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SUMARIO • SUMMARY • RESUMO

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Editorial

In Project Design & Management we are pleased to present this new issue, highlighting once again the joint effort of our group of collaborators and emphasizing, once again, innovation as a primary tool in the scientific-technological development and its importance through creative, collaborative, and integral work in the design and management of projects. This new edition includes different topics presented in 6 articles that have been selected to address from valuation modeling in 4.0 companies, the analysis of collaborative computing tools through the matrix modeling of marketing strategies in companies, the study of compost in the quality of crops in nurseries to the analysis of leadership and success in organizations according to the ISO 9001 model, and finally, the energy modeling of photovoltaic systems in urban areas.

The first article presents a model based on fuzzy logic that integrates the uncertainty of the digital technology and 4.0 strategy variables and relates them to the sustainability variable to generate a sustainability valuation model. The model is applied to exporting companies for decision making in digital skills and competences of jobs.

In the second article, an exploratory study is carried out to analyze the functionalities of the G Suite software platform considering collaborative academic and professional work environments.

In the third article, an integral system of strategic matrices of the marketing environment for decision making is presented, which was validated with a sample of MSME companies in Honduras to determine how they analyze their competitive environments, the proposed system contributes to the optimization of decision making of management indicators.

Continuing with the fourth article, a study is presented on the effect of E. crassipes compost on the quality of T. cacao nursery plants, identifying the appropriate percentages of compost with levels of contaminating elements such as lead, arsenic, and mercury. The results show that the translocation of lead to T. cacao plants was non-existent and it is recommended to use percentages of E. crassipes compost no higher than 20%.

The fifth article presents a study on the relationship between the impacts of leadership on organizational success considering the ISO 9001 certification model. The research was carried out in industrial companies of cotton and textile products in Bolivia. The statistical results indicate a strong and moderate positive relationship between the variables of the study, and it is in the middle management levels where leadership quality management is most frequently applied.

Finally, in the last article of this issue, a descriptive energy model for the feasibility of photovoltaic system installations is proposed. The proposed model is applied in the city of Nuevo Laredo, Mexico. The model integrates on-site measurements and information from databases, standards, equipment manufacturers, and benchmarks to determine the feasibility of each installation design.

Likewise, this editorial is grateful for all the work developed by the team of collaborators, IT and technical, as well as the Ibero-American University Foundation (FUNIBER) and the universities that have provided all the supporting material, so that this issue can be carried out with the conviction that we are on the right path towards international recognition.

Dr. Luis A. Dzul López
Dr. Roberto M. Álvarez
Editors-in-chief

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SUSTAINABILITY VALUATION MODEL FOR AN EXPORTING COMPANY 4.0.

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Abstract. Industry 4.0 came by digital technology and the promise of increased productivity based on data. The scenario is useful to the stakeholder of the sustainable exporting company because it allows it to create value for the goods it exports. But a model that accepts uncertainty is required to relate the input variables: digital technology and strategy 4.0 with the output variable: sustainability. A problem that is solved under a fuzzy logic approach and the fuzzy inference system which generates the data set to train, control, and validate the adaptive network of the fuzzy inference system (ANFIS). Which, creates the algorithm of the sustainability valuation model (SVM). Thus the general objective is completed, and then the model is used in five exporting companies to supervise, control, and calibrating the result of the output variable, which can be a value between zero and one, where zero means loss sustainability and one reflect high sustainability. Data and knowledge that allows the stakeholder to make strategic decisions about advanced digital skills and competencies in the workplace, which is an innovation in the context of Industry 4.0 that allows a contribution of knowledge to the economic literature and management of the business. The SVM will continue its training process with new exporting ecosystems, face-to-face interviews, and
adapt its content to another language.

Keywords. Sustainability, digital technology, Industry 4.0, and fuzzy logic.

MODELO DE VALUACIÓN DE SOSTENIBILIDAD PARA UNA EMPRESA EXPORTADORA 4.0.

Resumen. La Industria 4.0 llegó con la tecnología digital y la promesa de un incremento de la productividad sobre la base de dato. El escenario es útil al *stakeholder* de la empresa exportadora sostenible, porque le permite crear valor a

los bienes que exporta. Pero se requiere un modelo que acepte la incertidumbre para relacionar las variables de entrada: tecnología digital y estrategia 4.0 con la variable de salida: sostenibilidad. Un problema que se resuelve bajo un enfoque de la lógica difusa y el sistema de inferencia difusa el cual genera el conjunto de datos para entrenar, controlar y validar la red adaptativa del sistema de inferencia difusa (ANFIS). Lo que permite construir el algoritmo del modelo de valuación de sostenibilidad (MVS) y así se completa el objetivo general. Luego, el modelo se utiliza en cinco empresas exportadoras con el propósito de supervisar, controlar y calibrar el resultado de la variable de salida, el cual puede ser un valor, entre cero y uno, donde cero significa una baja sostenibilidad y uno refleja una alta sostenibilidad. Dato y conocimiento que le permite al *stakeholder* tomar decisiones estratégicas sobre las habilidades y competencias digitales avanzadas en el puesto de trabajo, lo cual es toda una innovación en el contexto de la Industria 4.0 que permite una contribución de conocimiento a la literatura económica y gestión de empresa. El MVS continuara su proceso de entrenamiento con nuevos ecosistemas exportadores, entrevistas presenciales y adaptar su contenido a otro idioma.

