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ANÁLISIS PEST BASADO EN MAPAS DE DECISIÓN DIFUSO APLICACIÓN A LA INDUSTRIA TECNOLÓGICA DEL ECUADOR

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PEST analysis based on fuzzy decision maps for the technology industry in Ecuador

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Abstract. The current PEST analysis model is used to obtain strategic components for the correct development of a business model. Therefore, a PEST analysis model based upon FDM (fuzzy decision maps) is used in the present work, aimed mainly at technology industries. The model consists of the following activities: identify factors, compare importance between factors and their influence, obtain the steady state vector matrix, lastly derive the matrix found to get the GWV (global weight vector). By conducting a case study, it was found that social awareness in the health field was chosen as the most important factor. Furthermore, the practical application showed the applicability of the model and its great flexibility and consideration of interdependencies for the cases of the Ecuadorian technology industry.

Keywords: Fuzzy Decision Maps (FDM), PEST, Technology Business, Fuzzy Cognitive Maps (FCM).

1 Introduction

The analysis tool that evaluates external factors like political, economic, social, and technological, known as PEST, is employed as the main factor to understand the business project's environment accurately. In addition, environmental and legal factors can be included by using the analysis of the political, economic, social, technological, environmental and legal factors known as PESTEL.

This analysis does not have a quantitative approach to measure the interrelationship between its factors [1]. Moreover, the standard framework of PEST analysis does not effectively support such approach. Therefore, a new approach was proposed based on Fuzzy Decision Maps [1].

In a framework for a PEST tool based on FDM it is needed that it provides the possibility of working with interconnected feedback for the technology business and methodological support [2].

This paper aims to present a model built on Fuzzy Decision Maps for the PEST analysis of the Ecuadorian technology industry. The article has the following structure: The theoretical concepts related to PEST analysis and fuzzy cognitive maps (FCM) are analyzed. Subsequently, the proposed methodology and a case study are presented. Finally, the article concludes with conclusions and recommendations for future work.

1.1 PEST Analysis

When analyzing an organization's macroenvironment, it is important to recognize the factors which could affect many crucial variables are likely to influence its supply and demand costs and levels [2].

