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SIMULATION MODEL OF ENVIRONMENTAL FACTORS OF ORGANIZATIONS USING FUZZY LOGIC

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Rezumat. *În contextul actual al crizei economice mondiale se impune tot mai mult descoperirea de noi abordări ale proceselor şi fenomenelor economice, astfel încât să fie posibilă analiza acestora din punct de vedere dinamic şi nu static cum sunt realizate în prezent. Modelele matematice utilizate în economie sunt bidimensionale, cu grade diferite de complexitate, care nu depăşesc analiză vectorială tridimensională. Modelul propus presupune introducerea de noţiuni matematice recente (fuzzy logic), utilizarea de soft matematic (Matlab) şi soft grafic 3D (Catia) pentru vizualizarea dinamică în 3D a evoluţiilor şi efectelor fenomenelor.*

Abstract. *In the context of the current global economic crisis, it is essential to discover new approaches to economic processes and phenomena, so as to enable their dynamic analysis instead of the static one that is currently conducted. The mathematical models used in economics are two-dimensional, with varying degrees of complexity that do not exceed three-dimensional vector analysis. The model submitted in this paper introduces recent mathematical concepts (fuzzy logic), the use of mathematical software (Matlab) and 3D graphic software (Catia) for a dynamic 3D visualization of trends and effects of various phenomena.*

Keywords: strategies, fuzzy logic, fractal, marketing mix, 3D modeling

1. Introduction

Currently, most research, especially in the economic field, materializes in theoretical and mathematical models. Putting the results into practice is difficult and incurs major errors. So far, nobody assembled several results in order to be analyzed as a whole (unification). Because during the analysis corrections are made to some results, it becomes difficult to visualize the whole and the interdependencies between them and to deliver and implement the right decision. In most cases, logic or foresight guide the making and implementing of the decision.
For example, researchers who sought to determine the mass of the universe have not taken $+\infty$ into account because it was considered too large a number or $-\infty$ because it was considered too small (insignificant); the result was as follows: 80 % of the mass of the universe is missing (the mass between galaxies had been neglected, "neglecting the singularities at infinity" - the unsolved part of A. Einstein's non-linear field equations [1].

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2. Current Stage

2.1. Ocean type theoretical models

Research and analysis of strategic movements in different industries have led to the concept of ocean type strategy: 1980 Red Ocean Strategy (Michael E. Porter), 2005 Blue Ocean Strategy (W. Chan Kim and Renee Mauborgne), 2007 Green Ocean Strategy (Hou Shengtian) and 2012 White Ocean Strategy (Danai Chanchaochai).

Strategy refers to when a company defines its value proposition, its market offer, which must determine: who the customers are, how to deliver, which distribution chains are available, what unique offering differentiates it and makes it count. Thus, avoiding side effects should have an active influence, be accessible and act on the causes generating a shift from functional to emotional.

2.2. Mixed theoretical-mathematical models

The BCG matrix (Boston Consulting Group)

The major weaknesses of this model derive from simplifying complex situations and from the consequent superficiality of principles arising from these situations. For the model to be useful, it has to overcome the problems related to evaluation and definition. Usually, identifying an appropriate portfolio of products requires a careful definition of the market on the narrowest segments possible [2]. Because the model uses only two dimensions, market share and growth rate, management is tempted to draw premature conclusions about a product. Also, the matrix *lacks the temporal quality*, as it is a snapshot of an organization at a given point in time. Other variables such as market size and competitiveness are important advantages that should be taken into account when making strategic decisions.

The GE matrix (General Electric – McKinsey)

From a practical standpoint, the main difficulty lies in the selection and weighting of the criteria relevant to assessing a company's position within the matrix.

In addition, when evaluating companies belonging to different industries, success factors differ as well, so if separate calculations for each outstanding are not carried out, direct comparison between companies within the same matrix can lead to false results. Often there are strategic reasons to stay on the market, even though financial indicators suggest exiting the market.