Palabras claves. sostenibilidad, tecnología digital, Industria 4.0 y lógica difusa.

Introduction

Justification

When the fourth industrial revolution or Industry 4.0 arrived, it was accompanied by the complex knowledge of digital technology (DT) widely used by exporting companies to add value to their export goods, while the current knowledge of DT is predominant in the traditional exporting company. In other words, in the universe of the goods exporting company there is a DT gap that the research takes advantage of to propose a sustainability valuation model, which has two input variables: (i) efficient use of digital technology and (ii) use of the strategy proposed by Industry 4.0.

With the two input variables, whose nature is linguistic, the architecture of the fuzzy inference system (FIS) and the adaptive neuro-fuzzy inference system (ANFIS) are built. A system under fuzzy logic that delivers an output variable called "sustainability" of the business. The proposal is defined as the sustainability valuation model (SVM), necessary in these times of uncertainty for the *stakeholder* and very useful in an export ecosystem to make public policy decisions under the context of Industry 4.0.

General Objective

Under the fuzzy logic approach, the general objective is to propose a sustainability valuation model (SVM) for use in an exporting company 4.0. The architecture, which is original and innovative, will be explained in the research methodology section. Under the use of fuzzy logic, FIS and ANFIS have a wide use in applied economics (Trigueros, 2019), engineering systems (Acheson, Dagli, and Kilicay-Ergin, 2013), high-tech manufacturing (Yadegaridehkordi, 2018), agriculture, and ecology (Gay and Vermonden, 2013). That is, an intense use in those branches of knowledge in which man relates to his equals, since it reflects more reliably the behavior of the human brain (Gil Aluja and Kaufmann, 1987).

Industry 4.0

In April 2011, the German government defined the project of "Industry 4.0: with the Internet of Things on the way to the Fourth Industrial Revolution." Since that date, Industry 4.0

has become mainstream in the industrial economy (Blanco, Fontrodona, and Poveda, 2017) and is the basis for the next wave of data-driven productivity increase (University 4 Industry, 2013). The other contribution is the Pyramid 4.0 strategy which has dual causality: (i) vertical causality that occurs from the pyramid base to the top, and (ii) horizontal causality that starts with data capture, data processing, and data use. See figure 1.

The third aspect of Industry 4.0 is the digital technology S-curve (S_{TD}) and the human adaptability S-curve (S_{AH}) (Bocci, 2019), see Figure 2. The S_{TD} curve represents the knowledge of digital technology and the S_{AH} curve represents the use of digital technology adopted by the people working in the company. The distance between the two S-curves represents the digital technology gap. The vertical distance between the S_{TD} curve and the S_{AH} curve represents the low uptake of digital technology in Industry 4.0.

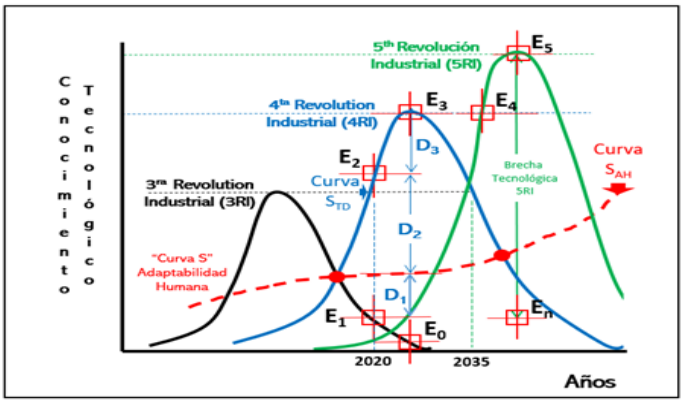

Figure 1. Pyramid 4.0. (cause-effect)
Note: Source: University 4 Industry, 2013

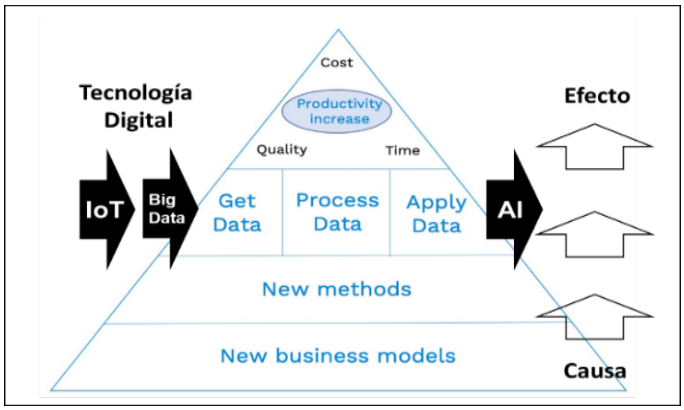

Figure 2. S_{TD} curve (color green) or S-4IR curve.
Note: Source: Own elaboration, 2020.

