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Abstract Recently, Neutrosophy theory and its application in decision-making has became in a significant issue for the scientific community. In this paper, an extension of the PESTEL (Political, Economic, Social, Technological, Ecological and Legal) technique adapted to the neutrosophic environment is proposed for decision making in management. The proposal is specially tailored for the dynamic analysis of the different factors in an uncertain environment. The framework developed for the extension of the PESTEL technique to the neutrosophic environment is compound for six fundamental activities. A system of recommendation is designed for practical purposes. A case study is developed for the use of the neutrosophic PESTEL to show the applicability of the technique. The paper ends with conclusions and recommendations for future work.

Keywords: PESTEL, business management, neutrosophy theory, decision making.

1 Introduction

The start-up of a company or a new business unit requires detailed knowledge of the context in which it is going to develop. There exist numerous external factors that will condition its operation, hence the analysis of the environment is the key to know future trends and define in advance the business strategy to follow. A useful tool to achieve this goal is the PESTEL (Political, Economic, Social, Technological, Ecological and Legal) technique, which allows a detailed investigation of the issues that most influence in the development of business activity or project that it is needed to promote.

This tool allows forecasting future trends in the short and medium term, offering to the organization a wide range of action and improving its ability to adapt to the changes that are anticipated. It also provides objective criteria to define the strategic position and provides information to take advantage of the opportunities that arise in certain markets. This is achieved through the description of variables that provide arguments about the behavior of the environment in the future.

PESTEL technique is useful to perform a strategic analysis to define the external environment of a company, as it is referred in [1-4], due to the advantages that this method provides, since it constitutes a research guide of the context surrounding the company. Among the advantages that most stand out are the following:

- **It adapts to each case**. There exist factors that can be included within others. For example, the legislature can be easily integrated into the political and industry can be included in economics. The ecological factor can also be easily included in social one. That depends on the area in which the activity of the company takes place and the peculiarities of its sector.
- **It helps to make decisions**. This is because it permits to know about the market and the factors that produce no growth or decline, their potential and attractiveness, the simple identification and control of the present risks which in turn can be potentially determined, and finally, about the convenience or not to enter on it. Therefore, it is useful when it is applied in internationalization processes.
- **It has a proactive approach**. It allows anticipating changes and glimpsing future trends in such a way that the organization will go one-step ahead and shall not have to suddenly react to the new market characteristics. In addition, it facilitates planning and minimizes the impact of adverse scenarios.
- **It is of broad application**. Whether it is to make decisions about the foundation of a new company, the

opening of an office in a foreign country or region, the redefinition of the brand, a possible acquisition or the association with partners, in every of these situations PESTEL analysis allows knowing in detail the trends that will mark the future of the market.

The aforementioned author refers that PESTEL factors serve to know the tendencies and redesign the business strategy. The variables that integrate these factors are the following:

- **Political variables**: These are the governmental aspects that directly affect the company. This variable involves tax policies or business incentives in certain sectors, employment regulations, the promotion of foreign trade, government stability, the government system, international treaties or the existence of conflicts of any kind, like internal, current external or future ones. In addition, it is related to the way in which the different local, regional and national administrations are organized. The projects of the major parties on the company are also included in this section.
- **Economic variables**: This variable is useful for analyzing macroeconomic data, the evolution of Gross National Product (GNP), interest rates, inflation, the unemployment rate, the level of income, exchange rates, access to resources, the level of development and economic cycles. Current and future economic scenarios and economic policies should also be investigated.
- **Social variables:** In this variable, the relevant factors are demographic evolution, social mobility and changes in lifestyle. Additionally, the educational level and other cultural patterns, religion, beliefs, gender roles, tastes, fashions and consumption habits of society should be included. In short, it contains the social trends that may affect the business project.
- **Technological variables**: This variable is somewhat more complex to analyze because of the accelerated changes in this area. It is necessary to know the public investment in research and the promotion of technological development, the penetration of technology, the degree of obsolescence, the level of coverage, the digital division, funds destined to Research and Development (R&D), as well as the trends in the use of new technologies.
- **Ecological variables:** This variable analyses factors related to the conservation of the environment, environmental legislation, climate change and variations in temperatures, natural risks, levels of recycling, energy regulation and possible regulatory changes in this area.
- **Legal variables:** This variable concerns all the legislation that has a direct relationship with the project, the information about licenses, labor legislation, intellectual property, sanitary laws, the regulated sectors, among others.

