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ANÁLISIS LOGÍSTICO: UN ENFOQUE INTEGRAL

EDITORES

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Competitiveness model based on Pythagorean Fuzzy Topsis approach to establish the labor indicator in a future scenario of the Industry 4.0

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Abstract—This research presents an innovative model associated with the human factor and its future change in Industry 4.0, considering a model of future competitiveness associated with a set of Pythagorean Fuzzy Topsis to determine the real impact of the effects of the Generation Z envelope on the use of this type of technology. Considering the radical evolution in the way working methods are conceived, the collaborative team structure based on technical knowledge, capable of creating and sustaining technological infrastructures. A Pythagorean Model is implemented to adequately model the competitiveness of a company associated with Industry 4.0 under a Blockchain Model. This paper applies a decision method under the paradigm of the Multicriteria Decision Making (MCDM) Theory under the perspective of fuzzy logic, to carry out the decision making in simulated environments. The fundamental contribution lies in the adaptation of this theory for this type of environment.

Keywords—intelligent forecast; human factor; holt-winters; predictive numerical model; cross correlation.

I. INTRODUCTION

Nowadays, the transformation and changes that are being witnessing as spectators and, at the same time, as protagonists, it's so rapid and successive, that there is hardly any time to assimilate its consequences, as well as the immediate future effects. Generation Z is becoming a concern to the areas of human capital in the organizations, causing a significant impact on the management and academic centers. Providing new habits and attitudes, different from those that we were used to. What used to make "people" to be committed, nowadays no longer works. In addition to this, the new facts and communicational processes are the ones that in way or another contextualize the characteristics of this new paradigm, highlighter for the hyper-communication, open to all members of society. It is no longer a question of isolated facts that define a student, a genuine change of paradigm that lays the basis for "new young people", techno-dependents who can do their homework with the television, music and computer on at the same time. Causing offline actions to be integrated into the online ones, and a new social manifestation to be generated, with new behaviors that are products of a new phenomenon of globalization and connectivity, called Generation Z.

For Generation Z on the labor market, as well as for the current generations, it is extremely crucial to minimize the level of uncertainty in the decision-making process, in order to plan, communicate and execute in the best possible way. Unfortunately, difficult decision often involve uncertainties for which definitive data is not available or not fully relevant. Whenever is necessary to make the decision, the decision maker must consider how relevant, even the best data, is to predict the future.

Due of this, it is increasingly common to use multi-criteria methods to solve decision-making problems. To address these problems, this article proposes the use of the Order by Similarity Preference Technique with the Ideal Solution (TOPSIS, by it is acronym).

TOPSIS is one of the methods of Multi criterion Decision-Making (MCDM) and is very simple and intuitive. In general terms, the idea behind TOPSIS is that the best alternative should be as close as possible to the best possible solution and as far as possible from the worst possible solution [1]. There are variants of TOPSIS, as mentioned by Chen [2] with fuzzy information, Ye [3] with interval value, he also mentions those of probability distribution, Beg & Rachid [4] speak of intuitionist fuzzy data. Dr. Perez [5] to validate the efficacy of both methods, a method comparison was made between fuzzy Pythagorean TOPSIS (PF-TOPSIS) and intuitionist fuzzy TOPSIS (IF-MOORA) in which PF-MOORA shows an advantage over the alternative methods in terms of contribution value over the ranking of the best alternative. Therefore, a comparison with data obtained with these methods may be a next project just to mention some examples of authors interested in the matter.

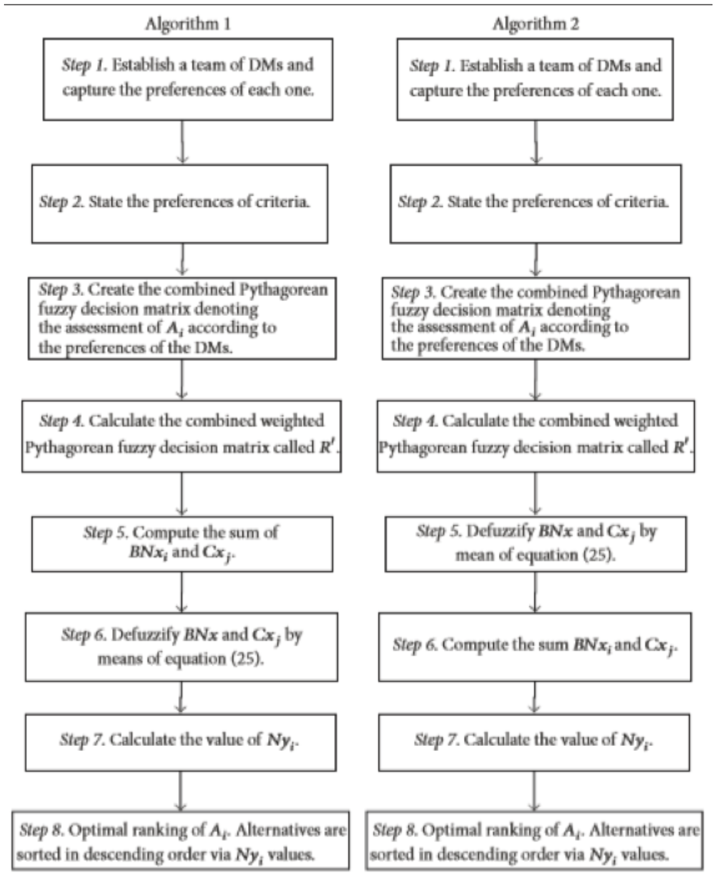

Figure 1. Flowcharts of the algorithms of the PF-MOORA method [5].

The purpose of this document is to develop a model step by step in order to obtain the best possible alternative in order to make a decision in a rational and coherent way, using some method that allows you to take into account the different advantages and disadvantages.

The rest of this document is organized as follows. Section 2 briefly presents the related concepts. Section 3 presents the explanation of the model and the methodology and conclusions are presented in Section 4.