Likewise, the S_{TD} curve intersects with the S_{AH} curve which generates a subset of firms below the S_{AH} curve and a subset of firms above the S_{AH} curve. Companies that are located in scenario E1, under the S_{AH} curve, are forced to position themselves above the S_{AH} curve. If they fail to do so, they run the risk of their export products becoming obsolete in the face of the fifth

industrial revolution (5IR). A disadvantage in the face of the arrival of quantum computer technology that will appear in 2030 (Stewart, 2019).

Export 4.0

The splendor of the export of goods began in 1971 when the Bretton Woods Conference agreement ended, a date that initiated the GATT-WTO agreement, the Doha Round and the Information Technology Agreement (ITA). This scenario allowed Industry 4.0 to boost the export economy 4.0 based on the intensive use of digital technology, the consequence of which is the promotion of digital industrial production and digital craftsmanship, which emulates the first industrial revolution (1IR).

Before the 1IR the production of a good was a handicraft production and the success of the export depended on the knowledge to take the artifact from point A to point B. With the advent of the industrial revolution, industrial production was introduced, the success of which depended on the use of the scientific and technological knowledge of the time. That is to say, during industrial production an artifact that is exported carries a hidden effect: the scientific and technological knowledge of the society of the time.

The Economic Complexity Index (OEC, 2020) shows each country with the knowledge associated with exportable goods. According to the index, developed countries are leaders in exporting goods with complex digital technology knowledge, while developing countries strive to ensure that their products do not have a larger digital technology gap. Based on the above, developing countries need to boost Industry 4.0 to improve the sustainability of exporting companies.

Sustainability

The exporting company 4.0 has the responsibility to adopt sustainable development that meets the needs of the present without compromising the ability of future generations to meet their own needs (ISO, 2010). It implies a shift from the idea of sustainability, mainly ecological, to a framework that emphasizes the economic and social context of development (Barcellos, 2010). In other words, sustainability and sustainable development can be seen as a way to express the broader expectation of society as a whole (ISO, 2010), which represents a motivation for the exporting company 4.0 to adopt a balance between economic, social, and environmental aspects. It is necessary to become more aware of its responsibilities towards society as a whole with the conviction that this is in its own interest (Olcese, 2005).

On the basis that the traditional company has a *shareholder* approach oriented to shareholders, customers, and collaborators, whose interest is to enhance tangible assets and their expectations in the short term (Barcellos, 2010), the only objective is to maximize profits and answer to shareholders. While the sustainable company has a *stakeholder* approach whose objective is to enhance tangible and intangible assets and its expectations are long-term. In other words, the company is subject to a strategy and internal codes of conduct that respect social and environmental rights. (Barcellos, 2010), conduct that the sustainable company must show in tangible form in its exportable goods.

For this reason, the concept of sustainability represents a new approach to doing business (Barcellos, 2010) and the creation of sustainable value requires companies to address one or more of four drivers: (i) clean technologies, (ii) pollution prevention, (ii) sustainable vision, and (iv) transparent products (Hart and Milstein, 2003). According to the authors, the clean technologies

engine is associated with disruptive technologies, innovation, and the future. Which is a driver used by the research to relate it to the sustainability of goods exporting companies through the use of the Industry 4.0 strategy.

There is a positive association and certainly very little evidence of a negative association between a company's social performance and its financial performance (Margolis and Walsh, 2003). Likewise, there is empirical evidence of a positive relationship between social performance and financial performance (Barcellos, 2010). This is verified by the social and financial performance of the companies that make up the Dow Jones Sustainability World Index. This index is composed of world leaders in sustainability as identified by Sustainable Asset Management (SAM).

Even so, the sustainable company is still looking for formal data before making the decision to adopt the Industry 4.0 strategy, but reality forces to make the best use of the available information, rich or poor (Gil Aluja and Kaufmann, 1987). *Stakeholder* expectations cannot be expected to be met under hard data and traditional statistics. Uncertainty and the dynamics of Industry 4.0 force us to use possibility instead of probability, subjectivity in the absence of the much desired objectivity. In other words, in the absence of measurement, we will examine "valuation", our reasoning and computers (Gil Aluja and Kaufmann, 1987) under fuzzy logic.