The decision-making process has been a central issue in the study and the configurations of organizational structures. This structure determines the definition of the organizational units, their objectives, functions, charges, and associated tasks, as well as the levels of authority-subordination, and consequently, the system of formal relations, see [5].

According to [5], in order to support decision-making in business management, it is necessary to define variables, which identify the most important aspects that are included in the business environment and that affect the future business environment, as well as those variables that identify factors less decisive and irrelevant to the operation of a business, business unit or project. For this purpose, it is recommended to start the analysis by the most general factors and finish with those that are more specific or characteristic of the company.

Once the factors of greater and less importance are obtained, it is possible to carry out a comparative analysis, assigning a qualification to each factor. This assignment facilitates the study of several characteristics that contribute to the knowledge of the environment, in particular, to know which is the most favorable or suitable environment for the purposes of the company. The weight assigned to each variable depends on the type of business, environment, among others.

These studies are often carried out using the PESTEL technique, which is an accessible tool, easy to apply and widely used by companies in different sectors and of different sizes. According to [1], PESTEL serves to evaluate the main external factors that influence a project or business. This technique facilitates the support for making early decisions because it guides the direction of the company towards future scenarios in order to determine the development of the activity. The results obtained by using the PESTEL technique are expressed qualitatively, whose results require to be treated for the solution of indeterminate problems that are obtained when applying PESTEL.

To solve the aforementioned drawback, it is proposed to translate the technique of PESTEL to the neutrosophic field. Neutrosophy is a branch of science that brings significant results when there exist problems containing indeterminacy. One example of the presence of indeterminacy in real life situations can be encountered when analysing the factors to consider for business management.

In business management area, neutrosophy theory is useful to include for obtaining greater data interpretability. It is a tool for supporting decision making, taking advantage of opposing positions as well as the neutral or

ambiguous ones. Assuming that every idea <A> tends to be neutralized, diminished, balanced by ideas, in clear rupture with the binary doctrines for explaining or understanding the phenomena [6]. Neutrosophy theory has been successfully hybridized with other decision-making techniques and methods like, with DEMATEL method, see [7], VIKOR and ANP, [8], and TOPSIS technique, [9].

Based on the aforementioned ideas, in the present study we propose the combination of PESTEL with the neutrosophic recommendation models, to make this combination a neutrosophic PESTEL technique, capable of supporting decision-making, providing a set of options in order to satisfy the business environments expectations [10]. Essentially the proposal is related to a recommendation model based on the knowledge obtained by applying the PESTEL technique.

The proposed model includes Single-Valued Neutrosophic Numbers (SVNN), which facilitates the use of linguistic terms [11]. PESTEL analysis based on a recommendation model takes into account the analysis of the factors, in order to support decision making for obtaining efficient business management. The neutrosophic PESTEL technique, which is proposed in the present work, has the possibility of treating the interdependence between the analyzed factors, feedback and treats the uncertainty.

Summarizing, in this paper a neutrosophic PESTEL analysis is designed with the purpose to be applied in business management. This model is the basis of a proposed system of recommendation, where the PESTEL analysis provides the knowledge, which is stored in a database. The data in dataset are represented in form of linguistic terms, and the calculi are made by using SVNNs. To illustrate the applicability of the model we utilize an actual example.

2 Preliminary

In this section, a brief review of the PESTEL technique and the interdependence of its factors are provided. Then we summarize those neutrosophic foundations that are able to adapt PESTEL technique to neutrosophy.

2.1 PESTEL Analysis

PESTEL analysis is applied to aid and consider subjects like, namely, political, economic, social, technological, legal and environmental. It is a tool of interest to understand the increase or decline of some specific market and consequently, the position, potential and direction of a business. PESTEL works as a frame to analyze such situations, or either to revise the strategy. In others words, PESTEL measures market potentialities and actual situation. It allows us to understand, present, discuss and take decisions about external factors. The aspects to measure PESTEL are displayed in Figure 1.