The Ansoff matrix

The choice to diversify in related or different industries is triggered by the synergy that cannot be achieved this way [2]. Products or markets generate the synergy found in diversification in related industries. Diversification in non-related industries is based on financial synergy or on managerial experience.

The ADL matrix (Arthur D. Little)

The limits of the model are:

- the model puts together the competitive position and profitability;
- a product in decline can be resumed internationally on the same market or on different markets;
- a new product may experience an unexpected and dynamic growth leading to fast decline;
- it doesn't measure/analyze the competitiveness of a production system;
- success factors restrict the scope of analysis and achieving these success factors doesn't result in critical activities or points for the system;
- a business improvement plan cannot be designed by applying the model.

A summary of aforementioned matrixes

It must be noted that there is a quantitative limit of segmentation that allows an analysis of the equilibrium of the portfolio by identifying diversification. By integrating the concepts of synergy and barriers, the GE-McKinsey model facilitates the selection of opportunities. The limits of the models derive from promoting free competition, and they serve only as analysis tools, but cannot provide systematic and elaborate answers to managers. Their purpose is to focus the strategy so as to facilitate a competitive analysis of activities and resource selection.

2.3. Other approaches

I. Management

Steve W. Martin conducted a study on 60 top vice-presidents to estimate how much of their time they used a particular style of management and employed an Osgood scale from 1 (least important) to 5 (most important) [3].

He identified 7 types of managers:

1. *Mentors (Charismatic Manager)* – used by 26% of respondents who ranked the style's importance at 4,3**;**
2. *Expressives (People-oriented Manager)* – used by 30% of respondents who ranked the style's importance at 4,0;
3. *Sergeants (Manager devoted to team)* – used by 18% of respondents who ranked the style's importance at 3,2;
4. *Teflons (Diplomatic Manager)* – used by 10% of respondents who ranked the style's importance at 2,0;
5. *Micromanagers (Methodical Manager)* – used by 7% of respondents who ranked the style's importance at 3,3;
6. *Overconfidents (Self-centered Manager)* – used by 6% of respondents who ranked the style's importance at 1,8;
7. *Amateurs (Manager with an identity crisis)* – used by 3% of respondents who ranked the style's importance at 1,0;

As it can be seen, each subject identified a certain type of manager without taking the other types into account. The prevailing features determine each style of management, but given that the manager is "a man", his/her management style also incorporates other management styles in an insignificant proportion.

A manager using the mentor style also employs characteristics of other styles, characteristics that he/she perceives as insignificant (subjectivity). If the study had been conducted using questions that covered all 7 types of managers and had been translated into 3D, we would have noticed the exact direction of the leadership style, not the subjective one of each vice president, thus pinpointing the cause if each manager's success/failure.

II. 6P vs 6C marketing:

This model was presented in 2003 by Balmer J.M.T. and Greyser S. A., and describes the correlation between 6P and 6C as follows [4]:

Table 1. Correlations between 6P and 6C

Product	Commodity
Price	Cost
Promotion	Communication
Placement-distribution	Channel
People	Constituencies
Perception	Concepts

Besides completing the concepts of 4P and 4C, the model also expands the area of theoretical marketing by providing explanations, and by aggregating different perspectives to create a whole, i.e. the basic principles of marketing, which according to Grönroos C. [5] and Gummesson E. [6] are limited. From a marketing perspective, it is important to look for solutions to approach the elements in a unified manner, and to assemble them in order to achieve a result that highlights the interdependence between them.