The results obtained from the model when the optimal alternatives were selected from a set of possible alternatives in relation to various criteria are shown at the end. With an approach that can simultaneously handle quantitative (tangible) and qualitative (intangible) information, commonly presented in the MDL problem.

II. PYTHAGOREAN FUZZY TOPSIS

A. Background

Yager [6] introduced a class of non-standard fuzzy subassemblies called PFS Pythagorean fuzzy sets. These non-standard fuzzy assemblies allow for the inclusion of imprecision and uncertainty in the specifications. In addition to introducing a family of add-on operators defined by.

$$C(a) = (1 - a^P)^{1/P} \qquad (1)$$

Where P (0, ∞). For P = 1 we get the classic linear complement C(a) = 1 - a. If p = 2 then we have

$$C(a) = (1 - a^2)^{1/2} \qquad (2)$$

We observe here

$$C^2(a) + a^2 = 1. \qquad (3)$$

Yanger [7] The "Pythagorean" denial of fuzzy sets is mentioned as an important distinction between the Pythagorean and the fuzzy intuitionist sets are related to their definitions of complement or denial. Before introducing the Pythagorean fuzzy set negation, we have to say something about the complement operator [8]. We remind you that the linear function C(a) = 1 - a is the classical example of a complement operator.

$$C: [0, 1] \rightarrow [0, 1] \qquad (4)$$

As satisfice:

1) Limit conditions: C (0) = 1 y C (1) = 0
2) Monotonicity: If a ≤ b then C(a) ≥ C(b)
3) Continuity
4) Involution: C(C(a)) = a

B. Definition of Interval Numbers

The interval number is followed by two distance formulas. In sequence, a method for sorting two interval numbers is presented: a and b. It can be obtained by the Euclidean distance between a and b is given by:

$$d(a,b) = \sqrt{\tfrac{1}{2}[(a^L - b^L) + (a^u - b^u)^2]} \qquad (5)$$

If uncertainty exists, a degree of preference can be considered to measure the degree of preference of one interval number over another [9].

C. MCDM

Multi-criteria analysis is a decision-making methodology that has established itself as the ideal one in many fields of application. For example, when it is necessary to decide between several alternatives, considering various criteria or points of view, which must be weighted numerically. The Multi-criteria decision is dedicated to this type of problem and its degree of scientific maturity is solidly established to help find the optimum option for decision-making.

The following Figure 2 shows the method's hierarchical representation and some of its most used branches TOPSIS. [10].

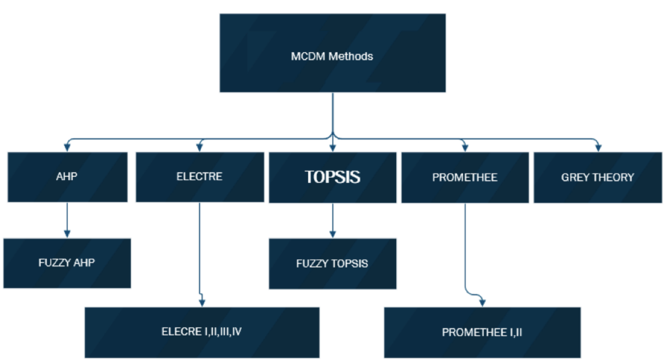

Figure 2. MCDM.

To select the best supplier, it is essential to balance these tangible and intangible factors, some of which may conflict. The process of determining the right vendor, the one that is able to provide the right quality products or services to the buyers, at the right price, at the right time and in the right quantities, is one of the most critical activities in establishing an effective supply chain. To approach this, several FMCDM methods such as TOPSIS, ELECTRE and AHP have been applied. ELECTRE is used to move towards the positive and away from the negative points.

D. TOPSIS

The concept of TOPSIS is based on selecting the alternative with the shortest distance from the positive ideal solution (PIS) and the most remote from the negative ideal solution (NIS). This method is used for classification purposes and to obtain the best performance in multi-criteria decision making. The FUZZY TOPSIS method is used to evaluate the criteria for each region, and then, rank the criteria by region. For this evaluation of relative proximity of alternatives for the ideal solution, the Euclidean distance approach is proposed. A series of comparisons of these relative distances will provide the order of preference of the alternatives.

$$X' = \begin{array}{c} \\ A_1 \\ A_2 \\ \vdots \\ A_l \end{array} \begin{pmatrix} C_1 & C_2 & \cdots & C_m \\ (\mu_{A_1 W}(C_1), \lambda_{A_1 W}(C_1), \pi_{A_1 W}(C_1)) & (\mu_{A_1 W}(C_2), \lambda_{A_1 W}(C_2), \pi_{A_1 W}(C_2)) & \cdots & (\mu_{A_1 W}(C_m), \lambda_{A_1 W}(C_m), \pi_{A_1 W}(C_m)) \\ (\mu_{A_2 W}(C_1), \lambda_{A_2 W}(C_1), \pi_{A_2 W}(C_1)) & (\mu_{A_2 W}(C_2), \lambda_{A_2 W}(C_2), \pi_{A_2 W}(C_2)) & \cdots & (\mu_{A_2 W}(C_m), \lambda_{A_2 W}(C_m), \pi_{A_2 W}(C_m)) \\ \vdots & \vdots & \ddots & \vdots \\ (\mu_{A_l W}(C_1), \lambda_{A_l W}(C_1), \pi_{A_l W}(C_1)) & (\mu_{A_l W}(C_2), \lambda_{A_l W}(C_2), \pi_{A_l W}(C_2)) & \cdots & (\mu_{A_l W}(C_m), \lambda_{A_l W}(C_m), \pi_{A_l W}(C_m)) \end{pmatrix}.$$

Figure 3. Example of a set of Pythagoreans Fuzzy Topsis.

