



# PEST analysis based on fuzzy decision maps for food industry

## Análisis PEST basado en mapas de decisión difusos de la industria alimentaria

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#### ABSTRACT:

Currently PEST analysis provides mainly a general idea about the macro environmental conditions and situation of a company or project. In this paper, a new model for PEST analysis is presented based on fuzzy decision maps for food industry. The proposed framework is composed of four activities obtaining a ranking of factors. A case study of how the food industry is affected by political, economic, social and technological factors is presented. Further works will concentrate on developing a software tool.

**Keywords:** PEST analysis, fuzzy decision maps, fuzzy cognitive maps, food industry

#### RESUMEN:

Actualmente el marco de trabajo del análisis PEST solo provee una idea general de las condiciones macro-ambientales de un compañía o proyecto. En el presente trabajo se propone un nuevo modelo para el análisis PEST basado en los mapas de decisión difusos para la industria alimenticia. Se desarrolla un estudio de caso basado en cómo esta industria es afectada por factores políticos económicos sociales y tecnológicos es presentado. Trabajos futuros se centrarán el desarrollo de una herramienta informática.

**Palabras clave:** Análisis PEST, mapas de decisión difusos, mapas cognitivos difusos, industria alimentaria

## 1. Introduction

The PEST (Political, Economic, Social and Technological) framework, is used to assess these four external factors in relation to a business situation (Healey, 1994). Environment and legal factors could be included and then is named PESTEL (Political, Economic, Socio-cultural, Technological, Environment and Legal) analysis (Yüksel, 2012).

PEST analysis lacks a quantitative approach to the measurement of interrelation among its factors (Yüksel, 2012). Standard technical framework of PEST does not adequately support that approach. A new approach based on fuzzy decision maps is presented in (VÁZQUEZ, HERNÁNDEZ, HERNÁNDEZ, SALVATIERRA, & BARYOLO, 2018).

In this paper a model for PEST analysis based fuzzy decision maps (FDM)(Yu & Tzeng, 2006)

is presented giving methodological support and the possibility of dealing with interdependence, and feedback for the food industry. This work is structured as follows: Section 1.1 and 1.2 reviews some important concepts about PEST analysis framework and fuzzy cognitive maps (FCM), respectively. In Section 2, a framework for PEST analysis based on FDM for the food industry } composed of five activities, identifying PEST factors and sub-factors, compare importance, modelling influence, obtaining the steady-state matrix and derive the global weight vector is presented. Section 3 shows a case study of the proposed model is presented. The paper ends with conclusions and further work recommendations.

## 1.1. PEST Analysis

PEST (Political, Economic, Social and Technological), analysis is a precondition analysis with the main function of the identification of the environment within which the company operates and providing data and information that will enable the organization to make predictions about new situations and circumstances (Frynas & Mellahi, 2015; Thompson & Martin, 2010). Factors in PEST analyzed are generally measured and evaluated independently (Yüksel, 2012). In (Yüksel, 2012) a proposal for PEST analysis in a multicriteria environment is presented but lacks interrelation analysis.

