Article

A Conceptual Hybrid Approach from a Multicriteria Perspective for Sustainable Third-Party Reverse Logistics Provider Identification

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Abstract: Reverse logistics (RL) is considered the reverse manner of gathering and redeploying goods at the end of their lifetime span from consumers to manufacturers in order to reutilize, dispose, or remanufacture. Whereas RL has many economic benefits, it presents compromises to businesses that wish to remain competitive but be responsible global citizens in terms of social, environmental, risk, and safety aspects of sustainable development. Managing RL systems therefore is considered a multifaceted mission that necessities a significant level of technology, infrastructure, experience, and competence. Consequently, various commerce institutions are looking to outsourcing their RL actions to third-party reverse logistics providers (3PRLPs). In this work, a novel hybrid multiple-criteria decision-making (MCDM) framework is proposed to classify and choose 3PRLPs, which comprises the analytic hierarchy process (AHP) technique, and technique for order of preference by similarity to ideal solution (TOPSIS) technique under neutrosophic environment. Accordingly, AHP is availed for defining weights of key dimensions and their subindices. In addition, TOPSIS was adopted for ranking the specified 3PRLPs. The efficiency of the proposed approach is clarified through application on a considered car parts manufacturing industry case in Egypt, which shows the features of the combined MCDM methods. A comparative and sensitivity analyses were performed to highlight the benefits of the incorporated MCDM methods and for clarifying the effect of changing weights in selecting the sustainable 3PRLP alternative, respectively. The suggested framework is also shown to present more functional execution when dealing with uncertainties and qualitative inputs, demonstrating applicability to a broad range of applications. Ultimately, the best sustainable 3PRLPs were selected and results show that social, environmental, and risk and safety sustainability factors have the greatest influence when determining 3PRLPs alternatives.

Keywords: sustainability; third-party reverse logistics providers; reverse logistics; multicriteria decision-making; AHP; TOPSIS

1. Introduction

Logistics has been defined as the mechanism of management and managing of the flow of products, energy, information, and other resources such as products and services and even individuals, from production through to consumption [1]. It is difficult or impossible to conduct any commercial or manufacturing/production or service activity without the support of logistics. Therefore, it can be also defined as the process of anticipating the needs and desires of customers and managing materials, manpower, technology, and information necessary to meet these requirements and desires while optimizing the production network of goods and services to meet customer demands [2]. Companies face increasing pressures

to recover products at the end of their life cycle as a result of limited resources, the prevalence of recall laws, the possibility of expansion into secondary markets, in addition customer pressure to fabricate environmentally friendly goods [3]. These issues have led to the adoption of modern methods through which companies can sustain their resources and operations, lower costs of production, whilst reducing negative environmental impacts—reverse logistics (RL) is one of those methods [4].

RL is the procedure of collecting goods and materials used by customers and users to reprocess, recycle, or use for other objectives [5]. It is also the process of planning, designing, scheduling, controlling, and warehousing and comprises the backflow of products returned in the supply chain in order to obtain a competitive benefit [6]. Recycling and disposal help to balance economic and environmental issues that are applicable, so that profit can be achieved through the renewal of used products, but the environment is also protected. Figure 1 shows the activities and flows of products in supply chains for forward and reverse logistics. RL is a major factor in modern supply chains because (i) many corporations have turned to RLs, due to a shortage of raw materials, costs, and increasing prices [7]; (ii) as a result of the trend of government awareness and officials to protect the environment, laws and legislation have been enacted that guarantee the protection of the environment [8]. Therefore, RL is a methodology that can assist commercial establishments to choose the best plans to balance the protection of the environment whilst achieving economic and financial advantages [9,10]. Therefore, RL operations are consequently a difficult task since they need to address the aspects of sustainability, including community, economic, and environmental dimensions, in addition the risk and safety dimension as mentioned in Figure 2.

Sustainability refers to the cleansing and salvaging of the environment in an economic way that serves the community, through its spread and penetration in all fields, so that through this concept, trade is accomplished in a sustainable way that serves the environment and society, as well as management in a sustainable way, and even living in a sustainable way that serves the environment and society in an economic way [11]. Thus, institutions take into account the ecological and social aspects as well as the economic dimensions in formulating, implementing, and controlling their strategies, for achieving their goals and adapting to the developments and stakes related to the requirements of sustainable development [12]. Additionally, creativity and innovation are among the means that logistical management relies on upon achieving sustainable efficiency, economic effectiveness, and value creation, especially as the world is witnessing transformations in all sectors, including the industrial sector, to discover strengths and weaknesses to ensure its ability to compete and excel [12]. Sustainable development has interrelated dimensions and focusing on it will advance the achievement of development [13]. The selection of sustainable third-party reverse logistics providers (3PRLPs) for institutions and companies is one form of sustainable development, as companies are obligated when choosing service providers to take into account sustainability aspects. Given the multiplicity of service providers, a good comprehension is desired of how to choose the best sustainable alternative.

As a result, we applied this research under a neutrosophic environment that has a great reputation in dealing with data ambiguities and inaccurate and complex data. Smarandache introduced the neutrosophic theory to deal with the problems of earlier theories such as classic theory, fuzzy theory, intuionistic fuzzy theory, grey system theory, etc. [14]. Additionally, neutrosophic set (NS) is considered a popularization of fuzzy set (FS) [15], and intuitionistic fuzzy set (IFS) [16]. Meanwhile, the NS can treat the indeterminacy part by considering indeterminism, while the FS does not consider indeterminism in expressing preferences, and the IFS is treating a part of indeterminism. Additionally, indeterminacy is a separate factor only in the neutrosophic approach, while in others fuzzy environment, intuitionistic fuzzy environment, etc., indeterminacy is dependent, or does not exist. In this regard, various neutrosophic numbers have been developed in the last years to express the nature of the problem from all directions and adequately address ambiguities. In recent years, the neutrosophic notion has caught the attention and concern of scholars

in their studies in all fields [17]. Moktadir et al. presented an article for identifying a comprehensive assessment of supply chain risk aspects under a neutrosophic environment considering a real case study of leather manufacturing [18]. Vafadarnikjoo et al. introduced a study about discovering the main motivational features for purchasing a refabricated bike grounded on the consumers' and experts' preferences by utilizing the Delphi technique and single-valued neutrosophic sets (SVNSs) [19].

Environmental legislation and awareness-raising are not only the primary reason for recycling the product again but recycling the products has proven to be very profitable in many industries [20]. There are many industries in which RL is practiced, such as devices, cars, computers, aircraft, photocopiers, steel, plastics, and carpets. Effective design of RL is a multifaceted task for any business, as there is a wide range of criteria such as recycling, dismantling, inspection, storage, reprocessing, repair, disposal, refurbishment, etc., which must be taken into consideration. It is often difficult to define some of these criteria. The level of ambiguity in the timing and numbers of products signifies the most common difficulties associated with the implementation of reverse logistical activities. Companies that tend to rely on RL services in one of two ways, either through the original network or outsourced through 3PRLPs, for raising the quality of recovering used goods and decreasing costs [21]. Consequently, organizations need support in selecting an appropriate 3PRLP alternative by considering the desirable selection criteria. In order to develop an optimum selection process, several criteria are evaluated in different dimensions at the same time and the techniques capable of doing that are the multiple-criteria decision-making (MCDM) techniques [22].

3PRLP determination is a MCDM issue that comprises both quantitative and qualitative indices [23]. 3PRLPs determination approach can be considered as a MCDM issue, as it is difficult for specialists and decision makers to strike stability between different factors to obtain an ideal solution. Additionally, the 3PRLP determination procedure is the most significant factor in effective logistics administration for a modern supply chain network as it assists to realize good-quality products and consumer contentment. Actual 3PRLP determination necessitates potent analytical approaches in order to be able to comprise multiple subjective and objective criteria [24].

Commonly, an amalgamation of various assessment methods aids researchers to achieve more precise outcomes [25]. Accordingly, this study suggested a new hybrid MCDM methodology for determining a 3PRLP in the auto parts industrialization manufacture by analytic hierarchy process (AHP) and technique for order of preference by similarity to ideal solution (TOPSIS) under the neutrosophic environment. Type-2 neutrosophic numbers (T2NNs) are applied in this study because they are very powerful for problems involving incomplete information environment, uncertainty, vagueness, and imprecision [26]. AHP is a technique that reflects the relevance and impact of factors with each other. Therefore, the AHP technique is appropriate to define the weights of the selection criteria and characterizing how much each criterion influences the decision. The TOPSIS method is utilized for rating alternates, again using neutrosophic numbers of type-2 in order to address ambiguous and qualitative inputs. Generally, we use the weights we extracted from the AHP technique with the decision matrix of the TOPSIS that is normalized to rank the 3PRLPs. We adopted this approach for its distinctive properties in both AHP and TOPSIS. Since there is no approach for determining logistics service providers in the Egyptian auto manufacturing, we studied here a company that manufactures auto parts, and some engine parts to identify the factors that influence the selection of reverse logistics service providers. Lastly, a model was created grounded on the dimensions and subindices identified to select the optimal quality logistics service provider to reduce supply chain hazards.

The main contributions of this article include:

- Developing an approach for service logistics provider determination for the first time under the neutrosophic environment to handle vague and uncertain data.

- Introducing hybrid MCDM techniques namely, neutrosophic AHP and neutrosophic TOPSIS.
- The substantiation that neutrosophic AHP-TOPSIS approach can efficiently handle linguistic uncertainty.
- Four sustainability aspects were evaluated including social, economic, ecological, and risk.
- The utility of the suggested technique is demonstrated with a case study.

The remnant of this article is organized in the following way: Section 2 shows the literature review on the topic of reverse logistics and some studies on it. The suggested neutrosophic MCDM approach is formulated in Section 3. Section 4 introduces a considered case study and MCDM approach outcomes. Section 5 presents comparative analysis with some previous studies followed by Section 6 which shows a sensitivity analysis of criteria weights to accentuate the robustness and advantages of this study's model. Section 7 discusses some of the managerial implications and advantages of the present model. Finally, Section 8 concludes and identifies some directions for future research.
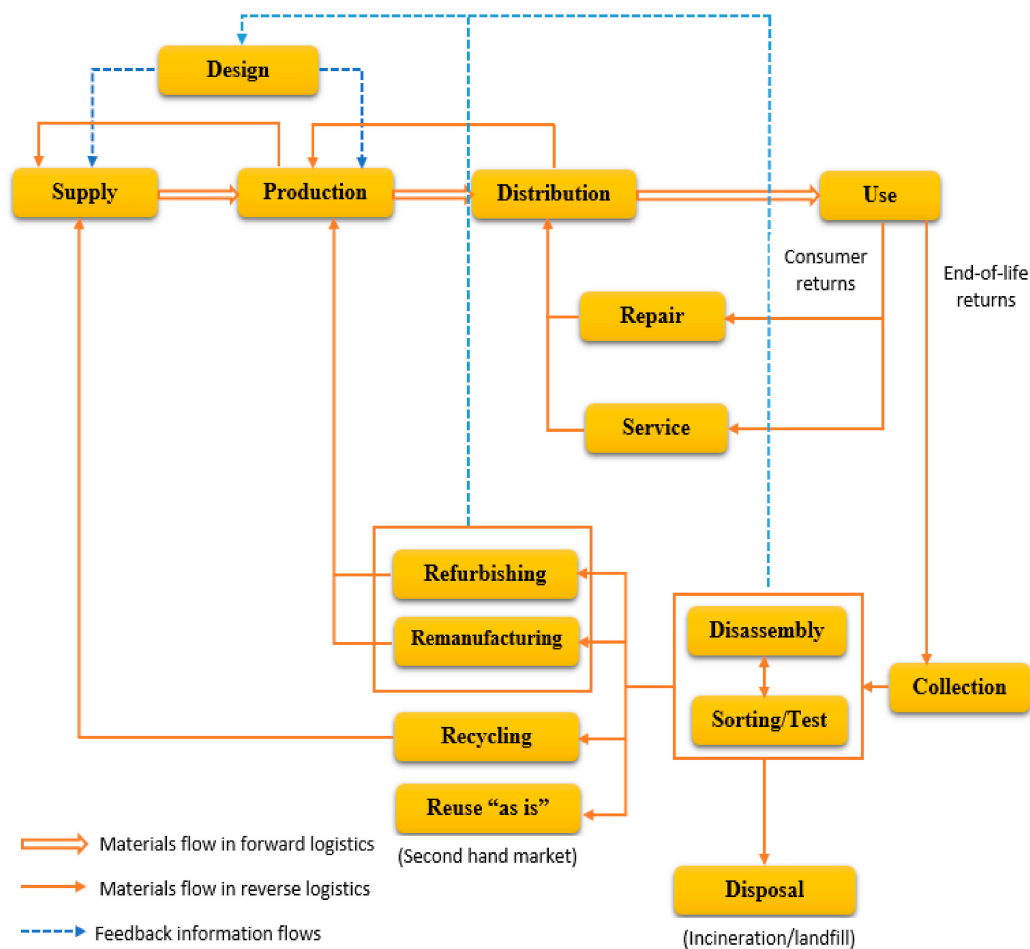

Figure 1. Activities and flows in reverse logistics. Reprinted with permission from ref. [27]. Copyright 2008 Sasikumar and Kannan.
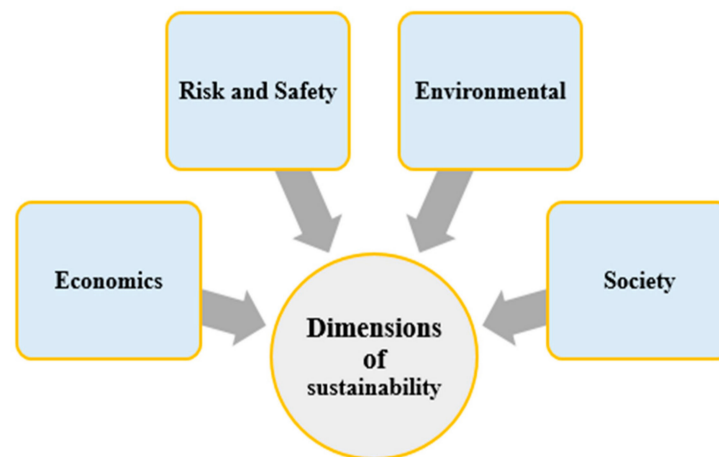
Figure 2. The dimensions of sustainability.

2. Literature Review

The importance of RL means that companies need to establish them in a sustainable way [28] to protect natural resources as in the social dimension, to maintain safety factors in the risk and safety dimension, to protect the environment by disposal and recycling of products, and lastly to reduce costs in the economic dimension [29–31]. The implementation of an RL strategy needs planning and design of a strong network and necessities a specialized backing team to maintain the network [32]. Accordingly, industrialists tend to outsource their RL activities to specialized service providers, which reduces the cost burden on the organization [33]. The selection of a suitably qualified service provider is therefore of principal concern [34] to determine an appropriate evaluation technique as well as an associated set of appropriate evaluation dimensions. The two issues are related to the dimensions and their subindices selected may often affect the suggested model. One of the most significant attributes of the proposed technique is the ability to convert qualitative criteria into quantitative criteria [35].

Furthermore, the appraisal approach must include a technique for determining the appropriate weight for each criterion. Researchers have undertaken several studies and compared several techniques for the selection of optimum 3PRLP. Such techniques are of great assistance to experts in making viable decisions, by improving the quality of the classification procedure, and accommodating ambiguity and ambiguous criteria. Moreover, the classification of alternatives is influenced by the existence of a set of appropriate criteria as some criteria are included or excluded depending on the decision-making process. Therefore, we seek to develop the MCDM classification approach and define a set of criteria from previous studies for application in our study. We present some of the methods used for 3PRLP selection and evaluation in recent years.

Chen et al., developed a study to build a multiperspective multiattribute decision making (MADM) methodology to give standardized decision support for institutions for choosing the best 3PRLPs under a fuzzy environment [20]. They used five criteria in the evaluation process for selecting the optimal 3PRLP. They suggested the comprehensive reasonable semantic terminologies for evaluating attributes, which can be converted into a hesitant fuzzy semantic terminology set for enhancing information reliability. Sarabi and Darestani introduced a decision support system (DSS) for determining the suitable logistic service provider under a fuzzy environment [36]. They applied a MCDM methodology that combined the Best Worst Method (BWM) for determining weights of the eight key dimensions and their subindices and Multiple Objective Optimizations on the basis of Ratio Analysis plus full Multiplicative Form (MULTIMOORA) is adopted for ranking three logistic service providers.