E. Multiple objectives

The problem includes multiple objectives, many of them may conflict with each other, in a way that progress in some of them lead to degradation in others. The individual will have as objectives the desire to "maximize the benefit", "minimize the costs". It seems clear that there will be no alternative, that achieves all the objectives simultaneously because of their complexity, thereof it should be consider the trade-offs between objectives.

Associated with each decision, there will be a consequence or result, that may be scalable or vectorially depending on whether the problem is single-objective or multi-objective, respectively. The decision-maker, based on personal judgments, will must quantify his or her preferences on the possible consequences, thus obtaining the values or utilities, which will constitute one more input of the decision model [11].

III. MODEL DESCRIPTION AND METHODOLOGY

A. Model formulation MCDM Fuzzy

A general multicriteria decision problem with m alternatives A_i (i = 1..., m) y n Criteria C_j (j = 1, ..., n) can be expressed as following:

$$D = [X_{ij}] \text{ and } W(w_j), \text{ where } i = 1, \ldots, m \text{ and } j = 1, \ldots, n. \qquad (6)$$

Here D references the decision matrix (where the entry x_ij represents the value for the alternative A_i with respect to the criterion C_j), y W as the vector of weights (where w_j represents the weight of the criteria C_j). In general, the criteria are classified as described below:

- Benefit criteria (where the best value for decision making is the highest value of x_{ij}).

- Cost criteria (where the best value for decision making is the lowest x_{ij}).

B. Normalization

To process criteria of different scales, a normalization process is applied. Specifically, fuzzy numbers are normalized in the decision matrix as the performance matrix [12]:

$$P = |p_{ij}| \qquad (7)$$

$$\text{where } p_{ij} \begin{cases} \left(\dfrac{x_{ij1}}{M}, \dfrac{x_{ij2}}{M}, \dfrac{x_{ij3}}{M}\right) \\ \left(\dfrac{N - x_{ij3}}{N}, \dfrac{N - x_{ij2}}{N}, \dfrac{N - x_{ij1}}{N}\right) \end{cases}$$

Where:

$M = \max_i \; x_{ij3}$

C_j is Benefit criteria.

Where:

$N = \max_i \; xij3$

C_j is Cost Criteria

To select the best option, each scenario is evaluated, weighting each of the criteria.

$$a_{ij} = \min_k\{a_{ij}^k\}, b_{ij} = \frac{i}{k}\sum_{k=1}^{K} b_{ij}^k, \;\; c_{ij} = \max_k\{c_{ij}^k\} \quad (8)$$

- The value of k is the one that represents the number of matrices given.

- The i represents how many columns are there.

- The j represents how many criteria are there.

$$\min_k\{a_{ij}^k\} \quad (9)$$

- A decision matrix is made to evaluate each of the options. Therefore, it is required to weigh out each of them with a mathematical figure and be able to evaluate the different ranges.

- It is recommended to use the fuzzy number for the evaluation.

- Triangulate the function to get the fuzzy number.

- Replace the words with the numbers obtained in the fuzzy number. After replacing the values, the matrix is obtained.

$$\tilde{x}_{ij} = (a_{ij}, b_{ij,}c_{ij}) \quad (10)$$

- The letters a, b and c represent the t values of each cell (this example is 3) and the subscript corresponds to its location in the x-y plane.

- The number of the matrix is obtained from the average of the three values, initial in each cell.

- The j and the i are obtained with the maximum value of each of the cells.

- Using the method, the words are converted into numbers using the system.

TABLE 1. EXAMPLE OF A MATRIX WITH 4 ATTRIBUTES AND THREE CRITERIA.

Atribute or Criteria	Search	Knowledge	Time to solve
C-1	3,5,7	5,7,9	5,7,9
C-2	5,7,9	3,5,7	3,5,7
C-3	5,7,9,	[illegible]	[illegible]
C-4	1,1,3	1,3,5	1,1,3

$a_{11}^3, b_{11}^3, c_{11}^3,$

$$w_{j1} = \min_k\{w_{j1}^k\}, w_{j2} = \frac{i}{k}\sum_{k=1}^{K} w_{j2}^k, \;\; w_{j3} = \max_k\{w_{j3}^k\} \quad (11)$$

- Compute the normalized fuzzy decision matrix.

- Using the alternatives m, and criteria n, calculate the normalized values $((r_{ij})$).

- To normalize the fuzzy decision matrix. You must add the benefit and the cost criteria.

- Define which cell is for criteria.

- To determine the value of c* take the maximum value from each cell.

- For cost is the lower value of each cell.

- Then, divide the value obtained by each of the cell values.

As the cost value is the lower, change the values abc by cba.

$$\tilde{r}_{ij} = \left(\frac{a_{ij}}{c*_j}, \frac{b_{ij}}{c*_j}, \frac{c_{ij}}{c*_j}\right) and\; c_j^* = \max_i\{c_{ij}\} \quad (12)$$

$$\tilde{r}_{ij} = \left(\frac{a_j^-}{c_{ij}}, \frac{a_j^-}{b_{ij}}, \frac{a_j^-}{a_{ij}}\right) and\; a_j^- = \min_i\{a_j^-\} \quad (13)$$

- Computer the weighted normalized fuzzy decision matrix.

- The formula is multiplying two fuzzy numbers.

- Multiply the component of a1 with the component of a2, then b1*b2 and continue with all the components.

$$\widetilde{v_{ij}} = \widetilde{r_{ij}}\; x\; w_j \quad (14)$$

$$\tilde{A}_1 \otimes \tilde{A}_2 = (a_1, b_1, c_1) \otimes (a_2, b_2, c_2)$$

$$\tilde{A}_1 \otimes \tilde{A}_2 (a_1 * a_1, b_1 * b_2, c_1 * c_2) \quad (15)$$

- Determining the ideal solution Fuzzy Positive (FPIS).

- Fuzzy negative ideal solution (FNIS).

- The v_{ij1} is the minimum value of a-.

- Select the maximum value.

- If the maximum value is the same, the value of position b is taken for the best candidate.

- At position, the minimum value of the cells is chosen.

