PEST Analysis Based on Neutrosophic Cognitive Maps: A Case Study for Food Industry

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Abstract.Neutrosophic cognitive maps and its application in decision making have become a topic of great importance for researchers and practitioners alike.PEST (Political, Economic, Social and Technological), analysis is a precondition analysis with the main functions of the identification of the environment within which and organization or project the operates and providing data and information for enabling the organization to make predictions about new situations and circumstances. In this paper, a new model PEST analysis for food industry is presented based on neutrosophic cognitive maps static analysis. The proposed framework is composed of four activities, identifying PEST factors and sub-factors, modeling interrelation among PEST factors, calculate centrality measures and factor classification andranking. A case study is presented for food industry environment analysis. Our approach allowsranking of factors based in interrelation and incorporating indeterminacy in the analysis. Further works will concentrate extending the model for incorporating scenario analysis and group decision making

Keywords:PEST, Neutrosophy, Neutrosophic Cognitive Maps, Static Analysis, Food Industry.

1 Introduction

PEST (Political, Economic, Social and Technological) analysis, is used to assess these four factors in relation to business or project situation [1]. If environment and legal factors are included it is named PESTEL (Political, Economic, Socio-cultural, Technological, Environment and Legal) analysis [2]. PEST analysis lacks a quantitative approach to the measurement of interrelation among factors.
Fuzzy cognitive maps (FCM) is a tool for modeling and analyzing interrelations [3]. Connections in FCMs are just numeric ones therefore relationship of two events should be linear [4]. Neutrosophy can handle indeterminate and inconsistent information, while fuzzy sets and intuitionistic fuzzy sets don't describe them appropriately [4].
Neutrosophic cognitive maps (NCM) is an extension of FCM where indeterminacy is included [5, 6]. The concept of fuzzy cognitive maps fails to deal with the indeterminate relation [7]. Neutrosophic Logic (NL) was introduced as a generalization of the fuzzy logic [8]. A logical proposition P is characterized by three neutrosophic components:

$$NL(P) = (T, I, F) \quad (1)$$

T is the degree of truth, F the degree of falsehood, and I the degree of indeterminacy. Neutrosophic Sets (NS) was introduced by F. Smarandache who introduced the degree of indeterminacy (I) as independent component [9].
A neutrosophic matrix is a matrix where the elementsa $= (a_{ij})$ have been replaced by elements in $\langle R \cup I \rangle$. A neutrosophic graph is a graph in which at least one edge is a neutrosophic edge [10]. If indeterminacy is introduced in cognitive mapping it is called Neutrosophic Cognitive Map (NCM) [11, 12]. NCM are based on neutrosophic logic to represent uncertainty and indeterminacy in cognitive maps [13]. A NCM is a directed graph in

which at least one edge is an indeterminacy denoted by dotted lines [14] (Figure 1.). NCMs are generalization of Fuzzy Cognitive Maps [15]. Recent development on NCM have been presented for example in the classification of Rheumatoid Arthritis disease with Dynamic Neutrosophic Cognitive Map with Bat Algorithm [16].

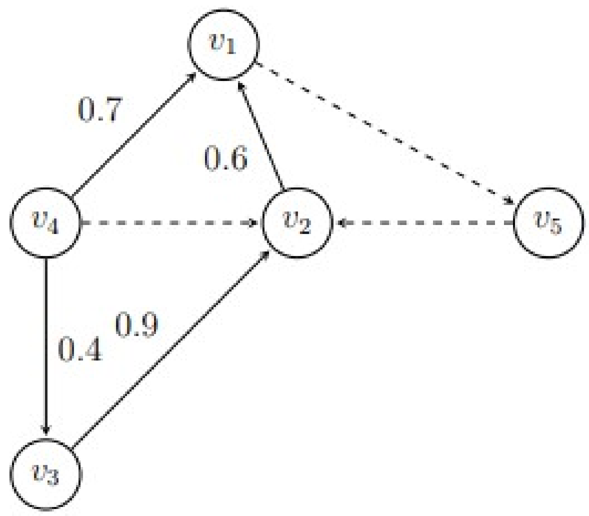

Figure 1: Neutrosophic Cognitive Map example.

In this paper a new model PEST analysis based on neutrosophic cognitive maps is presented giving methodological support and the possibility of dealing with interdependence, feedback and indeterminacy. Additionally the new approach make possible to rank and to reduce factors.
This paper is structured as follows: Section 2 reviews some important concepts about PEST analysis framework, a framework for PEST analysis based on NCM static analysis is presented. Section 4 shows a case study of the proposed model applied to food industry. The paper ends with conclusions and further work recommendations.

2 Preliminaries

In this section, we first provide a brief revision PEST analysis and the interdependency of its factors.

