patent value evaluation. Secondly, considering the fuzziness of decision makers' thinking and the uncertainty of patent indicators, this paper extends the traditional TOPSIS method to the field of TFNs, and proposes a TFN-TOPSIS multi-criteria decision model based on the possibility degree relation model. In addition, this study establishes a core patent value system using three aspects of technology, law and economy, and applies the TFN-TOPSIS model to the top 20 balanced car patents with the highest comprehensive evaluation to rank and analyze the measurement results. On this basis, this paper provides reference opinions for relevant industry personnel from the aspects of future product technology updates and patent layouts.

The rest of the paper is arranged as follows. Section 2 introduces the calculation rules of the possibility degree relation model and the specific calculation steps of the TFN-TOPSIS model; Section 3 analyzes the factors that affect the patent value of the balance car; Section 4 establishes the indicator system, takes the balance car patent value as an example in order to make a comprehensive evaluation, analyzes the results and puts forward corresponding suggestions; Section 5 summarizes this paper and looks forward to the future research.

2. TFN-TOPSIS Model

In this study, the patent value of the self-balancing vehicle is considered using twelve indicators from three dimensions of economy, technology and law. In view of its multi-dimensional and multi-indicator characteristics, a multi-criteria decision-making model, TFN-TOPSIS, based on the possibility degree relation model, is constructed to evaluate the patent value of the self-balancing vehicle, so as to select patents with a higher value. As shown in Figure 2, on the basis of calculating the indicators' weight through the possibility degree relation model, a weighted normalized decision matrix is established to calculate the distance and closeness degree of each patent to the positive and negative ideal solutions, and sort them according to the closeness degree.

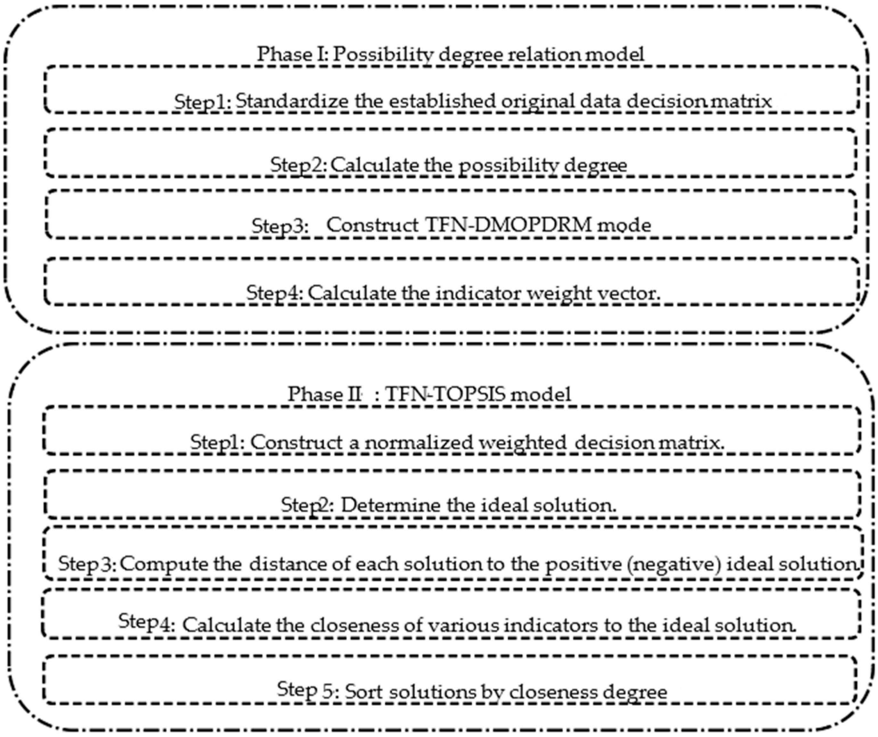

Figure 2. General scheme for TFN -TOPSIS model.

2.1. Phase I: Possibility Degree Relation Model

In the multi-criteria decision-making process, the optimization indicator weighting method is a research hotspot. This paper calculates the weight of each indicator according to the triangular fuzzy number (Abbreviated as TFN) possibility degree relation model proposed in the literature [31]. The TFN is defined as follows:

Definition 1. *If* $\tilde{\tilde{x}} = [x^L, x^M, x^U] = \{x | 0 < x^L \le x^M \le x^U, x, x^L, x^M, x^U \in R\}$, *then* $\tilde{\tilde{x}}$ *is called a TFN. Let* $\tilde{\tilde{x}} = [x^L, x^M, x^U]$, $\tilde{\tilde{y}} = [y^L, y^M, y^U]$, *then there are the following rules:*

Rule 1: $\tilde{\tilde{x}} + \tilde{\tilde{y}} = [x^L + y^L, x^M + y^M, x^U + y^U]$;
Rule 2: $\frac{1}{\tilde{\tilde{x}}} = [\frac{1}{x^U}, \frac{1}{x^M}, \frac{1}{x^L}], x^L, x^M, x^U \ne 0$;
Rule 3: $k\tilde{\tilde{x}} = [kx^L, kx^M, kx^U], k \ge 0$;
Rule 4: $\tilde{\tilde{x}} \times \tilde{\tilde{y}} = [x^L y^L, x^M y^M, x^U y^U]$.
Rule 5: If and only if $x^L = y^L$, $x^M = y^M$, $x^U = y^U$, *then* $\tilde{\tilde{x}} = \tilde{\tilde{y}}$.
Rule 6: If and only if $x^L \le y^L$, $x^M \le y^M$, $x^U \le y^U$, *then* $\tilde{\tilde{x}} \le \tilde{\tilde{y}}$.

Then, the specific steps for calculating the possibility degree are as follows:

Step 1: Standardize the established original data decision matrix $\tilde{\tilde{X}}$ into $\tilde{\tilde{R}}$.

In the process of standardization, it is assumed that all the alternative decision-making objects X_i in the utility measurement of each attribute U_j will obtain a matrix $\tilde{\tilde{X}} = (x_{ij})_{n \times m}$ that is composed of the measured values of the attributes of all the initial decision objects; this is called the initial TFN decision matrix. Here, $\tilde{\tilde{x}}_{ij} = [x_{ij}^L, x_{ij}^M, x_{ij}^U]$, where $M = \{1, 2, ..., m\}$, $N = \{1, 2, ..., n\}$. Let $I_j (j = 1, 2)$ denote the subscript set of benefit attributes and cost attributes. It is easy to see that $M = I_1 \cup I_2$. In order to exclude the interference of the dimension and the order of magnitude difference of each indicator in the results, standardization is usually carried out. We adopt the following formulas to standard the initial TFN decision matrix $\tilde{\tilde{X}} = (x_{ij})_{n\times m}$ into $\tilde{\tilde{R}} = (\tilde{\tilde{r}}_{ij})_{n\times m}$ [32].

$$\begin{cases} r_{ij}^{L} = x_{ij}^{L} / \sqrt{\sum\limits_{i=1}^{n} (x_{ij}^{U})^2} \\ r_{ij}^{M} = x_{ij}^{M} / \sqrt{\sum\limits_{i=1}^{n} (x_{ij}^{M})^2} \\ r_{ij}^{U} = x_{ij}^{U} / \sqrt{\sum\limits_{i=1}^{n} (x_{ij}^{L})^2} \end{cases}, i \in N, j \in I_1, \tag{1}$$

$$\begin{cases} r_{ij}^{L} = (1/x_{ij}^{U}) / \sqrt{\sum\limits_{i=1}^{n} (1/x_{ij}^{L})^2} \\ r_{ij}^{M} = (1/x_{ij}^{M}) / \sqrt{\sum\limits_{i=1}^{n} (1/x_{ij}^{M})^2} \\ r_{ij}^{U} = (1/x_{ij}^{L}) / \sqrt{\sum\limits_{i=1}^{n} (1/x_{ij}^{U})^2} \end{cases}, i \in N, j \in I_2. \tag{2}$$

Step 2: Calculate the possibility degree of the indicator value pairwise comparison.

Let $\tilde{\tilde{r}}_{ij} = [r_{ij}^{L}, r_{ij}^{M}, r_{ij}^{U}]$, $\tilde{\tilde{r}}_{ik} = [r_{ik}^{L}, r_{ik}^{M}, r_{ik}^{U}]$ be any two TFNs at the same time or let one of them be a TFN; then, the possibility degree [10] can be expressed as follows:

$$\begin{array}{c} p(\tilde{\tilde{r}}_{ij} \geq \tilde{\tilde{r}}_{ik}) = \lambda\left(max(r_{ij}^{U} - r_{ik}^{M}, 0) - max(r_{ij}^{M} - r_{ik}^{U}, 0)\right) / \left(l_{\tilde{\tilde{r}}ij}^{(1)} + l_{\tilde{\tilde{r}}ik}^{(1)}\right) + \\ (1-\lambda)\left(max(r_{ij}^{M} - r_{ik}^{L}, 0) - max(r_{ij}^{L} - r_{ik}^{M}, 0)\right) / \left(l_{\tilde{\tilde{r}}ij}^{(2)} + l_{\tilde{\tilde{r}}ik}^{(2)}\right) \end{array}, \tag{3}$$

where $l_{\tilde{\tilde{r}}_{ij}}^{(1)} = r_{ij}^{U} - r_{ij}^{M}$, $l_{\tilde{\tilde{r}}_{ik}}^{(1)} = r_{ik}^{U} - r_{ik}^{M}$, $l_{\tilde{\tilde{r}}_{ij}}^{(2)} = r_{ij}^{M} - r_{ij}^{L}$, $l_{\tilde{\tilde{r}}_{ik}}^{(2)} = r_{ik}^{M} - r_{ik}^{L}$.