Fuzzy logic

In 1965, Lotfy Zadeh applied multivalued logic to set theory at the scientific, academic, and industrial level, which allowed the use of fuzzy logic. It is very useful when it comes to generating new management and decision-making models based on the opinion and subjectivity of experts. Likewise, it allows the valuation of the complex knowledge of digital technologies without the need to submit to the technocracy of hard and certain data, since the system based on fuzzy logic emulates the most software part of the brain, trying to reproduce the highest level capabilities, especially that of approximate reasoning (Del Brío and Sanz, 2010). For this reason, the research makes use of two well-known systems: (i) FIS, and (ii) ANFIS.

The first architecture is the fuzzy inference system (FIS) with the following process: (i) the fuzzification interface that transforms the certain data into fuzzy data by using the linguistic variables and linguistic labels, (ii) definition of the fuzzy rules with the If-Then statements, (iii) the inference engine that delivers a fuzzy output value. Most fuzzy inference systems can be classified into three types: Type 1, Type 2, and Type 3 (Jang, 1993). For the study, it is decided to use Type 3 rule which uses Takagi and Sugeno's fuzzy rules (If-then). The output of each rule is a linear combination of input variables plus a constant term, and the final result is the weighted average of the output of each rule (Jang, 1993) and (iv) defuzzification is to convert each output from a fuzzy term to a number (see Figure 3).

The other architecture is the Adaptive Neural Fuzzy Inference System (ANFIS) presented by Jang (1993). It uses the routine of a fuzzy inference system (FIS) and the basic learning rule of adaptive networks which is based on gradient descent and the chain rule (Jang, 1993). An algorithm inspired by neural network theory to adjust the parameters of the rules of Sugeno-type fuzzy inference systems (Bermudez, et al, 2014), where the output variable is a function of the input variables (see figure 4).

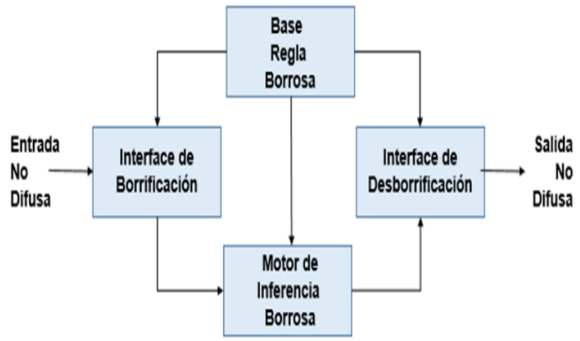

Figure 3. Fuzzy inference system (FIS). 2020

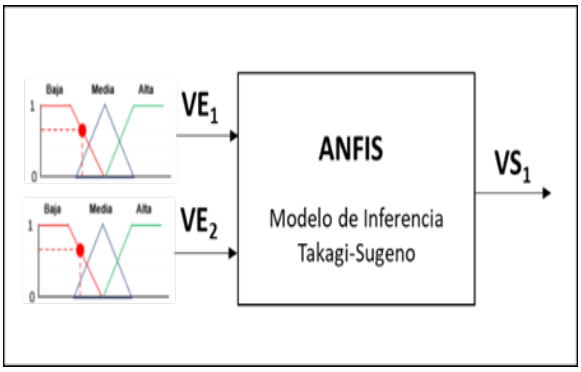

Figure 4. ANFIS architecture. 2020

Where:
$VS_1 = f(VE_1 , VE_2)$.
VE1 = input variable = efficiency = efficient use of digital technology [0 1].
VE2 = input variable = strategy 4.0 = use of Industry 4.0 strategy [0 1].
VS1 = output variable = sustainability = numerical value [0, 1].

Although, ANFIS is a soft computing technique (Bermudez, et al, 2014) and one of the neuro fuzzy models of greater impact (Del Brio and Sanz, 2001) allows the construction of expert systems and advanced models through the use of numerical input variables and numerical output variable. In industry it is one of the neuro fuzzy models with the greatest impact (Del Brio and Sanz, 2010) in artificial intelligence together with the FIS, the theory of fuzzy subsets, the triangular fuzzy numbers (TFN), and the Hamming Distance allow the construction of the general objective of the research.

Method

Research design

The research scenario is changing and uncertain and the analytical intention is predictive under a fuzzy logic approach, since a fuzzy methodology is to describe and formalize reality using flexible models that interpret the laws governing human behavior and human relationships (Lazzari, Machado and Perez, 2000). Likewise, the post-positivist paradigm is used to achieve a better understanding of reality in Industry 4.0. A reality that exists but cannot be studied from exact laws and can only be understood incompletely (Ramos, 2015). Even when the reality of the exporting company includes the inadequate use of resources, little scientific and technological knowledge in the design of goods, self-satisfied leaders, and skilled in procrastination of Industry 4.0., an epistemological vein that allows a methodological one under the fuzzy logic.