- v_i represents the c component to represent a*.

- For all criteria, each alternative distance itself from the best alternatives (A^*) u and the worst alternative (A^-).

$$A^* = (\tilde{v}_1^*, \tilde{v}_2^*, \ldots . \tilde{v}_n^*), where\ \tilde{v}_j^* = \max_i\{v_{ij3}\} \quad (16)$$
$$A^- = (\tilde{v}_1^-, \tilde{v}_2^-, \ldots . \tilde{v}_n^-), where\ \tilde{v}_j^- = \min_i\{v_{ij1}\} \quad (17)$$

- Formula to distinguish between two fuzzy numbers.

- Get the difference between the minimum in each column of position a.

- The cell values a are the value of a1 and the values of a* are the values of a2 you proceed the same for each cell in each option.

- For a- is calculated in the same way.

$$d(\tilde{x}, \tilde{y}) = \sqrt{\tfrac{1}{3}[(a_1 - a_2)^2 + (b_1 - b_2)^2 + (a_1 - c_2)^2]} \quad (18)$$

- To calculate the difference between the values of a- and the values of a^- and calls them $d*_i$ y d_i-.

- Calculate the distance between each FPOS alternative and FNIS. Determines the difference of the values.

- For d_i* add the values of each row, of each candidate.

- Using the vertex method, the distance between each alternative and the positive ideal solution and the negative ideal solution is calculated as:

$$d_i^* = \sum_{j=1}^{n} d(\tilde{v}_{ij}, \tilde{v}_{ij}^*) \quad (19)$$
$$d_i^- = \sum_{j=1}^{n} d(\tilde{v}_{ij}, \tilde{v}_{ij}^-) \quad (20)$$

- For all criteria, each alternative gets farest from the best alternative (d_i-) and the worst alternative (d_i-).

- Computer the closeness coefficient CC_i for each alternative.

- Determine how close each coefficient is CC_i for each alternative.

- Get the results to get the best alternative:

$$CC_i = \frac{d_i^-}{d_i^- + d_i^*} \quad (21)$$

C. Methodology

The decision-maker must define the vendors and design the distribution network strategy that meets all the capabilities and manufacturing requirements of the products. To determine which product to manufacture and the quantity of them. The objectives are the minimization of the total cost of the transfer of the raw material and the assertiveness in the decision-making process, considering the technological support factors. The assumptions used in this problem are:

1. The products to be manufactured are known, such as their demand and capacities.
2. The number of suppliers and their maximum capacities are known. Figure 4 presents a simple supply chain network.
3. The network consists of multiple suppliers where distance is an extremely important criterion for measuring the cost of geographically dispersed suppliers.
4. Inventory can be maintained at any facility subject to a predetermined maximum level.
5. Scarcity is not allowed; all customer demand must be met.
6. Partial deliveries are allowed.

D. Considerations associated with the generation of Z

In order to be able similar, the most efficient arrangement of individuals in a social network, is developed an atmosphere able to store the data of each one of the representing individuals of each society based on Cultural Algorithms, with the purpose of distributing by an optimal form each one of the evaluated societies [12]. The main experiment consisted of detailing each one of the 1187 communities in the Cultural Algorithm, with 500 agents and 200 different believes in the believe space, one condition of unemployment of 50 époques, this allowed to generate the best selection of each Quadrant and their possible location in a Dyoram, which was obtained after comparing the different cultural and social similarities from each community, and to evaluate with Multiple Matching Model each one of them as in [9]. The vector of weight used in the fitness function is Wi=[.6, .7, .8, .5, .6, .4, .9, .5], which represents the importance of attributes: emotional control, ability to fight, intelligence, agility, force, resistance, social leadership and speed, in the same order. The Cultural Algorithm will select the color and features of each society is selected with based in similarity of attributes and determine a kind of society, the time related to built a Diorama is showed in Figure 3. Multivariable analysis to determine creativity and mental fatigue in our three samples.

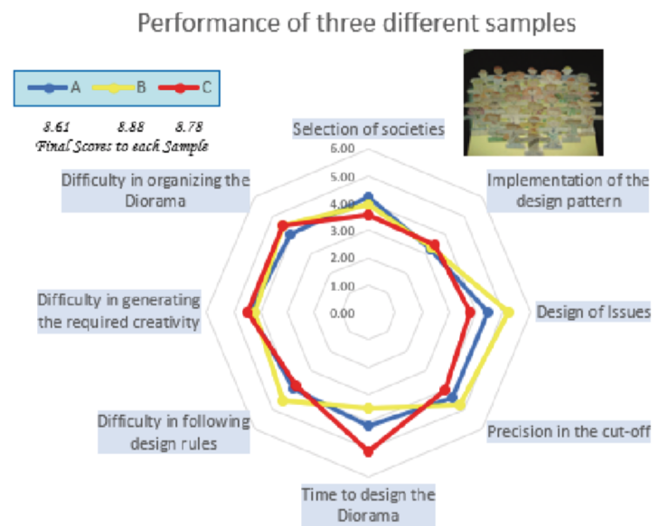

Figure 4. Multivariable analysis of three samples analyzed.

Each attribute is represented by a discrete value in a range from 0 to 5, where 0 means absence and 5 the highest value for the attribute. We propose the next Mathematical model (Equation 1) to understand the adequate similarity associated with the resultant Diorama:

$$\beta = \frac{\sum_{i=1}^{n} w_i \times sim(f_i^I, f_i^R)}{\sum_{i=1}^{n} w_i} \qquad (22)$$

Where in:

β is the index of compositional similarity

w_i determines for each weight the importance of an attribute.

sim is the similarity function.

f^I_i and f^R_i are the values of attribute i in the input cluster (I) and in the recovered cluster (R).