III. Corporate economic and financial analysis

Corporate economic and financial analysis implies [7]:

1. *Analysis of human resource*: human potential;
2. *Material and technical analysis:* working capital and fixed assets;
3. *Analysis of resource consumption:* the dynamics and structure of expenditures; fixed and variable costs; expenses: materials, wages, transportation, storage (warehousing) and interest; depreciation of fixed assets;
4. *Commercial analysis:* of turnover and added value;
5. *Effectiveness analysis*: profit and loss, account; intermediate management balances; the cash flow; result; trade; economic; resources consumed; financial;

6. *Asset analysis based on balance sheet:* accounting and functional;
7. *Asset analysis based on balance sheet:* accounting and functional;
8. *Analysis and evaluation of investment projects:* evaluation without update (recovery period and rate of return on investment), assessment with update (time value of money, net present value, internal rate of return).

The many types of economic and financial analysis an organization is subjected to are correlated and have different intensities of influences. The result of this complex analysis can only be viewed in 2D (or maximum 3D if there are three dimensions). The above analysis includes 8 types of diagnosis with 36 sub-components (the basic analysis package for an organization). It's not recommended to analyse the economic and financial profile of an organization based on 3 types of analysis or three subcomponents, or on combinations of diagnostic tests / sub-components because they are interdependent. (Ex.: 1. Human potential and 7. Financial balance (insolvency - insolvency) are closely interrelated).

3. Presentation method of analysis

Given that the analysis of research findings is extremely difficult to put into practice, I recommend using a method that allows this. In this context, it should be understood that I do not propose new methods or mathematical models, but a new way of assembling the final results (*Final Results Simulation - FRS*) to create an accurate and real-time imagine of *Past, Present and Future Stages (PPFS)* and the possibility of correcting *PPFS* using fuzzy logic. This FRS of PPFS leads to a better understanding of the behavior of variables in order to reach **the target area**. To reach the target area we can choose to change the values of variables, adjusting *PPFS* variables, so we employ lateral thinking by using Blue Ocean Strategy (BOS) to take advantage of the best opportunities.

Reaching the target area can be achieved in two ways using chaos theory:

a) the probability to reach the target area - agreed by most researchers;
b) the probability to remain in the target area – it has few followers because the research is very complex and the results are made available only at informative level [7];

The model that we propose is able to operate with 192 interdependent variables on three axes (a matrix of 64 variables on a single axis consisting of two arrays of 32 variables in opposition - using fractals) in three-dimensional space; the correction to the target area (feedback) is made in real time using **fuzzy logic** and leads to minimizing errors and maximizing opportunities (SRA - adjusting step by step until the correction is made - many steps - ineffective feedback).

This **dynamic model** can:

- *forecast*: the emergence of new situations and solutions for them; **the speed and the time** needed to reach into the target area; **the speed and the reaction time** needed to get back on the desired trajectory of a certain result in case of deviations from it.
- *perform* any time an analysis of the outcome at a certain moment, when it is influenced by many forces which in turn consist of sub-components with dynamic activity.

The model uses single volume or fractal tetrahedra on the following axes: $-x\_O\_+x$, $-y\_O\_+y$, and $-z\_O\_+z$, the vertices of the tetrahedra being inscribed in a sphere to obtain the **sphere-tetrahedra dualism.**

The stages of equilibrium of the *sphere* are:

a) *The ideal condition* is characterized by the fact that *the sphere does not deform (vibrate) and it does not roll*;
b) *The actual condition* is characterized by two conditions:
   1. The sphere deforms (vibrates), but doesn't roll;
   2. The sphere rolls.

Continuous deforming (vibration) of the sphere is given by infinitesimal changes of the **2, 4 or 6 tetrahedral volumes** and by **64, 128 or 192 fractal tetrahedra volumes**, which compensate each other. Particular attention should be paid to continuous deformation (vibration) that should not reach **the resonance frequency**, as this leads to overheating of the sphere, namely **self-destruction**.