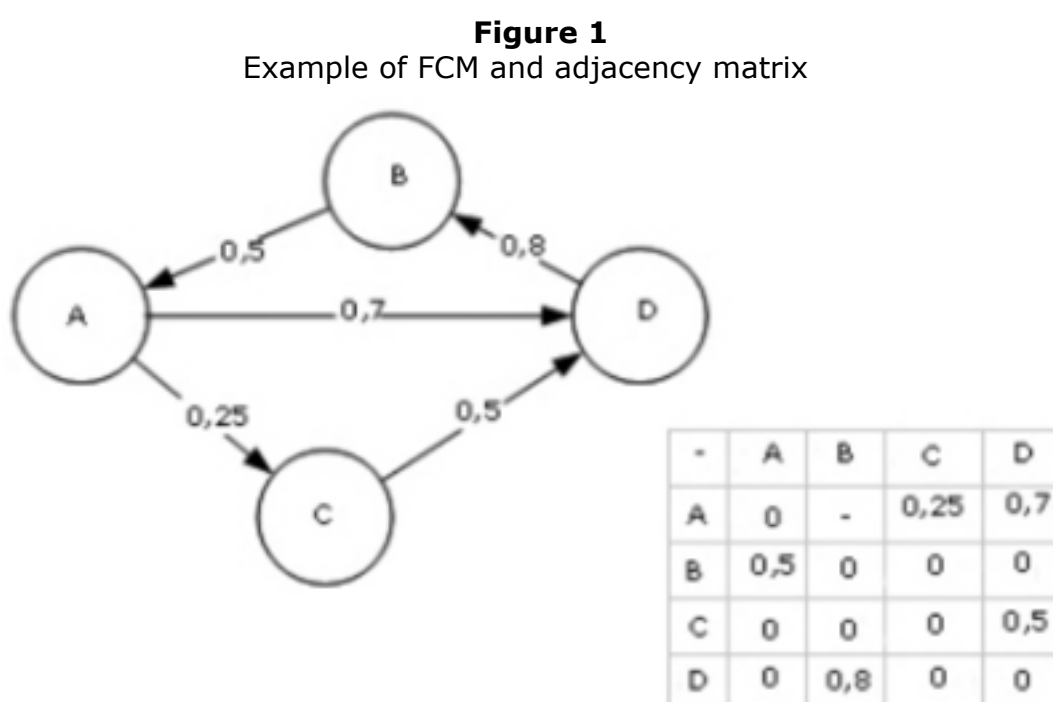
In (VÁZQUEZ et al., 2018) a new approach based on fuzzy decision maps is presented taking into account interdependency among general factor is taken into account. Additionally, factors and sub-factor have ambiguity, vagueness in their interrelations

This study presents a model to address problems encountered in the measurement and evaluation process of PEST analysis in food industry considering interdependencies among sub-factors. The structure of PEST sub-factors was modeled by FCM and a quantitative analysis is developed based on the FDM method.

## 1.2. Fuzzy cognitive maps and Fuzzy decision maps

Axelrod (Axelrod, 2015) introduce cognitive maps were introduced by where nodes represent concept or variables in a domain and arcs indicate positive or negative causal relations. Kosko extends cognitive maps with fuzzy logics as fuzzy cognitive maps (FCM) (Kosko, 1986) (Figure 1) . FCM are fuzzy graph for representing causal knowledge, extending cognitive maps with fuzzy values in the  $[-1,1]$  interval indicating the strength of causal relations.

The matrix representation of FCM allows causal inferences. there are three possible types of causal relations between nodes represented in the matrix: negative, positive and no relationship (Leyva-Vázquez, Santos-Baquerizo, Peña-González, Cevallos-Torres, & Guijarro-Rodríguez, 2016).