The design of the experiment consists in an orthogonal array test with interactions between the variables (the 8 attributes mentioned in a range from 0 to 5); these variables are studied within a color range (1 to 64). The orthogonal array is L-N (2**8), in other words, 8 factors in N executions. The value of N is defined by the combination of the 8 possible values of the variables, also values in the color range, in Table 1 is listed some possible scenarios result of combining the values of the attributes and the specific color to represent this issue (society). The results permit us to analyze the effect of the variables on the color selection in all the possible combinations of values.

TABLE II. ORTHOGONAL ARRAY TEST.

emotional control	ability to fight	intelligence	agility	force	resistance	social leadership	speed	Color
0	1	2	2	3	3	4	5	1
0	1	2	2	3	4	5	5	1
1	1	3	2	4	4	2	1	2
1	1	3	2	5	3	2	1	2
1	0	0	3	4	2	3	5	3
...	...	...	...	...	...	...	...	...

With this orthogonal array test, we try to reorganize the different attributes, and specify the best possibilities to adequate correct solutions (skills) in each society, the different attributes were used to identify the real possibilities to improve a society in a determine and potential environment and specify the correlations with other societies.

The first point to consider when organizing the model is to consider certainty estimates for events that are not directly observable (or only observed at an unacceptable cost), and the main task in building the model is to identify these events.

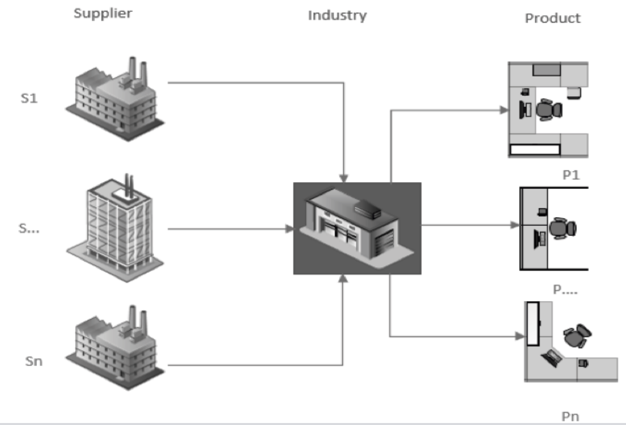

Figure 5. Simple network Supply Chain.

The decision matrix can be represented from the following table:

Table 3. Decision matrix.

Alternative	Criteria Search	Knowledge	Time to Solve
A1	3,5,7	5,7,9	5,7,9
A2	5,7,9	3,5,7	3,5,7
A3	5,7,9	1,3,5	1,2,3
A4	1,1,3	1,3,5	1,1,3

Each row represents one of the possible decisions that can be made by each of the agents involved in the environment (in our case cats and mice).

These decisions depend on a series of criteria (c_1), c_2 ,..., c_n), as many as there are columns in the table.

Each of the criteria is discussed in detail below: Within the criteria there are qualitative and quantitative data because I consider using the Likert scale of 7 to weight the qualitative data and to put unify the criteria. Table 4 shows the criteria, having a total of 27, which have a measure of weight, of which the sum of all the criteria must be equal to 1.

Table 4. Criterias applied.

Criteria	Weights	Criteria	Weights
C1	0.01	C15	0.02
C2	0.01	C16	0.04
C3	0.02	C17	0.02
C4	0.02	C18	0.03
C5	0.07	C19	0.03
C6	0.03	C20	0.05
C7	0.06	C21	0.03
C8	0.07	C22	0.07
C9	0.03	C23	0.05
C10	0.05	C24	0.01
C11	0.04	C25	0.01
C12	0.04	C26	0.05
C13	0.01	C27	0.08
C14	0.04	Total	1.00

Pythagorean Fuzzy Set.

Table 5. Decision table.

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
A	22.000	57.000	18.700	0.875	62.000	57.000	22.700	54.600	27.400	6.400
B	21.000	58.400	16.700	0.596	60.000	48.000	24.300	59.200	38.400	6.700
C	19.000	59.200	14.800	0.644	54.000	47.000	24.800	57.400	36.200	6.300
D	17.000	64.300	22.100	0.710	59.000	57.000	26.900	59.400	32.800	6.500
E	20.000	55.000	23.400	0.797	58.000	54.000	23.400	57.400	36.400	6.800
F	24.000	58.400	26.200	0.866	44.000	57.000	24.600	59.200	50.800	6.400
G	22.000	55.000	27.800	0.922	61.000	63.000	27.900	56.400	37.900	6.200
	Max	Min	Min	Min	Min	Min	Max	Max	Max	Max
weights	0.011	0.011	0.022	0.019	0.075	0.035	0.060	0.072	0.025	0.051

	C12	C13	C14	C15	C16	C17	C18	C19	C20
A	5500.000	22.000	22.700	10.000	34.000	28.200	0.294	34.000	14.000
B	6200.000	17.000	24.700	7.000	36.000	29.300	0.571	36.000	17.000
C	6350.000	24.000	23.800	9.000	37.000	30.700	0.423	37.000	21.000
D	5792.000	23.000	24.700	10.200	38.000	31.200	0.659	38.000	20.000
E	5874.000	24.000	27.200	10.700	44.000	30.500	0.596	44.000	19.000
F	5962.000	20.000	23.800	10.400	52.000	29.800	0.667	52.000	17.000
G	5470.000	17.000	21.900	10.100	57.000	27.900	0.458	57.000	16.000
	Min	Max	Min	Max	Max	Min	Min	Min	Max
weights	0.037	0.009	0.044	0.018	0.036	0.016	0.032	0.026	0.053

	C21	C21	C22	C22	C23	C23	C24	C24	C25	C25	C26	C26
A	0.100	0.970	0.250	0.920	0.810	0.430	0.900	0.200	0.100	0.990	0.740	0.330
B	0.500	0.800	0.800	0.440	0.250	0.920	0.850	0.260	0.330	0.860	0.260	0.910
C	0.600	0.720	0.580	0.620	0.510	0.790	0.770	0.320	0.660	0.690	0.390	0.880
D	0.400	0.870	0.700	0.590	0.250	0.920	0.400	0.750	0.500	0.800	0.700	0.600
E	0.100	0.990	0.800	0.430	0.500	0.800	0.220	0.900	0.100	0.980	0.250	0.920
F	0.250	0.920	0.230	0.910	0.100	0.970	0.650	0.550	0.550	0.690	0.100	0.990
G	0.800	0.440	0.730	0.510	0.220	0.900	0.440	0.880	0.110	0.960	0.320	0.890
	Min			Max		Max	Max		Max		Max	
weights	0.026		0.074		0.051		0.015		0.010		0.053	

Table 6. Pythagorean fuzzysets.