The rolling of the sphere is given by the change in volume/volumes which decrease/increase compared to opposed volume/volumes that increase/decrease depending on the dynamic that characterizes them, similar to higher volume/volumes. The rolling of the sphere is done three-dimensionally, in the spherical coordinates system, on polar coordinates (ρ,φ,θ) and on three axes *(x, y, z),* based on the direction of larger forces that are active at a certain time. Rolling the sphere is carried out in the space determined by the 8 quadrants, where $+x,+y,+z \Rightarrow dial\_1$ is the maximum and $-x,-y,-z \Rightarrow dial\_8$ is the minimum.

It should be mentioned that the two opposite tetrahedra on the same axis must have the same characteristics, that is either single volume or fractal, because a single volume tetrahedron has a bigger volume than the fractal tetrahedron. Consequently, the rolling of the sphere will always be done in the direction of the single volume tetrahedron; therefore errors occur in applying the proposed model. Data characterizing each pair of tetrahedra will be converted to % if they have different units (for example, the positive tetrahedron is measured in *lei*, while the negative one is measured in *pieces*).

Since the recommended model works in 3D + time (space-time), the constraints of dimensional models are no longer valid (e.g. Defining the decision-related problem or Defining the purpose of the research involve choosing a single research problem/purpose) and can be arranged and introduced in the model as interdependent crowds.

Fuzzy logic is used as feedback to adjust the characteristics of tetrahedra inscribed in the sphere.

In Figure 1 we use (axis: *–y_O_+y)* for a) price (%) of organization A's product and b) the price (%) of organization B's product. We obtain c) when assembling the two tetrahedra and the sphere will roll in the direction of the tetrahedron with the highest percentages.

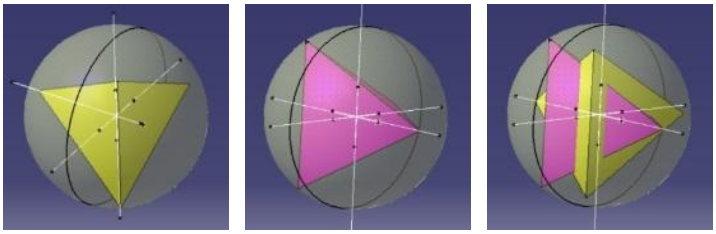

Fig. 1. Assembling regular tetrahedra of price in a sphere (using Catia V5R21).
a) b) c)

The interdependence between the 4P concept (product, price, promotion, place) and the 4C concept (consumer, cost, convenience, communication) can be presented as a fractal of a regular tetrahedron (Figure 2). To analyse the two main regular tetrahedra, we inscribed them in a sphere (axis: *–y_O_+y*), one regular tetrahedron being in opposition to the other.

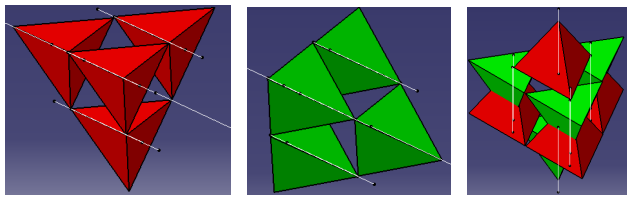

Fig. 2. 4P concept vs. 4C concept represented using fractals (using Catia V5R21).
Fractal - 4P Fractal - 4C Assembly.

In Figure 3 (axis: *–x_O_+x)* we use one of the pairs of (same color) marketing strategies recommended by Ph. Kotler for a) positive strategies, PS, (conversion, stimulation, development, remarketing) in (%) of the organization A and b) negative strategy, NS, (antimarketing, demarketing, maintenance, sincromarketing) in (%) of the organization B. We obtain c) when we assemble the two tetrahedrons and the sphere will roll in the direction of the tetrahedron with the highest percentages.