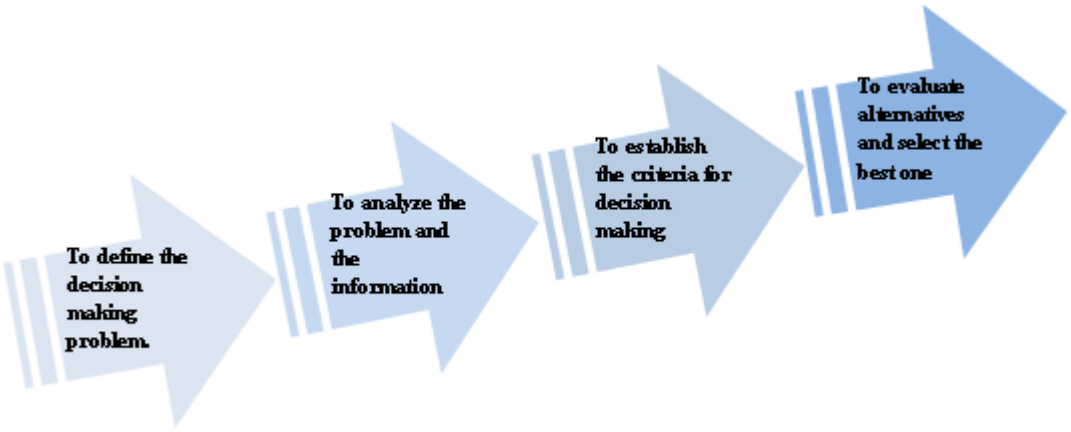

Figure 1. Pyramid PESTEL factors.

A recommendation model based on the knowledge acquired from the application of PESTEL analysis, has an integrated structure among the factors, it is modeled by a neutrosophic recommendation model and the quantitative analysis is developed from a static analysis that allows to classify and reduce the number of analysed factors.

2.2 Neutrosophic PESTEL and recommendation models based on knowledge, to support decision-making

Decision-making has been historically studied using multiple disciplines from classical ones such as philosophy, statistics, mathematics, and economics, to the most recent ones such as Artificial Intelligence [12, 13]. The developed theories and models point to rational support for making complex decisions [12]. The process for solving a decision-making problem according to [14] is shown in Figure 2.

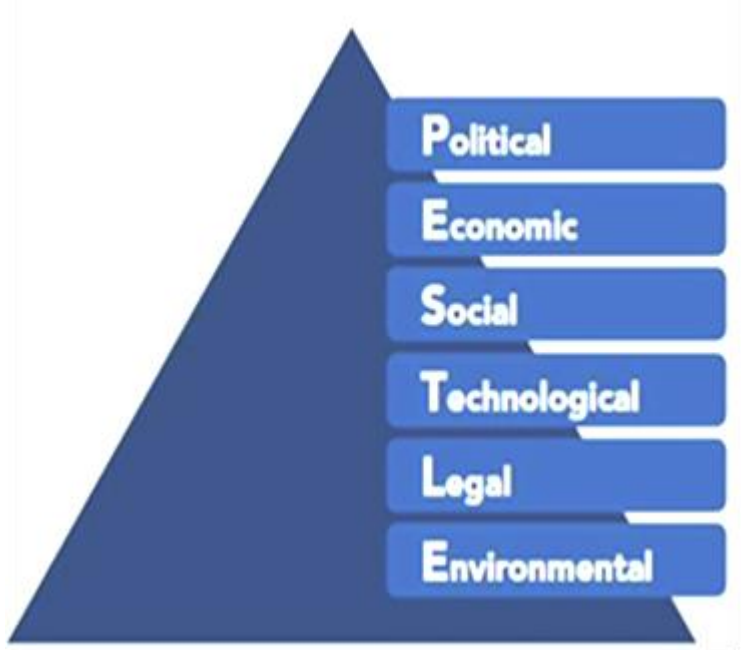

Figure 2. Phases for the solution of a decision-making problem ([14]).

Knowledge-based recommendation models provide suggestions by making inferences about the desired needs and preferences [15, 16]. The knowledge-based approach is distinguished because knowledge is used about how a particular object can satisfy the desired needs. Therefore, the knowledge-based recommendation models have the capacity to reason about the relationship between one need and the possible recommendation that is provided.