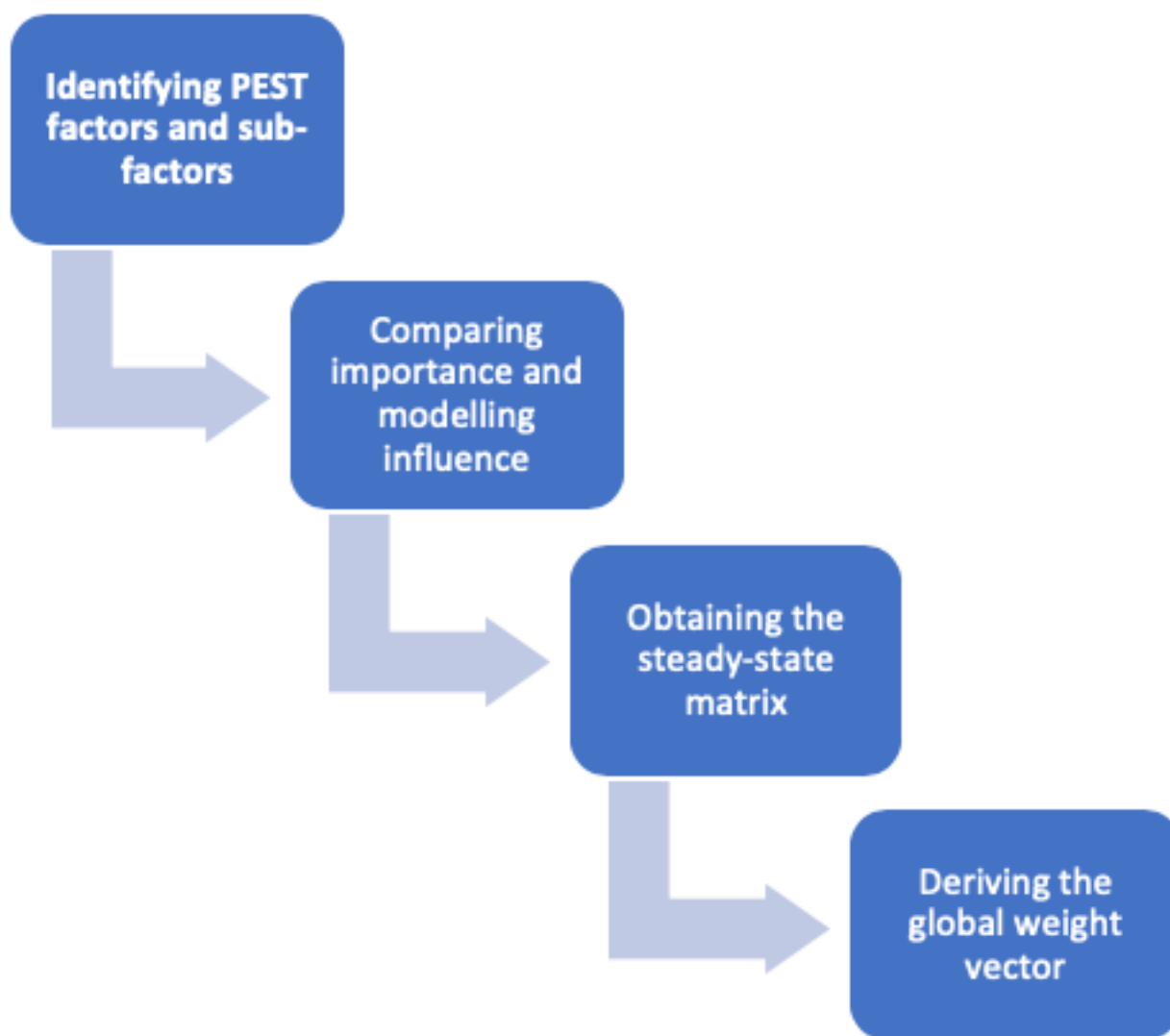
FCM have been applied diverse areas such as decision support and causality analysis (MY Leyva-Vázquez, KY PÉREZ-TERUEL, Ailyn Febles-Estrada, & Jorge Gulín-González, 2013). Fuzzy decision map (FDM) were proposed in 2006 for solving the multicriteria decision making problem taking into account dependence and feedback (Yu & Tzeng, 2006). For overcoming the shortcoming in the AHP and ANP methods. FDM incorporates the eigenvalue method, FCM, and the weighting equation (Elomda et al., 2013).

The advantages of FDM (Elomda, Hefny, & Hassan, 2013; Tzeng, Chen, Yu, & Shih, 2010) overcome the drawbacks of the AHP and ANP, employing the different threshold functions to indicate the various kinds of relationship among criteria. The ability to solve both the compound and the interaction effects and dealing with direct and indirect influences are another area of advantage.

## 2. Methodology

Our aim in the proposal is developing a framework for PEST analysis based on FDM for food industry. The model consists of the following phases (graphically, Figure 2).

**Figure 2**  
Proposed framework for PEST analysis



### 2.1. Identifying PEST factors and sub-factors

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

### 2.2. Comparing importance and modelling influence

The importance among nodes is compared to derive the local weight vector using the eigenvalue approach (Elomda et al., 2013). This should be done by domain experts

according to the preference scale shown in table1.