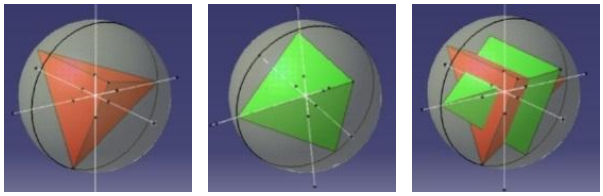

Fig. 3. Assembling 4PS and 4NS regular tetrahedra inscribed in a sphere (using Catia V5R21).
a) b) c)

In Figure 4 (axis *–z, O, +z)* we use one of the pairs (same color) for a) **market size** consisting of: market structure, market area, market dynamics, market capacity in (%) for organization A and b) **market indicators** including: market segments, degree of saturation of the market, market growth rate, market share in (%) for organization B. We obtain c) when assembling the two tetrahedrons and the sphere will roll in the direction of the tetrahedron with the highest percentages.

Fig. 4 Assembling 4MS and 4MI regular tetrahedra inscribed in a sphere (using Catia V5R21).
a) b) c)

Figure 5 presents the result of assembling the three cases presented above.

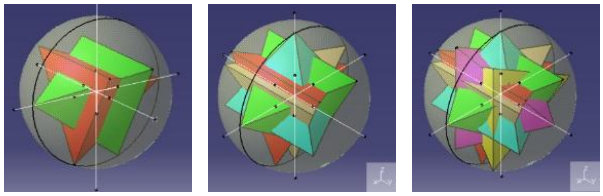

Fig. 5. Assembling the three pairs of regular single-volume tetrahedra inscribed in a sphere (using Catia V5R21).

To understand how the model works, we use the following values (Table 2) of the evolution of characteristics in an organization where x - product y - price, z - distribution.

Table 1. Product, price and distribution evolution

	S_1	S_2	S_3	S_4	S_5	S_6	S_7	S_8	S_9	S_{10}
x	-45	-35	-25	-20	-5	-10	5	15	10	45
y	-45	-40	-30	-20	5	5	5	5	35	45
z	-45	-35	-35	-20	0	-5	5	25	20	45

This table can be viewed in 2D using the following combinations: xy, xz, yz.

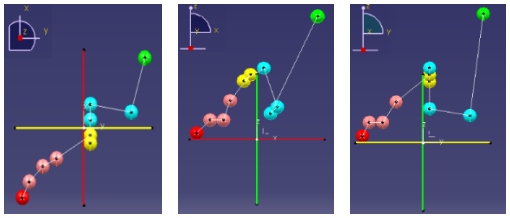

Fig. 6. 2D analysis of the three variables (using Catia V5R21).
Axes XY Axes XZ Axes YZ

From the analysis of Figure 6 for the three axes we cannot determine the effect of interdependence based on which the chart was made. Using the values for each sphere, Table 2 shows the events that have boosted the movement of the spheres.

One of the noticeable events that took place in 3D movement is shown in the following figure.

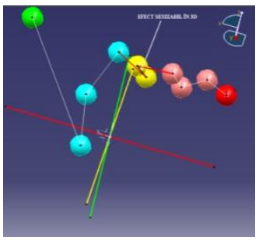

Figure 7 3D presentation of the movement of spheres (using Catia V5R21)

Corrections needed to see future development are done using fuzzy logic. Figure 8 shows the operating mechanism of fuzzy logic that allows modelling the perception of crowd x, characterized by subjectivity and uncertainty.

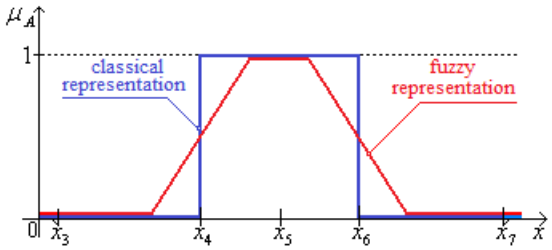

Fig. 8. Classical and fuzzy representations of the mechanism

A sequential system would start immediately after falling below x_4 and would stop immediately after it x_6. This ensures a certain precision and safety when making corrections, but it has two major drawbacks:

- it requires a large number of attempts to correct;
- it disregards the natural tendencies of evolution of the system, which can sometimes lead to unnecessary use of resources;

For example, if x (provide that $x_3 < x < x_4$) is smaller than the lowest permissible limit, but has a growth trend, the system would shortly fall in the $x_3 - x_6$ area.

