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Discrete Dynamic Model for The Evaluation of Performance and Components of Organizational Behavior

Carlos Jamil Bastidas Sánchez[1*], Edwin R. Sánchez-León[2], Walter Franco Vera[3]

[1,2,3]Universidad Estatal de Milagro

Email: esanchezl1@unemi.edu.ec[2], wfrancov@unemi.edu.ec[3]

ORCID: 0000-0003-1018-6956[1], 0000-0002-4964-7855[2], 0000-0003-1204-4038[3]

**Corresponding author's E-mail: cbastidass@unemi.edu.ec*

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Abstract

For an organization the study of behavioral factors such as performance, which can come to depend on human vigilance, family problems, communication, motivation and stress are independent factors. This research paper analyzes the relationships of performance factors by applying mathematical models that eliminate subjectivity in the evaluation process. To this end, we proceed with statistical studies that confirm the relationships between the components and study variables that allow us to define a model through multiple linear regression. The results confirm the existence of strong relationships between independent factors and performance, also a factor of 48.5% acceptance of the model.

Keywords: *Performance, mathematical model, discrete dynamical systems, cluster analysis.*

1. Introduction

The principles of management consist of the control and measurement of human talent and how to obtain its greatest efficiency. Organizations invest a lot of resources to determine a methodology with which they can apply more accurate measurements. There are a variety of tools that measure performance (Rasool et al., 2019) of human talent that end up being very subjective in their results. Previous studies have identified some behavioral factors related to employee effectiveness and performance.

The main objective is to determine if this relationship will allow us to establish a model with which to estimate the performance of employees in an organization. Identify which variables and components exist following a process of validation and analysis (Sánchez-León et al., 2023). We will apply multivariate statistical analysis techniques such as multiple linear regression and component (cluster) analysis (Taherdoost et al., 2004) Based on information obtained from a survey of employees of Ecuadorian companies.

In this way we apply a regression model that defines an equation and successively define a discrete dynamic model (Vasu et al., 2021) that allows organizations to effectively control human capital. Additionally, obtain the mechanisms to objectively evaluate their performance and productivity.

2. Materials And Methods

In this research we have developed the analysis of different performance factors, if we analyze performance as the potential of an individual to execute activities in a short time with minimal effort and with better quality (Olivera-Garay et al., 2021). It can be considered an important factor for organizations and their significant contribution to their results. for which we propose to determine the theoretical contributions that allow to sustain the hypothesis based on previous studies. Establish an equation model with the application of multiple linear regression.

For this work we have declared 6 main variables for statistical analysis within which we classify them as follows:

Dependent variable: there are several factors that affect the results of organizations such as organizational climate (Olivera-Garay et al., 2021) that affects the behavior of the members of the same. We must consider the importance of performance. (Olivera-Garay et al., 2021) There is an impact on performance, training, planning, job design among other elements that define the transcendence of performance within an institution as such. We have considered Performance as our dependent variable in relation to the other factors of organizational behavior (Sánchez-León et al., 2023).

Independent variables: within this set we will group the other factors of organizational behavior that can be related to performance. As determined (Echeverría et al., 2021) We have the variable of motivation as a driver of behavior, communication as a means of transfer, and stress as a variable of the work environment within the institution. In order to determine its relationship with performance, employee monitoring, as external factors relate family problems (Echeverría et al., 2020).

Database

Information was taken from a study conducted by (Echeverría et al., 2021) where the variables of 1239 companies of the Ecuadorian productive sector are analyzed, in them a survey is carried out that relates the surveillance and behavioral factors called "Surveillance Test and organizational behavior".

In this survey among general data are related questions on Factors of organizational behavior such as Human Vigilance, Stress Levels, Family Relationship, Organizational Communication, Motivation and Performance variables of our interest (Sánchez-León et al., 2023). In each of these factors, between 5 and 6 questions are related to determine the qualitative weighting of the variables. The estimated results in this survey are with a Likert scale from 1 to 5 as follows: 1: Never; 2: very rarely; 3: sometimes; 4: almost always; 5: Always

Definition of variables

Each variable its representation was assigned by the initial letter, giving the following result:

Table 2 Study variables and questions

Variable	**Representation**	**Questions (P_i)**
Performance	D	$P_1, P_2, P_3, P_4, P_5, P_6$
Human Surveillance	V	$P_1, P_2, P_3, P_4, P_5, P_6$
Family problems	P	P_1, P_2, P_3, P_4, P_5
Communication	C	$P_1, P_2, P_3, P_4, P_5, P_6$
Motivation	M	$P_1, P_2, P_3, P_4, P_5, P_6$
Stress	And	P_1, P_2, P_3, P_4, P_5

Note: Table prepared by the authors based on the information captured from the survey Test of Surveillance and organizational behavior of the work of (Echeverría et al., 2021).

nAnd the number of valid respondents for each company is represented by the letter. Resulting according to the number of questions that correspond to each variable:

$$D = \frac{\sum P_i}{n}; V = \frac{\sum P_i}{n}; P = \frac{\sum P_i}{n};$$
$$C = \frac{\sum P_i}{n}; M = \frac{\sum P_i}{n}; \ E = \frac{\sum P_i}{n}.$$

In this way we obtain the average for each variable per company under study in this work. Which finally does not reveal a total sample of 407 valid companies.

3. Results and Discussion

Modeling and Simulations

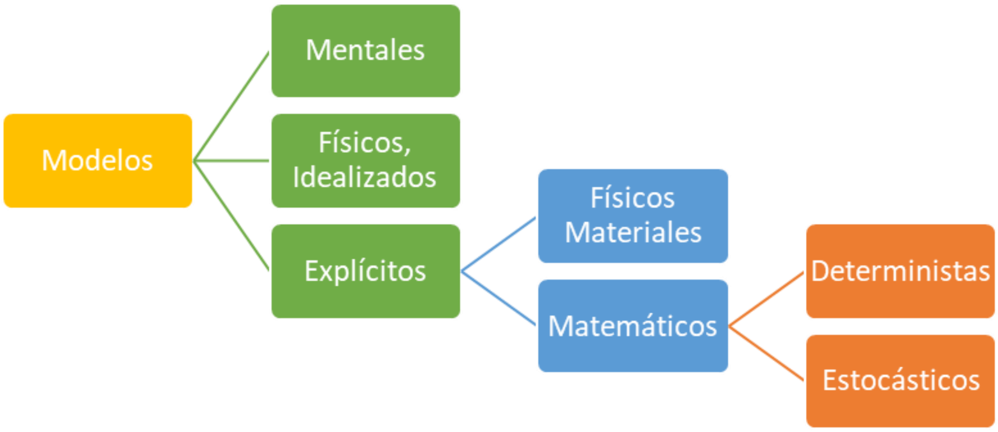
The measurement of performance in different job evaluations allowed us to detect that Subjectivity is the main drawback in management evaluations. Inconvenience that harms those evaluated producing lack of belonging and dissatisfaction due to injustice and inequity" (Véliz-Montero, 2021).

To avoid inconveniences (Romero Chico, 2015) We must eliminate the problem of performance subjectivity during your evaluation process. This can be achieved by applying a model of equations. Using statistical analysis it is possible to determine whether these equation models can be applied to behavioral and performance factors. (Sandoval & Leal, 2017, p. 39) If one looks for constant and invariable processes in human behavior, these could be considered as laws. It is possible to associate patterns of behavior to mathematical processes for evaluation.

The complexity of human behavior is constantly being addressed. Study the various variables that interact in decision making. This is how the interest in developing models that can be processed from a continuous perspective is born. (Mahamadi & Sastry, 2016).

Considering these circumstances understand that it is the model "We define it as an Image or Representation, generally incomplete and simplified of a System" (Kofman, 1999, p. 11), there are several models. Figure 1 shows the known model types.

Figure 1 Types of knowledge models



Note: Graph prepared by the authors based on the information in the article (Kofman, 1999, p. 11) "Computational models and simulations in physics education". Mathematical model is defined as "a set of symbols and mathematical relationships that attempt to explain, predict and solve some aspects of a phenomenon or situation" (Villa-Ochoa, 2007, p. 67).

Understanding these natural phenomena and their application in other fields of science, and choosing the model to be applied, it is essential to know what modeling is. To which (Halloun, 1996 and Sutton, 1996 cited by Greca & Moreira, 1998, p. 114) He defines it as the process of learning about a set of steps that allow recognizing the elements of a system or phenomenon by evaluating the rules of the model.