Research methodology

The appropriate use of a model under the fuzzy logic architecture should include four facets: (i) FLl = Logic Facet, (ii) FLs = Fuzzy subset theory facet, (iii) FLe = Epistemic facet, and (iv) Flr = Relational facet (Zadeh, 2008, p. 2754). The four facets are found in the three activities included in the methodology: (i) construction of the FIS, (ii) construction of the ANFIS, and (iii) application of the SVM (see Figure 5).

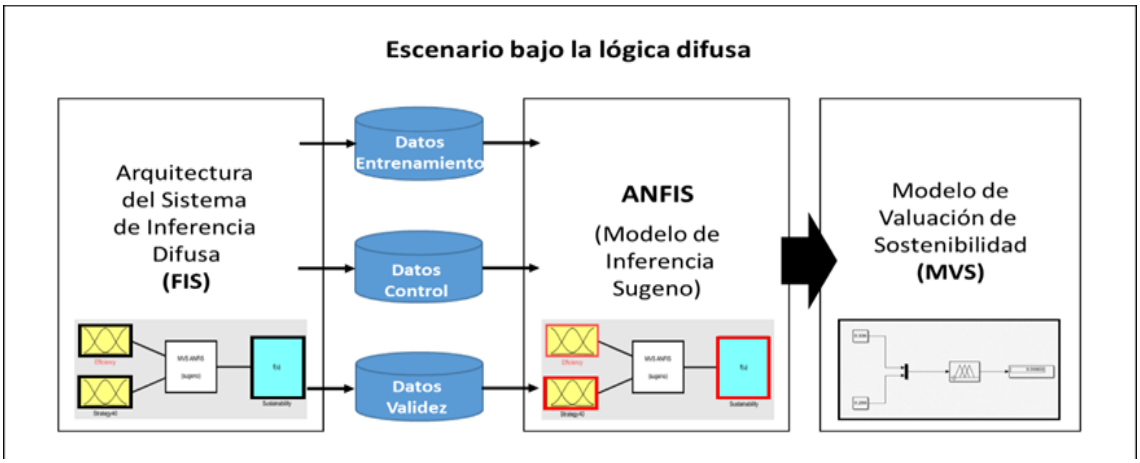

Figure 5. Diagram of the methodology. First the FIS, then ANFIS, and finally the SVM.
Note: Source: Own elaboration. 2020.

Methodology activities are explained:

i. The construction of the fuzzy inference system (FIS) through which the database required by the ANFIS is obtained. Once the FIS is built, 200 random numbers [0 1] are used for the input variable VE_1 and another equal amount for the input variable VE_2, which results in 200 output variable data VS_1.

ii. ANFIS construction. With the data generated by the FIS, the training, control and validity of the ANFIS architecture is executed, and the algorithm of the sustainability valuation model (SVM) is obtained. An architecture based on Sugeno's fuzzy model with a set of nine fuzzy if-then rules, for two inputs (VE_1 and VE_2) and one output variable (VS_1 or sustainability), (see figure 6). The fuzzy rules are represented by:
$R_k = si\ \mu_{A_i}(x)\ y\ \mu_{B_i}(y)\ where\ f = p_k x + q_k x + r_x$

Where k is the number of rules (9), A_i (A_1, A_2 and A_3) and B_i (B_1, B_2 and B_3) represent the number of fuzzy membership function of the input variables y p_k, q_k, r_k are the linear parameters of the consequent parts of the nine rules.

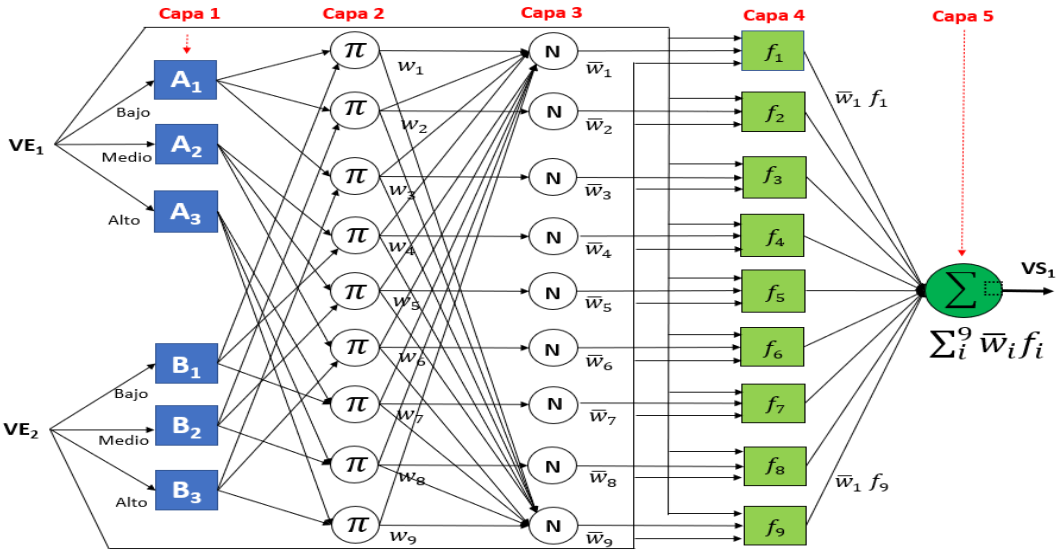

Figure 6. Layers of ANFIS - Sugeno Model. It is developed in five layers
Note: Source: Own elaboration, 2020.