2.1 PEST Analysis

PEST (Political, Economic, Social and Technological), analysis is a precondition analysis with the mains function of the identification of the environment within which and organization or project the operates and providing data and information for enabling the organization to make predictions about new situations and circumstances [17, 18]. Factors in PEST analyzed are generally measured and evaluated independently [2] not taking into account interdependency. In [19] a new approach based on fuzzy decision maps is presented taking into account ambiguity, vagueness in their interrelations

This study presents a model to address problems encountered in the measurement and evaluation process of PEST taking into account interdependencies among sub-factors. The integrated structure of PESTEL sub-factors were modeled by NCM and quantitative analysis is developed based on static analysis making possible to rank and to reduce factors.

For developing a quantitative analysis of PEST factor based on NCM a static analysis is needed. In [5] a model static analysis model for NCM is presented. The result of the static analysis result is in the form of neutrosophic numbers a+bI, for a, b ∈ R (all real numbers), which consists in the determinate part a and the indeterminate part bI[20] . So it can express determinate and/or indeterminate information in incomplete, uncertain, and indeterminate problems.A de-neutrosophication process as proposedby Salmeron and Smarandachecould be applied final ranking value[21] for the PEST analysis.

3. Proposed Framework

Our aim is to develop and further detail aframework based on PEST and NCM[22]. The model consists of the followingfour phases (graphically**, Figure 2**).

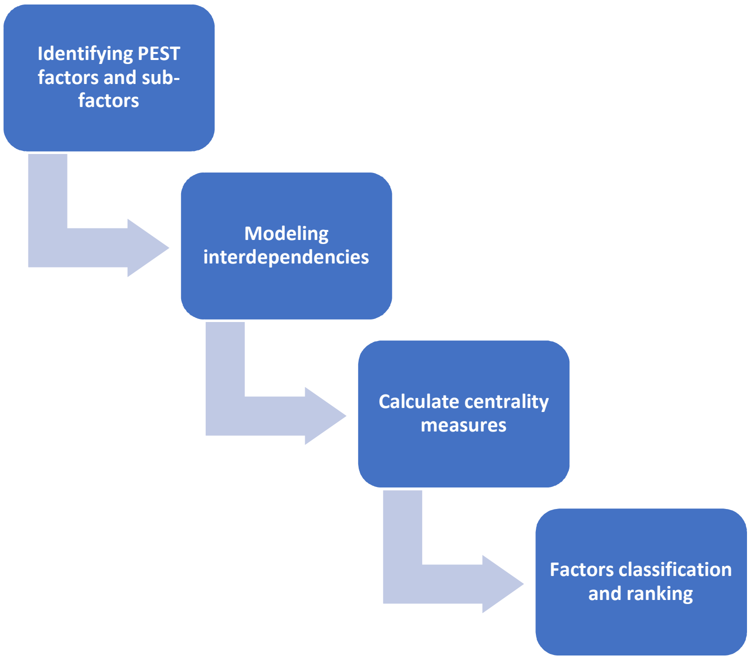

Figure 2: Proposed framework for PEST analysis.

3.1 Identifying PEST factors and sub-factors

In this step relevant PEST factors and sub-factors are identified. PEST factors are derived from the themes: political, economic, socio-cultural, technological factors. Identifying PEST factors and sub-factors to form a hierarchical structure of PEST model is the main goal.

The model consists of three levels[2]. The first level includes the objective function that is "to analyze the food industry's macro environment". The second level contains the 4 main factors of the PEST analysis. The third level of the model consists of sub-factors clustered within the main factors.

3.2 Modeling interdependencies

Causal interdependencies among PEST sub-factors are modeled. This step consists of the formation of NCM of sub-factors, according to the views of an expert orexpert's team.

When a set of experts (k) participates, the adjacency matrix of the collective NCM is calculated as follows:

$$\mathrm{E} = \mu(\mathrm{E}_1, \mathrm{E}_2, \dots, \mathrm{E}_\mathrm{k}) \quad (2)$$

the operator is usually the arithmetic mean [23].

3.3 Calculate centrality measures

Centrality measures are calculated[24] with absolute values of the NCM adjacency matrix [25]:

1. Outdegree$od(v_i)$ is the row sum of absolute values of a variable in the neutrosophic adjacency matrix. It shows the cumulative strengths of connections (c_{ij}) exiting the variable.

$$od(v_i) = \sum_{i=1}^{N} c_{ij} \quad (3)$$

2. Indegree$id(v_i)$ is the column sum of absolute values of a variable. It shows the cumulative strength of variables entering the variable.

$$id(v_i) = \sum_{i=1}^{N} c_{ji} \quad (4)$$

3. The centrality (total degree $td(v_i)$), of a variable is the summation of its indegree (in-arrows) and out-degree (out-arrows)

$$td(v_i) = od(v_i) + id(v_i) \quad (5)$$

3.4 Factors classification and ranking

Factors are classified according to the following rules:

a) Transmitter variables have a positive or indeterminacy outdegree, $od(v_i)$ and zero indegree, $id(v_i)$.

b) Receiver variables have a positive indegree or indeterminacy, $id(v_i)$., and zero outdegree, $od(v_i)$.

c) Ordinary variables have both a non-zero indegree and. Ordinary variables can be more or less a receiver or transmitter variables, based on the ratio of their indegrees and outdegrees.