Ideal	24.000	55.000	14.800	0.596	44.000	47.000	27.900	59.400	50.800
the worst	17.000	64.300	27.800	0.922	62.000	63.000	22.700	54.600	27.400
norma	55.091	154.14	57.818	2.067	151.20	145.41	66.148	152.61	99.768
ideal	6.800	5470.000	24.000	21.900	10.700	57.000	27.900	0.294	
the worst	6.200	6350.000	17.000	27.200	7.000	34.000	31.200	0.667	
norma	17.13	15573.37	56.06	63.94	25.67	114.69	78.526	1.427	

All criterions to maximize – it is a condition of TOPSIS method. So, the minimizing criterions had to be converted.

Tables 7. criteria conversion.

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
A	0.399	0.370	0.323	0.423	0.410	0.392	0.343	0.358	0.275	0.374
B	0.381	0.379	0.289	0.289	0.397	0.330	0.367	0.388	0.385	0.391
C	0.345	0.384	0.256	0.312	0.357	0.323	0.375	0.376	0.363	0.368
D	0.309	0.417	0.382	0.343	0.390	0.392	0.407	0.389	0.329	0.379
E	0.363	0.357	0.405	0.385	0.384	0.371	0.354	0.376	0.365	0.397
F	0.436	0.379	0.453	0.419	0.291	0.392	0.372	0.388	0.509	0.374
G	0.399	0.357	0.481	0.446	0.403	0.433	0.422	0.370	0.380	0.362

	C12	C13	C14	C15	C16	C17	C18	C19	C20
A	0.353	0.392	0.355	0.390	0.296	0.359	0.206	0.296	0.296
B	0.398	0.303	0.386	0.273	0.314	0.373	0.400	0.314	0.360
C	0.408	0.428	0.372	0.351	0.323	0.391	0.297	0.323	0.445
D	0.372	0.410	0.386	0.397	0.331	0.397	0.462	0.331	0.423
E	0.377	0.428	0.425	0.417	0.384	0.388	0.417	0.384	0.402
F	0.383	0.357	0.372	0.405	0.453	0.379	0.467	0.453	0.360
G	0.351	0.303	0.343	0.394	0.497	0.355	0.321	0.497	0.339

	C21		C22		C23		C24		C25		C26
A	0.00	0.03	0.02	0.07	0.04	0.02	0.01	0.00	0.00	0.01	0.04
B	0.01	0.02	0.06	0.03	0.01	0.05	0.01	0.00	0.00	0.01	0.01
C	0.02	0.02	0.04	0.05	0.03	0.04	0.01	0.00	0.01	0.01	0.02
D	0.01	0.02	0.05	0.04	0.01	0.05	0.01	0.01	0.00	0.01	0.04
E	0.00	0.03	0.06	0.03	0.03	0.04	0.00	0.01	0.00	0.01	0.01
F	0.01	0.02	0.02	0.07	0.01	0.05	0.01	0.01	0.01	0.01	0.01
G	0.02	0.01	0.05	0.04	0.01	0.05	0.01	0.01	0.00	0.01	0.02

Pythagorean fuzzy data does not require standardization so only the weights are multiplied with each value of the criteria.

Table 8. Criteria conversion.

	C21		C22		C23		C24		C25		C26		C27	
A	0.00	0.03	0.02	0.07	0.04	0.02	0.01	0.00	0.00	0.01	0.04	0.02	0.05	0.06
B	0.01	0.02	0.06	0.03	0.01	0.05	0.01	0.00	0.00	0.01	0.01	0.05	0.07	0.02
C	0.02	0.02	0.04	0.05	0.03	0.04	0.01	0.00	0.01	0.01	0.02	0.05	0.01	0.08
D	0.01	0.02	0.05	0.04	0.01	0.05	0.01	0.01	0.00	0.01	0.04	0.03	0.03	0.07
E	0.00	0.03	0.06	0.03	0.03	0.04	0.00	0.01	0.00	0.01	0.01	0.05	0.04	0.04
F	0.01	0.02	0.02	0.07	0.01	0.05	0.01	0.01	0.01	0.01	0.01	0.05	0.02	0.07
G	0.02	0.01	0.05	0.04	0.01	0.05	0.01	0.01	0.00	0.01	0.02	0.05	0.01	0.08

Weighted normed matrix.

Tables 9. weighted normed matrix.

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
A	0.004	0.004	0.007	0.008	0.031	0.014	0.021	0.026	0.007	0.019
B	0.004	0.004	0.006	0.005	0.030	0.011	0.022	0.028	0.010	0.020
C	0.004	0.004	0.006	0.006	0.027	0.011	0.022	0.027	0.009	0.019
D	0.003	0.005	0.008	0.006	0.029	0.014	0.024	0.028	0.008	0.020
E	0.004	0.004	0.009	0.007	0.029	0.013	0.021	0.027	0.009	0.020
F	0.005	0.004	0.010	0.008	0.022	0.014	0.022	0.028	0.013	0.019
G	0.004	0.004	0.011	0.008	0.030	0.015	0.025	0.027	0.010	0.019
ideal	0.005	0.004	0.006	0.005	0.022	0.011	0.025	0.028	0.013	0.020
the worst	0.003	0.005	0.011	0.008	0.031	0.015	0.021	0.026	0.007	0.019