Similarly,

$$\begin{array}{c} p(\tilde{\tilde{r}}_{ik} \geq \tilde{\tilde{r}}_{ij}) = \lambda\left(max(r_{ik}^{U} - r_{ij}^{M}, 0) - max(r_{ik}^{M} - r_{ij}^{U}, 0)\right) / \left(l_{\tilde{\tilde{r}}ij}^{(1)} + l_{\tilde{\tilde{r}}ik}^{(1)}\right) + \\ (1-\lambda)\left(max(r_{ik}^{M} - r_{ij}^{L}, 0) - max(r_{ik}^{L} - r_{ij}^{M}, 0)\right) / \left(l_{\tilde{\tilde{r}}ij}^{(2)} + l_{\tilde{\tilde{r}}ik}^{(2)}\right) \end{array}, \tag{4}$$

where $l_{\tilde{\tilde{r}}_{ij}}^{(1)} = r_{ij}^{U} - r_{ij}^{M}$, $l_{\tilde{\tilde{r}}_{ik}}^{(1)} = r_{ik}^{U} - r_{ik}^{M}$, $l_{\tilde{\tilde{r}}_{ij}}^{(2)} = r_{ij}^{M} - r_{ij}^{L}$, $l_{\tilde{\tilde{r}}_{ik}}^{(2)} = r_{ik}^{M} - r_{ik}^{L}$.

Note 1 The choice of λ value depends on the risk attitude of the decision-maker [33]: when $\lambda > 0.5$, the decision-maker is said to be inclined to risk preference; when $\lambda = 0.5$, the decision-maker is said to be risk neutral; when $\lambda < 0.5$, the decision-maker is said to be risk averse. In particular, when $\lambda = 1$, $p(\tilde{\tilde{r}}_{ij} \geq \tilde{\tilde{r}}_{ik})$ is called the optimistic probability of $\tilde{\tilde{r}}_{ij} \geq \tilde{\tilde{r}}_{ik}$; when $\lambda = 0$, $p(\tilde{\tilde{r}}_{ij} \geq \tilde{\tilde{r}}_{ik})$ is called the pessimistic probability of $\tilde{\tilde{r}}_{ij} \geq \tilde{\tilde{r}}_{ik}$.

Step 3: Construct the TFN-DMOPDRM model [32].

$$\max F(W) = \sum_{j=1}^{m} p(u_j) \cdot w_j = \sum_{j=1}^{m} \sum_{k=1,k\neq j}^{m} \sum_{i=1}^{n} p(\tilde{\tilde{r}}_{ij} \geq \tilde{\tilde{r}}_{ik}) \cdot w_j s.t. \sum_{j=1}^{m} {w_j}^2 = 1, w_j \geq 0, i \in N, k, j \in M \tag{5}$$

Step 4: By solving the above linear programming model in Equation (5), it is easy to calculate the indicator weight vector $W = (w_1, w_2, \ldots, w_m)$, as follows:

$$w_j = \frac{\sum\limits_{k=1,k\neq j}^{m} \sum\limits_{i=1}^{n} p(\tilde{\tilde{r}}_{ij} \geq \tilde{\tilde{r}}_{ik})}{\sum\limits_{j=1}^{m} \sum\limits_{k=1,k\neq j}^{m} \sum\limits_{i=1}^{n} p(\tilde{\tilde{r}}_{ij} \geq \tilde{\tilde{r}}_{ik})}, \ i \in N, k, j \in M. \tag{6}$$

2.2. Phase II: TFN-TOPSIS Model

TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) was first proposed by C.L. Hwang and K. Yoon in 1981 [34]. It is an evaluation method that ranks each evaluation object according to its proximity to the ideal target, and is suitable for the optimization problem of a limited number of evaluation objects. The theoretical core of the TOPSIS method is to set two idealized theoretical objectives, the optimal ideal objective and the worst ideal objective, and select the evaluation object that is closest to the optimal ideal objective and farthest from the worst ideal objective as the optimal one. According to the literature [35], this paper proposes the TFN-TOPSIS method based on the possibility degree relation model, which is a calculation method that uses the weight calculated by the possibility degree relation model to find the subsequent TOPSIS model.

The specific steps are as follows:

Step 1: Construct a normalized weighted decision matrix.

The normalized data processed by Formulas (1) and (2) are combined with the indicator weight obtained by Formula (5) to construct a normalized weighted decision matrix.

$$\tilde{\tilde{R}}(W) = (\tilde{\tilde{r}}_{ij} \cdot w_j)n \times m = \begin{bmatrix} [w_1 r_{11}^L, w_1 r_{11}^M, w_1 r_{11}^U] & [w_2 r_{12}^L, w_2 r_{12}^M, w_2 r_{12}^U] & \cdots & [w_m r_{1m}^L, w_m r_{1m}^M, w_m r_{1m}^U] \\ [w_1 r_{21}^L, w_1 r_{21}^M, w_1 r_{21}^U] & [w_2 r_{22}^L, w_2 r_{22}^M, w_2 r_{22}^U] & \cdots & [w_m r_{2m}^L, w_m r_{2m}^M, w_m r_{2m}^U] \\ \cdots & \cdots & \ddots & \vdots \\ [w_1 r_{n1}^L, w_1 r_{n1}^M, w_1 r_{n1}^U] & [w_2 r_{n2}^L, w_2 r_{n2}^M, w_2 r_{n2}^U] & \cdots & [w_m r_{nm}^L, w_m r_{nm}^M, w_m r_{nm}^U] \end{bmatrix},$$

where

$$w_j = \frac{\sum\limits_{k=1,k\neq j}^{m} \sum\limits_{i=1}^{n} p(\tilde{\tilde{r}}_{ij} \geq \tilde{\tilde{r}}_{ik})}{\sum\limits_{j=1}^{m} \sum\limits_{k=1,k\neq j}^{m} \sum\limits_{i=1}^{n} p(\tilde{\tilde{r}}_{ij} \geq \tilde{\tilde{r}}_{ik})}. \tag{7}$$

Step 2: Determine the ideal solution.

Define each indicator, that is, the maximum value of each column as a positive ideal solution:

$$\tilde{\tilde{f}}_j^{+} = \left[f_j^{L+}, f_j^{M+}, f_j^{U+}\right] = \left[\max_{1\leq i\leq n} w_j r_{ij}^L, \max_{1\leq i\leq n} w_j r_{ij}^M, \max_{1\leq i\leq n} w_j r_{ij}^U\right], \ j \in M. \tag{8}$$

Define the minimum value of each column as a negative ideal solution:

$$\tilde{\tilde{f}}_j^{-} = \left[f_j^{L-}, f_j^{M-}, f_j^{U-}\right] = \left[\min_{1\leq i\leq n} w_j r_{ij}^L, \min_{1\leq i\leq n} w_j r_{ij}^M, \min_{1\leq i\leq n} w_j r_{ij}^U\right], \ j \in M. \tag{9}$$

Step 3: Compute the distance of each solution to the positive (negative) ideal solution.

Define the distance between the ith object and the maximum distance as a positive ideal solution:

$$d_i^+ = \sqrt{\sum_{j=1}^{m} \left[(f_j^{L+} - w_j r_{ij}^L)^2 + (f_j^{M+} - w_j r_{ij}^M)^2 + (f_j^{U+} - w_j r_{ij}^U)^2\right]}, \ i \in N, j \in M. \tag{10}$$

Define the distance of the ith object from the maximum value as the distance from the negative ideal solution:

$$d_i^- = \sqrt{\sum_{j=1}^{m}\left[(f_j^{L-} - w_j r_{ij}^L)^2 + (f_j^{M-} - w_j r_{ij}^M)^2 + (f_j^{U-} - w_j r_{ij}^U)^2\right]},\ i \in N, j \in M. \quad (11)$$

Step 4: Calculate the closeness degree of each alternative object to the ideal solution.

$$Score_i = \frac{d_i^-}{d_i^+ + d_i^-},\ i \in N. \quad (12)$$

Step 5: The alternatives are ranked according to their relative closeness degree $Score_i$.

3. Evaluation Indicators Affecting Patent Value

Establishing a scientific and reasonable evaluation indicator system is an important part of the evaluation of the patent value of the self-balancing vehicle, and it is also the premise and foundation of the evaluation. The evaluation indicator system of the patent value of the balance car should not only meet the requirements of comprehensiveness and scientificity, but should also follow the relevant theoretical connotation and practical needs, realize the harmonious unity of theory and reality, and ensure the applicability of the evaluation indicator system in practical work.

The evaluation of patent value should consider the impact of technical factors, economic factors and legal factors on the patent value. Therefore, the patent value can be reflected in the technical value, legal value and economic value of the patent. In the existing patent value evaluation indicator system, a large number of evaluation indicators are difficult to calculate or quantify, such as the technological innovation degree and marketization ability, which pose challenges to the quantitative evaluation of patent value. Therefore, based on the patent value evaluation system issued by the State Intellectual Property Office of China 2012, this paper combines the characteristics of high competitiveness, high value and the irreplaceability of core patents, adjusts its evaluation indicators accordingly, and establishes the economic value (market application, number of enterprise patents, sales ratio), technical value (number of inventors [3], number of citations, number of classification numbers [36], Be cited [37]), and legal value (number of claims [37], number of family members [35], number of pages in the description, survival period, license status [38]) of the three-dimensional evaluation system.