Zarbakhshnia et al. submitted a novel combined MADM approach, which comprises AHP and multiobjective optimization by ratio analysis (MOORA) under a fuzzy environ-

ment [4]. They used fuzzy and grey numbers in the assessment procedure. Nine 3PRLPs were assessed based on four key dimensions and their 23 subindices to select the optimal 3PRLP. Bai and Sarkis proposed a novel MCDM approach that integrated TOPSIS and VIKOR methods with neighborhood rough set theory [5]. Their model evaluated 30 3PRLPs based on 13 criteria. Raut et al. developed an integrated MCDM methodology that combined AHP for determining weights of dimensions, data envelopment analysis (DEA) which decreases the number of 3PRLPs, and complex proportional assessment (COPRAS) which employed for ranks the 3PRLPs by applying grey numbers [37]. Thirty 3PRLPs measured grounded on 10 main dimensions to determine the optimal 3PRLP. Their approach was limited in that it only took into account 10 dimensions that did not comprise all dimensions of the issue.

Liu et al. developed a new interval-valued Pythagorean hesitant fuzzy set (IPHFS), the BWM technique and deviation model that is developed to identify the criteria weights, and the traditional BWM is employed to identify the best 3PRLP [38]. Their model depends on multicriteria group decision-making in the evaluating process. They applied their model to the mobile phone recycling case study. One of the limitations of their study was that ambiguity was not dealt with accurately. Govindan et al. introduced a hybrid ELimination Et Choix Traduisant la REalité I (ELECTRE I) and stochastic multicriteria acceptability analysis (SMAA) methodology for selection of 3PRLP [39]. Their model was applied with a considered case in an Indian industrialization corporation. Five 3PRLPs have been evaluated based on 14 main criteria. Their methodology was limited in that it did not take only 14 indices. Jayant et al. introduced an integrated MCDM approach which included stepwise weight assessment ratio (SWARA) which was applied for calculating dimensions weights, MOORA and weighted aggregated sum product assessment (WASPAS) techniques are employed for choosing the best 3PRLP [40]. Their approach was applied to a considered case study of mobile recycling in India which included nine 3PRLPs evaluated based on 10 criteria. Additionally, the limitation of their approach was limited in that most of the dimensions of the problem are not addressed through an adequate selection of dimensions.

Mavi et al. presented a novel approach that integrated the SWARA method that was utilized for calculating the criteria weights and their subindicators and MOORA method that was adopted for ranking the sustainable 3PRLPs under fuzzy environment [41]. Their approach had been applied on the plastic industry case study. Nine 3PRLPs are assessed based on four sustainability criteria included economic, environment, social, and risk and their 23 subindicators. The limitation of their approach was that it failed to address the decision maker's abstruseness. Tavana et al. developed a novel MCDM approach for rating of the decision dimensions identifying the choice of the optimum 3PRLP under intuionistic fuzzy environment [34]. Their approach divided into two parts, the key dimensions and subindices are identified by Strengths, Weaknesses, Opportunities, and Threats (SWOT) investigation; secondly, AHP method is applied for evaluating the proportional weights of fundamental dimensions and subindices. The shortcoming of their approach was that the ambiguities were not accurately interpreted as their research was conducted in an intuionistic fuzzy environment.

Zarbakhshnia et al. introduced a new MAMD model that included SWARA technique for computing the relative importance of dimensions and COPRAS technique for ranking and selecting the sustainable 3PRLP under fuzzy environment [3]. Their model was validated by applying a real case study from automotive industry. Seven 3PRLPs had been estimated grounded on four key dimensions ecological, economic, social, and risk and 16 subindicators. The deficiency in their approach was the limitation of dealing with aspects of the problem and covering all aspects of the valuation process. Additionally, the ambiguities were not accurately interpreted as their study was conducted in a fuzzy environment. Prakash and Barua advanced a hybrid MCDM approach that combined AHP and TOPSIS for ranking and selection RL partners under fuzzy environment [42]. Their model was validated by applying on a considered case of Indian electronics manufacturing. The deficiency in their approach was that the ambiguities were not accurately interpreted

as their study was conducted in a fuzzy environment. Senthil et al. advanced a hybrid MCDM approach utilizing AHP and TOPSIS for ranking and determining the most efficient reverse logistics contractor under fuzzy environment [43].

Commonly, as in most of the previous research published in this regard, AHP is popular for calculating weights of criteria related to 3PRLP. The TOPSIS method has been used in judgments related to RL and is one of the most important MCDM methods. Additionally, TOPSIS was not utilized in the problems of selection, improvement, and comparison, but because it is a versatile and flexible method, it has been applied to various applications, which indicates its importance [8].

To sum up, there are some problems that were not addressed in previous studies based on the opinions of specialists and authors, such as the dimensions of the 3PRLPs evaluation problem have not been studied in detail. Additionally, as identified earlier, logistics management and outsourcing have many social, environmental, and economic aspects, but most of the previous research has not included the safety and risk aspect which is vital in logistics management. Moreover, most of the existing literature only considered the classic set, FS, and IFS, etc., which is not convenient dealing with abstruseness in assessment of the matter and its aspects in a suitable way. Therefore, the committee of experts and decision makers was consulted to identify the most suitable criteria and their suitability as criteria for the case study. Finally, the committee recommended that the series of sustainable criteria be used and that covered key dimensions of the problem and its subindices of the 3PRLP selection. Accordingly, a set of main dimensions dealing with aspects of the problem and its subindices were identified, and the appropriate abbreviation was determined for each criterion, which would be used later in the remaining sections of the study as shown in Figure 3. Additionally, a novel methodology was proposed under a neutrosophic which comprises AHP-TOPSIS, where AHP was utilized for calculating the relative values of the dimensions and their subindicators and TOPSIS technique was employed to rate and select the most sustainable 3PRLP. Additionally, a novel methodology was proposed under a neutrosophic which comprises AHP-TOPSIS, where AHP was utilized for calculating the relative values of the dimensions and their subindicators and TOPSIS technique was employed to rate and select the most sustainable 3PRLP.
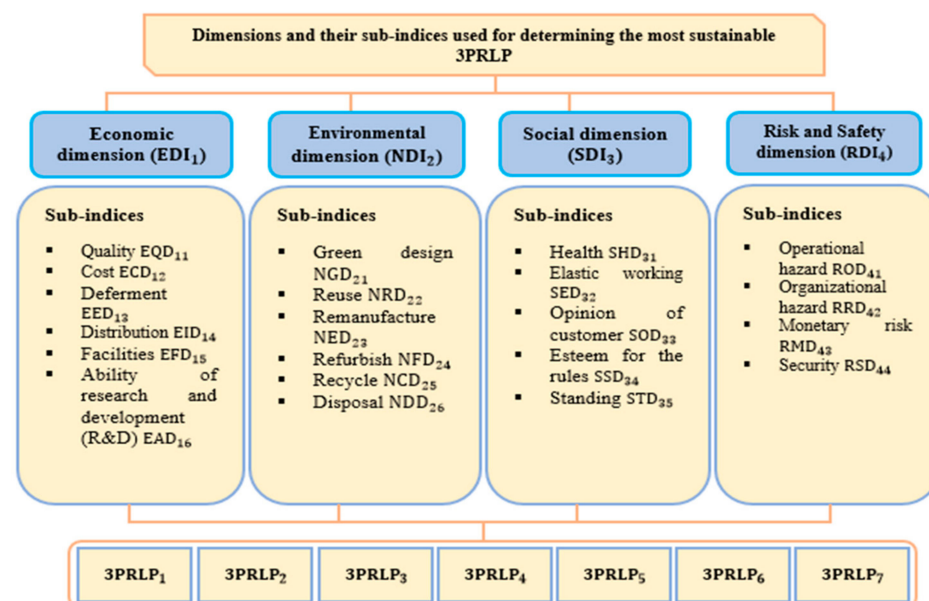
Figure 3. Main dimensions, subindices, and third-party reverse logistics providers (3PRLPs) used for determining sustainable 3PRLP.

3. Development Methodology

In this section, a methodology of this paper that integrated AHP and TOPSIS methods under a neutrosophic environment is proposed for selecting the sustainable 3PRLP. At first, the technique uses neutrosophic AHP to weight the fundamental dimensions and subindices of all dimensions. Then, it extends the neutrosophic TOPSIS to choose the most appropriate 3PRLP. Figure 4 illustrates the outline of the suggested methodology. In this regard, a matrix for comparisons between dimensions of sustainability was structured to calculate the significance value of the fundamental dimensions. Then, comparison matrices were developed for the subindices of each dimension. The consistency ratio in all matrices was checked to ensure that the combined provisions can be applied to the problem. Based on the computed weights, a decision matrix between subindices and the 3PRLPs was initialized. Then, TOPSIS was applied to rank 3PRLP alternatives. The semantic scales used during the process of evaluating dimensions and alternatives should be converted into quantitative scales as shown in Tables 1 and 2.

Figure 4. Proposed multiple-criteria decision-making (MCDM) framework for selecting the sustainable 3PRLP.

Table 1. Type-2 neutrosophic numbers (T2NNs) used for calculating weights of the dimensions and subindices.

Linguistic Scales	Abbreviations	T2NNs [(T_T, T_I, T_F), (I_T, I_I, I_F), (F_T, F_I, F_F)]
Weak importance	WIE	[(0.19, 0.29, 0.19), (0.59, 0.69, 0.79), (0.46, 0.74, 0.73)]
Just importance	JIE	[(0.39, 0.29, 0.26), (0.44, 0.56, 0.39), (0.46, 0.59, 0.54)]
Essential importance	EIE	[(0.64, 0.54, 0.56), (0.39, 0.44, 0.56), (0.36, 0.39, 0.34)]
Very strong importance	VS	[(0.79, 0.74, 0.69), (0.19, 0.16, 0.29), (0.16, 0.11, 0.21)]
Extremely preferred	EP	[(0.89, 0.86, 0.96), (0.09, 0.16, 0.11), (0.06, 0.07, 0.11)]

Table 2. T2NNs used for rating the 3PRLPs.

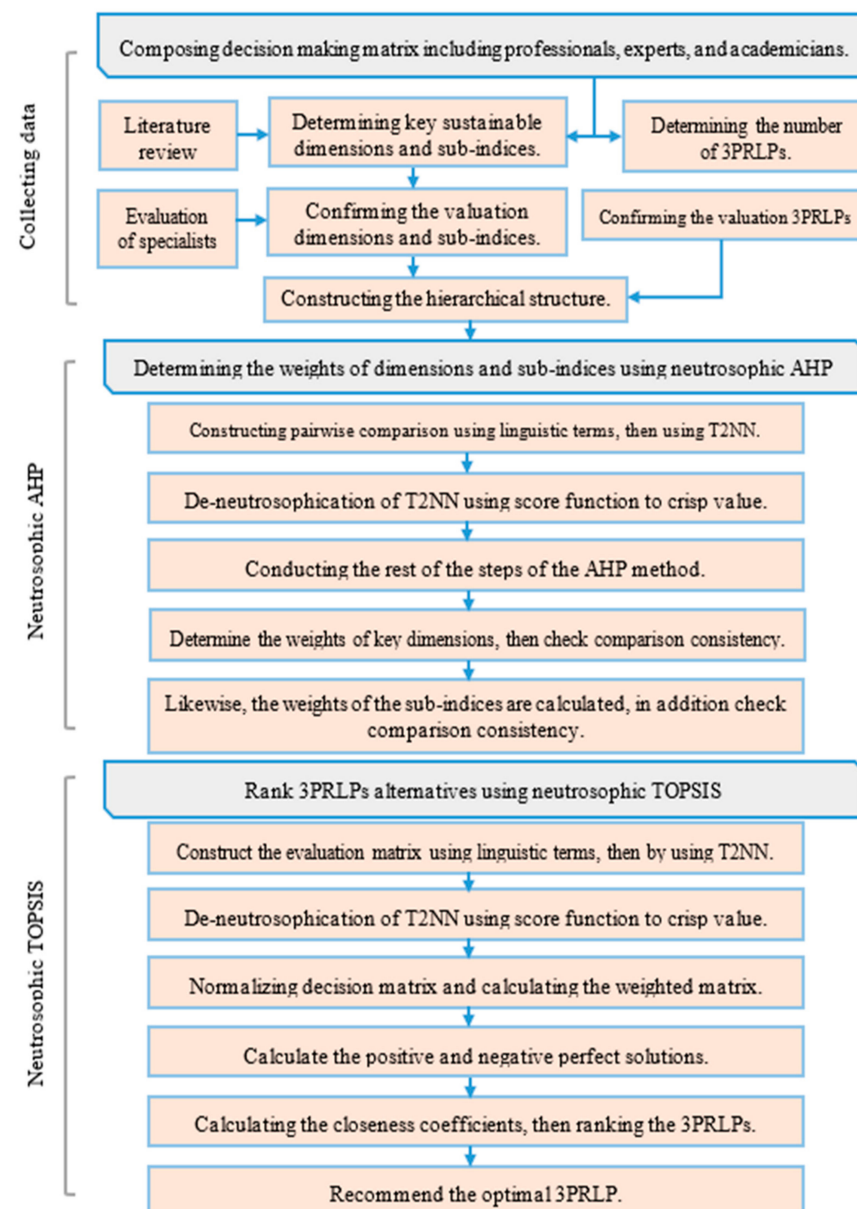| Linguistic Scales	Abbreviations	T2NNs [(T_T, T_I, T_F), (I_T, I_I, I_F), (F_T, F_I, F_F)]
Very poor	VPR	[(0.20, 0.20, 0.10), (0.65, 0.80, 0.85), (0.45, 0.80, 0.70)]
Poor	POR	[(0.35, 0.35, 0.10), (0.50, 0.75, 0.80), (0.50, 0.75, 0.65)]
Medium poor	MPR	[(0.50, 0.30, 0.50), (0.50, 0.35, 0.45), (0.45, 0.30, 0.60)]
Fair	FAI	[(0.40, 0.45, 0.50), (0.40, 0.45, 0.50), (0.35, 0.40, 0.45)]
Medium good	MGD	[(0.59, 0.46, 0.49), (0.19, 0.16, 0.24), (0.09, 0.24, 0.14)]
Good	GOO	[(0.69, 0.76, 0.79), (0.16, 0.19, 0.24), (0.11, 0.16, 0.19)]
Very good	VGD	[(0.96, 0.89, 0.94), (0.11, 0.11, 0.06), (0.06, 0.04, 0.06)]