Statistical Analysis Techniques

We will determine the conditions for the interpretation of the data obtained. We must establish the relationship with the study variables. We emphasize several statistical techniques for the analysis of the data this research which we will describe below:

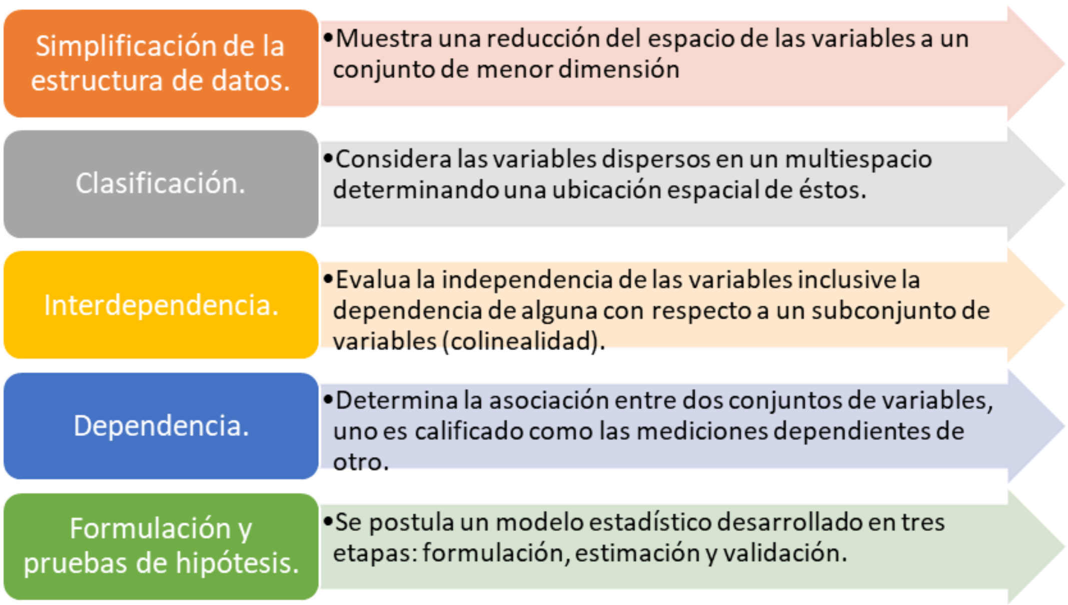
It is important to "find the association between two sets of variables, where one is considered as the performance of measurements dependent on another set of variables" (Díaz Monroy & Morales Rivera, 2012, p. 15). And "a regression analysis will show us how to determine both the nature and strength of a relationship between two variables." (Levin & Rubin, 2004, p. 510). We must analyze the dependency to evaluate its application to the mathematical model that we will proceed to develop. The dependency will help us determine if it is applicable in the proposed model.

Regression analysis: "when it is possible to have data, a statistical procedure called regression analysis can be used to obtain an equation that indicates what the relationship between the variables is" (Anderson et al., 2008, p. 545).

Multivariate analysis techniques

As indicated (Díaz Monroy & Morales Rivera, 2012) Taking into consideration the objectives and the type of data obtained, multivariate techniques must be chosen to transform them into information, as indicated in Figure 2 we will see the classification of the techniques:

Figure 2 Multivariate techniques according to the objective of the study



Note: Graphic prepared by the authors based on information from the Book of (Díaz Monroy & Morales Rivera, 2012, p. 14-15) "Multivariate statistics: inference and methods".

According to (Uriel and Aldás 2005, as cited in Closas et al., 2013) These methods are concentrated in two large groups the descriptive or interdependence methods and explanatory or dependence methods, we will describe those techniques related to dependence:

Table 3 Explanatory or Dependency Multivariate Techniques

A relationship	A Dependent Variable	Metric	Multiple Linear Regression	
		Non-Metric	Discriminant Analysis	
			Limited Dependent Variable Regression	
	More than one Dependent variable	Metric	Independent Metric	Canonical correlation
			Non-Metric Independent	MANOVA
		Non-Metric	Canonical correlation	
Various Relationships	Structural Equation Model			

Note: Table prepared by the authors based on the information in the Article Uriel and Aldás (2005, as cited in Closas et al., 2013, p. 69) "Multivariate analysis, concepts and applications in Educational Psychology and Psychometrics".