Patents include inventions, utility models and designs. Except for designs, both inventions and utility models require technical innovations or improvements. The technical value of a patent reflects the inherent quality value of the patent. The higher the degree of technological innovation is, the better the improvement effect is, and the higher the technical value is. Patent value is specifically reflected in the number of inventors, the number of citations, etc. The more citations, the more content the inventor refers to, the stronger the technical background, and the more secure the content; thus, it can be proven that its technology is widely recognized. In general, the greater the number of claims is, the wider the scope of its technical protection is.

The economic value and legal protection status of patents, as external variables that affect the value of patents, also have a great impact on patents. From an economic point of view, the more market applications, the higher the proportion of sales, and the more patents an enterprise has, the higher the economic benefits of the patent; from the perspective of legal protection, the stability of the legal value of a patent is reflected in whether it is susceptible to infringement or lawsuits; this essentially involves the scope of the protection of a patent, which is limited to the claims, and the number of claims plays a crucial role in its stability. If the legal value of a patent is to be high and the protection scope of a patent is to be as wide as possible, it requires a large number of claims and a large number of family members.

4. Empirical Analysis for Comprehensive Evaluation in the Patent of Self-Balancing Vehicle

4.1. Construction of a Patent Value Evaluation System for Self-Balancing Vehicles

Based on the above analysis, we have established the core patent value evaluation system, which sets the core patent value evaluation as the target layer A, the legal, economic and technical value as the system layer B, and the specific patent value evaluation index as the indicator layer C [38], as shown in the following Table 1:

Table 1. Core Patent Value Evaluation System [1].

First-Level Indicator A	Secondary Indicator B	Third-Level Indicator C
Patent Value A_1	Economic Value B_1	Market application C_1 Enterprise patents C_2 Sales ratio C_3
	Technical Value B_2	Number of inventors C_4 Citations C_5 Number of classification numbers C_6 Be cited C_7
	Legal Value B_3	Number of claims C_8 Number of siblings C_9 Manual pages C_{10} Survival period C_{11} License status C_{12}

4.2. TFN-TOPSIS Model Based on Possibility Degree Relation Model

4.2.1. Data Sources

The empirical case data in this paper come from the patent search websites Dawei, Baiteng and Huajing Intelligence Network. Appendix A Table A1 shows the top 20 patents and their related indicators in the patent search website for the comprehensive evaluation of domestic self-balancing vehicle patents.

4.2.2. Data Normalization

In decision analysis, due to the complexity of objective things and the finiteness and fuzziness of people's cognition, it is often difficult to accurately determine the parameters related to decision-making; therefore, it is closer to reality to use TFNs to describe problems [39]. Therefore, standardization is carried out according to Table 3 and Appendix A Table A1 in order to obtain the triangular fuzzy matrix shown in Appendix A Table A2. Then, the Appendix A Table A3 can be obtained by Formulas (1) and (2) to normalize the data, since the three-level indicators are all benefit indicators.

4.2.3. Determine Criteria Weights

Take $\lambda = 0.5$ and calculate the possibility degree between the indicators. Then, the weight of each indicator is determined by Formulas (3)~(6), as shown in Table 2.

Table 2. Weight calculation result.

ω_1	ω_2	ω_3	ω_4	ω_5	ω_6	ω_7	ω_8	ω_9	ω_{10}	ω_{11}	ω_{12}
0.0670	0.0905	0.0879	0.0810	0.0751	0.0712	0.0797	0.0732	0.0879	0.0922	0.0977	0.0964

Table 3. Patent value score table.

Attribute	(1,1,1)	(1,2,3)	(2,3,4)	(3,4,5)	(4,5,6)
Market application	Not applied, difficult to apply		Not applied, easy to apply		Applied
Proportion of patents	Rare	Less	General	Many	More
Sales ratio	Very small	Small	General	Large	Very Large
Number of inventors	1	2	3	4	5 people and above
Number of IPCs	1	2	3	4	Category 5 and above
Citations	0–5	6–10	11–20	20–30	30 and above
Be cited	0–10	11–20	21–30	31–40	40 and above
Number of weights	1–10	11–20	21–30	31–40	40 and above
Number of siblings	Domestic only		2–10		10 or more
Manual pages	1–7	8–14	15–21	22–28	28 pages or more
Survival period	within 3 years	4–7 years	8–11 years	12–15 years	16+ years
License status		No license		Licensed	

4.2.4. Evaluation Based on the TFN-TOPSIS Model

The normalized weighted decision matrix is shown in Appendix A Table A4. According to Formulas (8) and (9), the positive and negative ideal solutions of each indicator are specified, as shown in Table 4 below.

Table 4. Positive and negative ideal solutions.

$\tilde{\tilde{f}}_j^+$	(0.0192, 0.0301, 0.0477)	(0.0139, 0.0282, 0.0566)	(0.0152, 0.0267, 0.0480)	(0.0176, 0.0309, 0.0551)	(0.0322, 0.0502,0.076)	(0.0184, 0.0292, 0.0469)	(0.0275, 0.0457, 0.0776)	(0.0217, 0.0346, 0.0558)	(0.0163, 0.0250, 0.0385)	(0.0194, 0.0311, 0.0511)	(0.0190, 0.0348, 0.0684)	(0.0165, 0.0291, 0.0526)
$\tilde{\tilde{f}}_j^-$	(0.0048, 0.0060, 0.0080)	(0.0070, 0.0094, 0.0141)	(0.0051, 0.0067, 0.0096)	(0.0059, 0.0077, 0.0110)	(0.0080, 0.0100, 0.0127)	(0.0046, 0.0058, 0.0078)	(0.0069, 0.0091, 0.0129)	(0.0054, 0.0069, 0.0093)	(0.0041, 0.0050, 0.0064)	(0.0049, 0.0062, 0.0085)	(0.0063, 0.0087, 0.0137)	(0.0055, 0.0145, 0.0316)

Then, calculate the distance of each patent relative to the positive and negative ideal points by Formulas (10) and (11), as shown in Table 5.

Table 5. (1) The distance of each patent relative to the positive ideal solution. (2) The distance of each patent relative to the negative ideal solution.

(1)									
X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}
0.1412	0.1456	0.1265	0.1288	0.1356	0.1270	0.1440	0.1606	0.1304	0.1496
X_{11}	X_{12}	X_{13}	X_{14}	X_{15}	X_{16}	X_{17}	X_{18}	X_{19}	X_{20}
0.1154	0.1199	0.1355	0.1552	0.1328	0.1348	0.1383	0.1587	0.1354	0.1443
(2)									
X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}
0.0862	0.1025	0.1160	0.0941	0.0947	0.1040	0.0855	0.0765	0.0917	0.0886
X_{11}	X_{12}	X_{13}	X_{14}	X_{15}	X_{16}	X_{17}	X_{18}	X_{19}	X_{20}
0.1019	0.1341	0.1258	0.0742	0.0920	0.0948	0.0856	0.0701	0.0928	0.0981

Finally, the closeness degree of each patent to the ideal point is calculated according to Formula (12), as shown in Table 6.

Table 6. Closeness degree of each patent to the ideal point.

X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}
0.3790	0.4131	0.4784	0.4222	0.4112	0.4502	0.3725	0.3226	0.4130	0.3720
X_{11}	X_{12}	X_{13}	X_{14}	X_{15}	X_{16}	X_{17}	X_{18}	X_{19}	X_{20}
0.4689	0.5280	0.4814	0.3235	0.4092	0.4127	0.3823	0.3063	0.4067	0.4048

According to the closeness degree, one can pick and sort the set of alternative decision-making objects {X_i | i = 1, 2, . . . ,20} in descending order. The result is

$$X12 \succ X13 \succ X3 \succ X11 \succ X6 \succ X4 \succ X2 \succ X9 \succ X16 \succ X5 \succ X15 \succ X19 \succ X20 \succ X17 \succ X1 \succ X7 \succ X10 \succ X14 \succ X8 \succ X18,$$

and, therefore, X_{12} has the highest value.

4.2.5. Sensitivity Analysis

Then, we performed sensitivity analysis on λ, increasing λ from 0.1 to 0.9, increasing 0.1 each time (This paper excludes two extreme cases of λ = 0 and 1). The results are shown in Table 7.

Table 7. Sensitivity analysis of λ.

λ	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}
0.1	0.3730	0.4344	0.4694	0.4180	0.4022	0.4387	0.3636	0.3153	0.4125	0.3552
0.2	0.3341	0.4508	0.3733	0.4089	0.3845	0.4518	0.3524	0.3226	0.4058	0.3766
0.3	0.3364	0.4436	0.3824	0.4081	0.3874	0.4541	0.3529	0.3221	0.4050	0.3797
0.4	0.3412	0.4365	0.3975	0.4393	0.4051	0.4776	0.3962	0.3672	0.4459	0.3896
0.5	0.3790	0.4131	0.4784	0.4222	0.4112	0.4502	0.3725	0.3226	0.4130	0.3720
0.6	0.3531	0.4313	0.4066	0.4478	0.4135	0.4820	0.3987	0.3642	0.4477	0.4085
0.7	0.4040	0.3855	0.3911	0.4781	0.4543	0.4961	0.4435	0.4074	0.4573	0.4086
0.8	0.3848	0.3756	0.3840	0.4989	0.4860	0.5106	0.4022	0.3724	0.4173	0.4415
0.9	0.4094	0.3650	0.4035	0.4546	0.4437	0.4594	0.4249	0.3846	0.4365	0.3664
λ	X_{11}	X_{12}	X_{13}	X_{14}	X_{15}	X_{16}	X_{17}	X_{18}	X_{19}	X_{20}
0.1	0.4564	0.5112	0.4669	0.3181	0.3932	0.3983	0.3674	0.2933	0.3950	0.3968
0.2	0.4746	0.5321	0.5191	0.3464	0.4261	0.4449	0.4093	0.3166	0.4162	0.4482
0.3	0.4746	0.5337	0.5191	0.3470	0.4251	0.4415	0.4070	0.3178	0.4180	0.4447
0.4	0.5012	0.5518	0.5368	0.3436	0.4565	0.4761	0.4334	0.3429	0.4369	0.4688
0.5	0.4689	0.5280	0.4814	0.3235	0.4092	0.4127	0.3823	0.3063	0.4067	0.4048
0.6	0.5235	0.5537	0.5335	0.3465	0.4625	0.4913	0.4498	0.3603	0.4602	0.4824
0.7	0.5169	0.5416	0.5155	0.3541	0.4730	0.4855	0.4673	0.3739	0.4706	0.4993
0.8	0.5139	0.5624	0.4344	0.4257	0.4144	0.4155	0.4112	0.3399	0.4927	0.5039
0.9	0.4678	0.4844	0.4468	0.3528	0.4389	0.4392	0.4378	0.3510	0.4354	0.4594