In the first layer, the fuzzification task is executed where each node is an adaptive node dependent on the membership function (see Figure 6). In the research the trapezoidal membership function is used and the output is obtained by the following equation:

$O_i^1 = \mu_{A_i}(x)$, $O_i^1 = \mu_{B_i}(x)$, where: $(i = 1, 2, 3)$. Whose trapezoidal function is:

$$\mu(x) = \begin{cases} 0 & si\ x \leq a_1 \\ \frac{x - a_1}{a_2 - a_1} & si\ a_1 \leq x < a_2 \\ 1 & si\ a_2 \leq x \leq a_3 \\ \frac{-x + a_4}{a_4 - a_3} & si\ a_3 \leq x \leq a_4 \\ 0 & si\ x \geq a_4 \end{cases}$$

In the second layer each node has a fixed node tag π and the output is the product of all incoming signals (see figure 6). Therefore, the output of the second layer is obtained by the following equation:

$O_i^2 = w_i = \mu_{A_i}(x)$ x $\mu_{B_i}(x)$, where: $(i = 1, 2, 3, 4, 5, 6, 7, 8, 9)$.

The third layer is considered the normalization layer (N) (see figure 6). Therefore, the output of this layer is calculated by the following equation:

$O_i^3 = \overline{w}_i = \frac{w_i}{\sum_1^9 w_i}$, where: w_i is the normalized firing force.

The fourth layer is considered the defuzzification layer, where each node of this layer is an adaptive node. That is, node represents consequent parts of the fuzzy rule. The linear coefficients of the rule consequents can be trained (see Figure 6). The output of this layer is calculated by the following equation:

$O_i^4 = \overline{w}_i f_i = \overline{w}_i (p_i x + q_i x + r_i)$, where: $(i = 1, 2, 3, 4, 5, 6, 7, 8, 9)$.

The fifth layer is considered the output layer. Here the defuzzification of the consequent parts of the rules is performed by adding the results of all nine rules (see figure 6), which is calculated by the following equation:

$O_i^5 = \sum_i^9 \overline{w}_i f_i = \frac{\sum_i^9 w_i f_i}{\sum_i^9 w_i}$, where: $(i = 1, 2, 3, 4, 5, 6, 7, 8, 9)$

iii. Application of the SVM. The exporting company is selected, the scale of advanced digital skills and competences (HCDA) is applied, the Hamming Distance is calculated, and from the triangular fuzzy numbers the values of VE_1 and VE_2 are obtained. Values that are introduced to Simulink and deliver the VS_1 (Sustainability).

Development of activities

The section explains the development of the three activities of the methodology:

Activity 1. Construction of the fuzzy inference system (FIS). The objective of the activity is to build the FIS (Sugeno), to obtain the data required by the ANFIS. The Matlab development environment version R2020a. and its Fuzzy Logic Toolbox are used, where the following tasks are executed:

i. The Fuzzy Logic module of Matlab is accessed and the Takagi-Sugeno FIS is adopted.
ii. It is defined: (a) linguistic variable VE_1 = efficiency, with three linguistic labels (low, medium, and high), (b) linguistic variable VE_2 = strategy 4.0, with three linguistic labels (low, medium, and high), and (iii) linguistic variable VS_1 = sustainability, with three linguistic labels. The three variables use the same membership function: (i) low = trapezoidal type function, (ii) medium = triangular type function, and (iii) high: trapezoidal type function.
iii. The nine fuzzy rules are defined under the structure: if - Then
iv. At the end, the fuzzy inference system (FIS) is obtained to generate the data required in the ANFIS.