Multiple Linear Regression

According to Match (Anderson et al., 2008; Levin & Rubin, 2004; Walpole et al., 2012)This type of analysis can be applied when we want to determine the relationship of a dependent variable with several independent variables. To apply this process we must first make a model and the variables that interact in it. (Williamson, 1991). That is, the equation of the model, then we study the error and variability. Where we can apply the least squares estimation method to examine the results of the prediction. Finally, we can perform a correlation analysis to verify the particularity of the data explored. (Levin & Rubin, 2004; Newbold et al., 2008).

Multivariate normal regression is the regression of a -dimensional response in a design matrix of predictor variables, with normally distributed errors. Errors can be heteroscedastic and correlated.d

The model is

$$y_i = x_i\beta + e_i, \qquad i = 1, \ldots, n,$$

Where:

- y_i= It is a d-dimensional vector of its gate.
- x_i =It is a design matrix of the producing variables.
- β =It is a regression coefficient matrix.
- $\mathbf{e}_i$ = is a d-dimensional vector of error terms, with multivariate normal distribution.

$$\mathbf{e}_i \sim MVN_d(\mathbf{0}, \Sigma).$$

Table 4 Multivariate Descriptive or Interdependence Techniques

Relationship between variables	Metric	Principal Component Analysis
		Factor Analysis
	Non-Metric	Correspondence analysis
Relationship between cases	Cluster Analysis (Cluster)	
Relationship between objects	Multi-dimensional staggering	

Note: Table prepared by the authors based on the information in the Article Uriel and Aldás (2005, as cited in Closas et al., 2013, p. 73) "Multivariate analysis, concepts and applications in Educational Psychology and Psychometrics".

Cluster Analysis (Cluster)
It is designed to group the analyzed characteristics into different homogeneous groups. Try to make these sets sufficiently discordant with each other and the variables (Closas et al., 2013).

Test of clustering k means (Clustering)
The K-means grouping method is a non-hierarchical technique used to group observations into k groups. Each item is assigned to a group with the nearest center (Tamba et al., 2019). The algorithm iteratively updates the groups to minimize the variation of their elements. The basic k-means algorithm, which was used in this article, refers to the Euclidean metric to define the distance between the elements and the centers of clusters. (Stolz et al., 2020). The Euclidean distance is selected as the similarity index and the grouping objectives minimize the sum of the squares of the different types; that is, minimizes (Wang et al., 2012):

$$\boldsymbol{d} = \sum_{k=1}^{k}\sum_{i=1}^{k} \|(\boldsymbol{x}_i - \boldsymbol{u}_k)\|^2$$

Where k represents K cluster centers, uk represents the kth center, and xi represents the ith point in the dataset. The solution to the uk centroid is as follows:

$$\frac{\partial}{\partial \boldsymbol{u}_k} = \frac{\partial}{\partial \boldsymbol{u}_k}\sum_{k=1}^{k}\sum_{i=1}^{n}(\boldsymbol{x}_i - \boldsymbol{u}_k)^2 \quad = \sum_{k=1}^{k}\sum_{i=1}^{n}\frac{\partial}{\partial \boldsymbol{u}_k}(\boldsymbol{x}_i - \boldsymbol{u}_k)^2$$

$$= \sum_{i=1}^{n} 2\,(\boldsymbol{x}_i - \boldsymbol{u}_k) \quad \rightarrow \quad \boldsymbol{u}_k = \frac{1}{n}\sum_{i=1}^{n}\boldsymbol{x}_i$$

In addition, the result of the k-means method depends largely on the number of clusters defined in advance. (Sinaga & Yang, 2020). In general, the iterative grouping method of k-means is implemented as follows: Step 1: A value of k is chosen. It is used as the initial set of k centroids. Step 2: Each of the objects is assigned to the group with the nearest centroid. Step 3: The new centroids of the k groups are determined, calculating the average of the members of the group. Step 4: Steps 3 and 4 are repeated until there is no change to the criteria function after an iteration (Govender & Sivakumar, 2020).