In this regard, Saaty developed the AHP technique that can be utilized for weighting criteria and ranking alternatives in MCDM activities [44]. However, to rank alternates, AHP requires a lot of processing in the calculations process due to the many comparisons necessary among criteria. Yet, AHP is one of the best techniques in determining the importance value of the criteria because it takes into account the relationships between them and it is able to handle data ambiguity, uncertainty and qualitative inputs [45]. Therefore, AHP is generally employed to identify the weights of criteria and then integrated with other MCDM techniques to develop hybrid approaches. Additionally, Hwang and Yoon developed the TOPSIS technique that provides fundamental logic to define the positive perfect solution (PPS) which always increases the feature criteria and decreases the cost criteria or the negative perfect solution (NPS) which increases the cost criteria and decreases the benefit criteria [46]. According to the methods used in the proposed model as previously mentioned, it was conducted under a neutrosophic environment using the T2NNs. Thus, the primary mathematical operations on T2NNs were defined in [26] to simplify the handling of T2NNs in this work. Given neutrosophic numbers $A_1 = [(T_{T1}, T_{I1}, T_{F1}), (I_{T1}, I_{I1}, I_{F1}), (F_{T1}, F_{I1}, F_{F1})]$ and $A_2 = [(T_{T2}, T_{I2}, T_{F2}), (I_{T2}, I_{I2}, I_{F2}), (F_{T2}, F_{I2}, F_{F2})]$, the basic operations are as follows:

$$A_1 \oplus A_2 = \left\langle \begin{array}{c} (T_{T1} + T_{T2} - T_{T1}T_{T2}, T_{I1} + T_{I2} - T_{I1}T_{I2}, T_{F1} + T_{F2} - T_{F1}T_{F2}), \\ (I_{T1}I_{T2}, I_{I1}I_{I2}, I_{F1}I_{F2}), (F_{T1}F_{T2}, F_{I1}F_{I2}, F_{F1}F_{F2}) \end{array} \right\rangle \quad (1)$$

$$A_1 \otimes A_2 = \left\langle \begin{array}{c} (T_{T1}T_{T2}, T_{T1}T_{T2}, T_{F1}T_{F2}) \\ (I_{T1} + I_{T2} - I_{T1}I_{T2}, I_{I1} + I_{I2} - I_{I1}I_{I2}, I_{F1} + I_{F2} - I_{F1}I_{F2}), \\ (F_{T1} + F_{T2} - F_{T1}F_{T2}, F_{I1} + F_{I2} - F_{I1}F_{I2}, F_{F1} + F_{F2} - F_{F1}F_{F2}), \end{array} \right\rangle \quad (2)$$

$$\lambda A = \left\langle \begin{array}{c} (1 - (1 - T_{T1})^{\lambda}, 1 - (1 - T_{I1})^{\lambda}, 1 - (1 - T_{F1})^{\lambda}), \\ (I_{T1}{}^{\lambda}, I_{I1}{}^{\lambda}, I_{F1}{}^{\lambda}), (F_{T1}{}^{\lambda}, F_{I1}{}^{\lambda}, F_{F1}{}^{\lambda}) \end{array} \right\rangle ; \text{ for } \lambda > 0 \quad (3)$$

$$A^{\lambda} = \left\langle \begin{array}{c} (T_{T1}{}^{\lambda}, T_{I1}{}^{\lambda}, T_{F1}{}^{\lambda}), \\ (1 - (1 - I_{T1})^{\lambda}, 1 - (1 - I_{I1})^{\lambda}, 1 - (1 - I_{F1})^{\lambda}), \\ (1 - (1 - F_{T1})^{\lambda}, 1 - (1 - F_{I1})^{\lambda}, 1 - (1 - F_{F1})^{\lambda}) \end{array} \right\rangle ; \text{ for } \lambda > 0 \quad (4)$$

Accordingly, we will present in the next part the steps of the proposed model comprising AHP-TOPSIS with T2NNs that will be applied in detail as follows:

Step 1. The committee, comprising experts and decision makers determine the most important key dimensions of sustainability to be taken into consideration, and determine the most important subindices related to dimensions that affect the problem in a significant way. Then, subindices are confirmed by the panel to confirm their suitability for the problem at hand.

Step 2. The committee determines the most important alternatives, and their conformity and suitability with the specifications that are required to choose the best alternative from those available.

Step 3. Then, after the criteria and the most important alternatives have been identified, the committee begins to express their views in evaluating the criteria by using semantic terms as in Tables 1 and 2, to facilitate the evaluation process. When creating these terms, the contradiction in satisfaction and dissatisfaction of the decision makers is taken into account.

Step 4. We evaluate the criteria priority using pairwise comparisons, assign linguistic variables and T2NN from Table 1 to the assessment matrices to determine which aspect is important. In the pairwise assessment matrix, the outcome of a_{ij} demonstrates the relative significance of the element on row (i) over the element on column (j). The mutual value of the term $1/a_{ij}$ is utilized when the element (j) is more significant than element (i), as shown in Equation (5).

$$
\begin{pmatrix}
0.5 & \langle(T_{T12},T_{I12},T_{F12}),(I_{T12},I_{I12},I_{F12}),(F_{T12},F_{I12},F_{F12})\rangle & \cdots & \langle(T_{T1n},T_{I1n},T_{F1n}),(I_{T1n},I_{I1n},I_{F1n}),(F_{T1n},F_{I1n},F_{F1n})\rangle \\
\frac{1}{a_{21}} & 0.5 & a_{23} & \langle(T_{T2n},T_{I2n},T_{F2n}),(I_{T2n},I_{I2n},I_{F2n}),(F_{T2n},F_{I2n},F_{F2n})\rangle \\
\vdots & \vdots & \vdots & \vdots \\
\frac{1}{a_{n1}} & \frac{1}{a_{2n}} & \cdots & 0.5
\end{pmatrix}
\tag{5}
$$

Step 5. We convert the neutrosophic pairwise comparison matrix to a deterministic matrix as in Equation (7), using the score function of T2NNs according to Equation (6):

$$
S(a_{ij}) = \frac{1}{12}\left[8+(T_T+2T_I+T_F)-(I_T+2I_I+I_F)-(F_T+2F_I+F_F)\right]
\tag{6}
$$

$$
A = \begin{pmatrix}
0.5 & a_{12} & \cdots & a_{1n} \\
1/a_{21} & 0.5 & \cdots & a_{2n} \\
\vdots & \vdots & 0.5 & \vdots \\
1/a_{n1} & 1/a_{n2} & \cdots & 0.5
\end{pmatrix}
\tag{7}
$$

Step 6. Determine the dimensions weights as follows, standardize the column admissions by dividing each entry by the total of the column, and take the total of the row means.

Step 7. We check consistency of all matrices, which is one of the basic and significant conditions in the AHP method, to shows the consistency of expert opinions.

Step 8. Structure the neutrosophic judgment matrix among their subindices and the 3PRLPs with semantic scales as in Table 2. Then, we convert it to its equivalent by T2NNs in Table 2 where m indicates fundamental dimensions, and n indicates the 3PRLPs according to Equation (8).

$$
\begin{pmatrix}
(\langle,T_{T11},T_{I11},T_{F11}),(I_{T11},I_{I11},I_{F11}),(F_{T11},F_{I11},F_{F11})\rangle & \cdots & \langle(T_{T1n},T_{I1n},T_{F1n}),(I_{T1n},I_{I1n},I_{F1n}),(F_{T1n},F_{I1n},F_{F1n})\rangle \\
\vdots & \vdots & \vdots \\
& \vdots & \\
\langle(T_{Tm1},T_{Im1},T_{Fm1}),(I_{Tm1},I_{Im1},I_{Fm1}),(F_{Tm1},F_{Im1},F_{Fm1})\rangle & \cdots & \langle(T_{Tmn},T_{Imn},T_{Fmn}),(I_{Tmn},I_{Imn},I_{Fmn}),(F_{Tmn},F_{Imn},F_{Fmn})\rangle
\end{pmatrix}
\tag{8}
$$

Subsequently, we convert the neutrosophic pairwise comparison matrix to a crisp value matrix according to Equation (9), according to Equation (6).

$$
X = \begin{pmatrix}
X_{11} & X_{12} & \cdots & X_{1n} \\
X_{21} & X_{22} & \cdots & X_{2n} \\
\vdots & \vdots & \ddots & \vdots \\
X_{m1} & X_{m2} & \cdots & X_{mn}
\end{pmatrix} \tag{9}
$$

Step 9. We enhance the comparable capability by normalizing the neutrosophic judgment matrix by using Equation (10).

$$
q_{ij} = \frac{X_{mn}}{\sqrt{\sum\limits_{i=1}^{N} X_{ij}^2}} \tag{10}
$$

where i designates the substitutes, j indicates the selected dimensions, and X_{ij} indicates i substitute under the j dimension to be measured.

Step 10. We obtain the final weights of each dimension that are estimated with neutrosophic AHP.

$$
w = [w_1, w_2, \ldots\ldots\ldots\ldots\ldots\ldots w_n] \tag{11}
$$

Step 11. We multiply the normalized decision matrix by the achieved weights computed by neutrosophic AHP as Equation (12), obtain the weighted normalized matrix k.

$$
k = \begin{pmatrix}
q_{11} & q_{12} & \cdots & q_{1n} \\
q_{21} & q_{22} & \cdots & q_{2n} \\
\vdots & \vdots & \ddots & \vdots \\
q_{m1} & q_{m2} & \cdots & q_{mn}
\end{pmatrix} = \begin{pmatrix}
w_1 q_{11} & w_2 q_{12} & \cdots & w_n q_{1n} \\
w_1 q_{21} & w_2 q_{22} & \cdots & w_n q_{2n} \\
\vdots & \vdots & \ddots & \vdots \\
w_1 q_{m1} & w_2 q_{m2} & \cdots & w_n q_{mn}
\end{pmatrix} \tag{12}
$$

Step 12. Recognize the PPS and the NPS according to the following Equations (13) and (14).

$$
I^+ = \left\{ q_1^*, q_2^*, \ldots, q_j^*, \ldots, q_n^* \right\} = \left\{ \left(\max_{j} q_{ij} | j \, \epsilon \, J \right) | \, i = 1, \ldots, m \right\}, \tag{13}
$$

$$
I^- = \left\{ q_1^-, q_2^-, \ldots, q_j^-, \ldots, q_n^- \right\} = \left\{ \left(\min_{j} q_{ij} | j \, \epsilon \, J \right) | \, i = 1, \ldots, m \right\}, \tag{14}
$$

Step 13. Determine the Euclidean distance among the positive and negative perfect solution S_i^+ and S_i^-, respectively, by applying Equations (15) and (16).

$$
S_i^* = \sqrt{\sum_{j=1}^{n} \left(q_{ij} - q_i^* \right)^2}, \ i = 1, 2, \ldots, m, \tag{15}
$$

$$
S_i^- = \sqrt{\sum_{j=1}^{n} \left(q_{ij} - q_i^- \right)^2}, \ i = 1, 2, \ldots, m, \tag{16}
$$

Step 14. Determine the proportional closeness (Y_i) to the S_i^+ and S_i^- for each 3PRLP by applying the Equation (17), then rank the 3PRLPs according to value of Y_i.

$$
Y_i = \frac{S_i^-}{S_i^+ + S_i^-} \ i = 1, 2, \ldots, m \tag{17}
$$

4. Application of the Framework

We apply the considered case for illustrating the ability and validity of the suggested methodology. Accordingly, we specify how the information and inputs are aggregated from decision makers, show the results and consequences using the suggested technique, and discuss the managerial implication.

4.1. A Case Study

We selected the Holding Company for Metal Industries (HMI Co.) as this case study. HMI Co. began in 1983 as a special common stock company in the Cairo Governorate, Egypt under the name of the Public Sector Authority for Metal Industries. The company assembles the motor, gearbox, and axle and manufactures the major accessories of passenger automobile powertrain like gearbox housings, cylinder blocks, gearboxes, connecting rods, and pistons. HMI Co. started its premier gathering streak for motors, gearboxes, and axles in 2005, the piston casting and machining lines in 2010. Table 3 shows yearly assembly and industrial capabilities. HMI Co., as an authentic gear producer that has generated motor and arbors assemblies for many automobile producers.

Table 3. The yearly assembly and production capabilities of (HMI Co.).

Assembling Capability	Volume	Industrialization	Volume
Axle collection	100,000	Cylinder heads and blocks	80,000
Gearbox collection	50,000	Conveyor belts	60,000
Engine sets	75,000	Metal structures	100,000

HMI Co. cooperated with reputable companies from European and Asian countries in order to transfer technology in the various fields of manufacturing, production, and packaging. HMI Co. is able to provide relevant services in modulating new platforms, packaging, and earning certificates of expertise in all these areas. Furthermore, it produces motors between the lowest fuel-exhaustion engines in Egypt in accordance with the latest legal and international regulations on the environment and pollution. Therefore, company directors are keen to consider RL activities to raise the corporate image of sustainability as well as reduce cost. However, the evaluation of various schemes steered to the judgment for outsourcing RL activities to 3PRLPs, leading to the necessity to undertake appropriate assessment activity.

4.2. Data Gathering

In this study, the panel comprised the experts and decision makers, as listed in Table 4, that participated in determination of the valuation dimensions and classification of 3PRLP alternatives. All specialists who participated had more than five years of expertise in automotive manufacturing. The procedures of collecting and filling out the surveys with the 10 manufacture decision makers involved two stages: firstly, specialists were identified, appointments were organized, and the questionnaires were distributed, and the questionnaires were filled out according to Tables 1 and 2 to deal with vague data and misinterpretation. Then, the initial valuation was reviewed and any doubts clarified on expert responses. Secondly, the collected responses were then utilized to complete the initial neutrosophic judgment matrices. The opinions of decision makers and specialists were converted to T2NNs, to gain more accuracy and applicable weights, and then the matrix of decisions between dimensions and alternatives was completed to extract the ordering of 3PRLPs substitutes. As mentioned in previous sections, the dimensions and their subindices shown in Figure 3 were the outcomes from discussion reviewing the literature among decision makers and authors.

Table 4. Information of experts who participated in questionnaires.

Specialist No	Knowledge (Years)	Learning	Chief	Position
1	6	Master	Financial Management	Finance expert
2	7	PhD	Industrial Engineering	Project control engineer
3	5	Bachelor	Industrial Management	Industrial sector support
4	5	Master	Mechanical Engineering	R&D expert
5	6	Bachelor	Industrial Engineering	Logistics expert
6	8	Master	MBA Management	Vice of R&D
7	7	Master	Mechanical Engineering	Manufacture control
8	9	PhD	Financial Management	Finance expert
9	5	Master	Mechanical Engineering	Manufacture control
10	6	Master	Industrial Engineering	Logistics expert

4.3. Neutrosophic AHP-TOPSIS Results

Here, we present the outcomes of the neutrosophic AHP-TOPSIS methodology. Some dimensions may affect each other because they are interconnected so AHP is assumed to deal with effect and relations between dimensions and to handle uncertainty. Subsequently, TOPSIS was utilized to rate the 3PRLPs.

Firstly, the panel of specialists in Table 4 determined the weights of dimensions and their subindices. Then, we constructed a matrix between the four main sustainability dimensions in the horizontal and vertical directions of the matrix as shown in Table 5, by utilizing the semantic variables as in Table 1. By using Equation (5), we replaced the linguistic terms with their T2NNs equivalents as in Table 6. Subsequently, we transformed the neutrosophic matrix by using a score function Equation (6), to the deterministic matrix as in Equation (7). Consequently, AHP was utilized to calculate the importance of the fundamental dimensions. Table 6 presents the weights for each sustainability factor after normalizing them. We performed a check-consistency on the matrix of weights for sustainability factors.

Table 5. Assessment of key dimensions by all experts using the semantic variables.

Dimensions	EDI_1	NDI_2	SDI_3	RDI_4
EDI_1	-	⟨EPD⟩	⟨EIE⟩	⟨JIE⟩
NDI_2	1/⟨EPD⟩	-	⟨VSE⟩	⟨WIE⟩
SDI_3	1/⟨EIE⟩	1/⟨VSE⟩	-	⟨EIE⟩
RDI_4	1/⟨JIE⟩	1/⟨WIE⟩	1/⟨EIE⟩	-

Table 6. Assessment of key dimensions by all experts using T2NNs.