A de-neutrosophication process gives an interval number for centrality based on max-min values of I . A neutrosophic value is transformed in an interval with two values, the maximum and the minimum value $\in [0,1]$.

The contribution of a variable in a NCM can be understood by calculating its degree centrality, which shows how connected the variable is to other variables and what the cumulative strength of these connections are. The median of the extreme values as proposed by Merigo[26] is used to give an unified centrality value :

$$\lambda([a_1, a_2]) = \frac{a_1 + a_2}{2} \quad (6)$$

Then

$$A > B \Leftrightarrow \frac{a_1 + a_2}{2} > \frac{b_1 + b_2}{2} \quad (7)$$

Finally, a ranking of variables is given.

The numerical value it used for sub-factor prioritization and/or reduction [27]. Threshold values may be set to the 10 % of the total sum of total degree measures for subfactor reduction. Additionally, sub-factor could be grouped by parent factor a to extend the analysis to political economical social and technological general factor.

4Case Study

This case study is a demonstrative example from real data modeled by an expert. PEST analysis identifies external factors which influence a specific business. In this case, we’re examining how the food industry could be affected by political, economic, social and technological factors.

Public health policies are pushing the food industry to produces with lower sodium and sugar. Additionally, current policies push for the public to be more conscious when buying foods[28]. Political factor identified include environmental regulations, and evolving health policies. Economics factor of a country like unemployment rates can affect the food industry. Healthier alternatives to foods are more expensive to buy compared to fast food or easy-to-make meals. Economic factor identified are taxation, and consumer spending .

Food industry is not only pushed by governmental authorities, but by consumers, as well. Social factors identified are lifestyle changes and awareness of citizen about ecological issues[29]. Technology can give a competitive edge. In food industry Technology is necessary to create packaging, food labels, and the production of food and for reaching consumers in new and easier methods[30]. As technological factor identified are online presence and technological access.

Initially factors and sub-factors were identified. Figure 3 shows the hierarchical structure.

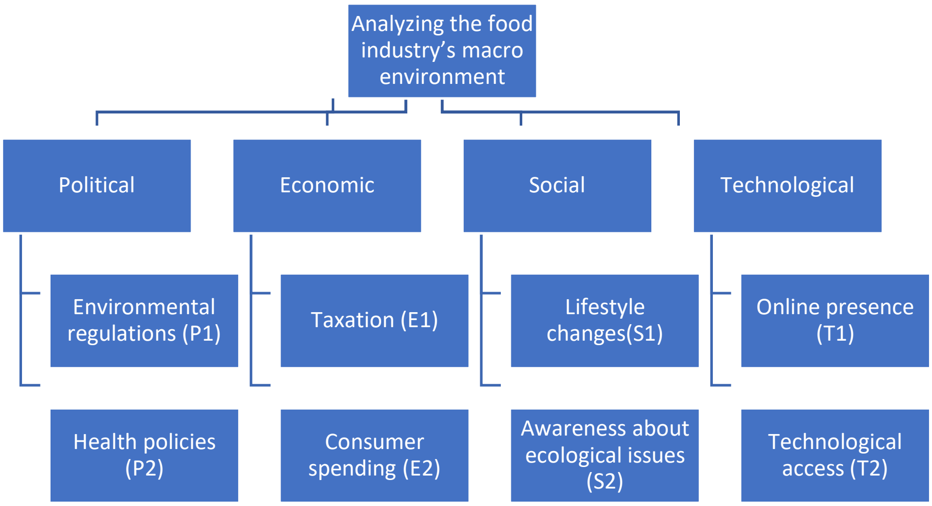

Figure 3: The hierarchical model of PEST in the vertical farming project.

Interdependencies are identified and modeled using a NCM. NCM with weighs is represented in Table 1.

	P1	P2	E1	E2	S1	S2	T1	T2
P1	0	0	0	-0.3	0	0	0	0
P2	0	0	0	0	0	0	0.25	0
E1	0	0	0	0.2	0	0	0	0
E2	0	0	0	0	0	0	0	0.3
S1	0.4	I	0	0	0	0	0.3	0
S2	0	0	0	0	I	0	0	0
T1	0	0	0	0.2	0	0	0	0
T2	0	0	0	0.35	0	0	0	0

Table 1: Neutrosophic Adjacency Matrix

The centralities measures are calculated. Outdegree and indegree measures are presented in Table 2.