	C12	C13	C14	C15	C16	C17	C18	C19	C20
A	0.013	0.003	0.015	0.007	0.011	0.006	0.007	0.008	0.016
B	0.015	0.003	0.017	0.005	0.011	0.006	0.013	0.008	0.019
C	0.015	0.004	0.016	0.006	0.012	0.006	0.009	0.009	0.024
D	0.014	0.004	0.017	0.007	0.012	0.006	0.015	0.009	0.023
E	0.014	0.004	0.019	0.008	0.014	0.006	0.013	0.010	0.021
F	0.014	0.003	0.016	0.007	0.016	0.006	0.015	0.012	0.019
G	0.013	0.003	0.015	0.007	0.018	0.006	0.010	0.013	0.018
ideal	0.013	0.004	0.015	0.008	0.018	0.006	0.007	0.008	0.024
the worst	0.015	0.003	0.019	0.008	0.011	0.006	0.015	0.013	0.016

	C21	C22	C23	C24	C25	C26	C27
A	-0.001	-0.004	0.001	0.000	0.000	0.001	-0.001
B	0.000	0.002	-0.002	0.000	0.000	-0.002	0.005
C	0.000	0.000	-0.001	0.000	0.000	-0.002	-0.006
D	0.000	0.001	-0.002	0.000	0.000	0.000	-0.004
E	-0.001	0.002	-0.001	0.000	0.000	-0.002	0.000
F	-0.001	-0.004	-0.002	0.000	0.000	-0.003	-0.005
G	0.000	0.001	-0.002	0.000	0.000	-0.002	-0.006
ideal	-0.001	0.002	0.001	0.000	0.000	0.001	0.005
the worst	0.000	-0.004	-0.002	0.000	0.000	-0.003	-0.006

It is then deformed so that only one value remains.

Table 10. weighted normed matrix.

	C21	C22	C23	C24	C25	C26	C27
A	-0.001	-0.004	0.001	0.000	0.000	0.001	-0.001
B	0.000	0.002	-0.002	0.000	0.000	-0.002	0.005
C	0.000	0.000	-0.001	0.000	0.000	-0.002	-0.006
D	0.000	0.001	-0.002	0.000	0.000	0.000	-0.004
E	-0.001	0.002	-0.001	0.000	0.000	-0.002	0.000
F	-0.001	-0.004	-0.002	0.000	0.000	-0.003	-0.005
G	0.000	0.001	-0.002	0.000	0.000	-0.002	-0.006
ideal	-0.001	0.002	0.001	0.000	0.000	0.001	0.005
the worst	0.000	-0.004	-0.002	0.000	0.000	-0.003	-0.006

Tables 11. From ideal.

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
A	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
B	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
C	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
D	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
E	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
F	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
G	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

	C12	C13	C14	C15	C16	C17	C18	C19	C20
A	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
B	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
C	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
D	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
E	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
F	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
G	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

	C21	C22	C23	C24	C25	C26	C27
A	0.000	0.000	0.000	0.000	0.000	0.000	0.0000
B	0.000	0.000	0.000	0.000	0.000	0.000	0.0000
C	0.000	0.000	0.000	0.000	0.000	0.000	0.0001
D	0.000	0.000	0.000	0.000	0.000	0.000	0.0001
E	0.000	0.000	0.000	0.000	0.000	0.000	0.0000
F	0.000	0.000	0.000	0.000	0.000	0.000	0.0001
G	0.000	0.000	0.000	0.000	0.000	0.000	0.0001

Table 12. S+.

A	0.0187
B	0.0149
C	0.0152
D	0.0169
E	0.0148
F	0.0178
G	0.0183

Table 13. From the worst.

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
A	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
B	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
C	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
D	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
E	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
F	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
G	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

	C12	C13	C14	C15	C16	C17	C18	C19	C20
A	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
B	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
C	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
D	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
E	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
F	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
G	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

	C21	C22	C23	C24	C25	C26	C27
A	0.000	0.000	0.000	0.000	0.000	0.000	0.0000
B	0.000	0.000	0.000	0.000	0.000	0.000	0.0001
C	0.000	0.000	0.000	0.000	0.000	0.000	0.0000
D	0.000	0.000	0.000	0.000	0.000	0.000	0.0000
E	0.000	0.000	0.000	0.000	0.000	0.000	0.0000
F	0.000	0.000	0.000	0.000	0.000	0.000	0.0000
G	0.000	0.000	0.000	0.000	0.000	0.000	0.0000

A	0.0133
B	0.0161
C	0.0146
D	0.0121
E	0.0126
F	0.0134
G	0.0127

Table 15. Ranking.

	Ci	Ranking
A	0.416	6.000
B	**0.519**	**1.000**
C	0.490	2.000
D	0.416	5.000
E	0.459	3.000
F	0.429	4.000
G	0.410	7.000

The table shows that the best alternative is option B, however, it can be presented to internal manipulations within the process, through the personnel directly involved and who have the hierarchy to make the decision for which the implementation of Block Chain is proposed as a highly qualified and proven security measure.

Once the model is presented and tested, the Block Chain is implemented. After obtaining the best alternative, it is sent to a decentralized database through a network of virtual machines, which acquire a copy of the file and validate the information, approving a hash which must be compared by each machine in the virtual network to verify that the file did not suffer any modification in the path. As can be seen in figure 6.

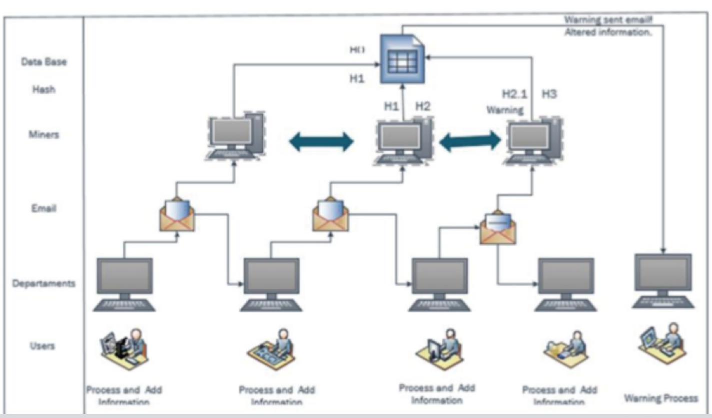

Figure 6. Block Chain Process.