Activity 2. ANFIS construction. The objective of this activity is to build the ANFIS and its corresponding algorithm for use in the SVM. The tasks to be executed are:

i. Enter Matlab and type <anfisedit> and the Neuro Fuzzy Designer window is displayed and saved with: <File>, < Export>, <Data>, and assign the name SVM. Then the file is reloaded

using: <File>, < Import>, <Data> and the SVM is chosen. The Neuro Fuzzy Designer SVM window is displayed, ready to load the data files.

ii. The file with the training set data is loaded. The data are used by the learning algorithm to adjust the network parameters. The objective is to bring the prediction error on this training set to a minimum (Diaz, Etse, Flores, Folino and Will, 2007).

iii. The file with the control set data is loaded. The data does not participate in the training and only avoids the phenomenon of overtraining (Diaz, et al, 2007).

iv. The data for the validity set is loaded. (Checking Set). The data does not participate in the training. Its use is to provide a measure of the quality of the network prediction on new data, not available at the time of training.

v. ANFIS delivers: (i) the six-layer ANFIS structure model, (ii) the VE_1, VE_2, and VS_1 with their linguistic label values (low, medium, high), (ii) the nine fuzzy rules, (iii) the training error, and (iv) ANFIS SVM algorithm that is exported to file and Matlab, for use in Simulink.

Activity 3. Application of the SVM**.** The objective is to use the algorithm generated by the ANFIS SVM in the Simulink simulator, Matlab version R2020a. Simulink is a graphical environment to be used in the simulation of nonlinear dynamic systems. It is very useful for simulations of a complex system because it allows to explore with relative simplicity different solutions (Del Brío and Sanz, 2001). The following tasks are executed.

i. Face-to-face or virtual interview to fill in the data of the scale of advanced digital skills and competencies (HCDA), which takes into account the nine technological pillars of Industry 4.0: virtual reality, artificial intelligence, industrial internet, industrial big data, industrial robot, 3D printing, cloud computing, knowledge work automation, and industrial network security (Chen, Liu, Quiang, & Liu, 2016). The other three pillars are included by the researcher: use of GIS, agile projects, and Social Networks (see Table 1). The interview is with each job manager which is classified into two groups: (i) jobs assigned to the efficient use of digital technology under the "efficiency" denomination, and (ii) jobs assigned to the use of Industry 4.0 strategy under the "strategy 4.0" denomination (see table 1). The efficiency group corresponds to jobs in the value chain and the 4.0 strategy group corresponds to jobs that support the value chain.

ii. The HCDA scale data is processed using Hamming Distance and the certain value of [0 1] is defined for each job. The valuation means the use of digital technology and Industry 4.0 strategy.

iii. The values of each work center are ordered: (i) the jobs assigned to efficiency (WP1, WP2, WP3, WP4, WP5), with which the triangular fuzzy number (NBT_1) is constructed and the mean of $NBT_1 = VE_1$ is obtained, and (ii) the jobs assigned to strategy 4.0 (WP6, WP7, WP8, WP9, WP10), with which the triangular fuzzy number (NBT_2) is constructed and the mean of $NBT_2 = VE_2$ is obtained.

iv. The values VE_1 and VE_2 are input to the Simulink and deliver a certain value [0 1] which is the VS_1 = sustainability (S). This is repeated as many times as necessary.

Results

Construction of the FIS

The objective is to build the FIS to obtain the data set required by ANFIS.

i. Enter Matlab, type <fuzzy>, display the Fuzzy Logic Designer window, select <File>, then select <New FIS>, < Sugeno>. Then choose <File>, <Export>, <To File>, type the name of the FIS SVM file and choose <Save>. This saves the file with the FIS architecture (*fis). The FIS SVM file is imported to execute the FIS construction.

ii. In which window the FIS <Input> variables are defined: (a) VE_1 = efficiency with three labels (low, medium, and high), and (b) VE_2 = strategy 4.0 with three labels (low, medium, and high). Both input variables (VE_1 and VE_2) use the same membership function and linguistic labels in the range [0 1].
Low = trapezoidal type function = $[a_1\ a_2\ a_3\ a_4]$ = [0 0 0.1 0.4].
Medium = trapezoidal type function = $[a_1\ a_2\ a_3\ a_4]$ = [0.3 0.5 0.5 0.5 0.7] = [0.3 0.5 0.5 0.7].
High = trapezoidal type function = $[a_1\ a_2\ a_3\ a_4]$ = [0.6 0.9 1 1].

iii. The variable FIS <Output> f(u) = Sustainability = VS_1 is defined. The parameters are values of [0 1], for the three linguistic labels: (i) Low = 0, (ii) Medium = 0.5, and (iii) High = 1. The FIS architecture is concluded (see Figure 7).

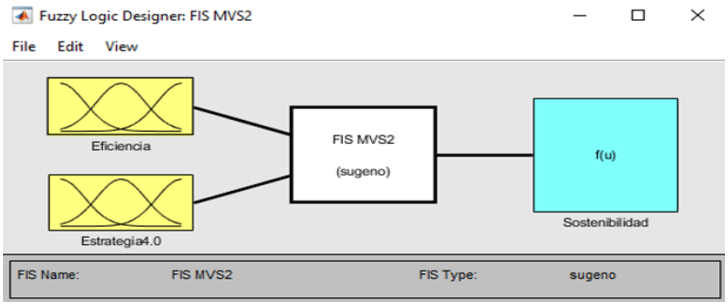

Figure 7. FIS SVM architecture. 2020

Figure 8. FIS SVM Rules. 2020

iv. Then proceed to define the fuzzy rules under the <if - and - Then > structure. In the Fuzzy Logic Disigner FIS SVM window, select < Edit> <Rules> and the Rules Editor FIS SVM

window appears, where, using the < if - and - Then > rule, the nine rules are incorporated (see figure 8).

v. To obtain the FIS construction, select <View> <Rules> and the Rules Viewer FIS SVM window is displayed (see figure 9). Likewise, choose <View> <Surface> and the Surface Viewer FIS SVM is displayed (see figure 10).