The main advantages of the k-means algorithm are its low complexity, computationally high complexity, the ability to handle large data sets, and the flexibility to adjust the number of groups. (Sinaga & Yang, 2020). K-media clustering was used to extract clusters from the dataset that had been optimized by feature selection.

Results analysis K means (Cluster)

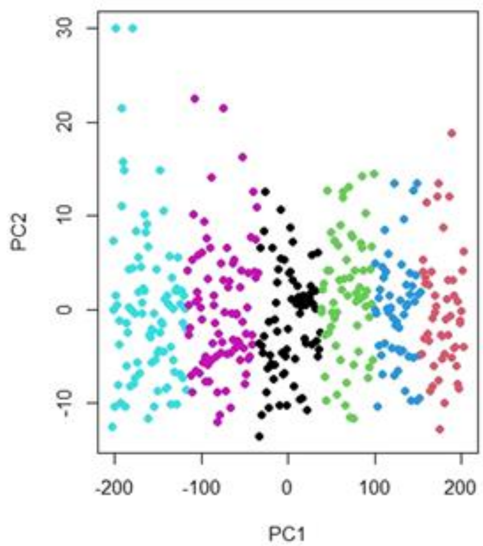
The principal component analysis (PCA) method is applied, (Lozares Colina & Lòpez Roldán, 1991) An algebraic method that condenses and shapes the information in our data matrix. Its objective is to generate linear combinations between the variances of the clusters. (Rivas & Martinez Arias, 1991). Also maintaining the linear independence between the groups that allows to explain the total variance (Lozares Colina & Lòpez Roldán, 1991).

In our data we have applied this method to reduce the size of the data groups by implementing the clusters through the similarity of their variances. To obtain an x-ray of the data showing its internal structure (Piza Volio, 1996).

To define the steps, the main components of each group are classified as Principal Components 1 (PC1), which is the component that best fits through its variances taking distances perpendicular to the line (Zubcoff, 2017). Apply the least squares method by maximizing data projections(Rivas & Martinez Arias, 1991).

In the second group of principal components (PC2) which is defined as the second normalized vector perpendicular to PC1 (Rivas & Martinez Arias, 1991). This PC2 component is a rotation of the initial axis and has orthogonality constraints by adjusting the values to the first (Zubcoff, 2017).

Figure 3 Kmedias (INTERACTIONS) using 6 clusters of factors related to organizational performance

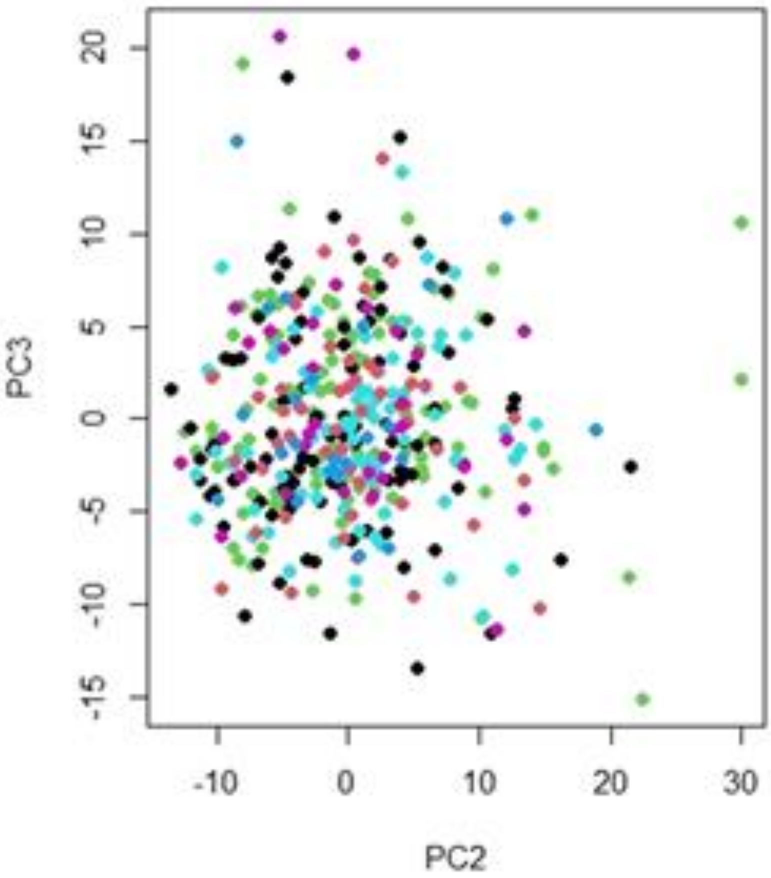


Note: graph generated by the authors based on the information captured from the results of the analysis of K means performed in the R software.