From the mathematical point of view, the proposed recommendation model is distinguished by X, which is called the universe of study. A set of unique *Single-Valued Neutrosophic* Set (SVNS) A on X, is an object that satisfies the formula given in Equation 1.

$$A = \{\langle x, \mathrm{T}_A(x), \mathrm{I}_A(x), \mathrm{F}_A(x)\rangle : x \in X\} \quad (1)$$

Where, $\mathrm{T}_A: X \rightarrow [0,1]$, $\mathrm{I}_A: X \rightarrow [0,1]$ and $\mathrm{F}_A: X \rightarrow [0,1]$ satisfy $0 \leq \mathrm{T}_A(x) + \mathrm{I}_A(x) + \mathrm{F}_A(x) \leq 3$, for every $x \in A$. $\mathrm{T}_A(x)$, $\mathrm{I}_A(x)$ and $\mathrm{F}_A(x)$ represent the truth-membership, indeterminate-membership and false-membership of x in A. A *Single-Valued Neutrosophic Number* (SVNN) is expressed as: = (T, I, F), where T, I, F ∈ [0,1], and $0 \leq \mathrm{T} + \mathrm{I} + \mathrm{F} \leq 3$.

The models of recommendation based on sideways constructions are structures of knowledge which learn either by themselves or by processes of inference. Thus, they can be enriched with the use of natural language expressions [17, 18].

3 Proposed Framework

The proposed framework to support decision making in business management using the PESTEL technique, with a neutrosophic environment consists of four fundamental phases, they are graphically shown in Figure 3. This framework is based on [17, 19], for knowledge-based recommendation systems allowing the representation of linguistic terms and indetermination in form of SVNNs.

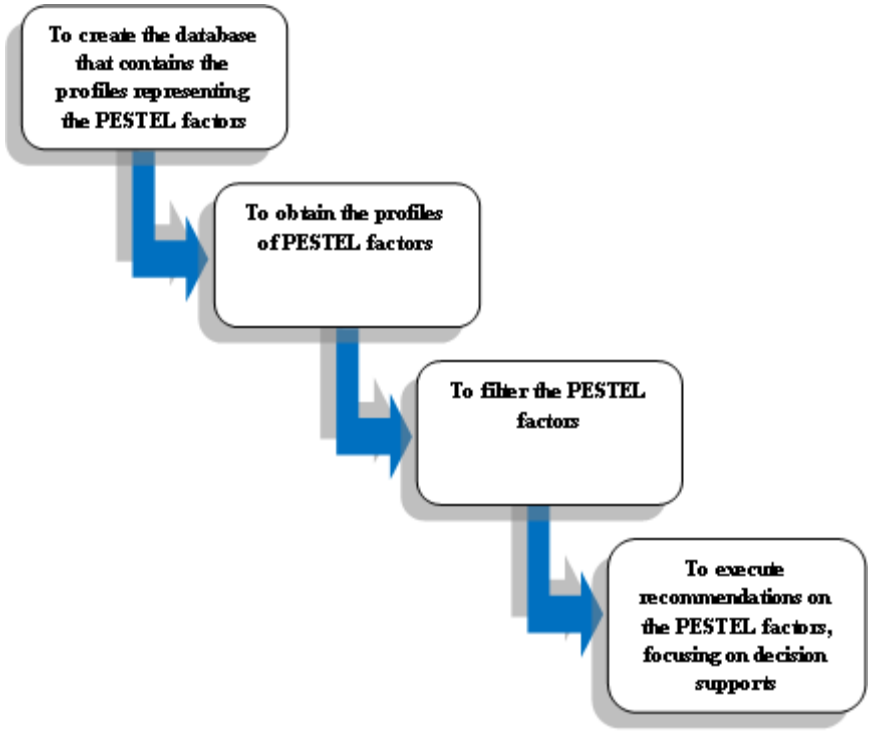

Figure 3. Proposed model for the PESTEL analysis.

3.1 Creation of the Database with the profiles that represent the factors of PESTEL

Each of the PESTEL factors are represented by a_i, which are described by a set of characteristics that will make up the profile of the factors. They are mathematically expressed by the set $C = \{c_1, \dots, c_k, \dots, c_l\}$.

In order to obtain the PESTEL factors database, the profile of each PESTEL factor is obtained by SVNNs [20, 21].

Let $A^* = \{A_1^*, A_2^*, \cdots, A_n^*\}$ be a vector of SVNNs, such that $A_j^* = (a_j^*, b_j^*, c_j^*)$, for j = 1, 2, …, n. Additionally, let $B_i = (B_{i1}, B_{i2}, \cdots, B_{im})$, i = 1, 2, …, m, be m vectors of n SVNNs, where $B_{ij} = (a_{ij}, b_{ij}, c_{ij})$, i = 1, 2, …, m and j = 1, 2,…, n. Then, the Euclidean distance between A^* and B_i is defined in Equation 2, see [20].

$$d_i = \left(\frac{1}{3}\sum_{j=1}^{n}\left\{\left(a_{ij} - a_j^*\right)^2 + \left(b_{ij} - b_j^*\right)^2 + \left(c_{ij} - c_j^*\right)^2\right\}\right)^{\frac{1}{2}} \quad (2)$$

Where i = 1, 2,…, m.