**Table 1**  
Scale for relationship among criteria

Description	Numerical Value
Equal importance	1
Moderate importance	2
Strong importance	3
Very strong importance	4
Extreme importance	5

Fuzzy cognitive map to indicate the influence among criteria by the expert is developed. Causal interdependencies among PEST sub-factors are modelled this way. This step consists of the formation of FCM of sub-factors, as nodes according to experts.

### 2.3. Obtaining the steady-state matrix

Calculating the updating equation to obtain the steady-state matrix is as follows:

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

where  $I_{n \times n}$  denotes the identity matrix,  $E = [W_{ij}]$  is  $n \times n$  matrix, which gathers the values of causal edge weight between concepts  $C_i$  and  $C_j$ ,  $C^{(t+1)}$  and  $C^{(t)}$  are the state matrices at iterations  $(t + 1)$  and  $(t)$ , respectively,  $C(0)$  is the initial matrix, and  $f$  is the threshold transformation function.

### 2.4. Deriving the global weight vector

We should first normalize the local weight vector ( $V$ ) and the steady-state matrix ( $M$ ) as follows:

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

where  $k$  is the largest element of  $V$  and  $c$  is the largest row sum of  $M$ . Then, the global weight vector ( $W$ ) can be computed as follows:

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

where  $V_n$  is the normalization of the local weight vector, and  $M_n$  is the normalization of the steady-state matrix. Finally, we normalize the global weight ( $W$ ).

## 3. Case study

**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. Political factor identified include environmental regulations, and evolving health policies.

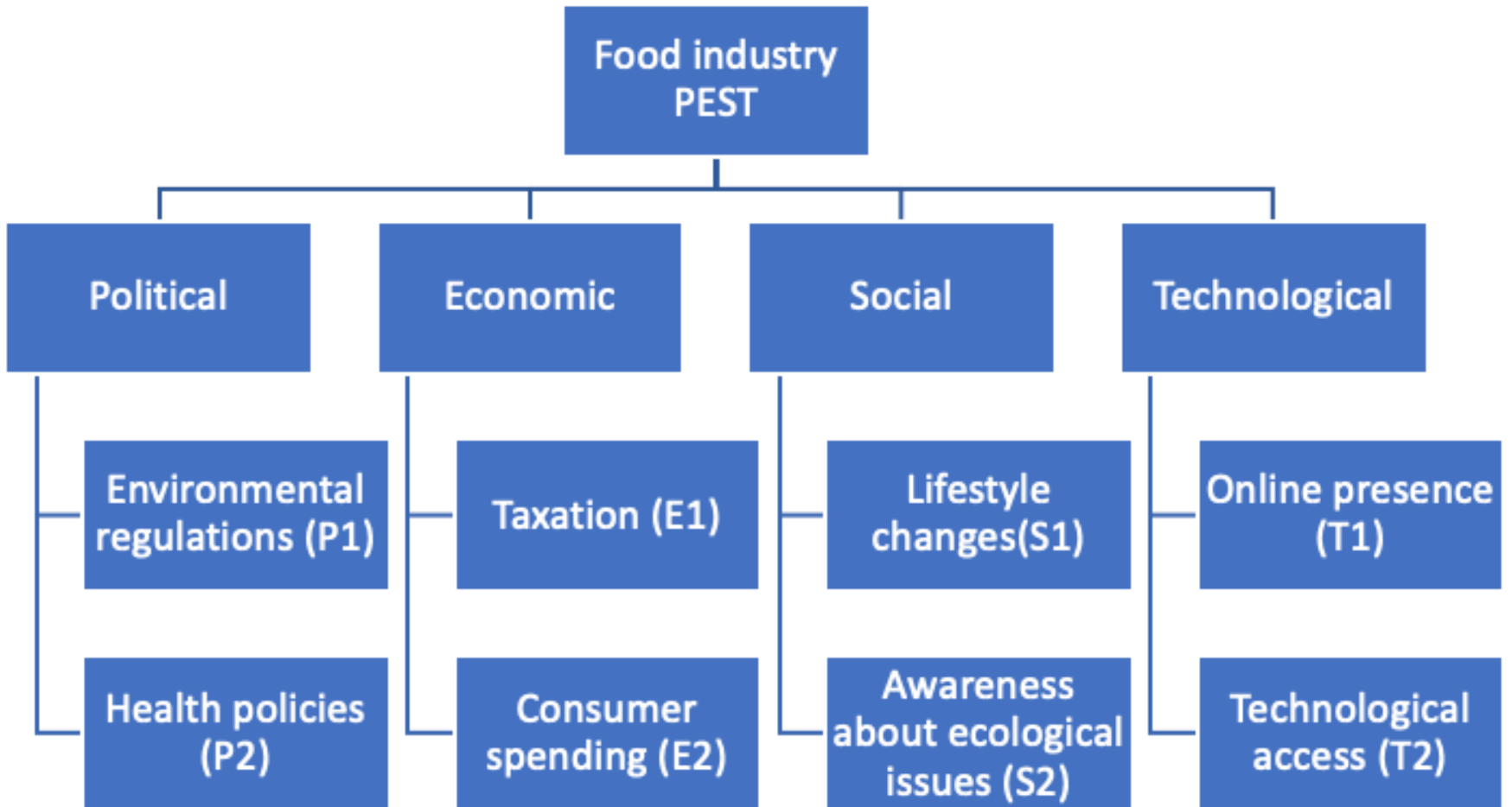
**Economics factor of a country like unemployment rates can affect the food industry.** Healthier alternatives to foods are more expensive to buy compared to fast food or easy-to-make meals. Economic factor identified are taxation, and consumer spending .