Dimensions	EDI_1	NDI_2	SDI_3	RDI_4	Weights
EDI_1	0.5	⟨(0.89, 0.86, 0.96), (0.09, 0.16, 0.11), (0.06, 0.07, 0.11)⟩	⟨(0.64, 0.54, 0.56), (0.39, 0.44, 0.56), (0.36, 0.39, 0.34)⟩	⟨(0.39, 0.29, 0.26), (0.44, 0.56, 0.39), (0.46, 0.59, 0.54)⟩	0.17
NDI_2	$\frac{1}{⟨(0.89,0.86,0.96),(0.09,0.16,0.11),(0.06,0.07,0.11)⟩}$	0.5	⟨(0.79, 0.74, 0.69), (0.19, 0.16, 0.29), (0.16, 0.11, 0.19)⟩	⟨(0.19, 0.29, 0.19), (0.59, 0.69, 0.79), (0.46, 0.74, 0.73)⟩	0.22
SDI_3	$\frac{1}{⟨(0.64,0.54,0.56),(0.39,0.44,0.56),(0.36,0.39,0.34)⟩}$	$\frac{1}{⟨(0.79,0.74,0.69),(0.19,0.16,0.29),(0.16,0.11,0.19)⟩}$	0.5	⟨(0.64, 0.54, 0.56), (0.39, 0.44, 0.56), (0.36, 0.39, 0.34)⟩	0.30
RDI_4	$\frac{1}{⟨(0.39,0.29,0.26),(0.44,0.56,0.39),(0.46,0.59,0.54)⟩}$	$\frac{1}{⟨(0.19,0.29,0.19),(0.59,0.69,0.79),(0.46,0.74,0.73)⟩}$	$\frac{1}{⟨(0.64,0.54,0.56),(0.39,0.44,0.56),(0.36,0.39,0.34)⟩}$	0.5	0.31

In this regard, and referring to Table 6 and Figure 5, we note that the risk and safety dimension is the most significant of the dimensions with weight 0.310, then the social

dimension with weight 0.300, and the environmental dimension is last with weight 0.170. According to this case study, the risk and safety dimension has the highest weight which reflects the opinions of decision makers on problems and issues such as safety and operational risk. The social dimension occupies the second rank as it is concerned with workers' rights and human rights issues. The economic aspect ranks third, since one of the main objectives of 3PRLP processes is to improve the competitive feature and profit to organizations. The results demonstrated the precision and confirmed the suggested neutrosophic AHP.
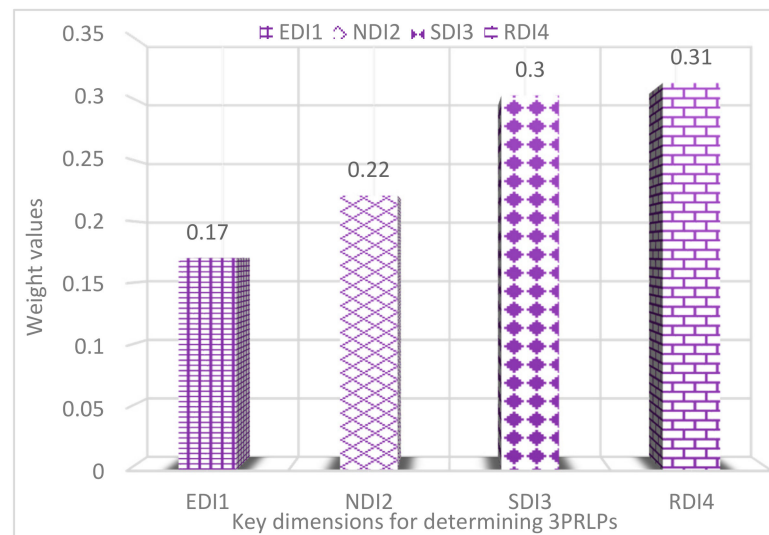
Figure 5. Final weights of main sustainability dimensions.

Based on the linguistic terms and the neutrosophic membership functions of T2NNs as in Table 1, we constructed all matrices for identifying the importance of subindices for every dimension separately for economic, environmental, social, and risk and safety factor as in Appendix A, Tables A1–A8. A consistency check on all matrices utilized for identifying the weights of subindices was performed. A consistency ratio in all matrices less than 0.1 means that the opinions of decision makers are consistent according to the rules of decision provisions. Note that subindices weights are called the local weights. The local and global weights of subindices are exhibited in Table 7 and charted in Figure 6.
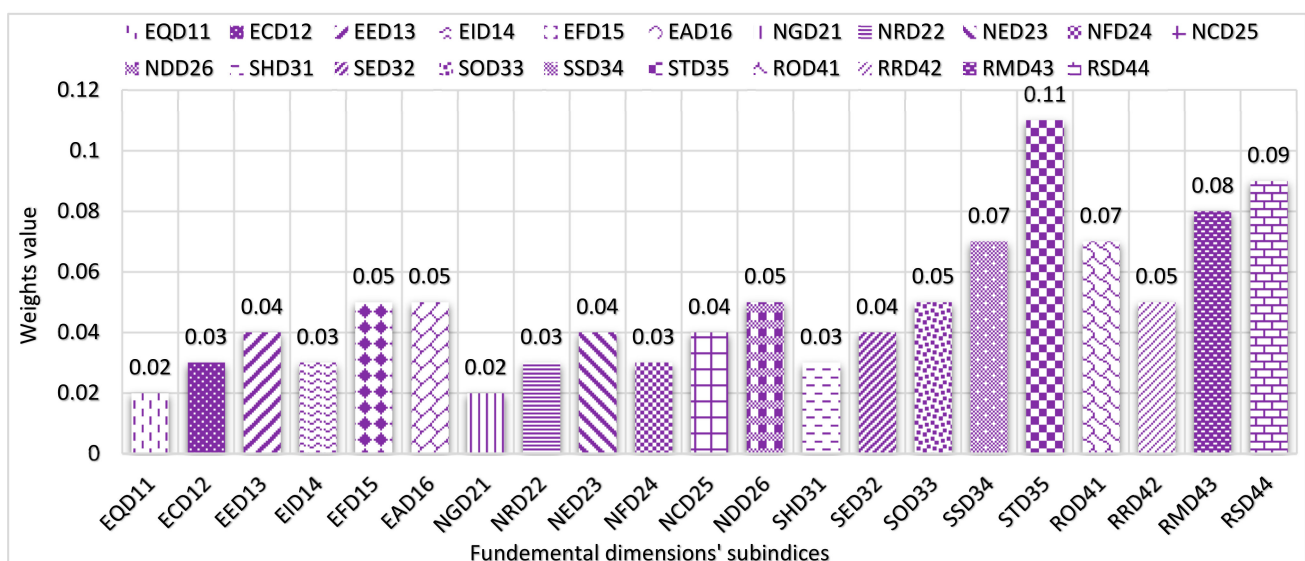
Figure 6. Final global weights of subindices.

Table 7. Final weights value of subindices.

Dimension Weight	EDI$_1$ (0.17)						NDI$_2$ (0.22)					
Subindices	EQD$_{11}$	ECD$_{12}$	EED$_{13}$	EID$_{14}$	EFD$_{15}$	EAD$_{16}$	NGD$_{21}$	NRD$_{22}$	NED$_{23}$	NFD$_{24}$	NCD$_{25}$	NDD$_{26}$
Local weights	0.10	0.11	0.18	0.16	0.21	0.23	0.11	0.09	0.14	0.19	0.23	0.24
Global weights	0.02	0.03	0.04	0.03	0.05	0.05	0.02	0.03	0.04	0.03	0.04	0.05
Rank	21	17	12	16	8	7	20	18	13	15	11	7
Dimension weight	SDI$_3$ (0.30)					RDI$_4$ (0.31)						
Subindices	SHD$_{31}$	SED$_{32}$	SOD$_{33}$	SSD$_{34}$	STD$_{35}$	ROD$_{41}$	RRD$_{42}$		RMD$_{43}$		RSD$_{44}$	
Local weights	0.10	0.14	0.16	0.23	0.37	0.24	0.19		0.26		0.31	
Global weights	0.03	0.04	0.05	0.07	0.11	0.07	0.05		0.08		0.09	
Rank	19	14	10	5	1	4	9		3		2	

For the economic aspect, which has six subindices, the R&D and facilities indices have the highest weights of 0.23 and 0.21, followed by the deferment index with weight 0.18, then the distribution index with weight 0.16. The quality criterion has the lowest value 0.11, then the cost index with weight 0.10 as in Table A2. The environmental aspect has six subindices, of which the disposal index has the highest weight of 0.24, then the recycle index with weight 0.23 and the reuse index is last with weight 0.09 as shown in Table A4. The social aspect has five subindices, of which the standing index has the highest weight of 0.37, followed by esteem for the rules with weight 0.23 and the health index is last with weight 0.10 as shown in Table A6. Finally, the risk and safety aspect has four subindices, of which the security index is the most significant with value equal to 0.31, then, the monetary risk index with weight 0.26, whereas the organizational hazard index is the least important index with weight 0.19 as shown in Table A8.

Table A9 presents the initial decision matrix, which is structured by the 10 experts and by applying the semantic scales exhibited in Table 2, by utilizing to Equation (8). Subsequently, we replace the linguistic terms with T2NNs as shown in Table A10. By using Equation (6), we transformed the neutrosophic numbers to crisp value according to Equation (9), called the deterministic matrix as in Table A11. Table A12 presents the normalized decision matrix, as normalized by Equation (10). Then, we used the weights we obtained from the neutrosophic AHP method as in Equation (11) with the normalized decision matrix to obtain the weighted normalized matrix as in Equation (12), as exhibited in Table A13. Table A13 presents the positive and negative perfect solution computed by Equations (13) and (14). Table A13 also presents the Euclidean distance among the PPS and the NPS and the proportional closeness calculated by Equations (15)–(17).

Table 8 shows the final ranking of the 3PRLPs substitutes. Consequently, from the results obtained in the previous matrices, it is clear that alternative 3PRLP$_6$ has the highest closeness measurements, followed by 3PRLP$_1$ and 3PRLP$_4$. Alternatives 3PRLP$_2$ and 3PRLP$_5$ are in the last of ranking with 3PRLP$_7$. Figure 7 represents the relation among the 3PRLPs on the horizontal axis and closeness coefficients on the vertical axis—3PRLP$_6$ has the highest value of closeness measurements and is therefore ranked highest. Finally, if an alternative is requested to replace alternative 3PRLP$_6$, there will be three other alternatives 3PRLP$_1$, 3PRLPs$_3$ and 3PRLP$_4$, which are very close in value, but the closest is alternative 3PRLP$_1$.

Table 8. The concerned closeness coefficients and rating of 3PRLPs.

3PRLPs	Distance S^*	Distance S^-	Closeness Measurements Y_i	Rank
$3PRLPs_1$	0.13	0.12	0.474065	2
$3PRLPs_2$	0.20	0.08	0.278927	5
$3PRLPs_3$	0.14	0.11	0.445539	4
$3PRLPs_4$	0.13	0.11	0.465156	3
$3PRLPs_5$	0.21	0.05	0.202659	6
$3PRLPs_6$	0.08	0.22	0.739986	1
$3PRLPs_7$	0.23	0.05	0.183166	7
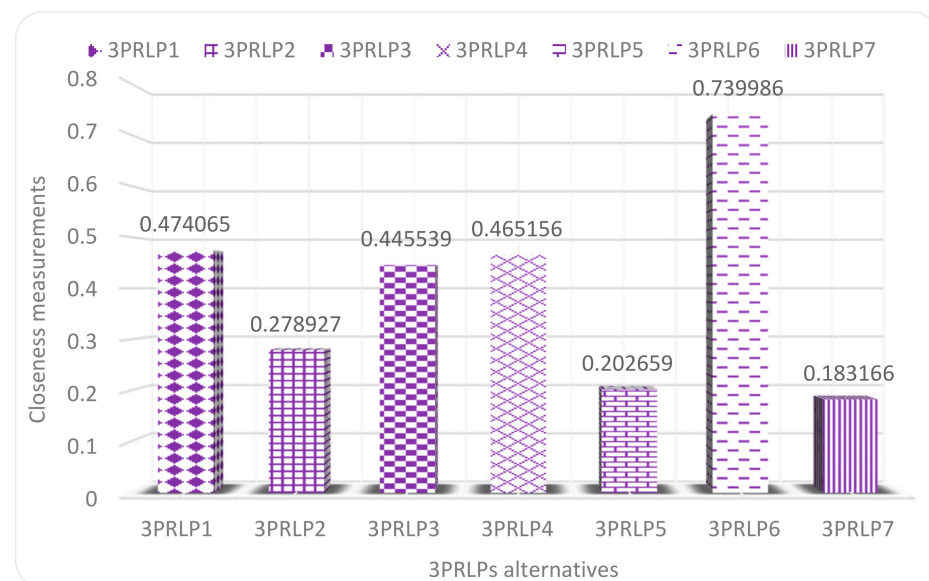
Figure 7. Final ranking of the 3PRLPs.

5. Comparative Analysis

In this section, we conducted several comparisons with previous studies, such as the TOPSIS-VIKOR approach [5], AHP-MOORA approach [4], BWM-MULTIMOORA approach [36], AHP-DEA-COPRAS approach [37], SWARA-MOORA-WASPAS approach [40], SWARA-MOORA approach [41], and SWARA-COPRAS approach [3] for confirming the potential, and efficiency of the submitted approach AHP-TOPSIS under the neutrosophic environment. All the previous studies that have been conducted have different dimensions in terms of the criteria and subindices, the number of substitutions, the environment in which the study was conducted, the numbers used, and the various scales that affected the arrangement of alternatives. Commonly, MCDM methods have several objectives that must be achieved, including the perfect alternate and the best arrangement. In this regard, this research is grounded on its comparison with the previous approaches on these two purposes, the optimal alternate and the best arrangement, as shown from the results in Table 9.

Table 9. Proportional comparison between various MCDM methodologies.

The MCDM Technique Applied in Their Paper			
TOPSIS-VIKOR approach [5]	AHP–MOORA approach [4]	BWM-MULTIMOORA approach [36]	AHP-DEA-COPRAS approach [37]
Environment of the used approach			
Rough set	Fuzzy	Fuzzy	Classic
The type of modification used in the approach			
Hybridization			
The persons responsible for expressing their opinions in the aforementioned studies			
A collection of experts			
Numeral of dimensions and their subindices			
Thirteen dimensions	Four core dimensions and 23 subindices	Eight core dimensions and 24 subindices	Ten dimensions
Number of 3PRLPs			
Thirty 3PRLPs	Nine 3PRLPs	Three 3PRLPs	Thirty 3PRLPs
Scales and numbers			
Classic numbers	Fuzzy numbers and grey numbers	Fuzzy numbers	Grey numbers
Rating 3PRLPs by other approaches			
Rating by TOPSIS-VIKOR approach $3PRLP_6 > 3PRLP_4 > 3PRLP_1 > 3PRLP_3 > 3PRLP_2 > 3PRLP_5 > 3PRLP_7$	Rating by AHP-MOORA approach $3PRLP_6 > 3PRLP_4 > 3PRLP_1 > 3PRLP_2 > 3PRLP_3 > 3PRLP_7 > 3PRLP_5$	Rating by BWM-MULTIMOORA approach $3PRLP_3 > 3PRLP_6 > 3PRLP_4 > 3PRLP_1 > 3PRLP_2 > 3PRLP_7 > 3PRLP_5$	Rating by AHP-EDAS-COPRAS approach $3PRLP_6 > 3PRLP_1 > 3PRLP_4 > 3PRLP_5 > 3PRLP_7 > 3PRLP_2 > 3PRLP_3$
Spearman rank correlation coefficient			
0.893	0.500	0.179	0.400
The MCDM technique applied in their paper			
SWARA-MOORA-WASPAS approach [40]	SWARA-MOORA approach [41]	SWARA-COPRAS framework [3]	The submitted model AHP-TOPSIS
Environment of the used approach			
Classic	Fuzzy	Fuzzy	Neutrosophic
The type of modification used in the approach			
Hybridization			
The people responsible for expressing their opinions in the aforementioned studies			
A group of experts			
Case study			
Mobile recycling in India	Plastic industry	Automotive industry	Automotive industry
Numeber of dimensions and their subindices			
Ten dimensions	Four key sustainability dimensions including economic, environment, social, and risk and 23 subindices	Four key dimensions and 16 subindices	Four core sustainability dimensions including: economic, environment, social, and risk and safety and 21 subindices
Number of 3PRLPs			
Nine 3PRLPs	Nine 3PRLPs	Seven 3PRLPs	Seven 3PRLPs
Scales and numbers			
Classic numbers	Fuzzy numbers		T2NNs
Rating 3PRLPs by other approaches			
Rating by SWARA-MOORA-WASPAS approach $3PRLP_1 > 3PRLP_6 > 3PRLP_4 > 3PRLP_3 > 3PRLP_2 > 3PRLP_5 > 3PRLP_7$	Rating by SWARA-MOORA approach $3PRLP_4 > 3PRLP_6 > 3PRLP_1 > 3PRLP_3 > 3PRLP_2 > 3PRLP_7 > 3PRLP_5$	Rating by SWARA-COPRAS approach $3PRLP_6 > 3PRLP_1 > 3PRLP_4 > 3PRLP_3 > 3PRLP_5 > 3PRLP_2 > 3PRLP_7$	Rating by the proposed model AHP-TOPSIS $3PRLP_6 > 3PRLP_1 > 3PRLP_4 > 3PRLP_3 > 3PRLP_2 > 3PRLP_5 > 3PRLP_7$
Spearman rank correlation coefficient			
0.624	0.179	0.821	-

In realization of the principle of the optimal alternative, this study proposes a novel approach that includes AHP and TOPSIS under a neutrosophic environment and by using

linguistic scales and T2NNs to arrange 3PRLPs, and based on the results obtained from Table 6, the best sustainable alternative is namely $3PRLP_6$. Additionally, $3PRLP_6$ is the optimal alternative by TOPSIS-VIKOR approach, AHP-MOORA approach, AHP-DEA-COPRAS approach, and SWARA-COPRAS approach. On the contrary, $3PRLP_3$ is the optimal alternative by BWM-MULTIMOORA approach, $3PRLP_1$ is the best alternative by SWARA-MOORA-WASPAS approach and $3PRLP_4$ is the best alternative by SWARA-MOORA approach. Based on the results, $3PRLP_6$ is the most sustainable alternate for each of the submitted techniques and some other approaches mentioned in the comparison, which means stability among these techniques, which used the identical data. Lastly, selecting the optimal 3PRLP utilizing other associated approaches varies from our proposed model, emphasizing that the other approaches did not treat aspects of the problem as in our proposed approach.