The Euclidean distance calculated with Equation 2 defines a measure of similarity, according to it is referred in [21].

The measure of similarity varies in correspondence with the alternative A_i. Closer is A^* to the profile that represents the PESTEL factors, greater is the measure of similarity (s_i), favouring the establishment of an order between alternatives [23]. The profile that represents the PESTEL factors can be obtained directly from experts' criterion. The formula of s_i is given in Equation 3.

$$s_i = 1 - d_i \quad (3)$$

The evaluation of the PESTEL characteristics of the factors a_j, are expressed using a linguistic scale S,

Where $S = \{s_1, ..., s_g\}$ is the set of linguistic terms defined to assess the corresponding characteristics of each PESTEL factor, c_k, which is evaluated by using the SVNNs. For this end, the linguistic terms to employ are defined. Once the factors are described, they are included in the previously created database, like $A = \{a_1, \cdots, a_j, \cdots, a_n\}$.

The system outputs a recommendation about the best factors for either maintain or improve the current market situation. The recommendation is obtained from previous experiences and strategies of the company in this situation, which were stored in the database.

3.2 Obtaining profiles by PESTEL factors

In this phase we obtain the company information related to the PESTEL factors, these preferences are profiles

that are stored in the database, mathematically they are expressed as shown in Equation 4.

$$P_e = \{p_1^e, \dots, p_k^e, \dots, p_l^e\} \quad (4)$$

Where $P_k^e \in$ S.

The profiles of the obtained PESTEL factors, which have been analyzed according to the preferences of the company are integrated by a set of attributes as shown in Equation 5.

$$C_e = \{c_1^e, \dots, c_k^e, \dots, c_l^e\} \quad (5)$$

Where $c_k^e \in$ S.

3.3. Filtering of the PESTEL factors

In this phase, the PESTEL factors are filtered according to the profile of each obtained factor, in order to find out what PESTEL factors need to be addressed for supporting decision making in a company. For this purpose, the similarity between the profiles of each PESTEL factor, P_e and the characteristics corresponding to each PESTEL factor, a_j, previously registered in the Database, was calculated. Equation 6 is used to calculate the total similarity.

$$F_{a_j} = \{v_1^j, \dots, v_k^j, \dots, v_l^j\} \quad (6)$$

j = 1, 2, …, n; $v_k^e \in$ S.

The function s_i calculates the similarity between the values of the user profile attributes and that of the products, a_j, according to [24].

3.4. Execute recommendations of the factors of PESTEL attend for the decision making support

The similarity between the profile of the PESTEL factors of the Database and each one of the characteristics corresponding to each PESTEL factor is calculated, see [25], these are ordered according to the obtained similarity, which is represented by the similarity vector denoted by $D = (d_1, d_2, \dots, d_n)$.

The best results are those that best meet the needs of the profile of the PESTEL factors determined in a company to support decision-making. The system outputs the factors with the best performance.

As a kind of discussion it is noteworthy to remark that our research contribution is the design of a system of recommendation based on PESTEL analysis for business management, as well as the extension of this technique to the framework of neutrosophy theory.

This approach has the advantage that decision makers can interact with the system using linguistic terms. Furthermore, the system can be coded to create a Decision Support System, which shall be useful for decision makers.

Nevertheless, we have to acknowledge that we could encounter difficulties that managers accept to apply these results in their companies, which is the main objective of our work and this is the way to validate the results. To overcome this difficult we should design strategies to introduce this techniques in real life.

4 Case study

In the present paper, we use a model of companies with specialized treatment in Cuba as the case study. These companies are not totally financed by the Cuban State, therefore, they aims to be self-financed in most of the economic aspects.