**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.

**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. As technological factor identified are online presence and technological access.

Figure 3 shows the hierarchical structure.

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



For choosing the best alternative, we should derive the influence scores of each criterion and calculate the influence scores of each factor.

The Scoring matrix (E) was elicited as follows:

From the matrix above, we can calculate the local weights by means of the eigenvalue method (Table 2).

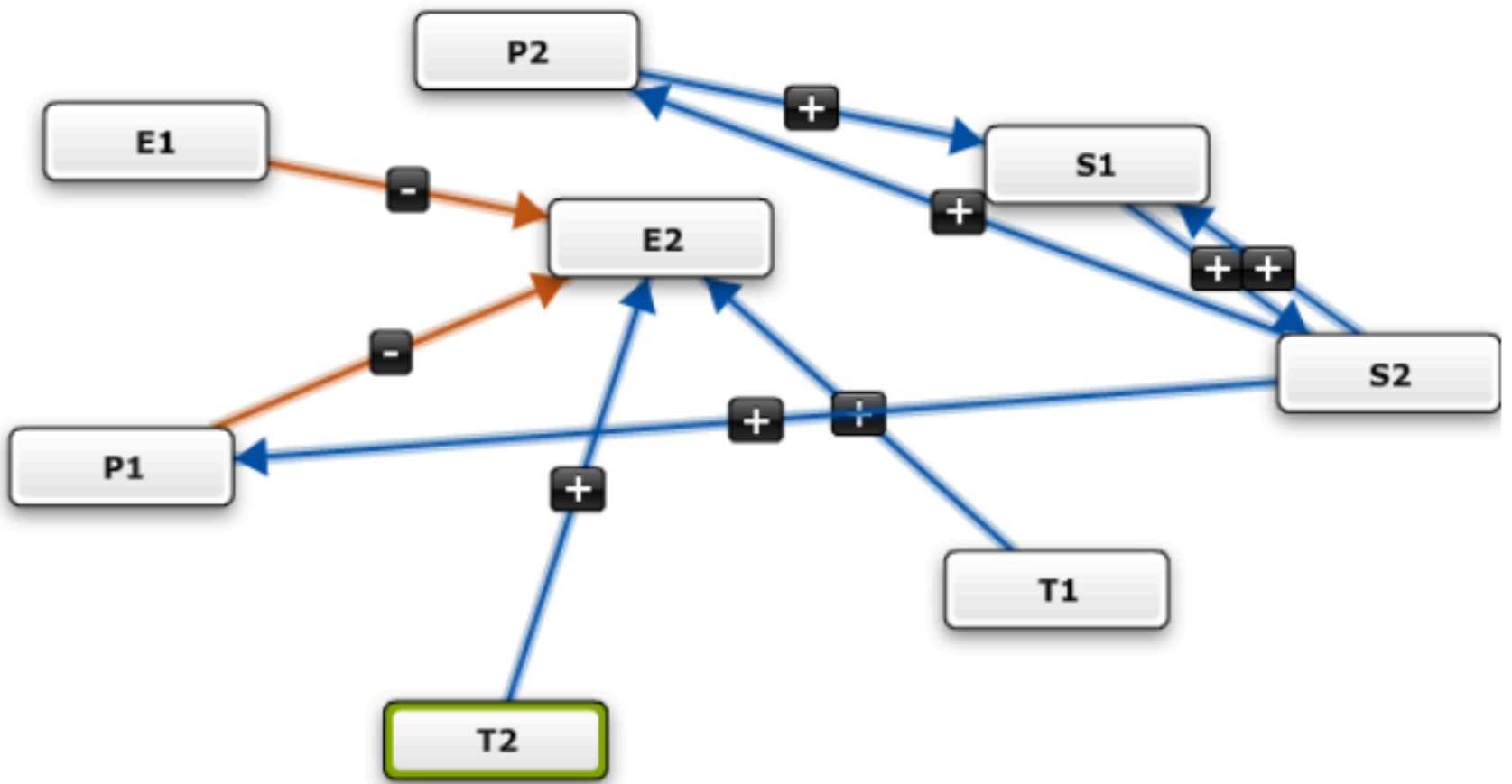
**Table 2**  
Local Weights

	Local Weights
P1	0.12674983
P2	0.24620347
E1	0.08644919

E2	0.5241169
S1	0.19905528
S2	0.18926886
T1	0.24261768
T2	0.38553879

Interdependencies among nodes are identified and modelled by means of a FCM. using the Mental Modeler Tool(Gray, Gray, Cox, & Henly-Shepard, 2013).

**Figure 4**  
Fuzzy Cognitive Map



Adjacency matrix of the FCM is shown in Figure 5.

**Figure 5**  
Adjacency matrix

$$\begin{bmatrix}
 0. & 0. & 0. & -0.31, & 0. & 0. & 0. & 0. & 0. \\
 0. & 0. & 0. & 0. & 0. & 0. & 0. & 0.24, & 0. \\
 0. & 0. & 0. & -0.21, & 0. & 0. & 0. & 0. & 0. \\
 0. & 0. & 0. & 0. & 0. & 0. & 0. & 0. & 0.29 \\
 0.32, & 0.44, & 0. & 0. & 0. & 0. & 0. & 0.27, & 0. \\
 0. & 0. & 0. & 0. & 0. & 0. & 0. & 0. & 0. \\
 0. & 0. & 0. & 0.22, & 0. & 0. & 0. & 0. & 0. \\
 0. & 0. & 0. & 0.27, & 0. & 0. & 0. & 0. & 0. \\
 \end{bmatrix}$$

Using the pure-linear the steady-state matrices. Finally, using Eq. (3), we can obtain the global weights as shown in Table 3.

**Table 3**  
Global weights

	<b>Local Weights</b>
P1	0.02705181
P2	0.13684334
E1	0.01808746
E2	0.27804667
S1	0.1670944
S2	0.07817771
T1	0.15657394
T2	0.22840322

The ranking obtained is as follows:

Consumer spending was selected as the top environment factor. After application in this case study the model is found to be practical to use giving high flexibility and considering interdependencies within PEST analysis for food industry.

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## 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 considering interdependencies among sub-factors and modeling uncertainty for the food industry. The integrated structure of PEST sub-factors was modeled by FCM.

To demonstrate the applicability of the proposal a case study is presented. Most notably, this is the first study to our knowledge to integrate FDM to the PEST analysis Schema for food industry. Further works will concentrate in extending the model for dealing scenario analysis. Another area of future is the development of a software tool.

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