Accordingly, for achieving the principle of the optimal arrangement, though the submitted model and other models that were compared with it an ideal screening scheme can be obtained, and there are some differences as a result of dealing with the information. In this regard, the difference among the submitted model and the TOPSIS-VIKOR methodology [5] is the ranking positions of $3PRLP_1$ and $3PRLP_4$. Additionally, the difference among the submitted model and the AHP-MOORA methodology [4] is the ranking positions of $3PRLP_1$, $3PRLP_4$, $3PRLP_2$, $3PRLP_3$, $3PRLP_5$, and $3PRLP_7$. Then, the difference between the proposed approach and the BWM-MULTIMOORA approach [36] is the arrangement positions of $3PRLP_6$, $3PRLP_1$, $3PRLP_3$, $3PRLP_5$, and $3PRLP_7$. Similarly, the difference between the proposed approach and the AHP-DEA-COPRAS approach [37] is the ranking positions of $3PRLP_2$, $3PRLP_3$, $3PRLP_5$, and $3PRLP_7$. Similarly, the difference among the submitted model and the SWARA-MOORA-WASPAS framework [40] is in the ranking positions of $3PRLP_1$ and $3PRLP_6$. Additionally, the difference between the proposed approach and the SWARA- MOORA approach [41] is the arrangement position of $3PRLP_4$, $3PRLP_6$, $3PRLP_1$, $3PRLP_5$, and $3PRLP_7$. In addition, the difference between the proposed framework and the SWARA-COPRAS methodology [3] is the ranking positions of $3PRLP_5$ and $3PRLP_2$. Lastly, Figure 8 presents the ranking of alternatives using different approaches employed in the comparison. These changes and the presence of a slight similarity among the results of the submitted model and the other methods with which it is compared is acceptable and natural, due to the different opinions of experts and decision makers. Finally, these differences are allowable to determine the success, effectiveness, validity, appropriateness, and superiority of the submitted approach.
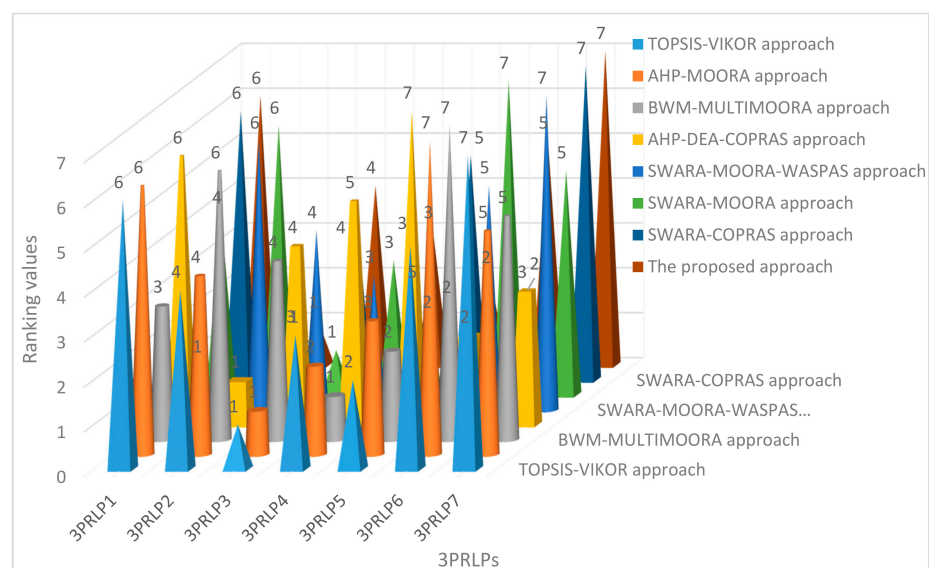
Figure 8. Ranking of 3PRLPs alternatives using different approaches used in comparison.

6. Sensitivity Analysis

In this part, a sensitivity analysis was conducted to determine the effects of potential variations in the weights of key sustainable dimensions on selecting the best 3PRLPs. Figures 9–12 illustrate the variations in the weights value of the dimensions, and regardless of the changes, $3PRLP_6$ alternative remains in the first place. In Figure 9, it becomes clear that $3PRLP_6$ is ranked first, followed by $3PRLP_1$, while $3PRLP_7$ remains the least preferred alternative. $3PRLP_2$ and $3PRLP_3$ are very close together, and $3PRLP_4$ is also close to $3PRLP_6$. In Figure 10, there are some slight changes that do not affect the arrangement of the 3PRLPs. However, $3PRLP_2$ is close to $3PRLP_5$ at the end of the weight line. Additionally, in Figure 11, according to changes in the weight value of the social dimension, the ratings of 3PRLPs alternates are changed. For example, $3PRLP_3$ takes the place of $3PRLP_4$. $3PRLP_1$ also comes close to $3PRLP_3$ at the first part of the weight line. In the last case as in Figure 12, the arrangement of alternatives remains the same, with some slight changes—$3PRLP_3$ occupies the place of $3PRLP_1$ in the arrangement, and $3PRLP_2$ occupies the place of $3PRLP_5$.
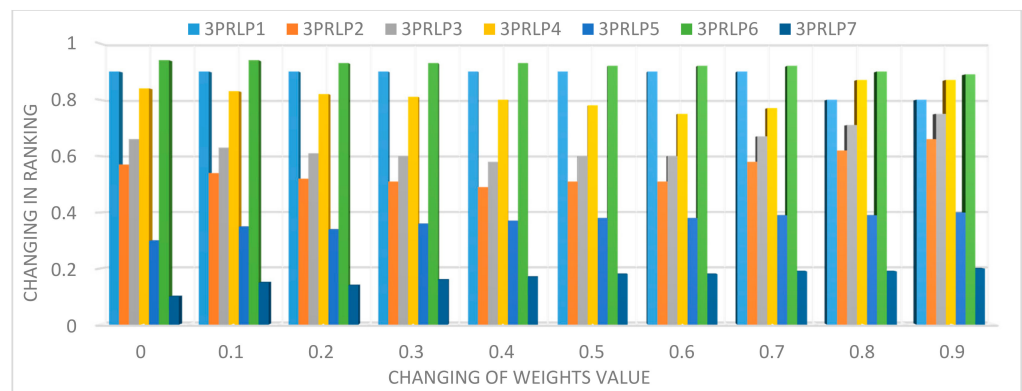
Figure 9. Economic dimension sensitivity.
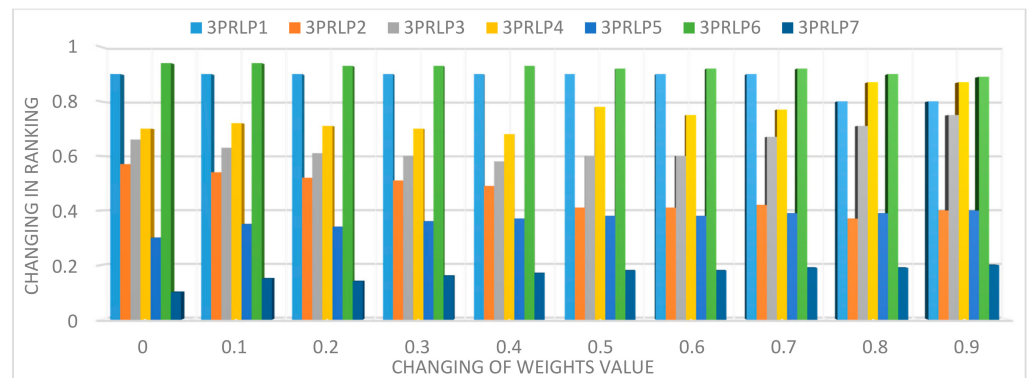
Figure 10. Environmental dimension sensitivity.
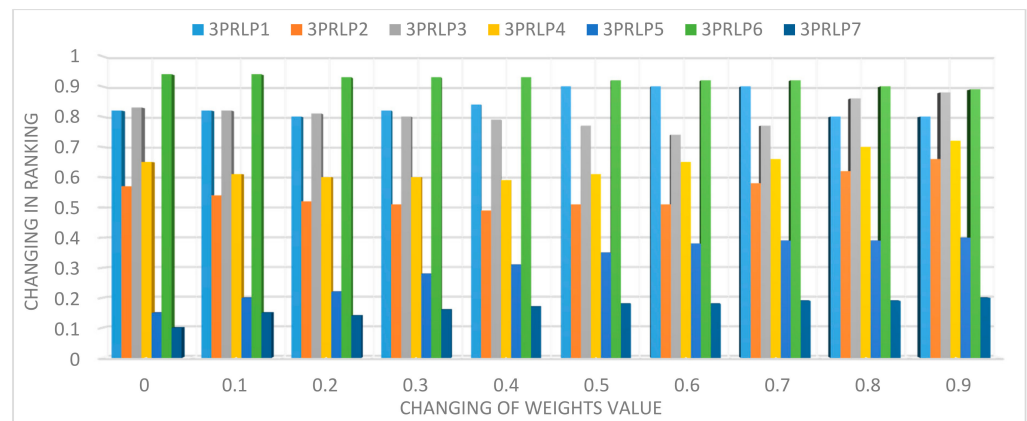
Figure 11. Social dimension sensitivity.
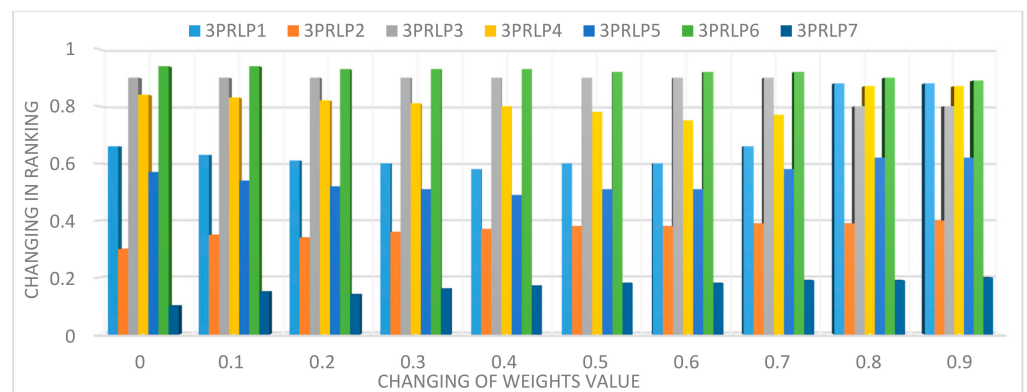
Figure 12. Risk and safety dimension sensitivity.

7. Managerial Implications

Selecting an appropriate 3PRLP requires a ranking procedure, which generally includes several selection dimensions. Often, the selection criteria comprise specific choices or opinions of experts and specialists. The proposed neutrosophic AHP-TOPSIS shows its applicability to handling qualitative and unverified data and develops a robust decision. The organization in the case study can choose the Table 3 PRLP alternative and assess it through a broad range of selection dimensions. Indeed, because of the large number of possible dimensions due to the multifaceted nature of RL, the selection procedure is difficult. Consequently, one robust dimension of the suggested technique is that it is able compute the weights value of the determination dimensions by AHP which considers the consistency in the decision.

One of the utmost significant features of the submitted method is its ability to deal with qualitative and unconfirmed inputs under the neutrosophic environment. Additionally, the case company can determine the strengths and weaknesses of each service provider, which then could be utilized to request the specified service provider to ameliorate in specific fields so that they can qualify for future selection. Generally, the approach suggested in this research is able to be extended to different decisions related to other manufacturing problems.

The suggested technique can be utilized as a reference guide for service provisions for conducting modifications to procedures and strategies to meet the requirements of consumers and societies. Furthermore, regulatory bodies and governments can use the suggested technique to investigate the relations amongst social, economic and environmental problems, and utilize the outcomes to prompt fulfillment on sustainability.

8. Concluding Remarks

A new MCDM technique, which integrated neutrosophic AHP and TOPSIS, was suggested and utilized in a considered real case study of the car components industrial industry for evaluating and selecting an alternative for 3PRLP. The neutrosophic AHP was utilized for weighting all related subindices and defining the effect of these subindices on the decision, which were subsequently approved and used by the neutrosophic TOPSIS to make the eventual classification.

In this approach, the AHP-TOPSIS technique was established to deal with vague relationships to address the challenge caused by qualitative and uncertain data. The suggested approach was utilized in a considered real case study to demonstrate the validity and applicability—the suggested approach was shown to be flexible and adaptable in dealing with uncertain, ambiguous and qualitative data. The obtained results successfully addressed the selection dimensions taking into account safety and risk, economic, environmental and social dimensions, and in a sustainable manner. The implementation procedures and the outcomes addressed the ability of the suggested technique in dealing with multiple aspects of valuation criteria and handling qualitative and uncertain data.

In future, the suggested approach can be extended. Firstly, it would be beneficial for future research to be concentrated on increasing the numbers of criteria so as to progress the fineness and accuracy of selection and valuation. It would also be useful to determine the performance of the proposed technique utilized in other aspects of manufacturing such as supplier selection and market selection, and in other manufacturing domains like appliances, glasses, paper for 3PRLP selection and beyond. In addition, as the number of papers on selection of 3PRLPs is increasing, future research can associate and differentiate the validity and reliability of other MCDM such as VIKOR, PROMETHEE and TODIM with neutrosophic numbers in a variety of scenarios.

Appendix A

Table A1. Assessment of economic dimension by 10 experts utilizing semantic terms.

Factor EDI$_1$	EQD$_{11}$	ECD$_{12}$	EED$_{13}$	EID$_{14}$	EFD$_{15}$	EAD$_{16}$
EQD$_{11}$	-	$\langle$VSE$\rangle$	$\langle$WIE$\rangle$	$\langle$JIE$\rangle$	$\langle$EIE$\rangle$	$\langle$EPD$\rangle$
ECD$_{12}$	1/$\langle$VSE$\rangle$	-	$\langle$JIE$\rangle$	$\langle$JIE$\rangle$	$\langle$EPD$\rangle$	$\langle$EIE$\rangle$
EED$_{13}$	1/$\langle$WIE$\rangle$	1/$\langle$JIE$\rangle$	-	$\langle$EIE$\rangle$	$\langle$JIE$\rangle$	$\langle$EPD$\rangle$
EID$_{14}$	1/$\langle$JIE$\rangle$	1/$\langle$JJIE$\rangle$	1/$\langle$EIE$\rangle$	-	$\langle$EIE$\rangle$	$\langle$WIE$\rangle$
EFD$_{15}$	1/$\langle$EIE$\rangle$	1/$\langle$EPD$\rangle$	1/$\langle$JIE$\rangle$	1/$\langle$EIE$\rangle$	-	$\langle$EPD$\rangle$
EAD$_{16}$	1/$\langle$EPD$\rangle$	1/$\langle$EIE$\rangle$	1/$\langle$EPD$\rangle$	1/$\langle$WIE$\rangle$	1/$\langle$EPD$\rangle$	-

Table A2. Assessment of economic dimension by 10 experts utilizing T2NNs.