The aspects of PESTEL study are reflected in Figure 4

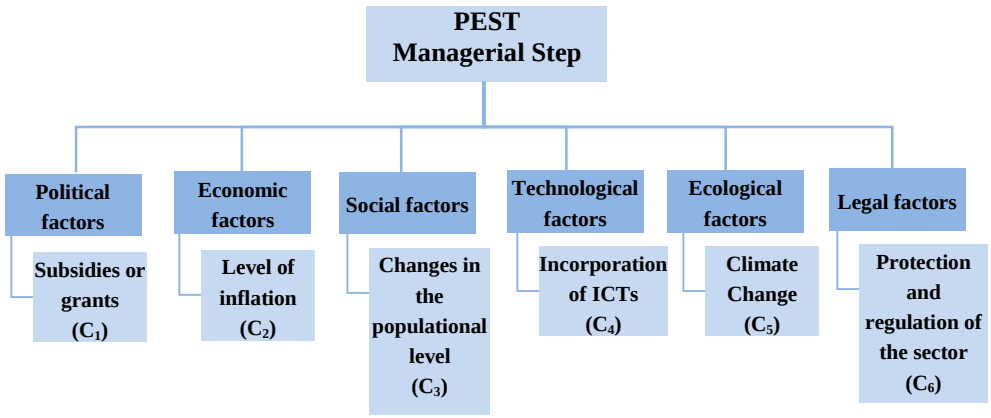

Figure 4. Feature to attend related to the PESTEL factors for business management.

According to Figure 4, specialists considered that one characteristic per factor are sufficient to determine the factors that are adequate and those that decision makers have to improve. These characteristics are the following:

C_1: Subsidies or grants, which are indicators of how the Cuban State politically supports these enterprises.

C_2: Level of inflation, which is an important economic indicator mainly for a company that sell products and the management success depends on fair prices.

C_3: Changes of the population level, which is the social factor that indicates the potential users constitute a good market for the products sold by these companies.

C_4: Incorporation of Information and Communication Technologies (ICTs), it is an important factor, because efficiency is consequence of the well use of ICTs.

C_5: Climate change, because ecology is a state policy of the Cuban government, taking into account that these are enterprises partially supported by the Cuban State. On the other side, Cuba is affected by natural disasters, mainly, hurricanes.

C_6: Protection and regulation of the sector, is a factor that guarantees that the rights of the enterprises shall be respected, and enterprises shall fulfil with their legal duties and obligations.

For this case study, we count on a database that contains all the factors profiles and their characteristics related to the analysis carried out with the PESTEL technique. These profiles are represented by a vector of shape $A = \{a_1, a_2, a_3, a_4, a_5, a_6\}$.

Where, a_1 corresponds to the Political Factor, a_2 to the Economic Factor, a_3 to the Social Factor, a_4 to the Technological Factor, a_5 to the Ecological Factor and a_6 to the Legal Factor.

The vector that describes the profiles of the PESTEL factors and their characteristics related to the realized analysis, in our case study are represented in form of neutrosophic attributes. Then, the characteristic corresponding to each factor of each PESTEL of neutrosophic attributes are measured using linguistic scales, which are shown in Table 1.

Linguistic term	SVNN
Extremely good (EG)	(1,0,0)
Very very good (VVG)	(0.9, 0.1, 0.1)
Very good (VG)	(0.8,0.15,0.20)
Good (G)	(0.70,0.25,0.30)
Moderately good (MDG)	(0.60,0.35,0.40)
Average (A)	(0.50,0.50,0.50)
Moderately bad (MDB)	(0.40,0.65,0.60)
Bad (B)	(0.30,0.75,0.70)
Very bad (VB)	(0.20,0.85,0.80)
Very very bad (VVB)	(0.10,0.90,0.90)
Extremely bad (EB)	(0,1,1)

Table 1: Linguistic terms associated to a SVNN, see [20].

We have $P_e = \{\text{MDG}, \text{VG}, \text{VVG}, \text{VG}, \text{VG}, \text{G}\}$, see Equation 4, as the results of the characteristic evaluation by the specialists, which their meanings can be read in Table 1.

In our case study, we concluded that the Political Factor has characteristics that make it "Fairly good" for the achievement of adequate business management, within the framework of the characteristics of the companies with specialized treatment in Cuba.

- It is obtained that the PESTEL factor related to the Economic Factor, is assessed as "Very good" according to the characteristic that identifies it.
- The Social Factor of PESTEL is evaluated as "Very very good" since there exists continuous changes in the population level.
- The Technological Factor of PESTEL, with the incorporation of Information and Communication Technologies (ICTs), helps companies to obtain "Very good" results.
- The Ecological Factor of PESTEL obtains "Good" results, however, in this factor it is necessary to specify what means the term climate change, to mitigate the deficiencies existing on the subject at the country and business levels.
- Concerning to the Legal Factor of PESTEL, for organizational management in companies with the previously mentioned characteristics, possesses "Very good" result, given by the protection and regulation that exists in the business sector in Cuba.