Node	Id	Od
P1	0.4	0.3
P2	I	0.25
E1	0	0.2
E2	1.05	0.3
S1	I	0.7+I
S2	0	I
T1	0.55	0.2
T2	0.3	0.35

Table 2: Centrality measures, outdegree, indegree.

Later nodes are classified. In this case, E2 and S2 nodes are receiver. The rest of the nodes are ordinary.

	Transmitter	**Receiver**	**Ordinary**
P1			**X**
P2			**X**
E1			**X**
E2	**X**		
S1			**X**
S2	**X**		
T1			**X**
T2			**X**

Table 3: Nodes classification

Total degree (Eq. 5) was calculated. Results are show in Table 4.

	td
P1	0.7
P2	0.25+I
E1	0.2
E2	1.35
S1	0.7+2I
S2	I
T1	0.75
T2	0.65

Table 4: Total degree

The next step is the de-neutrosophication process as proposes by Salmeron and Smarandache[31]. I ∈[0,1] is replaced by both maximum and minimum values. In Table 5 are presented as interval values.

	Td
P1	0.7
P2	[0.25, 1.25]
E1	0.2
E2	1.35
S1	[0.7, 2.7]
S2	[0, 1]
T1	0.75
T2	0.65

Table 5: De-neutrosophication, total degree values

Finally we work with the median of the extreme values (Eq 6) [26].

	Td
P1	0.7
P2	0.75
E1	0.2
E2	1.35
S1	1.7
S2	0.5
T1	0.75
T2	0.65

Table 6: Total degree using median of the extreme values

Graphically the result is shown in Figure 4.

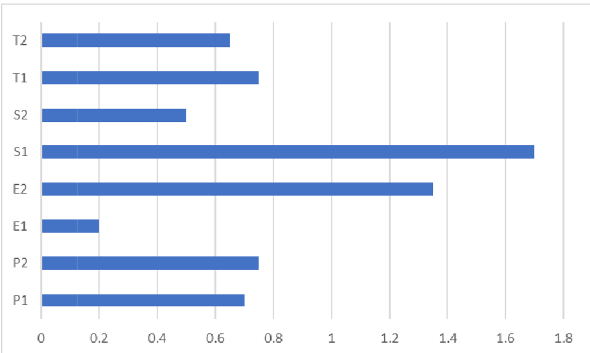

Figure 4: Total degree measures

The ranking obtained is as follows:

$$S_1 \succ E_2 \succ P_2 \sim T_1 \succ P_1 \succ T_2 \succ S_2 \succ E_1$$

Lifestyle changes and Consumer spending are the top factors. Centrality measures of sub factor were grouped according to its parent factor (Figure 5).

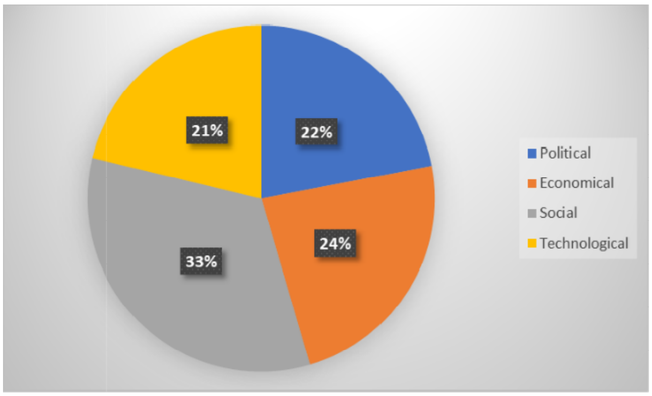

Figure 5: Aggregated total centrality values by factors

Based on total centrality measure, factors with less than 10% of totalsum might be eliminated. According to this rule in current case study E1 could be eliminated. After application of the proposed framework NCM gives a high flexibility and take into account interdependencies PEST analysis.

4. Conclusions

Food industry is affected by political, economic, social and technological factors.This study presents a model to address problems encountered in the measurement and evaluation process of PEST analysis in food industry taking into account interdependencies among sub-factors for modeling uncertainty and indeterminacy. The integrated structure of PEST sub-factors was modeled by NCM and a quantitative analysis is developed based on static analysis. The proposed framework is composed of four activities, identifying PEST factors and sub-factors, modeling interrelation among PEST factors, calculate centrality measures, factor classification and ranking.Further works will concentrate in extending the model for dealing scenario analysis. Another area of future work is the developing a consensus framework for NCM and the development of a software tool.

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