Factor EDI$_1$	EQD$_{11}$	ECD$_{12}$	EED$_{13}$	EID$_{14}$	EFD$_{15}$	EAD$_{16}$	Weights
EQD$_{11}$	0.5	⟨(0.79, 0.74, 0.69), (0.19, 0.16, 0.29), (0.16, 0.11, 0.19)⟩	⟨(0.19, 0.29, 0.19), (0.59, 0.69, 0.79), (0.46, 0.74, 0.73)⟩	⟨(0.39, 0.29, 0.26), (0.44, 0.56, 0.39), (0.46, 0.59, 0.54)⟩	⟨(0.64, 0.54, 0.56), (0.39, 0.44, 0.56), (0.36, 0.39, 0.34)⟩	⟨(0.89, 0.86, 0.96), (0.09, 0.16, 0.11), (0.06, 0.07, 0.11)⟩	0.10
ECD$_{12}$	$\frac{1}{⟨(0.79, 0.74, 0.69), (0.19, 0.16, 0.29), (0.16, 0.11, 0.19)⟩}$	0.5	⟨(0.39, 0.29, 0.26), (0.44, 0.56, 0.39), (0.46, 0.59, 0.54)⟩	⟨(0.39, 0.29, 0.26), (0.44, 0.56, 0.39), (0.46, 0.59, 0.54)⟩	⟨(0.89, 0.86, 0.96), (0.09, 0.16, 0.11), (0.06, 0.07, 0.11)⟩	⟨(0.65, 0.55, 0.55), (0.40, 0.45, 0.55), (0.35, 0.40, 0.35)⟩	0.11
EED$_{13}$	$\frac{1}{⟨(0.19, 0.29, 0.19), (0.59, 0.69, 0.79), (0.46, 0.74, 0.73)⟩}$	$\frac{1}{⟨(0.39, 0.29, 0.26), (0.44, 0.56, 0.39), (0.46, 0.59, 0.54)⟩}$	0.5	⟨(0.64, 0.54, 0.56), (0.39, 0.44, 0.56), (0.36, 0.39, 0.34)⟩	⟨(0.39, 0.29, 0.26), (0.44, 0.56, 0.39), (0.46, 0.59, 0.54)⟩	⟨(0.89, 0.86, 0.96), (0.09, 0.16, 0.11), (0.06, 0.07, 0.11)⟩	0.18
EID$_{14}$	$\frac{1}{⟨(0.39, 0.29, 0.26), (0.44, 0.56, 0.39), (0.46, 0.59, 0.54)⟩}$	$\frac{1}{⟨(0.39, 0.29, 0.26), (0.44, 0.56, 0.39), (0.46, 0.59, 0.54)⟩}$	⟨(0.65, 0.55, 0.55), (0.40, 0.45, 0.55), (0.35, 0.40, 0.35)⟩	0.5	⟨(0.64, 0.54, 0.56), (0.39, 0.44, 0.56), (0.36, 0.39, 0.34)⟩	⟨(0.19, 0.29, 0.19), (0.59, 0.69, 0.79), (0.46, 0.74, 0.73)⟩	0.16
EFD$_{15}$	$\frac{1}{⟨(0.64, 0.54, 0.56), (0.39, 0.44, 0.56), (0.36, 0.39, 0.34)⟩}$	$\frac{1}{⟨(0.90, 0.85, 0.95), (0.10, 0.15, 0.10), (0.05, 0.05, 0.10)⟩}$	$\frac{1}{⟨(0.39, 0.29, 0.26), (0.44, 0.56, 0.39), (0.46, 0.59, 0.54)⟩}$	$\frac{1}{⟨(0.64, 0.54, 0.56), (0.39, 0.44, 0.56), (0.36, 0.39, 0.34)⟩}$	0.5	⟨(0.89, 0.86, 0.96), (0.09, 0.16, 0.11), (0.06, 0.07, 0.11)⟩	0.21
EAD$_{16}$	$\frac{1}{⟨(0.89, 0.86, 0.96), (0.09, 0.16, 0.11), (0.06, 0.07, 0.11)⟩}$	$\frac{1}{⟨(0.64, 0.54, 0.56), (0.39, 0.44, 0.56), (0.36, 0.39, 0.34)⟩}$	$\frac{1}{⟨(0.89, 0.86, 0.96), (0.09, 0.16, 0.11), (0.06, 0.07, 0.11)⟩}$	$\frac{1}{⟨(0.19, 0.29, 0.19), (0.59, 0.69, 0.79), (0.46, 0.74, 0.73)⟩}$	$\frac{1}{⟨(0.89, 0.86, 0.96), (0.09, 0.16, 0.11), (0.06, 0.07, 0.11)⟩}$	0.5	0.23

Table A3. Assessment of environmental dimension by 10 experts utilizing semantic terms.

Factor NDI$_2$	NGD$_{21}$	NRD$_{22}$	NED$_{23}$	NFD$_{24}$	NCD$_{25}$	NDD$_{26}$
NGD$_{21}$	-	⟨VSE⟩	⟨VSE⟩	⟨WIE⟩	⟨EIE⟩	⟨EPD⟩
NRD$_{22}$	1/⟨VSE⟩	-	⟨JIE⟩	⟨JIE⟩	⟨JIE⟩	⟨EIE⟩
NED$_{23}$	1/⟨VSE⟩	1/⟨JIE⟩	-	⟨EIE⟩	⟨JIE⟩	⟨EPD⟩
NFD$_{24}$	1/⟨WIE⟩	1/⟨JIE⟩	1/⟨EIE⟩	-	⟨EIE⟩	⟨JIE⟩
NCD$_{25}$	1/⟨EIE⟩	1/⟨JIE⟩	1/⟨JIE⟩	1/⟨EIE⟩	-	⟨EIE⟩
NDD$_{26}$	1/⟨EPD⟩	1/⟨EIE⟩	1/⟨EPD⟩	1/⟨JIE⟩	1/⟨EIE⟩	-

Table A4. Assessment of environmental dimension by 10 experts utilizing T2NNs.

Factor NDI$_2$	NGD$_{21}$	NRD$_{22}$	NED$_{23}$	NFD$_{24}$	NCD$_{25}$	NDD$_{26}$	Weights
NGD$_{21}$	0.5	⟨(0.79, 0.74, 0.69), (0.19, 0.16, 0.29), (0.16, 0.11, 0.19)⟩	⟨(0.79, 0.74, 0.69), (0.19, 0.16, 0.29), (0.16, 0.11, 0.19)⟩	⟨(0.19, 0.29, 0.19), (0.59, 0.69, 0.79), (0.46, 0.74, 0.73)⟩	⟨(0.64, 0.54, 0.56), (0.39, 0.44, 0.56), (0.36, 0.39, 0.34)⟩	⟨(0.89, 0.86, 0.96), (0.09, 0.16, 0.11), (0.06, 0.07, 0.11)⟩	0.11
NRD$_{22}$	$\frac{1}{⟨(0.79, 0.74, 0.69), (0.19, 0.16, 0.29), (0.16, 0.11, 0.19)⟩}$	0.5	⟨(0.39, 0.29, 0.26), (0.44, 0.56, 0.39), (0.46, 0.59, 0.54)⟩	⟨(0.39, 0.29, 0.26), (0.44, 0.56, 0.39), (0.46, 0.59, 0.54)⟩	⟨(0.39, 0.29, 0.26), (0.44, 0.56, 0.39), (0.46, 0.59, 0.54)⟩	⟨(0.64, 0.54, 0.56), (0.39, 0.44, 0.56), (0.36, 0.39, 0.34)⟩	0.09
NED$_{23}$	$\frac{1}{⟨(0.79, 0.74, 0.69), (0.19, 0.16, 0.29), (0.16, 0.11, 0.19)⟩}$	$\frac{1}{⟨(0.39, 0.29, 0.26), (0.44, 0.56, 0.39), (0.46, 0.59, 0.54)⟩}$	0.5	⟨(0.64, 0.54, 0.56), (0.39, 0.44, 0.56), (0.36, 0.39, 0.34)⟩	⟨(0.39, 0.29, 0.26), (0.44, 0.56, 0.39), (0.46, 0.59, 0.54)⟩	⟨(0.89, 0.86, 0.96), (0.09, 0.16, 0.11), (0.06, 0.07, 0.11)⟩	0.14
NFD$_{24}$	$\frac{1}{⟨(0.19, 0.29, 0.19), (0.59, 0.69, 0.79), (0.46, 0.74, 0.73)⟩}$	$\frac{1}{⟨(0.40, 0.30, 0.25), (0.45, 0.55, 0.40), (0.45, 0.60, 0.55)⟩}$	$\frac{1}{⟨(0.64, 0.54, 0.56), (0.39, 0.44, 0.56), (0.36, 0.39, 0.34)⟩}$	0.5	⟨(0.64, 0.54, 0.56), (0.39, 0.44, 0.56), (0.36, 0.39, 0.34)⟩	⟨(0.39, 0.29, 0.26), (0.44, 0.56, 0.39), (0.46, 0.59, 0.54)⟩	0.19
NCD$_{25}$	$\frac{1}{⟨(0.64, 0.54, 0.56), (0.39, 0.44, 0.56), (0.36, 0.39, 0.34)⟩}$	$\frac{1}{⟨(0.39, 0.29, 0.26), (0.44, 0.56, 0.39), (0.46, 0.59, 0.54)⟩}$	$\frac{1}{⟨(0.39, 0.29, 0.26), (0.44, 0.56, 0.39), (0.46, 0.59, 0.54)⟩}$	$\frac{1}{⟨(0.64, 0.54, 0.56), (0.39, 0.44, 0.56), (0.36, 0.39, 0.34)⟩}$	0.5	⟨(0.64, 0.54, 0.56), (0.39, 0.44, 0.56), (0.36, 0.39, 0.34)⟩	0.23
NDD$_{26}$	$\frac{1}{⟨(0.89, 0.86, 0.96), (0.09, 0.16, 0.11), (0.06, 0.07, 0.11)⟩}$	$\frac{1}{⟨(0.64, 0.54, 0.56), (0.39, 0.44, 0.56), (0.36, 0.39, 0.34)⟩}$	$\frac{1}{⟨(0.89, 0.86, 0.96), (0.09, 0.16, 0.11), (0.06, 0.07, 0.11)⟩}$	$\frac{1}{⟨(0.39, 0.29, 0.26), (0.44, 0.56, 0.39), (0.46, 0.59, 0.54)⟩}$	$\frac{1}{⟨(0.64, 0.54, 0.56), (0.39, 0.44, 0.56), (0.36, 0.39, 0.34)⟩}$	0.5	0.24

Table A5. Assessment of social dimension by 10 experts utilizing semantic terms.

Factor SDI$_3$	SHD$_{31}$	SED$_{32}$	SOD$_{33}$	SSD$_{34}$	STD$_{35}$
SHD$_{31}$	-	⟨VSE⟩	⟨JIE⟩	⟨EIE⟩	⟨WIE⟩
SED$_{32}$	1/⟨VSE⟩	-	⟨VSE⟩	⟨JIE⟩	⟨WIE⟩
SOD$_{33}$	1/⟨JIE⟩	1/⟨VSE⟩	-	⟨EIE⟩	⟨JIE⟩
SSD$_{34}$	1/⟨EIE⟩	1/⟨JIE⟩	1/⟨EIE⟩	-	⟨EIE⟩
STD$_{35}$	1/⟨EIE⟩	1/⟨WIE⟩	1/⟨JIE⟩	1/⟨EIE⟩	-

Table A6. Assessment of social dimension by 10 experts utilizing T2NNs.

Factor SDI$_3$	SHD$_{31}$	SED$_{32}$	SOD$_{33}$	SSD$_{34}$	STD$_{35}$	Weights
SHD$_{31}$	0.5	⟨ (0.79, 0.74, 0.69), (0.19, 0.16, 0.29), (0.16, 0.11, 0.19) ⟩	⟨ (0.39, 0.29, 0.26), (0.44, 0.56, 0.39), (0.46, 0.59, 0.54) ⟩	⟨ (0.64, 0.54, 0.56), (0.39, 0.44, 0.56), (0.36, 0.39, 0.34) ⟩	⟨ (0.19, 0.29, 0.19), (0.59, 0.69, 0.79), (0.46, 0.74, 0.73) ⟩	0.10
SED$_{32}$	$\frac{1}{⟨(0.79,0.74,0.69),(0.19,0.16,0.29),(0.16,0.11,0.19)⟩}$	0.5	⟨ (0.79, 0.74, 0.69), (0.19, 0.16, 0.29), (0.16, 0.11, 0.19) ⟩	⟨ (0.39, 0.29, 0.26), (0.44, 0.56, 0.39), (0.46, 0.59, 0.54) ⟩	⟨ (0.19, 0.29, 0.19), (0.59, 0.69, 0.79), (0.46, 0.74, 0.73) ⟩	0.14
SOD$_{33}$	$\frac{1}{⟨(0.39,0.29,0.26),(0.44,0.56,0.39),(0.46,0.59,0.54)⟩}$	$\frac{1}{⟨(0.79,0.74,0.69),(0.19,0.16,0.29),(0.16,0.11,0.19)⟩}$	0.5	⟨ (0.64, 0.54, 0.56), (0.39, 0.44, 0.56), (0.36, 0.39, 0.34) ⟩	⟨ (0.39, 0.29, 0.26), (0.44, 0.56, 0.39), (0.46, 0.59, 0.54) ⟩	0.16
SSD$_{34}$	$\frac{1}{⟨(0.64,0.54,0.56),(0.39,0.44,0.56),(0.36,0.39,0.34)⟩}$	$\frac{1}{⟨(0.39,0.29,0.26),(0.44,0.56,0.39),(0.46,0.59,0.54)⟩}$	$\frac{1}{⟨(0.64,0.54,0.56),(0.39,0.44,0.56),(0.36,0.39,0.34)⟩}$	0.5	⟨ (0.64, 0.54, 0.56), (0.39, 0.44, 0.56), (0.36, 0.39, 0.34) ⟩	0.23
STD$_{35}$	$\frac{1}{⟨(0.19,0.29,0.19),(0.59,0.69,0.79),(0.46,0.74,0.73)⟩}$	$\frac{1}{⟨(0.19,0.29,0.19),(0.59,0.69,0.79),(0.46,0.74,0.73)⟩}$	$\frac{1}{⟨(0.19,0.29,0.19),(0.59,0.69,0.79),(0.46,0.74,0.73)⟩}$	$\frac{1}{⟨(0.64,0.54,0.56),(0.39,0.44,0.56),(0.36,0.39,0.34)⟩}$	0.5	0.37

Table A7. Assessment of risk and safety dimension by 10 experts utilizing semantic terms.

Factor RDI$_4$	ROD$_{41}$	RRD$_{42}$	RMD$_{43}$	RSD$_{44}$
ROD$_{41}$	-	⟨JIE⟩	⟨VSE⟩	⟨EIE⟩
RRD$_{42}$	1/⟨JIE⟩	-	⟨JIE⟩	⟨WIE⟩
RMD$_{43}$	1/⟨VSE⟩	1/⟨JIE⟩	-	⟨EPD⟩
RSD$_{44}$	1/⟨EIE⟩	1/⟨WIE⟩	1/⟨EPD⟩	-

Table A8. Assessment of risk and safety dimension by 10 experts utilizing T2NNs.

Factor RDI$_4$	ROD$_{41}$	RRD$_{42}$	RMD$_{43}$	RSD$_{44}$	Weights
ROD$_{41}$	0.5	⟨ (0.39, 0.29, 0.26), (0.44, 0.56, 0.39), (0.46, 0.59, 0.54) ⟩	⟨ (0.79, 0.74, 0.69), (0.19, 0.16, 0.29), (0.16, 0.11, 0.19) ⟩	⟨ (0.64, 0.54, 0.56), (0.39, 0.44, 0.56), (0.36, 0.39, 0.34) ⟩	0.24
RRD$_{42}$	$\frac{1}{⟨(0.39,0.29,0.26),(0.44,0.56,0.39),(0.46,0.59,0.54)⟩}$	0.5	⟨ (0.39, 0.29, 0.26), (0.44, 0.56, 0.39), (0.46, 0.59, 0.54) ⟩	⟨ (0.19, 0.29, 0.19), (0.59, 0.69, 0.79), (0.46, 0.74, 0.73) ⟩	0.19
RMD$_{43}$	$\frac{1}{⟨(0.79,0.74,0.69),(0.19,0.16,0.29),(0.16,0.11,0.19)⟩}$	$\frac{1}{⟨(0.39,0.29,0.26),(0.44,0.56,0.39),(0.46,0.59,0.54)⟩}$	0.5	⟨ (0.89, 0.86, 0.96), (0.09, 0.16, 0.11), (0.06, 0.07, 0.11) ⟩	0.26
RSD$_{44}$	$\frac{1}{⟨(0.64,0.54,0.56),(0.39,0.44,0.56),(0.36,0.39,0.34)⟩}$	$\frac{1}{⟨(0.19,0.29,0.19),(0.59,0.69,0.79),(0.46,0.74,0.73)⟩}$	$\frac{1}{⟨(0.89,0.86,0.96),(0.09,0.16,0.11),(0.06,0.07,0.11)⟩}$	0.5	0.31

Table A9. The valuation matrix for 3PRLPs alternatives with subindices.