Block Chain is part of the 4.0 industry within the cyber security, therefore, it is important to consider that the 4.0 industry is replacing labor by machines or robots. This has presented an increase in productivity, as well as it has transformed the industrial sector itself with a significant increase in competitiveness and, consequently, in offshoring to countries with better productivity conditions.

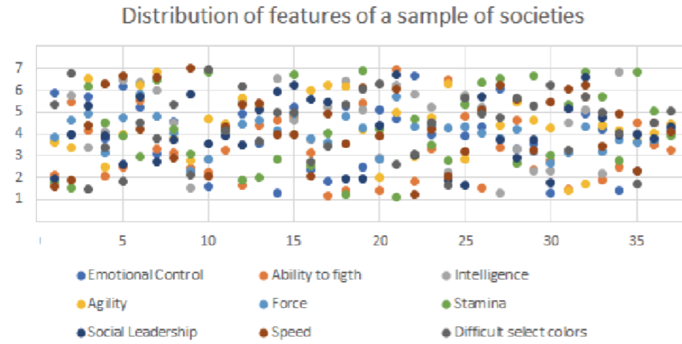

Figure 7. Graphics represent the values after applying Orthogonal Array to evaluate data.

The efficiency of the machines will virtually be the same anywhere in the world because the manufacturers are global, while the local use of the labor will continue to be reduced more and more, and their contribution to the differential productivity will also be reduced. In this context, productivity will have to measure the factors evaluated here and undoubtedly many more, such as the integration of the machines in the production system, especially in the logistics of the suppliers; the excellence in their maintenance, which allows to increase their availability; the increase of their flexibility, to adapt to the continuous changes of the demand, just to mention some. And this is where human resources play a fundamental role, but with very different profiles to the current ones. This is the reason why Generation Z, with its high level of mastery in technology, could easily become involved in the labor sector.

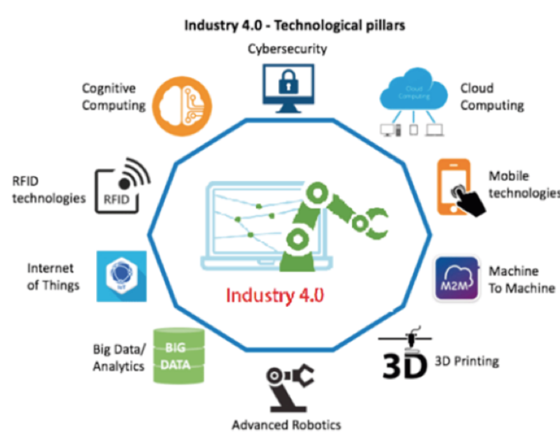

Figure 8. Components of the 4.0 Industry specifying the usage of the Block Chain as part to the Cybersecurity and Cognitive Computing.

Generation Z is immersed in technology from a very early age, it has generated a paradigm shift in their learning process. As Steve Jobs said, "the computer is a bicycle for the mind" and this concept is clearly activated by Zs who seek collaboration, creativity, critical thinking, contributing, talking, connecting, learning. And this learning is different, because it is a personalized learning, of exchange, analytical that they carry out themselves. However, the collaborative work in a personal environment is a topic that is still needs to be discussed.

For this new generation within the 4.0 industry, more knowledge capabilities are required, such as imagination to devise solutions or to innovate new processes; of leadership, in complex environments with personnel of different culture and nationality, to break down barriers between society; of teamwork, focused on carrying out collaborative work. This is where Generation Z can easily establish an affinity with anyone anywhere in the world, but not so easily with those who are next to them. For example, according to a recent study by the World Economic Forum, the least required skills in 2020 will be physical (4%) and content-related (10%), while those most in demand will be complex problem solving (35%) and social skills (19%).

IV. CONCLUSIONS AND FUTURE RESEARCH

An effort verifies the effectiveness of this theory, a simulation environment has been designed to be as simple as possible, so that it does not mask the results produced by FUZZY TOPSIS. The results have been analyzed in chapter 3, showing the effectiveness of the proposed method for this type of environment.

The approach that was made about the developed environment in which the situations described in this work are simulated, is easily extensible to environments with a greater number of agents without more than increasing or modifying the decision variables and even the criteria itself. Undoubtedly, guaranteeing its reliability by means of the Block Chain is a way to counteract any malicious manipulation in the process.

It will be necessary to act on the one hand, in the educational field, preparing the new generations in technical knowledge capable of creating and sustaining the necessary technological infrastructures; but also, especially, in the promotion of creative skills, social relations, decision making in uncertain environments, facilitating leadership, etc.; skills necessary for the management of the complexity of the new productive environment.

An important aspect is to describe a Business Model that contemplates vital aspects in the improvement of productivity as it can be observed in Figure 9.

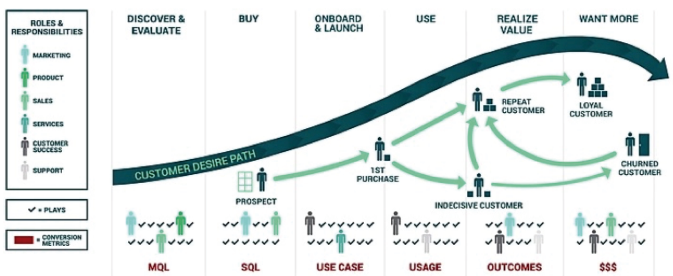

Figure 9. A proposed model for the implementation of competitiveness improvement in Industry 4.0 considering the factor of generation Z.

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