Having the PESTEL factors and the their characteristics, to support decision making in the interest of efficient business management, we calculated the similarity between the profile of the analyzed factors with PESTEL and the characteristics corresponding to each factor previously stored in the database. The result is shown in Table 2.

a_1	a_2	a_3	a_4	a_5	a_6
0.43	0.80	0.41	0.83	0.75	0.33

Table 2. Similarity between the PESTEL factors and the characteristics related to the factors**.**

During the recommendation phase, the system recommends the characteristic corresponding to each PESTEL factor which is the nearest to the factors profile. The obtained ranking of the PESTEL factors based on this comparison is the following: $a_4 \succ a_2 \succ a_5 \succ a_1 \succ a_3 \succ a_6$.

Whether we have to give a recommendation about the more similar factors according to the characteristics of the enterprises for achieving an appropriate managerial step, system recommends to maintain a_4 and a_2, i.e., those that represent the Technological and the Economic Factors with the analysis of PESTEL, respectively.

Whereas, the system does not recommend a_1, a_3 or a_6, because the results had a small level of similarity.

Conclusions

In the present study, an extension of the PESTEL technique was proposed to the neutrosophic environment to support decision-making in business management, taking into account uncertainty. The integrated structure of PESTEL has factors that are modeled.

To illustrate the scope of application of the proposed model, companies with specialized treatment in Cuba was used as case study. These companies are affected by economic, political, social and technological factors.

On the other hand, a study of the recommendation models was carried out to address problems encountered in the measurement and evaluation process of PESTEL analysis. The integrated structure of PESTEL was modeled by a recommendation model. The proposed recommender system compares the stored knowledge in a database , extracted from PESTEL analysis, with the current evaluation of the company. This assessment is facilitated by using linguistic terms for calculation, which allows a better communication between the decision makers and the system.

Future work will focus on the development of a software tool and the use of aggregation operators to indicate interdependency among subfactors in the PESTEL analysis.

Future directions will consist in exploring the hybridization of the model that we exposed in this paper with other decision-making techniques, with the aims to improve the results in management decision, e.g., the SWOT method.

Additionally, a challenge consists in accelerating the search in the database when the number of items is big. Therefore, we also will explore to incorporate heuristics for optimizing the selection of the best option in the database, as well as to deepen the knowledge contained in the database incorporating an expert system model.

References

[1] Martín, J. (2017) Study your enviroment with a PEST-EL (Estudia tu entorno con un PEST-EL)(In Spanish),. Cerem International Business School.