The size of each cluster is related to the number of data points, Figure 4 shows: cluster size 1 (light blue) is 68, cluster size 2 (purple) is 68, cluster size 3 (black) is 70, cluster size 4 (green) is 72, cluster size 5 (blue) is 65, and cluster size 6 (red) is 64. Because data points are typically distributed, groups vary in size with maximum data points and minimum data points.

The next of the data group are 3 major components (PC3) is an axis that is directly perpendicular to the other components PC1 and PC2 (Zubcoff, 2017). We use it to determine the interrelationship of clusters with each other, affirming their intrinsic relationship.

Figure 4 Kmedias (CLUSTER) using 6 clusters for interactions of factors related to organizational performance.



Note: graph generated by the authors based on the information captured from the results of the analysis of K means performed in the R software.

Sample size determination and power calculations are essential in the design of a K means with interactions. The cluster number required for a target statistical power should be estimated at the experimental design stage (Diggle et al., 2002). To this end, we rely on sample size formulas for data structures to explicitly derive closed-form power function and sample size formulas to detect a hypothetical interaction effect. The referrals are based on a distribution of a test statistic that used the maximum likelihood estimate of the interaction effect.

Performance Model

We take as a starting point the statistical technique the multiple linear regression with which we can determine the relationship of the study variables which interact applying the Multiple linear regression model (Morantes-Quintana et al., 2019).

$$yi = \beta_0 + \beta_1 x_{1i} + \beta_2 x_{2i} + \cdots + \beta_k x_{ki} + e_i$$

The explanation of the proposed performance model is as follows:

$Yi = variable\ dependiente$
$Xi = variable\ independiente$
$Bi = parámetros$
$ei = variables\ residuales\ (errores)\ de\ las\ variables\ medidas.$

The assumptions of multivariate regression analysis are the normal distribution, linearity, absence of extreme values, and absence of multiple links between independent variables. For linear models involving two or more continuous variables, linearity between pairs of continuous variables is assumed (Tabachnick & Fidell, 2001; Warner, 2008). The linearity assumption is that there is a straight-line relationship between two variables.

$Yi = Desempeño$
$V = Vigilancia\ Humana,$
$P = Problemas\ familiares,$
$C = Comunicación,$
$M = Motivación,$
$E = Estrés$
$Bi = parámetros$

Table 5 Beta Coefficients

Model	Coefficients	Variables
β_0	3.646	Constant
β_1	0.223	V
β_2	0.039	P
β_3	0.175	C
β_4	0.442	M
β_5	-0.018	E

Note: Table prepared by the authors based on the information captured from the results of the analysis in Matlab.

Dynamic system of discrete variables
A dynamic discrete time model is considered for the work performance model studied in this project. (Treesatayapun, 2020). This dynamic model considers all the independent and dependent variables used in the multiple linear regression applied in this study, all variables are considered as state variables which are variants in time, for this case, in discrete time based on the characteristic of its measurement (Ding et al., 2020).

Taking into account that, in continuous time, dynamic models in state space have the following expression:

$$\dot{X}(t) = A * X(t) + B * U(t)$$
$$\dot{Y}(t) = C * X(t) + D * U(t)$$

In this case it represents the vector of state variables while representing its derivative. For the representation of state space in a dynamic, discrete-time model, one has the "differentiation" of the vector of state variables instead of its "derivative". Which is defined as:“$X(t)$”$\dot{X}(t)$

$$Diff\big(X(k)\big) = X(k+1) - X(k) \quad ,k = 0,1,2,3,\dots$$

This leaves us as an alternative for the dynamic model the following expression in discrete time.