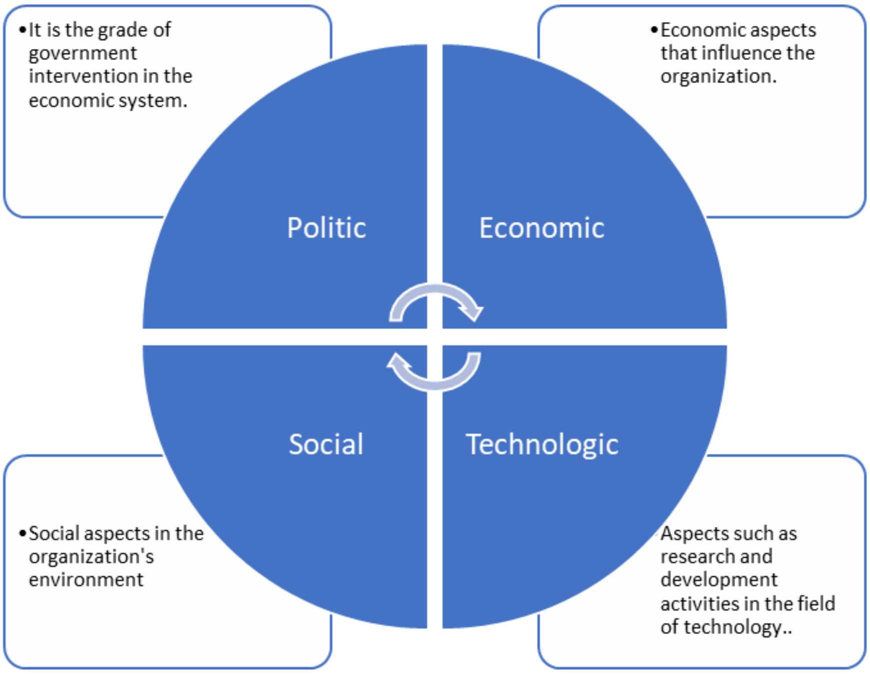

Fig. 1. Aspects for PEST

PEST evaluates the impact of each aspect of the factors on the business. The results are used to make contingency plans for threats when preparing business and strategic plans, and take advantage of opportunities [2]. Kotler emphasis that PEST is a useful strategic tool for understanding market decline or growth, potential, business position, and direction of operations. PEST Analysis can be considered suitable for business and strategic planning, product development and business, marketing planning, and research reporting. This analysis also ensures that corporative performance is positively aligned with the influential forces of change affecting the current business environment [3].

1.2 Fuzzy Cognitive Maps

Cognitive maps were proposed in (Axelrod et al., 1976); the author of that study focused mainly on the political field, wanting to represent social scientific knowledge.

Being deterministic, a simple cognitive map can be characterized by concepts and causal influences. However, taking each aspect within the society and environment in which it is found, these points can change drastically.

Cognitive maps have been widely used for decision-making, robotic simulations, etc. However, despite the benefits that cognitive maps provide for managing acquired knowledge, the capabilities to represent all the factors present are very limited due to the complications in generating relationships without specifying an exact degree of causality.

To solve such limitations, Bart Kosko expanded the theory of cognitive maps by introducing FCM in (Kosko, 1986) by considering the application of Fuzzy Logic (McNeill and Thro, 1994) in the quantification of nodes representing concepts and arcs linking nodes through membership degrees and fuzzy thresholds. Without loss of generality, FCM can be defined by a State Vector that contains the values of n concepts and a causal weights matrix that contains the weights $wiij$ of the causal interconnections between concepts.

In general, FCM combines Neural Networks and fuzzy logic that allows us to predict changes in the concepts represented in the cognitive maps [4]. Among its main advantages is the simple representation of the system's variables and the interrelation between them through causal relationships.

2 Methodology

This paper aims to develop an interface for PEST analysis built on FCM oriented to technology industry. This model has been structured with the four phases as is show below (graphically, figure 2).

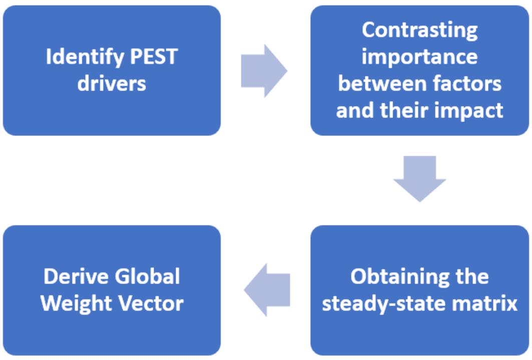

Fig. 2. PEST proposed interface.

2.1 Identify PEST drivers

In this phase, the most important factors of the analysis are acknowledged in the technology industry. The PEST analysis factors are resultant from the Political, Economic, Socio-Cultural and Technological themes. Recognizing these various aspects makes it possible to generate a solid hierarchical base structure for the interface.

2.2 Contrasting importance between factors and their impact

Local weight vector is obtained by the comparison of the importance between each node, is compared to derive using the single value approach [4]. For accuracy, this must be performed by subject matter specialists according to the preferences shown in the following table.

Table 1. Criteria Ranking.

Description	Value
Equal Importance	1
Moderate Importance	2
Strong Importance	3
Full Importance	4
Extremely Important	5

To specify the impact between criteria by the specialists a FCM is established. All the interconnections between the factors are modeled the same way. According to the experts, this point involves the MSC development of sub-factors as nodes.

2.3 Obtaining the steady-state matrix

To find the Steady State Vector Matrix the update equation is calculated as follows:

$$C^{(t+1)} = f\left(C^{(t)} \cdot E\right), C^0 = I_{n\times n} \quad (1)$$

Where $E = [W_{ij}]$ is a matrix $n \times n$ which recollects values of the causal edge weight between Ci and Cj, C (0) is a preliminary matrix and f is the conversion function, C(t+1) and C(t) are the state vectors at iterations (t+1) and (t), correspondingly, and $I_{n\times n}$ represents the Identity Matrix.