To avoid a cluttered image, we select λ = 0.1, 0.3, 0.5, 0.7 and 0.9, respectively, for further analysis; the sorting results are shown in Table 8. In Figure 3, the abscissa represents the first 20 balance vehicle patents; the ordinate represents their respective closeness degree. It can be seen from Figure 3 that the trend in the five curves is roughly the same; in other words, X_{12} (CN201180011306.1-Apparatus and method for vehicle control) performs the best, which is consistent with the conclusion of this paper. This verifies the feasibility of the model proposed in this paper.

Table 8. Sorting results.

λ	Sorting Results
0.1	$X12 \succ X3 \succ X13 \succ X11 \succ X6 \succ X2 \succ X4 \succ X9 \succ X5 \succ X16 \succ X20 \succ X19 \succ X15 \succ X1 \succ X17 \succ X7 \succ X10 \succ X14 \succ X8 \succ X18$
0.3	$X12 \succ X13 \succ X11 \succ X6 \succ X20 \succ X2 \succ X16 \succ X15 \succ X19 \succ X4 \succ X17 \succ X9 \succ X5 \succ X3 \succ X10 \succ X7 \succ X14 \succ X1 \succ X8 \succ X18$
0.5	$X12 \succ X13 \succ X3 \succ X11 \succ X6 \succ X4 \succ X2 \succ X9 \succ X16 \succ X5 \succ X15 \succ X19 \succ X20 \succ X17 \succ X1 \succ X7 \succ X10 \succ X14 \succ X8 \succ X18$
0.7	$X12 \succ X11 \succ X13 \succ X20 \succ X6 \succ X16 \succ X4 \succ X15 \succ X19 \succ X17 \succ X9 \succ X5 \succ X7 \succ X10 \succ X8 \succ X1 \succ X3 \succ X2 \succ X18 \succ X14$
0.9	$X12 \succ X11 \succ X20 \succ X6 \succ X4 \succ X13 \succ X5 \succ X16 \succ X15 \succ X17 \succ X9 \succ X19 \succ X7 \succ X1 \succ X3 \succ X10 \succ X8 \succ X2 \succ X14 \succ X18$

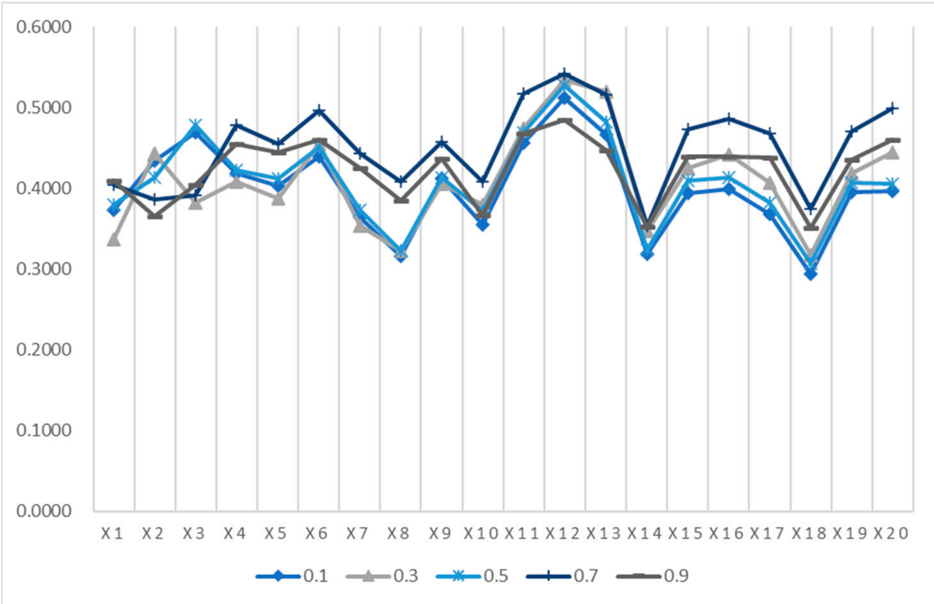

Figure 3. Sensitivity analysis diagram of λ.

4.2.6. Comparison Analysis

In addition, we adopt the triangular fuzzy number-based decision-making object maximizing deviation programming model (TFN-DMOMDPM), as in [40], and the triangular fuzzy number-based decision-making object relative similarity programming model (TFN-DMORSPM), as in [41], to make a comparative analysis of the patent value evaluation of the self-balance vehicle. In addition, the attribute weight measurement formulas based on the TFN-DMOMDPM and TFN-DMORSPM algorithm are as follows:

(1) Calculate the attribute weight measurement formulas based on TFN-DMOMDPM.

$$w_j = \frac{\sum_{i=1}^{n}\sum_{k=1}^{n} d_{TFN}(\widetilde{\widetilde{r}}_{ij}, \widetilde{\widetilde{r}}_{kj})}{\sum_{j=1}^{m}\sum_{i=1}^{n}\sum_{k=1}^{n} d_{TFN}(\widetilde{\widetilde{r}}_{ij}, \widetilde{\widetilde{r}}_{kj})}, i,k \in N, j \in M. \quad (13)$$

(2) Calculate the attribute weight measurement formulas based on TFN-DMORSPM.

$$w_j = \frac{1/\sum_{i=1}^{n}\sum_{k=1,k\neq i}^{n} rs_{TFN}(\widetilde{\widetilde{r}}_{ij}, \widetilde{\widetilde{r}}_{kj})}{\sum_{j=1}^{m}\left(1/\sum_{i=1}^{n}\sum_{k=1,k\neq i}^{n} rs_{TFN}(\widetilde{\widetilde{r}}_{ij}, \widetilde{\widetilde{r}}_{kj})\right)}, i,k \in N, j \in M \quad (14)$$

According to the implementation steps of the multi-attribute decision-making algorithm of TFN-DMOMDPM and TFN-DMORSPM, the following results can be obtained:

(1) The result of the implementation based on TFN-DMOMDPM is

$$X12 \succ X3 \succ X2 \succ X11 \succ X13 \succ X6 \succ X5 \succ X4 \succ X1 \succ X20 \succ X19 \succ X9 \succ X15 \succ X16 \succ X7 \succ X14 \succ X17 \succ X10 \succ X8 \succ X18 \quad (15)$$

(2) The result of the implementation based on TFN-DMORSPM is

$$X3 \succ X2 \succ X4 \succ X11 \succ X5 \succ X1 \succ X6 \succ X12 \succ X9 \succ X7 \succ X20 \succ X19 \succ X13 \succ X15 \succ X8 \succ X14 \succ X16 \succ X10 \succ X17 \succ X18 \quad (16)$$

According to the above results, it is easy to draw the geometrical comparison diagrams of the closeness degree of the TFN-TOPSIS model given in this paper with the TFN-DMOMDPM and TFN-DMORSPM proposed in [40,41], as shown in Figure 4.

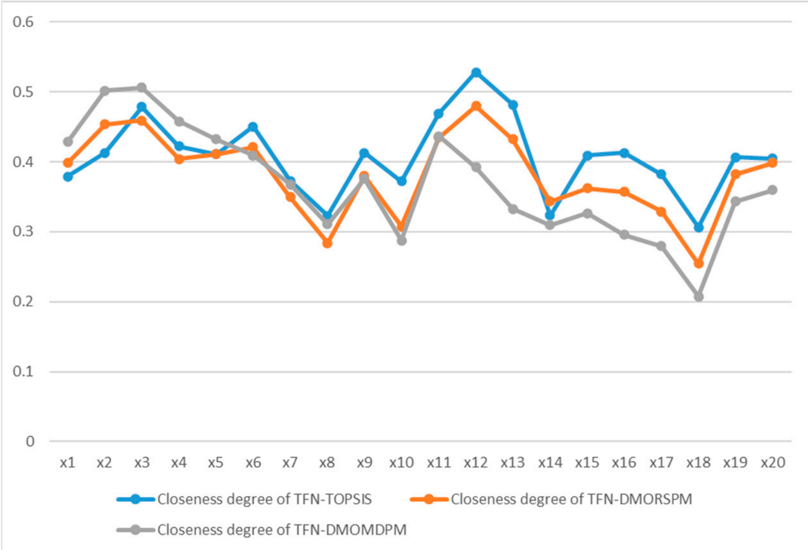

Figure 4. Geometrical comparison of closeness degree of TFN-TOPSIS, closeness degree of TFN-DMORSPM and closeness degree of TFN-DMOMDPM.