$$X(k+1) = X(k) + A * X(k) + B * U(k) \quad ,k = 0,1,2,3,\dots$$

The vector "" represents the input variables to the system, in this case with independent variables which can be a function of the discrete time "k", as well as constants. In the case of constant values, the dynamic model can be simplified as:$U(k)$

$$X(k+1) = X(k) + A * X(k) + B \quad ,k = 0,1,2,3,\dots$$

Dynamic System of the Performance Model
At present it is proposed to establish a dynamic model to make consecutive variations for the discrete dynamic equation, a magnitude D is studied that takes values in a discrete set of instants of time that

we will assume ordered from lowest to highest, although it is usually considered to simplify. We will use the notation to refer to the value of D at the instant, instead of the notation$\{t_1;\ t_2;\ t_3;\ \ldots\}$ (es decir, dados $\hat{\imath}, \hat{\jmath} \in N = \{0; 1; 2; \ldots\}$ con $\hat{\imath} < \hat{\jmath}$ se tiene que $t\_\hat{\imath} < t\_\hat{\jmath}$)$t_0 = 0,\ t\_1 = 1,$ etc. … D_k t_n (con n ∈ N)Usual D(t_n) (Bolós, 2018).

In addition, the evolution of this magnitude is governed by a law: an expression in the form of an equation in which the values of D are related at different moments, and where D plays the role of unknown. (Kajiwara et al., 2002).

$$\begin{bmatrix} D_{k+1} \\ V_{k+1} \\ P_{k+1} \\ C_{k+1} \\ M_{k+1} \\ E_{k+1} \end{bmatrix} = \begin{bmatrix} a_{11} & a_{12} & a_{13} & a_{14} & a_{15} & a_{16} \\ a_{21} & a_{22} & a_{23} & a_{24} & a_{25} & a_{26} \\ a_{31} & a_{32} & a_{33} & a_{34} & a_{35} & a_{36} \\ a_{41} & a_{42} & a_{43} & a_{44} & a_{45} & a_{46} \\ a_{51} & a_{52} & a_{53} & a_{54} & a_{55} & a_{56} \\ a_{61} & a_{62} & a_{63} & a_{64} & a_{65} & a_{66} \end{bmatrix} \begin{bmatrix} D_k \\ V_k \\ P_k \\ C_k \\ M_k \\ E_k \end{bmatrix} + \begin{bmatrix} b_1 \\ b_2 \\ b_3 \\ b_4 \\ b_5 \\ b_6 \end{bmatrix}$$

$k\ k\ +\ 1$In this model the values represent the current time. The parameters represent the following measurements (Kupka, 2011) with the assessment tool Test of Surveillance and organizational behavior of the work of (Echeverría et al., 2021). and the study variables are represented according to the variable column in Table 5.

The elements of matrix A are represented by the averages obtained in each measurement made by applying the formula for calculating the average of the results of the respondents by companies for each of the specified variables.

Example of the proposed formula for average performance (Bel et al., 2020):

$$D = \frac{\sum P_i}{n}$$

4. Conclusion

In this study, a cluster analysis of K means was carried out to carry out this test, the statistical analysis software R was used in order to evaluate the groups defined by the sizes of clusters (Cluster) that were between 68 and 72 units per cluster for each variable in which we observe in the resulting graph a normal distribution between them thus fulfilling another of the characteristics of the linear regression model that It is the normality of the variables.

Finally, the results of the coefficients obtained in the linear regression model were confirmed by the values obtained by applying the linear regression analysis process in the Matlab mvregress function, obtaining the results of the values for the predicted function:

$$Desempeño\ = 3.646 +\ 0.223\, X_1 + 0.039\, X_2 +\ 0.175\, X_3 +\ 0.442\, X_4 - 0.018\, X_5$$

Where the variables are equivalent to the order of the factors Human Vigilance, Family Problems, Communication, Motivation and Stress respectively. The normality and linearity of the variables were validated, the absence of conjunctures between the independent variables that confirm the viability of the model.X_i

Due to the complications of the measurements in the times the projection of the model raised for the measurement of the performance. The effectiveness of the same cannot be demonstrated. This requires reconducting the survey at each evaluation time to obtain the corresponding coefficients and values. The complexity of performing to measure the system prevents us from executing the processes of validation and the schema of the model demonstration. For this reason, it is proposed to develop it in future studies.

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