[2] Lamas Leite, J. G., de Brito Mello, L. C. B., Longo, O. C., and Cruz, E. P. (2017). Using Analytic Hierarchy Process to Optimize PESTEL Scenario Analysis Tool in Huge Construction Projects. In Applied Mechanics and Materials (Vol. 865, pp. 707-712). Trans Tech Publications.
[3] Song, J., Sun, Y., and Jin, L. (2017). PESTEL analysis of the development of the waste-to-energy incineration industry in China. Renewable and Sustainable Energy Reviews, 80, 276-289.
[4] Pan, W., Chen, L., and Zhan, W. (2018). PESTEL analysis of construction productivity enhancement strategies: A case study of three economies. Journal of Management in Engineering, 35(1).
[5] Zapata, G. J., Sigala, L.E. and Canet, M.T (2016) Characteristics of the organizational design: A study in the medium companies of the state of Lara, Venezuela (Características de diseño organizativo: Un estudio en las medianasempresas del estado Lara, Venezuela)(In Spanish), unpublished document.
[6] Smarandache, F., Neutrosophy, a new Branch of Philosophy (2002): Infinite Study.
[7] Abdel-Basset, M., Manogaran, G., Gamal, A., and Smarandache, F. (2018). A hybrid approach of neutrosophic sets and DEMATEL method for developing supplier selection criteria.Design Automation for Embedded Systems, 1-22.
[8] Abdel-Baset, M., Chang, V., Gamal, A., and Smarandache, F. (2019). An integrated neutrosophic ANP and VIKOR method for achieving sustainable supplier selection: A case study in importing field. Computers in Industry, 106, 94-110.
[9] Abdel-Basset, M., Saleh, M., Gamal, A., and Smarandache, F. (2019). An approach of TOPSIS technique for developing supplier selection with group decision making under type-2 neutrosophic number. Applied Soft Computing, 77, 438-452.
[10] Leiva, J. L., Guevara, A., Rossi, C. and Aguayo, A. (2014) Augmented reality and group recommender systems: A new perspective in tourist destinations systems (Realidad aumentada y sistemas de recomendación grupales: Una nueva perspectiva en sistemas de destinos turísticos)(In Spanish) Estudios y perspectivas en turismo, 23(1), 40-59.
[11] Biswas, P., Pramanik, S. and Giri, B.C. (2016) TOPSIS method for multi-attribute group decisionmaking under single-valued neutrosophic environment. Neural computing and Applications, 27(3), 727-737.
[12] Mata, F. (2006) Models for Consensus Support Systems in Group Decision Making problems defined in multigranular linguistic contexts (Modelos para Sistemas de Apoyo al Consenso en Problemas de Toma de Decisión en Grupo definidos en Contextos Lingüısticos Multigranulares)(In Spanish) PhD Thesis, University of Jaén, Jaén, Spain.
[13] Barberis, G.F and Ródenas, M.C.E. (2011) The aid to multicriteria decision: Origins, evolutions and current situation, in VI International Congress of Statistic and Probability History, Valencia, Spain.
[14] Herrera, F., Alonso, S., Chiclana, F., and Herrera-Viedma, E. (2009) Computing with words in decision making: foundations, trends and prospects. Fuzzy Optimization and Decision Making, 8(4), 337-364.
[15] Dietmar, J. (2013) Tutorial: Recommender Systems In International Joint Conference on Artificial Intelligence, Beijing, August 4, 2013.
[16] Bonilla-Freire, J., Mata-Villagomez, M., Sánchez-Delgado, M. A., and Peña-Gónzalez, M. (2016) A product recommendation model based on computing with word and OWA operators (Modelo de recomendación de productos basado en computación con palabras y operadores OWA)(In Spanish). International Journal of Innovation and Applied Studies, 16(1), 78-83.
[17] Lu, J., Wu, D., Mao, M., Wang, W., and Zhang, G. (2015). Recommender system application developments: a survey. Decision Support Systems, 74, 12-32.
[18] Herrera, F. L. and Martínez, A. (2000) 2-tuple fuzzy linguistic representation model for computing with words, IEEE Transactions on Fuzzy Systems, 8(6), 746-752.
[19] Maridueña-Arroyave, M. R. ;Febles-Estrada, A. ; Cañizares-González, R. (2016) Recommendation models for vocational orientation based on computing with words (Modelo de recomendación para la orientación vocacional basado en la computación con palabras)(In Spanish) International Journal of Innovation and Applied Studies, 15(1), 80-92.
[20] Şahin, R. and Yiğider, M., A (2016) Multi-criteria neutrosophic group decision making metod based TOPSIS for supplier selection. Applied Mathematics & Information Sciences, 10(5), 1-10.
[21] Ye, J. (2014) Single-valued neutrosophic minimum spanning tree and its clustering method. Journal of intelligent Systems, 23(3), 311-324.
[22] Pérez-Teruel, K., Leyva-Vázquez, M. and Estrada-Sentí, V. (2015) Mental models consensus process using fuzzy cognitive maps and computing with words. Ingeniería y Universidad, 19(1), 173-188.
[23] Leyva-Vázquez, M. Y., Pérez-Teruel, K., Febles-Estrada, A. and Gulín-González, J. (2013) Model for the analysis of scenarios based on cognitive fuzzy maps: A case study in biomedical software (Modelo para el análisis de escenarios basados en mapas cognitivos difusos: estudio de caso en software biomédico)(In Spanish). Ingenieria y Universidad: Engineering for Development, 17(2), 375-390.
[24] Pérez-Teruel, K., Leyva-Vázquez, M., Estrada-Sentí, V. (2015) Mental Models Consensus Process Using Fuzzy Cognitive Maps and Computing with Words. Ingenieria y Universidad, 19(1), 7-22.
[25] Taş, F., Topal, S., and Smarandache, F. (2018). Clustering neutrosophic data sets and neutrosophic valued metric space, Symmetry, 10(10), 430.

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