From Figure 4 above, we can see that the overall trend in the three curves is relatively similar, among which the trend in TFN-TOPSIS and TFN-DMORSPM are the most consistent, both better than the TFN-DMOMDPM curve. This is because the d_{TFN} in Formula (13) represents the deviation degree of the sum of the absolute values of the small, medium and large elements in the TFNs; this causes the accumulation of lots of errors. There are also subtle differences between the first two curves, which are caused by two factors: first, the number of patents in this paper is relatively large, up to 20; second, there are slight differences in the ranking results due to different calculation weight formulas, but X_{12} (CN201180011306.1-Apparatus and method for vehicle control) is considered to be the most valuable patent relative to TFN-TOPSIS and TFN-DMORSPM, which is consistent with the conclusion of this paper. Therefore, this further reflects the stability, rationality and scientificity of TFN-TOPSIS and TFN-DMORSPM, thus verifying the feasibility of the TFN-TOPSIS model proposed in this paper.

4.3. Analysis and Recommendations

The 20 self-balancing vehicle patents are visualized according to the calculated closeness degree, as shown in Figure 5 below. It can be seen that X_{12} (CN201180011306.1-Apparatus and method for vehicle control) performs the best and is significantly superior to other patents. These high-value patents belong to Segway Co., Ltd. (New Hampshire in America), and among the 20 high-value self-balance vehicle patents, the main brands are Segway, Hangzhou Chike, Xiaomi, and Ninebot. Since Ninebot received investment from Xiaomi and acquired Segway in April 2015, Segway's products and patents currently belong to Ninebot, and Xiaomi's balance car products are mainly manufactured by Ninebot; therefore, the three patent holders can be regarded as one.

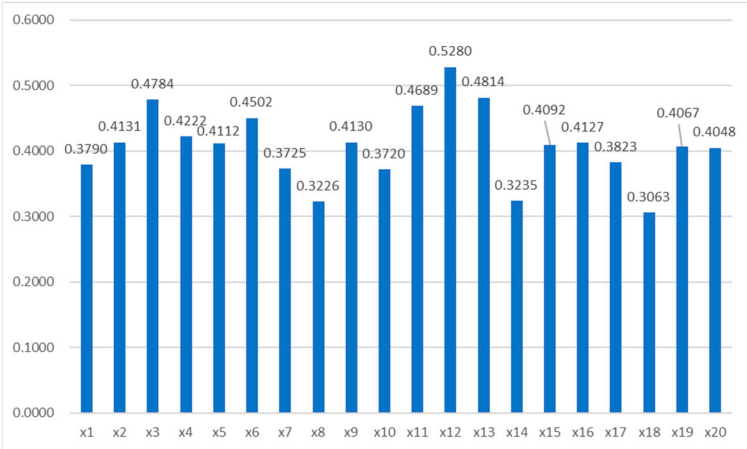

Figure 5. Closeness degree of 20 patents on the basis of calculating the indicators weight.

As can be seen from Figure 6, among the 12 patent evaluation indicators, the weight ranking values of enterprise patents, be cited, and survival period are relatively high, and they are the highest among economic value, technical value and legal value, respectively, which can better reflect the economic, technical and legal value of patents.

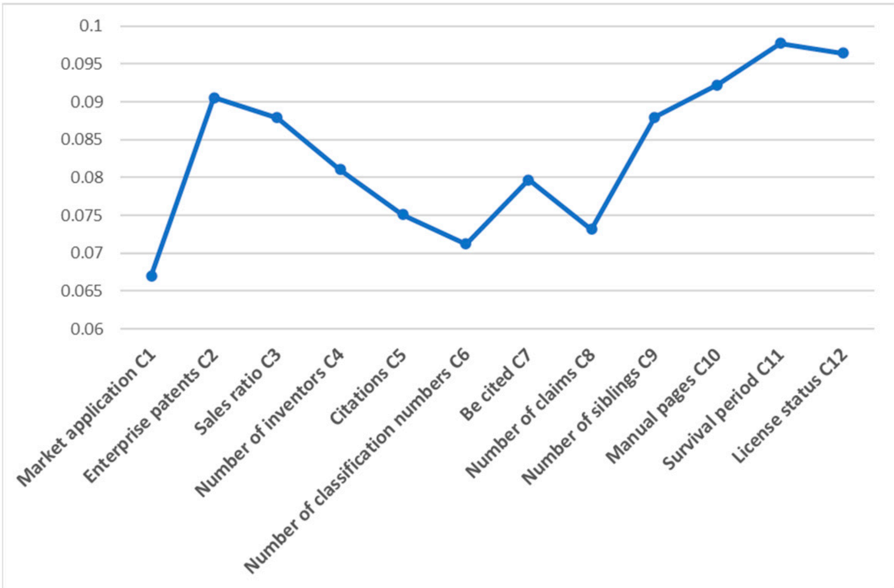

Figure 6. Weight of each indicator.

From Figure 7 below, we can know that technical value and legal value are more important. Technological innovation and an improvement in patents are the most important indicators that affect the value of patents. Legal indicators provide a protective environment for patents, fully maintain their intellectual achievements, and ensure legal protection, while ensuring the technical value and good basic conditions.

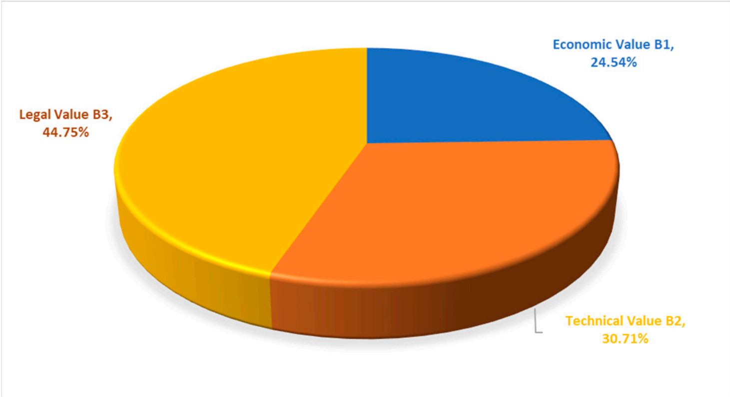

Figure 7. The proportion of economic, technological and legal weights.

Based on the above analysis, in order to better carry out the patent layout and industry development of self-balancing vehicles, the following suggestions are put forward:

(1) From the technical point of view of self-balancing vehicle products, improving product design and improving the safety performance of self-balancing vehicle products mainly depends on the technical content of the product design. At present, domestic enterprises need to actively improve unreasonable control technology to improve current product defects, in order to break down technical barriers from other countries. The fact that the self-balancing vehicle is restricted from entering the road is ultimately due to the unreasonable design of its control system, which will cause harm to the human body when driving. China's self-balancing vehicle enterprises must speed up the improvement in the control system design, develop and promote new technologies, and improve the safety performance of the self-balancing vehicle.

(2) From the perspective of the economic market of the self-balancing vehicle industry, the patent layout of the self-balancing vehicle control technology is mainly concentrated in China, Japan and the United States. The United States and Japan have strong research and development strength. When China's self-balancing vehicle products enter the Japanese and American markets, it is necessary to pay attention to preventing related technical risks.

(3) Considering the relevant legal system, the introduction of national standards should be promoted and the healthy development of the industry should be ensured. The formulation of national standards can create a benign and standardized industrial development environment. Only in this way can a virtuous cycle of technology research and development, and the healthy development of the industry, be promoted.

5. Conclusions

Innovation is the primary driving force of development, and patents are the main representatives of scientific and technological innovation. The evaluation of their value helps to designate scientific and technological decisions, promote the transformation of scientific and technological achievements, and adjust the strategic layout of science and technology. This study also has certain practical significance: it provides a fuzzy decision-making framework for the evaluation of the patent value of balanced vehicles. For example, enterprise R&D personnel can use this model to analyze the level of patent value in order to determine the future research direction.

In this paper, the TFN-TOPSIS model is established, combined with the patent value evaluation system, in order to evaluate the domestic self-balancing vehicle patents. The indicator system is established from the three dimensions of economy, technology and law, the weight of each refinement standard is calculated according to the possibility degree, and 20 outstanding patents are comprehensively evaluated. Then, the core patents of the self-balancing vehicle industry are screened out, and some targeted suggestions are put forward, which are very beneficial to an improvement in the current situation and the future development of the Chinese self-balancing vehicle industry. At the same time, the research content of this paper provides a reference for the patent layout of China's self-balancing vehicle industry, which is conducive to promoting the research and creation of the core technology of Chinese self-balancing vehicles.

In the study that will follow, we may consider using a linguistic decision model and distance measurement method in a spherical fuzzy environment to estimate the patent value of self-balancing vehicles, so as to obtain more scientific and accurate conclusions. At the same time, other distance measurement methods, such as fuzzy EDAS, ARAS, MARCOS, SPOTIS and COMET and their applications, are also one of our research ideas.

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Data Availability Statement: The top 20 patents and their related attributes in the comprehensive evaluation of domestic self-balancing vehicle patents shown in Table 3 of this paper come from the Chinese patent search websites Dawei, Baiteng and Huajing Intelligent Network.

Conflicts of Interest: The authors declare that there are no conflict of interest regarding the publication of this paper.

Appendix A

Table A1. Original Attribute Data Matrix of Balance Vehicle Patents.