2.4 Derive Global Weight Vector

First, we must standardize the steady-state matrix (M) and local weight vector (V) as follows:

$$V_n = \frac{1}{k}V \quad , \quad M_n = \frac{1}{c}M \quad (2)$$

Where c is the sum of largest rows of M and k is the longest element of V. Consequently, the overall Weight Vector (W) are obtained with the following equation:

$$W = V_n + V_n M_n \quad (3)$$

Where M_n is the normalization of the stationary matrix and V_n is the standardization of the Local Weight Vector. Lastly, we normalize the Overall Weight (W).

3 Case Study

Technology Industry external factors that impact businesses are measured mainly by utilizing PEST analysis. Therefore, this article will focus on analyzing political, economic, social and technological factors of software technology development industries [7].

During the last year, the technology industry, like all other businesses, was affected by the global pandemic caused by the SARS-CoV-2 virus [8]. With respect to the political factor, governments forced social confinement and the initiation of teleworking, which drove demand for mobile application development and e-business platforms [9].

In the economic environment, many businesses suffered economic losses due to the lack of sales; and in order to increase them, they had to adapt to new technologies that would make it easier for consumers to purchase their products or services [10]. Businesses that could not adapt to this change were overtaken by their competitors, which caused them to cease operations.

Society found the need to purchase their necessities online to avoid crowded spots, and e-learning platforms for students of all levels of education became popular due to the closure of educational institutions. Thanks to the high increase in demand for this type of project, many technology companies had to put on hold developments they had already planned during the year to prioritize new trends [11].

Hybrid development languages became popular for the various mobile platforms, thus avoiding a double effort in the projects, some of these languages were Flutter, Xamarin, React Native [12]. The software technology industries were forced to choose among the new development trends, thus managing their resources and the requirements requested by customers more optimally; in these efforts, PEST analysis was used to identify which technology and type of development were more feasible in each case.

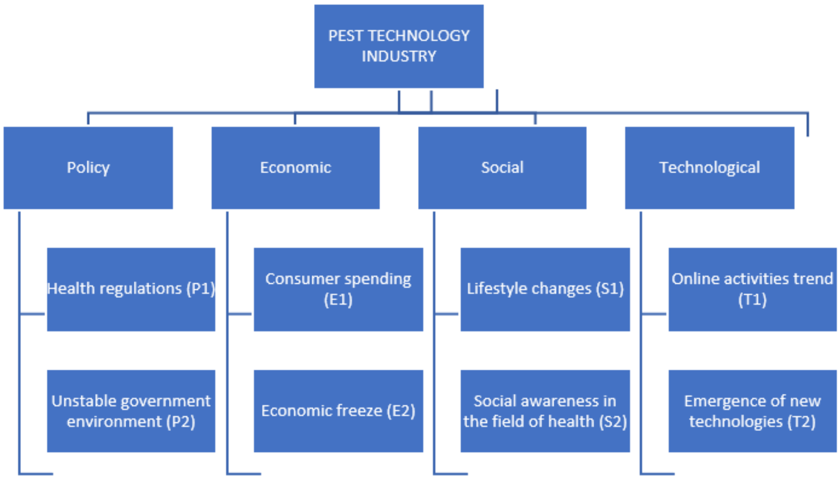

Fig. 3. Hierarchical map of the PEST analysis.

To choose the best alternative, it is necessary to derive the impact or influence value of every criterion and obtain the influence value for all the factors.

Value matrix (E) was generated as shows the table below:

	P1	P2	E1	E2	S1	S2	T1	T2
P1	1,00	3,00	1,20	0,50	2,00	2,00	0,75	0,20
P2	0,33	1,00	1,20	0,50	1,00	0,33	2,60	2,10
E1	0,83	0,83	1,00	0,50	1,00	0,33	2,60	2,10
E2	2,00	2,00	2,00	1,00	1,00	0,33	2,60	2,10
S1	0,50	1,00	1,00	1,00	1,00	2,60	2,10	2,10
S2	0,50	3,03	3,03	3,03	3,03	1,00	5,00	5,00
T1	1,33	0,38	0,38	0,38	0,38	0,38	1,00	0,81
T3	5,00	0,48	0,48	0,48	0,20	0,30	0,50	1,00

From the resultant matrix, using the eigenvalue method we calculated local weights [5].