3PRLPs	Subindices																				
	EQD_{11}	ECD_{12}	EED_{13}	EID_{14}	EFD_{15}	EAD_{16}	NGD_{21}	NRD_{22}	NED_{23}	NFD_{24}	NCD_{25}	NDD_{26}	SHD_{31}	SED_{32}	SOD_{33}	SSD_{34}	STD_{35}	ROD_{41}	RRD_{42}	RMD_{43}	RSD_{44}
3PRLPs$_1$	⟨VPR⟩	⟨MPR⟩	⟨VGD⟩	⟨GOD⟩	⟨VPR⟩	⟨MPR⟩	⟨MPR⟩	⟨VPR⟩	⟨MPR⟩	⟨MGD⟩	⟨FAI⟩	⟨MGD⟩	⟨MPR⟩	⟨VGD⟩	⟨POR⟩	⟨MPR⟩	⟨FAI⟩	⟨GOD⟩	⟨POR⟩	⟨GOD⟩	⟨MPR⟩
3PRLPs$_2$	⟨MPR⟩	⟨VPR⟩	⟨MPR⟩	⟨MGD⟩	⟨FAI⟩	⟨MGD⟩	⟨POR⟩	⟨GOD⟩	⟨FAI⟩	⟨MPR⟩	⟨FAI⟩	⟨VPR⟩	⟨MPR⟩	⟨MGD⟩	⟨VGD⟩	⟨VPR⟩	⟨MPR⟩	⟨VGD⟩	⟨FAI⟩	⟨MGD⟩	⟨VGD⟩
3PRLPs$_3$	⟨POR⟩	⟨GOD⟩	⟨FAI⟩	⟨MPR⟩	⟨FAI⟩	⟨VPR⟩	⟨MPR⟩	⟨VPR⟩	⟨POR⟩	⟨FAI⟩	⟨MPR⟩	⟨FAI⟩	⟨FAI⟩	⟨MPR⟩	⟨VPR⟩	⟨MPR⟩	⟨MGD⟩	⟨FAI⟩	⟨GOD⟩	⟨MPR⟩	⟨VPR⟩
3PRLPs$_4$	⟨FAI⟩	⟨VPR⟩	⟨MPR⟩	⟨FAI⟩	⟨MPR⟩	⟨FAI⟩	⟨MPR⟩	⟨VPR⟩	⟨POR⟩	⟨MGD⟩	⟨FAI⟩	⟨MGD⟩	⟨MPR⟩	⟨VGD⟩	⟨POR⟩	⟨MPR⟩	⟨FAI⟩	⟨GOD⟩	⟨POR⟩	⟨GOD⟩	⟨MPR⟩
3PRLPs$_5$	⟨MGD⟩	⟨VGD⟩	⟨VPR⟩	⟨MPR⟩	⟨VGD⟩	⟨FAI⟩	⟨POR⟩	⟨GOD⟩	⟨FAI⟩	⟨MPR⟩	⟨FAI⟩	⟨VPR⟩	⟨MPR⟩	⟨MPR⟩	⟨VPR⟩	⟨MPR⟩	⟨MGD⟩	⟨FAI⟩	⟨MGD⟩	⟨MPR⟩	⟨VPR⟩
3PRLPs$_6$	⟨GOD⟩	⟨MPR⟩	⟨VPR⟩	⟨MGD⟩	⟨VPR⟩	⟨MPR⟩	⟨GOD⟩	⟨MPR⟩	⟨VPR⟩	⟨MPR⟩	⟨VPR⟩	⟨POR⟩	⟨GOD⟩	⟨MPR⟩	⟨VPR⟩	⟨MPR⟩	⟨VPR⟩	⟨MPR⟩	⟨FAI⟩	⟨MPR⟩	⟨FAI⟩
3PRLPs$_7$	⟨VGD⟩	⟨POR⟩	⟨MPR⟩	⟨FAI⟩	⟨GOD⟩	⟨POR⟩	⟨GOD⟩	⟨MPR⟩	⟨GOD⟩	⟨MPR⟩	⟨VPR⟩	⟨MGD⟩	⟨VPR⟩	⟨MPR⟩	⟨GOD⟩	⟨POR⟩	⟨GOD⟩	⟨FAI⟩	⟨MPR⟩	⟨FAI⟩	⟨VPR⟩

Table A10. Initial comparison matrix with 3PRLPs alternatives and subindices.

3PRLPs	EQD_{11}	ECD_{12}	EED_{13}	EID_{14}	EFD_{15}	EAD_{16}	NGD_{21}
3PRLPs$_1$	⟨(0.20, 0.20, 0.10), (0.65, 0.80, 0.85), (0.45, 0.80, 0.70)⟩	⟨(0.50, 0.30, 0.50), (0.50, 0.35, 0.45), (0.45, 0.30, 0.60)⟩	⟨(0.95, 0.90, 0.95), (0.10, 0.10, 0.05), (0.05, 0.05, 0.05)⟩	⟨(0.70, 0.75, 0.80), (0.15, 0.20, 0.25), (0.10, 0.15, 0.20)⟩	⟨(0.20, 0.20, 0.10), (0.65, 0.80, 0.85), (0.45, 0.80, 0.70)⟩	⟨(0.70, 0.75, 0.80), (0.15, 0.20, 0.25), (0.10, 0.15, 0.20)⟩	⟨(0.50, 0.30, 0.50), (0.50, 0.35, 0.45), (0.45, 0.30, 0.60)⟩
3PRLPs$_2$	⟨(0.50, 0.30, 0.50), (0.50, 0.35, 0.45), (0.45, 0.30, 0.60)⟩	⟨(0.20, 0.20, 0.10), (0.65, 0.80, 0.85), (0.45, 0.80, 0.70)⟩	⟨(0.35, 0.35, 0.10), (0.50, 0.75, 0.80), (0.50, 0.75, 0.65)⟩	⟨(0.60, 0.45, 0.50), (0.20, 0.15, 0.25), (0.10, 0.25, 0.15)⟩	⟨(0.40, 0.45, 0.50), (0.40, 0.45, 0.50), (0.35, 0.40, 0.45)⟩	⟨(0.60, 0.45, 0.50), (0.20, 0.15, 0.25), (0.10, 0.25, 0.15)⟩	⟨(0.35, 0.35, 0.10), (0.50, 0.75, 0.80), (0.50, 0.75, 0.65)⟩
3PRLPs$_3$	⟨(0.35, 0.35, 0.10), (0.50, 0.75, 0.80), (0.50, 0.75, 0.65)⟩	⟨(0.70, 0.75, 0.80), (0.15, 0.20, 0.25), (0.10, 0.15, 0.20)⟩	⟨(0.40, 0.45, 0.50), (0.40, 0.45, 0.50), (0.35, 0.40, 0.45)⟩	⟨(0.50, 0.30, 0.50), (0.50, 0.35, 0.45), (0.45, 0.30, 0.60)⟩	⟨(0.40, 0.45, 0.50), (0.40, 0.45, 0.50), (0.35, 0.40, 0.45)⟩	⟨(0.20, 0.20, 0.10), (0.65, 0.80, 0.85), (0.45, 0.80, 0.70)⟩	⟨(0.40, 0.45, 0.50), (0.40, 0.45, 0.50), (0.35, 0.40, 0.45)⟩
3PRLPs$_4$	⟨(0.40, 0.45, 0.50), (0.40, 0.45, 0.50), (0.35, 0.40, 0.45)⟩	⟨(0.20, 0.20, 0.10), (0.65, 0.80, 0.85), (0.45, 0.80, 0.70)⟩	⟨(0.35, 0.35, 0.10), (0.50, 0.75, 0.80), (0.50, 0.75, 0.65)⟩	⟨(0.40, 0.45, 0.50), (0.40, 0.45, 0.50), (0.35, 0.40, 0.45)⟩	⟨(0.50, 0.30, 0.50), (0.50, 0.35, 0.45), (0.45, 0.30, 0.60)⟩	⟨(0.40, 0.45, 0.50), (0.40, 0.45, 0.50), (0.35, 0.40, 0.45)⟩	⟨(0.50, 0.30, 0.50), (0.50, 0.35, 0.45), (0.45, 0.30, 0.60)⟩
3PRLPs$_5$	⟨(0.60, 0.45, 0.50), (0.20, 0.15, 0.25), (0.10, 0.25, 0.15)⟩	⟨(0.95, 0.90, 0.95), (0.10, 0.10, 0.05), (0.05, 0.05, 0.05)⟩	⟨(0.20, 0.20, 0.10), (0.65, 0.80, 0.85), (0.45, 0.80, 0.70)⟩	⟨(0.50, 0.30, 0.50), (0.50, 0.35, 0.45), (0.45, 0.30, 0.60)⟩	⟨(0.95, 0.90, 0.95), (0.10, 0.10, 0.05), (0.05, 0.05, 0.05)⟩	⟨(0.40, 0.45, 0.50), (0.40, 0.45, 0.50), (0.35, 0.40, 0.45)⟩	⟨(0.20, 0.20, 0.10), (0.65, 0.80, 0.85), (0.45, 0.80, 0.70)⟩
3PRLPs$_6$	⟨(0.70, 0.75, 0.80), (0.15, 0.20, 0.25), (0.10, 0.15, 0.20)⟩	⟨(0.50, 0.30, 0.50), (0.50, 0.35, 0.45), (0.45, 0.30, 0.60)⟩	⟨(0.20, 0.20, 0.10), (0.65, 0.80, 0.85), (0.45, 0.80, 0.70)⟩	⟨(0.60, 0.45, 0.50), (0.20, 0.15, 0.25), (0.10, 0.25, 0.15)⟩	⟨(0.20, 0.20, 0.10), (0.65, 0.80, 0.85), (0.45, 0.80, 0.70)⟩	⟨(0.35, 0.35, 0.10), (0.50, 0.75, 0.80), (0.50, 0.75, 0.65)⟩	⟨(0.70, 0.75, 0.80), (0.15, 0.20, 0.25), (0.10, 0.15, 0.20)⟩
3PRLPs$_7$	⟨(0.95, 0.90, 0.95), (0.10, 0.10, 0.05), (0.05, 0.05, 0.05)⟩	⟨(0.35, 0.35, 0.10), (0.50, 0.75, 0.80), (0.50, 0.75, 0.65)⟩	⟨(0.50, 0.30, 0.50), (0.50, 0.35, 0.45), (0.45, 0.30, 0.60)⟩	⟨(0.40, 0.45, 0.50), (0.40, 0.45, 0.50), (0.35, 0.40, 0.45)⟩	⟨(0.70, 0.75, 0.80), (0.15, 0.20, 0.25), (0.10, 0.15, 0.20)⟩	⟨(0.35, 0.35, 0.10), (0.50, 0.75, 0.80), (0.50, 0.75, 0.65)⟩	⟨(0.70, 0.75, 0.80), (0.15, 0.20, 0.25), (0.10, 0.15, 0.20)⟩

Table A10. *Cont.*

3PRLPs	NRD$_{22}$	NED$_{23}$	NFD$_{24}$	NCD$_{25}$	NDD$_{26}$	SHD$_{31}$	SED$_{32}$
3PRLPs$_1$	⟨(0.20, 0.20, 0.10), (0.65, 0.80, 0.85), (0.45, 0.80, 0.70)⟩	⟨(0.35, 0.35, 0.10), (0.50, 0.75, 0.80), (0.50, 0.75, 0.65)⟩	⟨(0.60, 0.45, 0.50), (0.20, 0.15, 0.25), (0.10, 0.25, 0.15)⟩	⟨(0.40, 0.45, 0.50), (0.40, 0.45, 0.50), (0.35, 0.40, 0.45)⟩	⟨(0.60, 0.45, 0.50), (0.20, 0.15, 0.25), (0.10, 0.25, 0.15)⟩	⟨(0.50, 0.30, 0.50), (0.50, 0.35, 0.45), (0.45, 0.30, 0.60)⟩	⟨(0.95, 0.90, 0.95), (0.10, 0.10, 0.05), (0.05, 0.05, 0.05)⟩
3PRLPs$_2$	⟨(0.70, 0.75, 0.80), (0.15, 0.20, 0.25), (0.10, 0.15, 0.20)⟩	⟨(0.40, 0.45, 0.50), (0.40, 0.45, 0.50), (0.35, 0.40, 0.45)⟩	⟨(0.50, 0.30, 0.50), (0.50, 0.35, 0.45), (0.45, 0.30, 0.60)⟩	⟨(0.40, 0.45, 0.50), (0.40, 0.45, 0.50), (0.35, 0.40, 0.45)⟩	⟨(0.20, 0.20, 0.10), (0.65, 0.80, 0.85), (0.45, 0.80, 0.70)⟩	⟨(0.35, 0.35, 0.10), (0.50, 0.75, 0.80), (0.50, 0.75, 0.65)⟩	⟨(0.60, 0.45, 0.50), (0.20, 0.15, 0.25), (0.10, 0.25, 0.15)⟩
3PRLPs$_3$	⟨(0.20, 0.20, 0.10), (0.65, 0.80, 0.85), (0.45, 0.80, 0.70)⟩	⟨(0.35, 0.35, 0.10), (0.50, 0.75, 0.80), (0.50, 0.75, 0.65)⟩	⟨(0.40, 0.45, 0.50), (0.40, 0.45, 0.50), (0.35, 0.40, 0.45)⟩	⟨(0.50, 0.30, 0.50), (0.50, 0.35, 0.45), (0.45, 0.30, 0.60)⟩	⟨(0.40, 0.45, 0.50), (0.40, 0.45, 0.50), (0.35, 0.40, 0.45)⟩	⟨(0.40, 0.45, 0.50), (0.40, 0.45, 0.50), (0.35, 0.40, 0.45)⟩	⟨(0.50, 0.30, 0.50), (0.50, 0.35, 0.45), (0.45, 0.30, 0.60)⟩
3PRLPs$_4$	⟨(0.20, 0.20, 0.10), (0.65, 0.80, 0.85), (0.45, 0.80, 0.70)⟩	⟨(0.35, 0.35, 0.10), (0.50, 0.75, 0.80), (0.50, 0.75, 0.65)⟩	⟨(0.60, 0.45, 0.50), (0.20, 0.15, 0.25), (0.10, 0.25, 0.15)⟩	⟨(0.40, 0.45, 0.50), (0.40, 0.45, 0.50), (0.35, 0.40, 0.45)⟩	⟨(0.60, 0.45, 0.50), (0.20, 0.15, 0.25), (0.10, 0.25, 0.15)⟩	⟨(0.50, 0.30, 0.50), (0.50, 0.35, 0.45), (0.45, 0.30, 0.60)⟩	⟨(0.95, 0.90, 0.95), (0.10, 0.10, 0.05), (0.05, 0.05, 0.05)⟩
3PRLPs$_5$	⟨(0.70, 0.75, 0.80), (0.15, 0.20, 0.25), (0.10, 0.15, 0.20)⟩	⟨(0.40, 0.45, 0.50), (0.40, 0.45, 0.50), (0.35, 0.40, 0.45)⟩	⟨(0.50, 0.30, 0.50), (0.50, 0.35, 0.45), (0.45, 0.30, 0.60)⟩	⟨(0.40, 0.45, 0.50), (0.40, 0.45, 0.50), (0.35, 0.40, 0.45)⟩	⟨(0.20, 0.20, 0.10), (0.65, 0.80, 0.85), (0.45, 0.80, 0.70)⟩	⟨(0.35, 0.35, 0.10), (0.50, 0.75, 0.80), (0.50, 0.75, 0.65)⟩	⟨(0.50, 0.30, 0.50), (0.50, 0.35, 0.45), (0.45, 0.30, 0.60)⟩
3PRLPs$_6$	⟨(0.50, 0.30, 0.50), (0.50, 0.35, 0.45), (0.45, 0.30, 0.60)⟩	⟨(0.20, 0.20, 0.10), (0.65, 0.80, 0.85), (0.45, 0.80, 0.70)⟩	⟨(0.60, 0.45, 0.50), (0.20, 0.15, 0.25), (0.10, 0.25, 0.15)⟩	⟨(0.20, 0.20, 0.10), (0.65, 0.80, 0.85), (0.45, 0.80, 0.70)⟩	⟨(0.35, 0.35, 0.10), (0.50, 0.75, 0.80), (0.50, 0.75, 0.65)⟩	⟨(0.70, 0.75, 0.80), (0.15, 0.20, 0.25), (0.10, 0.15, 0.20)⟩	⟨(0.50, 0.30, 0.50), (0.50, 0.35, 0.45), (0.45, 0.30, 0.60)⟩
3PRLPs$_7$	⟨(0.50, 0.30, 0.50), (0.50, 0.35, 0.45), (0.45, 0.30, 0.60)⟩	⟨(0.70, 0.75, 0.80), (0.15, 0.20, 0.25), (0.10, 0.15, 0.20)⟩	⟨(0.50, 0.30, 0.50), (0.50, 0.35, 0.45), (0.45, 0.30, 0.60)⟩	⟨(0.20, 0.20, 0.10), (0.65, 0.80, 0.85), (0.45, 0.80, 0.70)⟩	⟨(0.60, 0.45, 0.50), (0.20, 0.15, 0.25), (0.10, 0.25, 0.15)⟩	⟨(0.20, 0.20, 0.10), (0.65, 0.80, 0.85), (0.45, 0.80, 0.70)⟩	⟨(0.35, 0.35, 0.10), (0.50, 0.75, 0.80), (0.50, 0.75, 0.65)⟩