	Application Number and Name	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}
X_1	CN201510607441.2 Electric balance torsion car	transfer	56	1.80%	1	0	2	12	9	61	9	7	
X_2	CN201520864881.1 Electric balance car	transfer	56	1.80%	1	0	2	0	10	0	9	0	
X_3	CN201410262108.8 Electric balance torsion car		143	2.50%	2	36	1	81	10	61	6	8	
X_4	CN201510324294.8 An improved electric balance car	transfer	143	2.50%	1	9	1	16	10	74	17	7	transfer
X_5	CN201510328631.0 New electric balance car	transfer	143	2.50%	1	10	4	12	9	74	9	6	transfer
X_6	CN201810180450.1 Electric balance car and its supporting cover, starting method and turning method	transfer	143	2.50%	2	0	3	3	29	74	20	8	transfer
X_7	CN201510324381.3 Electric balance car		143	2.50%	1	3	3	12	10	61	15	7	
X_8	CN201510324580.4 Electric balance car		143	2.50%	1	2	1	9	9	73	16	6	
X_9	CN201611222975.4 A human–machine interactive somatosensory vehicle and its control method and device		143	2.50%	2	1	2	5	23	65	20	6	
X_{10}	CN201210421265.X A dual-wheel self-balancing vehicle control system and dual-wheel self-balancing vehicle	transfer	32	8.60%	3	2	2	16	10	1	19	10	transfer
X_{11}	CN200980151327.6 Apparatus and method for control of a dynamically self-balancing vehicle		6	8.60%	4	8	10	14	69	10	59	13	
X_{12}	CN201180011306.1 Apparatus and method for vehicle control		6	8.60%	4	5	4	6	46	21	40	12	
X_{13}	CN201810005593.9 Human–computer interaction somatosensory vehicle and its supporting frame		17	0.01%	1	0	1	0	10	0	8	7	

Table A1. *Cont.*

	Application Number and Name	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}
X_{14}	CN201710206692.9 A kind of balance car and its control method	transfer	2	0.03%	1	0	6	4	13	4	12	5	transfer
X_{15}	CN201510627152.9 Control method and device for balance car		27	8.60%	3	3	1	24	15	8	23	7	
X_{16}	CN201510363955.8 Control method and device for balance car		27	8.60%	3	3	1	12	27	8	35	5	
X_{17}	CN201510626948.2 Control method and device for two-wheeled balance car		27	8.60%	3	2	1	14	13	8	22	7	
X_{18}	CN201810180448.4 Electric balance car and its supporting cover, body and rotating mechanism	transfer	15	2.50%	2	0	3	0	25	73	19	8	transfer
X_{19}	CN201810005593.9 Human–computer interaction somatosensory vehicle and its supporting frame	transfer	15	2.50%	2	1	5	2	15	65	39	5	transfer
X_{20}	CN201810005593.9 Human–computer interaction somatosensory vehicle and its supporting frame	Applicated	15	2.50%	2	1	5	2	15	65	39	5	transfer

Table A2. Transformation of TFNs.

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}
X_1	(4,5,6)	(1,2,3)	(1,2,3)	(1,1,1)	(1,1,1)	(1,2,3)	(1,2,3)	(1,1,1)	(4,5,6)	(1,2,3)	(1,2,3)	(1,2,3)
X_2	(4,5,6)	(1,2,3)	(1,2,3)	(1,1,1)	(4,5,6)	(1,2,3)	(1,1,1)	(1,1,1)	(1,1,1)	(1,2,3)	(1,1,1)	(1,2,3)
X_3	(1,1,1)	(2,3,4)	(1,2,3)	(1,2,3)	(1,2,3)	(1,1,1)	(4,5,6)	(1,1,1)	(4,5,6)	(1,1,1)	(2,3,4)	(1,2,3)
X_4	(2,3,4)	(2,3,4)	(1,2,3)	(1,1,1)	(1,2,3)	(1,1,1)	(1,2,3)	(1,1,1)	(4,5,6)	(2,3,4)	(1,2,3)	(3,4,5)
X_5	(2,3,4)	(2,3,4)	(1,2,3)	(1,1,1)	(1,1,1)	(3,4,5)	(1,2,3)	(1,1,1)	(4,5,6)	(1,2,3)	(1,2,3)	(3,4,5)
X_6	(2,3,4)	(2,3,4)	(1,2,3)	(1,2,3)	(1,1,1)	(2,3,4)	(1,1,1)	(2,3,4)	(4,5,6)	(2,3,4)	(2,3,4)	(3,4,5)
X_7	(1,1,1)	(2,3,4)	(1,2,3)	(1,1,1)	(1,1,1)	(2,3,4)	(1,2,3)	(1,1,1)	(4,5,6)	(2,3,4)	(1,2,3)	(1,2,3)
X_8	(1,1,1)	(2,3,4)	(1,2,3)	(1,1,1)	(1,1,1)	(1,1,1)	(1,1,1)	(1,1,1)	(4,5,6)	(2,3,4)	(1,2,3)	(1,2,3)
X_9	(1,1,1)	(2,3,4)	(1,2,3)	(1,2,3)	(1,2,3)	(1,2,3)	(1,1,1)	(2,3,4)	(4,5,6)	(2,3,4)	(1,2,3)	(1,2,3)
X_{10}	(1,1,1)	(1,2,3)	(3,4,5)	(2,3,4)	(1,1,1)	(1,1,1)	(1,1,1)	(1,1,1)	(2,3,4)	(1,2,3)	(2,3,4)	(3,4,5)
X_{11}	(2,3,4)	(1,2,3)	(3,4,5)	(2,3,4)	(1,2,3)	(1,2,3)	(1,2,3)	(1,1,1)	(1,1,1)	(2,3,4)	(2,3,4)	(3,4,5)
X_{12}	(1,1,1)	(1,1,1)	(3,4,5)	(3,4,5)	(1,1,1)	(3,4,5)	(1,2,3)	(4,5,6)	(4,5,6)	(4,5,6)	(3,4,5)	(1,2,3)
X_{13}	(1,1,1)	(1,1,1)	(3,4,5)	(3,4,5)	(1,1,1)	(3,4,5)	(1,1,1)	(4,5,6)	(1,2,3)	(4,5,6)	(3,4,5)	(1,2,3)
X_{14}	(2,3,4)	(1,1,1)	(1,1,1)	(1,1,1)	(1,1,1)	(4,5,6)	(1,1,1)	(1,2,3)	(1,2,3)	(1,2,3)	(1,2,3)	(3,4,5)
X_{15}	(1,1,1)	(1,1.5,2)	(3,4,5)	(2,3,4)	(1,1,1)	(1,1,1)	(2,3,4)	(1,2,3)	(1,2,3)	(3,4,5)	(1,2,3)	(1,2,3)
X_{16}	(1,1,1)	(1,1.5,2)	(3,4,5)	(2,3,4)	(1,1,1)	(1,1,1)	(1,2,3)	(2,3,4)	(1,2,3)	(4,5,6)	(1,2,3)	(1,2,3)
X_{17}	(1,1,1)	(1,1.5,2)	(3,4,5)	(2,3,4)	(1,1,1)	(1,1,1)	(1,2,3)	(1,2,3)	(1,2,3)	(3,4,5)	(1,2,3)	(1,2,3)
X_{18}	(1,1,1)	(1,1.5,2)	(3,4,5)	(2,3,4)	(1,1,1)	(1,1,1)	(1,1,1)	(1,1,1)	(1,2,3)	(1,2,3)	(1,2,3)	(1,2,3)
X_{19}	(2,3,4)	(1,1,1)	(1,2,3)	(1,2,3)	(1,1,1)	(2,3,4)	(1,1,1)	(2,3,4)	(4,5,6)	(2,3,4)	(2,3,4)	(3,4,5)
X_{20}	(2,3,4)	(1,1,1)	(1,2,3)	(1,1,1)	(1,1,1)	(4,5,6)	(1,1,1)	(1,2,3)	(4,5,6)	(4,5,6)	(1,2,3)	(3,4,5)

Table A3. Normalized matrix.

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}
X_1	(0.286, 0.449, 0.712)	(0.077, 0.207, 0.469)	(0.058, 0.152, 0.327)	(0.073, 0.095, 0.136)	(0.107, 0.134, 0.169)	(0.065, 0.164, 0.329)	(0.086, 0.229, 0.487)	(0.074, 0.094, 0.127)	(0.185, 0.284, 0.438)	(0.053, 0.135, 0.277)	(0.065, 0.178, 0.42)	(0.057, 0.151, 0.327)
X_2	(0.286, 0.449, 0.712)	(0.077, 0.207, 0.469)	(0.058, 0.152, 0.327)	(0.073, 0.095, 0.136)	(0.429, 0.668,1.014)	(0.065, 0.164, 0.329)	(0.086, 0.115, 0.162)	(0.074, 0.094, 0.127)	(0.046, 0.058, 0.073)	(0.053, 0.135, 0.277)	(0.065, 0.089, 0.14)	(0.057, 0.151, 0.327)
X_3	(0.072, 0.09, 0.119)	(0.154, 0.311, 0.625)	(0.058, 0.152, 0.327)	(0.073, 0.191, 0.408)	(0.107, 0.267, 0.507)	(0.065, 0.082, 0.11)	(0.346, 0.115, 0.162)	(0.074, 0.094, 0.127)	(0.185, 0.284, 0.438)	(0.053, 0.067, 0.092)	(0.129, 0.267, 0.56)	(0.057, 0.151, 0.327)
X_4	(0.143, 0.269, 0.475)	(0.154, 0.311, 0.625)	(0.058, 0.152, 0.327)	(0.073, 0.095, 0.136)	(0.107, 0.267, 0.507)	(0.065, 0.082, 0.11)	(0.086, 0.229, 0.487)	(0.074, 0.094, 0.127)	(0.185, 0.284, 0.438)	(0.105, 0.202, 0.37)	(0.065, 0.178, 0.42)	(0.171, 0.302, 0.546)
X_5	(0.143, 0.269, 0.475)	(0.154, 0.311, 0.625)	(0.058, 0.152, 0.327)	(0.073, 0.095, 0.136)	(0.107, 0.134, 0.169)	(0.194, 0.328, 0.549)	(0.086, 0.229, 0.487)	(0.074, 0.094, 0.127)	(0.185, 0.284, 0.438)	(0.053, 0.135, 0.277)	(0.065, 0.178, 0.42)	(0.171, 0.302, 0.546)
X_6	(0.143, 0.269, 0.475)	(0.154, 0.311, 0.625)	(0.058, 0.152, 0.327)	(0.073, 0.191, 0.408)	(0.107, 0.134, 0.169)	(0.129, 0.246, 0.439)	(0.086, 0.115, 0.162)	(0.148, 0.283, 0.508)	(0.185, 0.284, 0.438)	(0.105, 0.202, 0.37)	(0.129, 0.267, 0.56)	(0.171, 0.302, 0.546)
X_7	(0.072, 0.09, 0.119)	(0.154, 0.311, 0.625)	(0.058, 0.152, 0.327)	(0.073, 0.095, 0.136)	(0.107, 0.134, 0.169)	(0.129, 0.246, 0.439)	(0.086, 0.229, 0.487)	(0.074, 0.094, 0.127)	(0.185, 0.284, 0.438)	(0.105, 0.202, 0.37)	(0.065, 0.178, 0.42)	(0.057, 0.151, 0.327)
X_8	(0.072, 0.09, 0.119)	(0.154, 0.311, 0.625)	(0.058, 0.152, 0.327)	(0.073, 0.095, 0.136)	(0.107, 0.134, 0.169)	(0.065, 0.082, 0.11)	(0.086, 0.115, 0.162)	(0.074, 0.094, 0.127)	(0.185, 0.284, 0.438)	(0.105, 0.202, 0.37)	(0.065, 0.178, 0.42)	(0.057, 0.151, 0.327)