Table 2. Resultant Local Weights.

	V
P1	0.26680301
P2	0.18391272
E1	0.18630638
E2	0.27793082
S1	0.27043914
S2	0.51884517
T1	0.1098025
T2	0.18596027

The interrelationships between the nodes are identified and modeled through the use of DCM, using the Mental Modeler tool [6].

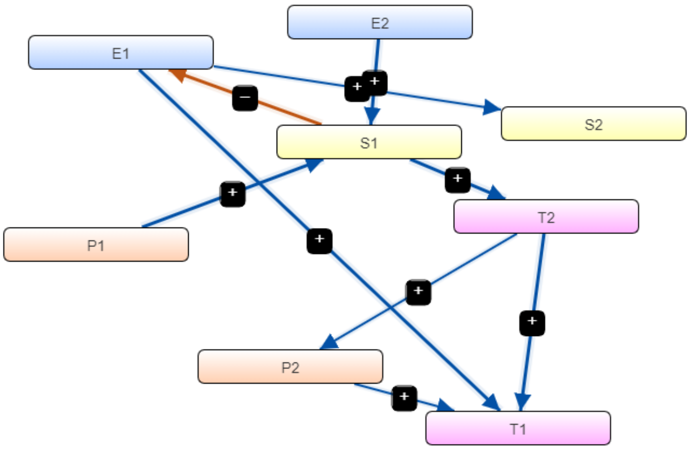

Fig. 4. Design of Fuzzy Cognitive Map.

In Fig. 5 adjacency vector matrix based on FCM is shown.

```
[[ 0.      0.     -0.32    0.      0.64   -0.0704 -0.16    0.    ]
 [ 0.      0.      0.      0.      0.      0.      0.25    0.    ]
 [ 0.      0.      0.      0.      0.      0.22    0.5     0.    ]
 [ 0.      0.     -0.36    0.      0.72   -0.0792 -0.18    0.    ]
 [ 0.      0.     -0.5     0.      0.     -0.11   -0.25    0.    ]
 [ 0.      0.      0.      0.      0.      0.      0.      0.    ]
 [ 0.      0.      0.      0.      0.      0.      0.      0.    ]
 [ 0.      0.25    0.      0.      0.      0.      0.7325  0.    ]]
```

Fig. 5. Fuzzy Cognitive Map Adjacency Vector Matrix.

With the use of exclusively linear Steady State Vector Matrices. It was possible to find the Overall Weights [14] [15].

Table 3. Overall Weights

	W
P1	0.14375954
P2	0.09307196
E1	0.15743845
E2	0.15196655
S1	0.03936246
S2	0.22794155
T1	0.04823896
T2	0.13822052

Obtained impact list consists of the following:

$$\mathbf{S_2} \succ \mathbf{E_1} \succ \mathbf{E_2} \succ \mathbf{P_1} \succ \mathbf{T_2} \succ \mathbf{P_2} \succ \mathbf{T_1} \succ \mathbf{S_1}$$

Social awareness in the health field was chosen as the most important factor. After applying this study model, it has been found that the use of PEST analysis is practical due to its great flexibility and consideration of interdependencies for the cases of the Ecuadorian technology industry.

4 LNCS Online

The technology industry is affected by the organization's factors within a political, economic, social and technology environment. The paper offers a framework to solve issues by measuring and evaluating the factors, considering interconnections between subfactors and managing the technology business uncertainty. The unified model of the PEST subfactors was created using DCM.

A case study was presented to validate the applicability of the proposal. It is necessary to emphasize that this is the first study, as far as is known, that integrates DCM into the PEST evaluation scheme for the technology industry.

Further work will concentrate on expanding the model to cover a more significant number of factors. In addition, a future project will focus on developing a software tool that will contribute to the generation of these analyses.

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