3PRLPs	SOD$_{33}$	SSD$_{34}$	STD$_{35}$	ROD$_{41}$	RRD$_{42}$	RMD$_{43}$	RSD$_{44}$
3PRLPs$_1$	⟨(0.35, 0.35, 0.10), (0.50, 0.75, 0.80), (0.50, 0.75, 0.65)⟩	⟨(0.50, 0.30, 0.50), (0.50, 0.35, 0.45), (0.45, 0.30, 0.60)⟩	⟨(0.40, 0.45, 0.50), (0.40, 0.45, 0.50), (0.35, 0.40, 0.45)⟩	⟨(0.70, 0.75, 0.80), (0.15, 0.20, 0.25), (0.10, 0.15, 0.20)⟩	⟨(0.35, 0.35, 0.10), (0.50, 0.75, 0.80), (0.50, 0.75, 0.65)⟩	⟨(0.70, 0.75, 0.80), (0.15, 0.20, 0.25), (0.10, 0.15, 0.20)⟩	⟨(0.50, 0.30, 0.50), (0.50, 0.35, 0.45), (0.45, 0.30, 0.60)⟩
3PRLPs$_2$	⟨(0.95, 0.90, 0.95), (0.10, 0.10, 0.05), (0.05, 0.05, 0.05)⟩	⟨(0.20, 0.20, 0.10), (0.65, 0.80, 0.85), (0.45, 0.80, 0.70)⟩	⟨(0.50, 0.30, 0.50), (0.50, 0.35, 0.45), (0.45, 0.30, 0.60)⟩	⟨(0.95, 0.90, 0.95), (0.10, 0.10, 0.05), (0.05, 0.05, 0.05)⟩	⟨(0.40, 0.45, 0.50), (0.40, 0.45, 0.50), (0.35, 0.40, 0.45)⟩	⟨(0.60, 0.45, 0.50), (0.20, 0.15, 0.25), (0.10, 0.25, 0.15)⟩	⟨(0.95, 0.90, 0.95), (0.10, 0.10, 0.05), (0.05, 0.05, 0.05)⟩
3PRLPs$_3$	⟨(0.20, 0.20, 0.10), (0.65, 0.80, 0.85), (0.45, 0.80, 0.70)⟩	⟨(0.35, 0.35, 0.10), (0.50, 0.75, 0.80), (0.50, 0.75, 0.65)⟩	⟨(0.60, 0.45, 0.50), (0.20, 0.15, 0.25), (0.10, 0.25, 0.15)⟩	⟨(0.40, 0.45, 0.50), (0.40, 0.45, 0.50), (0.35, 0.40, 0.45)⟩	⟨(0.70, 0.75, 0.80), (0.15, 0.20, 0.25), (0.10, 0.15, 0.20)⟩	⟨(0.50, 0.30, 0.50), (0.50, 0.35, 0.45), (0.45, 0.30, 0.60)⟩	⟨(0.20, 0.20, 0.10), (0.65, 0.80, 0.85), (0.45, 0.80, 0.70)⟩
3PRLPs$_4$	⟨(0.35, 0.35, 0.10), (0.50, 0.75, 0.80), (0.50, 0.75, 0.65)⟩	⟨(0.50, 0.30, 0.50), (0.50, 0.35, 0.45), (0.45, 0.30, 0.60)⟩	⟨(0.40, 0.45, 0.50), (0.40, 0.45, 0.50), (0.35, 0.40, 0.45)⟩	⟨(0.70, 0.75, 0.80), (0.15, 0.20, 0.25), (0.10, 0.15, 0.20)⟩	⟨(0.35, 0.35, 0.10), (0.50, 0.75, 0.80), (0.50, 0.75, 0.65)⟩	⟨(0.70, 0.75, 0.80), (0.15, 0.20, 0.25), (0.10, 0.15, 0.20)⟩	⟨(0.50, 0.30, 0.50), (0.50, 0.35, 0.45), (0.45, 0.30, 0.60)⟩
3PRLPs$_5$	⟨(0.20, 0.20, 0.10), (0.65, 0.80, 0.85), (0.45, 0.80, 0.70)⟩	⟨(0.35, 0.35, 0.10), (0.50, 0.75, 0.80), (0.50, 0.75, 0.65)⟩	⟨(0.60, 0.45, 0.50), (0.20, 0.15, 0.25), (0.10, 0.25, 0.15)⟩	⟨(0.40, 0.45, 0.50), (0.40, 0.45, 0.50), (0.35, 0.40, 0.45)⟩	⟨(0.60, 0.45, 0.50), (0.20, 0.15, 0.25), (0.10, 0.25, 0.15)⟩	⟨(0.50, 0.30, 0.50), (0.50, 0.35, 0.45), (0.45, 0.30, 0.60)⟩	⟨(0.20, 0.20, 0.10), (0.65, 0.80, 0.85), (0.45, 0.80, 0.70)⟩
3PRLPs$_6$	⟨(0.20, 0.20, 0.10), (0.65, 0.80, 0.85), (0.45, 0.80, 0.70)⟩	⟨(0.40, 0.45, 0.50), (0.40, 0.45, 0.50), (0.35, 0.40, 0.45)⟩	⟨(0.20, 0.20, 0.10), (0.65, 0.80, 0.85), (0.45, 0.80, 0.70)⟩	⟨(0.35, 0.35, 0.10), (0.50, 0.75, 0.80), (0.50, 0.75, 0.65)⟩	⟨(0.40, 0.45, 0.50), (0.40, 0.45, 0.50), (0.35, 0.40, 0.45)⟩	⟨(0.50, 0.30, 0.50), (0.50, 0.35, 0.45), (0.45, 0.30, 0.60)⟩	⟨(0.40, 0.45, 0.50), (0.40, 0.45, 0.50), (0.35, 0.40, 0.45)⟩
3PRLPs$_7$	⟨(0.70, 0.75, 0.80), (0.15, 0.20, 0.25), (0.10, 0.15, 0.20)⟩	⟨(0.35, 0.35, 0.10), (0.50, 0.75, 0.80), (0.50, 0.75, 0.65)⟩	⟨(0.70, 0.75, 0.80), (0.15, 0.20, 0.25), (0.10, 0.15, 0.20)⟩	⟨(0.40, 0.45, 0.50), (0.40, 0.45, 0.50), (0.35, 0.40, 0.45)⟩	⟨(0.50, 0.30, 0.50), (0.50, 0.35, 0.45), (0.45, 0.30, 0.60)⟩	⟨(0.40, 0.45, 0.50), (0.40, 0.45, 0.50), (0.35, 0.40, 0.45)⟩	⟨(0.20, 0.20, 0.10), (0.65, 0.80, 0.85), (0.45, 0.80, 0.70)⟩

Table A11. Matrix of crisp values between 3PRLPs alternatives and subcriteria.

3PRLPs	Subindices																				
	EQD$_{11}$	ECD$_{12}$	EED$_{13}$	EID$_{14}$	EFD$_{15}$	EAD$_{16}$	NGD$_{21}$	NRD$_{22}$	NED$_{23}$	NFD$_{24}$	NCD$_{25}$	NDD$_{26}$	SHD$_{31}$	SED$_{32}$	SOD$_{33}$	SSD$_{34}$	STD$_{35}$	ROD$_{41}$	RRD$_{42}$	RMD$_{43}$	RSD$_{44}$
3PRLPs$_1$	0.24	0.5	0.9	0.8	0.24	0.8	0.5	0.24	0.3	0.7	0.5	0.7	0.5	0.9	0.3	0.5	0.5	0.8	0.3	0.8	0.5
3PRLPs$_2$	0.5	0.24	0.3	0.7	0.5	0.7	0.3	0.8	0.5	0.5	0.5	0.24	0.3	0.7	0.9	0.24	0.5	0.9	0.5	0.7	0.9
3PRLPs$_3$	0.3	0.8	0.5	0.5	0.5	0.24	0.5	0.24	0.3	0.5	0.5	0.5	0.5	0.5	0.24	0.3	0.7	0.5	0.8	0.5	0.24
3PRLPs$_4$	0.5	0.24	0.3	0.5	0.5	0.5	0.5	0.24	0.3	0.7	0.5	0.7	0.5	0.9	0.3	0.5	0.5	0.8	0.3	0.8	0.5
3PRLPs$_5$	0.7	0.9	0.24	0.5	0.9	0.5	0.3	0.8	0.5	0.5	0.5	0.24	0.3	0.5	0.24	0.3	0.7	0.5	0.7	0.5	0.24
3PRLPs$_6$	0.8	0.5	0.24	0.7	0.24	0.3	0.8	0.5	0.24	0.7	0.24	0.3	0.8	0.5	0.24	0.5	0.24	0.3	0.5	0.5	0.5
3PRLPs$_7$	0.9	0.3	0.5	0.5	0.8	0.3	0.8	0.5	0.8	0.5	0.24	0.7	0.24	0.3	0.8	0.3	0.8	0.5	0.5	0.5	0.24

Table A12. Matrix of normalized values between 3PRLPs alternatives and subindices.

3PRLPs	EQD$_{11}$	ECD$_{12}$	EED$_{13}$	EID$_{14}$	EFD$_{15}$	EAD$_{16}$	NGD$_{21}$	NRD$_{22}$	NED$_{23}$	NFD$_{24}$	NCD$_{25}$
3PRLPs$_1$	0.149	0.341	0.71	0.49	0.158	0.585	0.336	0.172	0.248	0.4454	0.428
3PRLPs$_2$	0.311	0.163	0.237	0.43	0.329	0.512	0.202	0.572	0.413	0.3181	0.428
3PRLPs$_3$	0.186	0.545	0.395	0.31	0.329	0.176	0.336	0.172	0.248	0.3181	0.428
3PRLPs$_4$	0.311	0.163	0.237	0.31	0.329	0.366	0.336	0.172	0.248	0.4454	0.428
3PRLPs$_5$	0.435	0.613	0.189	0.31	0.591	0.366	0.202	0.572	0.413	0.3181	0.428
3PRLPs$_6$	0.497	0.341	0.189	0.43	0.158	0.22	0.538	0.358	0.198	0.4454	0.205
3PRLPs$_7$	0.559	0.204	0.395	0.31	0.526	0.22	0.538	0.358	0.66	0.3181	0.205

3PRLPs	NDD$_{26}$	SHD$_{31}$	SED$_{32}$	SOD$_{33}$	SSD$_{34}$	STD$_{35}$	ROD$_{41}$	RRD$_{42}$	RMD$_{43}$	RSD$_{44}$
3PRLPs$_1$	0.5	0.392	0.524	0.223	0.482	0.321	0.467	0.21	0.48	0.38
3PRLPs$_2$	0.17	0.235	0.408	0.67	0.231	0.321	0.526	0.35	0.42	0.68
3PRLPs$_3$	0.36	0.392	0.291	0.179	0.289	0.449	0.292	0.56	0.3	0.18
3PRLPs$_4$	0.5	0.392	0.524	0.223	0.482	0.321	0.467	0.21	0.48	0.38
3PRLPs$_5$	0.17	0.235	0.291	0.179	0.289	0.449	0.292	0.49	0.3	0.18
3PRLPs$_6$	0.22	0.627	0.291	0.179	0.482	0.154	0.175	0.35	0.3	0.38
3PRLPs$_7$	0.5	0.188	0.175	0.596	0.289	0.513	0.292	0.35	0.3	0.18

Table A13. Matrix of weighted values between 3PRLPs alternatives and subindices.

3PRLPs	EQD_{11}	ECD_{12}	EED_{13}	EID_{14}	EFD_{15}	EAD_{16}	NGD_{21}	NRD_{22}	NED_{23}	NFD_{24}	NCD_{25}
$3PRLPs_1$	0.003	0.01	0.028	0.01	0.008	0.029	0.007	0.002	0.005	0.0134	0.017
$3PRLPs_2$	0.006	0.005	0.009	0.01	0.016	0.026	0.004	0.006	0.008	0.0095	0.017
$3PRLPs_3$	0.004	0.016	0.016	0.01	0.016	0.009	0.007	0.002	0.005	0.0095	0.017
$3PRLPs_4$	0.006	0.005	0.009	0.01	0.016	0.018	0.007	0.002	0.005	0.0134	0.017
$3PRLPs_5$	0.009	0.018	0.008	0.01	0.03	0.018	0.004	0.006	0.008	0.0095	0.017
$3PRLPs_6$	0.01	0.01	0.008	0.01	0.008	0.011	0.011	0.004	0.004	0.0134	0.008
$3PRLPs_7$	0.011	0.006	0.016	0.01	0.026	0.011	0.011	0.004	0.013	0.0095	0.008
Ideal I^+	0.011	0.018	0.028	0.01	0.03	0.029	0.011	0.006	0.013	0.0134	0.017
Ideal I^-	0.003	0.005	0.008	0.01	0.008	0.009	0.004	0.002	0.004	0.0095	0.008

3PRLPs	NDD_{26}	SHD_{31}	SED_{32}	SOD_{33}	SSD_{34}	STD_{35}	ROD_{41}	RRD_{42}	RMD_{43}	RSD_{44}
$3PRLPs_1$	0.03	0.196	0.016	0.009	0.029	0.032	0.042	0.01	0.05	0.04
$3PRLPs_2$	0.01	0.118	0.012	0.027	0.014	0.032	0.047	0.02	0.04	0.08
$3PRLPs_3$	0.02	0.196	0.009	0.007	0.017	0.045	0.026	0.04	0.03	0.02
$3PRLPs_4$	0.03	0.196	0.016	0.009	0.029	0.032	0.042	0.01	0.05	0.04
$3PRLPs_5$	0.01	0.118	0.009	0.007	0.017	0.045	0.026	0.03	0.03	0.02
$3PRLPs_6$	0.01	0.314	0.009	0.007	0.029	0.015	0.016	0.02	0.03	0.04
$3PRLPs_7$	0.03	0.094	0.005	0.024	0.017	0.051	0.026	0.02	0.03	0.02
Ideal I^+	0.03	0.314	0.016	0.027	0.029	0.051	0.047	0.04	0.05	0.08
Ideal I^-	0.01	0.094	0.005	0.007	0.014	0.015	0.016	0.01	0.03	0.02

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