Table A3. *Cont.*

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}
X_9	(0.072, 0.09, 0.119)	(0.154, 0.311, 0.625)	(0.058, 0.152, 0.327)	(0.073, 0.191, 0.408)	(0.107, 0.267, 0.507)	(0.065, 0.164, 0.329)	(0.086, 0.115, 0.162)	(0.148, 0.283, 0.508)	(0.185, 0.284, 0.438)	(0.105, 0.202, 0.37)	(0.065, 0.178, 0.42)	(0.057, 0.151, 0.327)
X_{10}	(0.072, 0.09, 0.119)	(0.077, 0.207, 0.469)	(0.173, 0.304, 0.546)	(0.145, 0.286, 0.544)	(0.107, 0.134, 0.169)	(0.065, 0.082, 0.11)	(0.086, 0.115, 0.162)	(0.074, 0.094, 0.127)	(0.092, 0.17, 0.292)	(0.053, 0.135, 0.277)	(0.129, 0.267, 0.56)	(0.171, 0.302, 0.546)
X_{11}	(0.143, 0.269, 0.475)	(0.077, 0.207, 0.469)	(0.173, 0.304, 0.546)	(0.145, 0.286, 0.544)	(0.107, 0.267, 0.507)	(0.065, 0.164, 0.329)	(0.086, 0.229, 0.487)	(0.074, 0.094, 0.127)	(0.046, 0.058, 0.073)	(0.105, 0.202, 0.37)	(0.129, 0.267, 0.56)	(0.171, 0.302, 0.546)
X_{12}	(0.72, 0.09, 0.119)	(0.077, 0.104, 0.156)	(0.173, 0.304, 0.546)	(0.145, 0.286, 0.544)	(0.107, 0.134, 0.169)	(0.194, 0.328, 0.549)	(0.086, 0.229, 0.487)	(0.296, 0.472, 0.762)	(0.185, 0.284, 0.438)	(0.211, 0.337, 0.555)	(0.194, 0.356, 0.7)	(0.057, 0.151, 0.327)
X_{13}	(0.72, 0.09, 0.119)	(0.077, 0.104, 0.156)	(0.173, 0.304, 0.546)	(0.145, 0.286, 0.544)	(0.107, 0.134, 0.169)	(0.194, 0.328, 0.549)	(0.086, 0.115, 0.162)	(0.296, 0.472, 0.762)	(0.046, 0.114, 0.219)	(0.211, 0.337, 0.555)	(0.194, 0.356, 0.7)	(0.057, 0.151, 0.327)
X_{14}	(0.143, 0.269, 0.475)	(0.077, 0.104, 0.156)	(0.058, 0.076, 0.109)	(0.073, 0.095, 0.136)	(0.107, 0.134, 0.169)	(0.259, 0.41, 0.659)	(0.086, 0.115, 0.162)	(0.074, 0.189, 0.381)	(0.046, 0.114, 0.219)	(0.053, 0.135, 0.277)	(0.065, 0.178, 0.42)	(0.171, 0.302, 0.546)
X_{15}	(0.72, 0.09, 0.119)	(0.077, 0.156, 0.312)	(0.173, 0.304, 0.546)	(0.145, 0.286, 0.544)	(0.107, 0.134, 0.169)	(0.065, 0.082, 0.11)	(0.173, 0.344, 0.649)	(0.074, 0.189, 0.381)	(0.046, 0.114, 0.219)	(0.158, 0.27, 0.462)	(0.065, 0.178, 0.42)	(0.057, 0.151, 0.327)
X_{16}	(0.72, 0.09, 0.119)	(0.077, 0.156, 0.312)	(0.173, 0.304, 0.546)	(0.145, 0.286, 0.544)	(0.107, 0.134, 0.169)	(0.065, 0.082, 0.11)	(0.086, 0.229, 0.487)	(0.148, 0.283, 0.508)	(0.046, 0.114, 0.219)	(0.211, 0.337, 0.555)	(0.065, 0.178, 0.42)	(0.057, 0.151, 0.327)
X_{17}	(0.72, 0.09, 0.119)	(0.077, 0.156, 0.312)	(0.173, 0.304, 0.546)	(0.145, 0.286, 0.544)	(0.107, 0.134, 0.169)	(0.065, 0.082, 0.11)	(0.086, 0.229, 0.487)	(0.074, 0.189, 0.381)	(0.046, 0.114, 0.219)	(0.158, 0.27, 0.462)	(0.065, 0.178, 0.42)	(0.057, 0.151, 0.327)
X_{18}	(0.72, 0.09, 0.119)	(0.077, 0.156, 0.312)	(0.173, 0.304, 0.546)	(0.145, 0.286, 0.544)	(0.107, 0.134, 0.169)	(0.065, 0.082, 0.11)	(0.086, 0.115, 0.162)	(0.074, 0.094, 0.127)	(0.046, 0.114, 0.219)	(0.053, 0.135, 0.277)	(0.065, 0.178, 0.42)	(0.057, 0.151, 0.327)
X_{19}	(0.143, 0.269, 0.475)	(0.077, 0.104, 0.156)	(0.058, 0.152, 0.327)	(0.073, 0.191, 0.408)	(0.107, 0.134, 0.169)	(0.129, 0.246, 0.439)	(0.086, 0.115, 0.162)	(0.148, 0.283, 0.508)	(0.185, 0.284, 0.438)	(0.105, 0.202, 0.37)	(0.129, 0.267, 0.56)	(0.171, 0.302, 0.546)
X_{20}	(0.143, 0.269, 0.475)	(0.077, 0.104, 0.156)	(0.058, 0.152, 0.327)	(0.073, 0.095, 0.136)	(0.107, 0.134, 0.169)	(0.259, 0.41, 0.659)	(0.086, 0.115, 0.162)	(0.074, 0.189, 0.381)	(0.185, 0.284, 0.438)	(0.211, 0.337, 0.555)	(0.065, 0.178, 0.42)	(0.171, 0.302, 0.546)

Table A4. Normalized weighted decision matrix.