Booting up the system ensures faster entering in the desired range at the cost of additional resources injected into the system. Because of the system's inertia, the maximum value is quickly exceeded while the system loses to reach equilibrium.

The fuzzy system and its set of management rules and regulations governing resource optimization admit $x_3 < x < x_4$, to be *fairly* comfortable without launching the correction process. The decision will not be wrong because very few elements from the organization's environment could notify if $x_3 < x < x_4$ where x is below a set point. Due to the natural tendency of the environment, the system will sooner or later reach the desired range without wasting resources.

This regulation applies to each single-volume or fractal tetrahedron. Based on the objective, it can be decided on what tetrahedra to apply these corrections.

If automation is desired when forecasting the evolution of the sphere, a vector can be attached to it and we can use MATLAB software and the Maximum Power Point (MPP) to determine a method to explore the characteristic of the movement of the sphere.

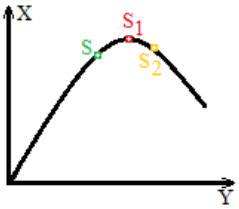

Fig. 9 Determining the Maximum Power Point.

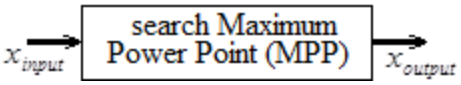

Fig. 10 Classic block schema.

Thus, when the sphere is situated in a certain point S, the algorithm uses fuzzy logic to check if the value of the next point is higher, S_1, or lower, S_2, than the reference value of the initial point S (the position of the sphere before checking the next point); if the value is bigger, a command is given to the control systems of the tetrahedra to change the parameters so that the sphere moves to the new position. Therefore, if the sign of the derivative of x_{output} is known and if it shows that x_{output} is furthering away from the maximum, fuzzy logic (as a regulator) changes sign and direction of x_{input}, to find the maximum again.

This permanent development of x_{output} generates permanent oscillations around the maximum. The downside is that there are oscillations around the MPP during its search, so downtime occurs. Because economic processes don't have rapid changes within the range of 0-2 min. (see Capital/Commodities Stock

Market that have a delay in transmitting information; for example EU stock markets have a delay of 1-2 minutes, while stock markets from other continents have different time zones), we can rank the precision of the system as accurate, i.e. no resources are lost.

4. Conclusions

Designing this 3D + time simulator was based on the need of unified analysis and visualization of data resulting from management and marketing research in the company in which I operate and I consider it to be a very useful tool in analysing interrelated factors from different areas of activity.

The paper has designed the following elements:

- The analysis module and the software tools to be used;
- The possibility to use single-volume tetrahedra because they interlock (in the tetrahedron made of fractal tetrahedra, void areas are occupied by the tetrahedron made of opposite fractal tetrahedra);
- The rigid variables that the control element (fuzzy logic) cannot change. Examples: a country's population (births, deaths, emigration), religion, sex and population mobility (handling mobility by regions). These variables are taken into account in the economy.

This approach use simultaneous analysis of 192 variables, increasing the precision of unified information, because extreme results are not neglected. Correcting results using real-time fuzzy logic leads to minimizing errors and maximizing opportunities. It is very hard to do a correction if there are no means of analysis and interpretation, and the result can often be disastrous, without the slightest hope of recovery and return to the market. Converting two-dimensional or three-dimensional results into dynamic dualistic space-time results (spherical coordinates + time) leads to: a realistic analysis of the economic environment of the local and national area (companies with domestic activity) or of the regional and global area (companies with international business) in real time, predicting the types of economic flows (tangible goods, service, and financial flows) that will influence the economic cycle.

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