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}
X_1	(0.0192, 0.0301, 0.0477)	(0.0070, 0.0188, 0.0424)	(0.0051, 0.0134, 0.0288)	(0.0059, 0.0077, 0.0110)	(0.0080, 0.0100, 0.0127)	(0.0046, 0.0117, 0.0234)	(0.0069, 0.0183, 0.0388)	(0.0054, 0.0069, 0.0093)	(0.0163, 0.0250, 0.0385)	(0.0049, 0.0124, 0.0256)	(0.0063, 0.0174, 0.0411)	(0.0055, 0.0145, 0.0316)
X_2	(0.0192, 0.0301, 0.0477)	(0.0070, 0.0188, 0.0424)	(0.0051, 0.0134, 0.0288)	(0.0059, 0.0077, 0.0110)	(0.0322, 0.0502, 0.0762)	(0.0046, 0.0117, 0.0234)	(0.0069, 0.0091, 0.0129)	(0.0054, 0.0069, 0.0093)	(0.0041, 0.0050, 0.0064)	(0.0049, 0.0124, 0.0256)	(0.0063, 0.0087, 0.0137)	(0.0055, 0.0145, 0.0316)
X_3	(0.0048, 0.0060, 0.0080)	(0.0139, 0.0282, 0.0566)	(0.0051, 0.0134, 0.0288)	(0.0059, 0.0155, 0.0331)	(0.0080, 0.0201, 0.0381)	(0.0046, 0.0058, 0.0078)	(0.0275, 0.0457, 0.0776)	(0.0054, 0.0069, 0.0093)	(0.0163, 0.0250, 0.0385)	(0.0049, 0.0062, 0.0085)	(0.0126, 0.0261, 0.0548)	(0.0055, 0.0145, 0.0316)
X_4	(0.0096, 0.0181, 0.0318)	(0.0139, 0.0282, 0.0566)	(0.0051, 0.0134, 0.0288)	(0.0059, 0.0077, 0.0110)	(0.0080, 0.0201, 0.0381)	(0.0046, 0.0058, 0.0078)	(0.0069, 0.0183, 0.0388)	(0.0054, 0.0069, 0.0093)	(0.0163, 0.0250, 0.0385)	(0.0097, 0.0186, 0.0341)	(0.0063, 0.0174, 0.0411)	(0.0165, 0.0291, 0.0526)
X_5	(0.0096, 0.0181, 0.0318)	(0.0139, 0.0282, 0.0566)	(0.0051, 0.0134, 0.0288)	(0.0059, 0.0077, 0.0110)	(0.0080, 0.0100, 0.0127)	(0.0138, 0.0233, 0.0391)	(0.0069, 0.0183, 0.0388)	(0.0054, 0.0069, 0.0093)	(0.0163, 0.0250, 0.0385)	(0.0049, 0.0124, 0.0256)	(0.0063, 0.0174, 0.0411)	(0.0165, 0.0291, 0.0526)
X_6	(0.0096, 0.0181, 0.0318)	(0.0139, 0.0282, 0.0566)	(0.0051, 0.0134, 0.0288)	(0.0059, 0.0155, 0.0331)	(0.0080, 0.0100, 0.0127)	(0.0092, 0.0175, 0.0313)	(0.0069, 0.0091, 0.0129)	(0.0108, 0.0207, 0.0372)	(0.0163, 0.0250, 0.0385)	(0.0097, 0.0186, 0.0341)	(0.0126, 0.0261, 0.0548)	(0.0165, 0.0291, 0.0526)
X_7	(0.0048, 0.0060, 0.0080)	(0.0139, 0.0282, 0.0566)	(0.0051, 0.0134, 0.0288)	(0.0059, 0.0077, 0.0110)	(0.0080, 0.0100, 0.0127)	(0.0092, 0.0175, 0.0313)	(0.0069, 0.0183, 0.0388)	(0.0054, 0.0069, 0.0093)	(0.0163, 0.0250, 0.0385)	(0.0097, 0.0186, 0.0341)	(0.0063, 0.0174, 0.0411)	(0.0055, 0.0145, 0.0316)
X_8	(0.0048, 0.0060, 0.0080)	(0.0139, 0.0282, 0.0566)	(0.0051, 0.0134, 0.0288)	(0.0059, 0.0077, 0.0110)	(0.0080, 0.0100, 0.0127)	(0.0046, 0.0058, 0.0078)	(0.0069, 0.0091, 0.0129)	(0.0054, 0.0069, 0.0093)	(0.0163, 0.0250, 0.0385)	(0.0097, 0.0186, 0.0341)	(0.0063, 0.0174, 0.0411)	(0.0055, 0.0145, 0.0316)
X_9	(0.0048, 0.0060, 0.0080)	(0.0139, 0.0282, 0.0566)	(0.0051, 0.0134, 0.0288)	(0.0059, 0.0155, 0.0331)	(0.0080, 0.0201, 0.0381)	(0.0046, 0.0117, 0.0234)	(0.0069, 0.0091, 0.0129)	(0.0108, 0.0207, 0.0372)	(0.0163, 0.0250, 0.0385)	(0.0097, 0.0186, 0.0341)	(0.0063, 0.0174, 0.0411)	(0.0055, 0.0145, 0.0316)
X_{10}	(0.0048, 0.0060, 0.0080)	(0.0070, 0.0188, 0.0424)	(0.0152, 0.0267, 0.0480)	(0.0118, 0.0232, 0.0441)	(0.0080, 0.0100, 0.0127)	(0.0046, 0.0058, 0.0078)	(0.0069, 0.0091, 0.0129)	(0.0054, 0.0069, 0.0093)	(0.0081, 0.0150, 0.0257)	(0.0049, 0.0124, 0.0256)	(0.0126, 0.0261, 0.0548)	(0.0165, 0.0291, 0.0526)
X_{11}	(0.0096, 0.0181, 0.0318)	(0.0070, 0.0188, 0.0424)	(0.0152, 0.0267, 0.0480)	(0.0118, 0.0232, 0.0441)	(0.0080, 0.0201, 0.0381)	(0.0046, 0.0117, 0.0234)	(0.0069, 0.0183, 0.0388)	(0.0054, 0.0069, 0.0093)	(0.0041, 0.0050, 0.0064)	(0.0097, 0.0186, 0.0341)	(0.0126, 0.0261, 0.0548)	(0.0165, 0.0291, 0.0526)
X_{12}	(0.0048, 0.0060, 0.0080)	(0.0070, 0.0094, 0.0141)	(0.0152, 0.0267, 0.0480)	(0.0176, 0.0309, 0.0551)	(0.0080, 0.0100, 0.0127)	(0.0138, 0.0233, 0.0391)	(0.0069, 0.0183, 0.0388)	(0.0217, 0.0346, 0.0558)	(0.0163, 0.0250, 0.0385)	(0.0194, 0.0311, 0.0511)	(0.0190, 0.0348, 0.0684)	(0.0055, 0.0145, 0.0316)
X_{13}	(0.0048, 0.0060, 0.0080)	(0.0070, 0.0094, 0.0141)	(0.0152, 0.0267, 0.0480)	(0.0176, 0.0309, 0.0551)	(0.0080, 0.0100, 0.0127)	(0.0138, 0.0233, 0.0391)	(0.0069, 0.0091, 0.0129)	(0.0217, 0.0346, 0.0558)	(0.0041, 0.0100, 0.0192)	(0.0194, 0.0311, 0.0511)	(0.0190, 0.0348, 0.0684)	(0.0055, 0.0145, 0.0316)
X_{14}	(0.0096, 0.0181, 0.0318)	(0.0070, 0.0094, 0.0141)	(0.0051, 0.0067, 0.0096)	(0.0059, 0.0077, 0.0110)	(0.0080, 0.0100, 0.0127)	(0.0184, 0.0292, 0.0469)	(0.0069, 0.0091, 0.0129)	(0.0054, 0.0138, 0.0279)	(0.0041, 0.0100, 0.0192)	(0.0049, 0.0124, 0.0256)	(0.0063, 0.0174, 0.0411)	(0.0165, 0.0291, 0.0526)
X_{15}	(0.0048, 0.0060, 0.0080)	(0.0070, 0.0141, 0.0283)	(0.0152, 0.0267, 0.0480)	(0.0118, 0.0232, 0.0441)	(0.0080, 0.0100, 0.0127)	(0.0046, 0.0058, 0.0078)	(0.0138, 0.0274, 0.0517)	(0.0054, 0.0138, 0.0279)	(0.0041, 0.0100, 0.0192)	(0.0146, 0.0249, 0.0426)	(0.0063, 0.0174, 0.0411)	(0.0055, 0.0145, 0.0316)

Table A4. *Cont.*

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}
X_{16}	(0.0048, 0.0060, 0.0080)	(0.0070, 0.0141, 0.0283)	(0.0152, 0.0267, 0.0480)	(0.0118, 0.0232, 0.0441)	(0.0080, 0.0100, 0.0127)	(0.0046, 0.0058, 0.0078)	(0.0069, 0.0183, 0.0388)	(0.0108, 0.0207, 0.0372)	(0.0041, 0.0100, 0.0192)	(0.0194, 0.0311, 0.0511)	(0.0063, 0.0174, 0.0411)	(0.0055, 0.0145, 0.0316)
X_{17}	(0.0048, 0.0060, 0.0080)	(0.0070, 0.0141, 0.0283)	(0.0152, 0.0267, 0.0480)	(0.0118, 0.0232, 0.0441)	(0.0080, 0.0100, 0.0127)	(0.0046, 0.0058, 0.0078)	(0.0069, 0.0183, 0.0388)	(0.0054, 0.0138, 0.0279)	(0.0041, 0.0100, 0.0192)	(0.0146, 0.0249, 0.0426)	(0.0063, 0.0174, 0.0411)	(0.0055, 0.0145, 0.0316)
X_{18}	(0.0048, 0.0060, 0.0080)	(0.0070, 0.0141, 0.0283)	(0.0152, 0.0267, 0.0480)	(0.0118, 0.0232, 0.0441)	(0.0080, 0.0100, 0.0127)	(0.0046, 0.0058, 0.0078)	(0.0069, 0.0091, 0.0129)	(0.0054, 0.0069, 0.0093)	(0.0041, 0.0100, 0.0192)	(0.0049, 0.0124, 0.0256)	(0.0063, 0.0174, 0.0411)	(0.0055, 0.0145, 0.0316)
X_{19}	(0.0096, 0.0181, 0.0318)	(0.0070, 0.0094, 0.0141)	(0.0051, 0.0134, 0.0288)	(0.0059, 0.0155, 0.0331)	(0.0080, 0.0100, 0.0127)	(0.0092, 0.0175, 0.0313)	(0.0069, 0.0091, 0.0129)	(0.0108, 0.0207, 0.0372)	(0.0163, 0.0250, 0.0385)	(0.0097, 0.0186, 0.0341)	(0.0126, 0.0261, 0.0548)	(0.0165, 0.0291, 0.0526)
X_{20}	(0.0096, 0.0181, 0.0318)	(0.0070, 0.0094, 0.0141)	(0.0051, 0.0134, 0.0288)	(0.0059, 0.0077, 0.0110)	(0.0080, 0.0100, 0.0127)	(0.0184, 0.0292, 0.0469)	(0.0069, 0.0091, 0.0129)	(0.0054, 0.0138, 0.0279)	(0.0163, 0.0250, 0.0385)	(0.0194, 0.0311, 0.0511)	(0.0063, 0.0174, 0.0411)	(0.0165, 0.0291, 0.0526)

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