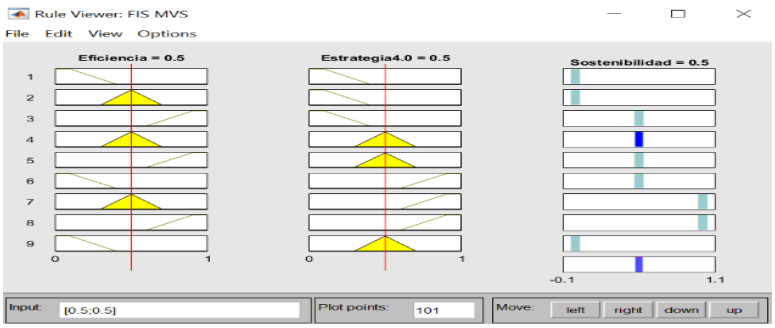

Figure 9. FIS SVM rule. 2020

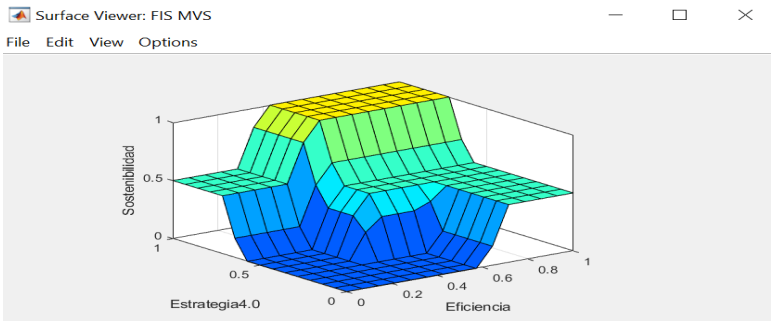

Figure 10. SVM FIS area. 2020

vi. The Rule Viewer FIS SVM (Figure 8) is used to obtain the 200 VS_1 data. In < Input > the value shown [0.5 0.5] = [VE_1 VE_2] is modified with the random data and filed in an Excel sheet. The Excel file with three columns records: (i) the VE_1 value with 200 values, (ii) the VE_2 value with 200 values, and (iii) the VS_1 column with 200 values (see Appendix I).

vii. The data file is sorted: (i) 60% of the data for the training set, (ii) 30% of the data for the control set, and (iii) 10% of the data for the validity set. Data used in the construction of ANFIS.

ANFIS construction

The objective of the ANFIS construction is to achieve the SVM algorithm, for which the Fuzzy Logic Toolbox module of Matlab, version R2020a, is used.

i. Enter Matlab and type <anfisedit> and the Neuro Fuzzy Designer window is displayed and the file is saved with the name ANFIS SVM. Then the file is reloaded using: <File>, < Import>, <Data>, and ANFIS SVM is chosen.

ii. Check: <Training>, < File>, <Load Data>, and select the file < Entresvm>. Load the data and select < Generate FIS> and in the Add Membership Function window check: INPUT, Number of MFs [3 3], and MF Type select <trapmf> of the trapezoidal type function. In

OUTPUT select: < Constant>, <OK>. Then, in the Train FIS column under < Epochs> write: <10>, <15>, and <20>. Finish the training with 20 epochs, an error of: 0.055 and 110 input data. See figure 11. Finally, choose: <Clear Plot>.

iii. Check: < Testing>, <File>, <Load Data>, and select the <Controlsvm> file. Load the data and select <Generate FIS> and in the Add Membership Function window check: INPUT, Number of MFs [3 3], and MF Type select <trapmf> of the trapezoidal type function. In OUTPUT select: <Constant>, <OK>. Then, in the Train FIS column under < Epochs > write: <10>, <15>, and <20>. Finish the control with 20 epochs, an error of: 0.055 and 60 input data (see Figure 12). Finally, <Clear Plot> is chosen.

iv. Check: < Checking>, <File>, <Load Data>, and select the file <Validitysvm>. Load the data and select < Generate FIS> and in the Add Membership Function window check: INPUT, Number of MFs [3 3] and MF Type select <trapmf> of the trapezoidal type function. In OUTPUT select: <Constant>, <OK>. Then, in the column, Train FIS and under <Epochs > write: <10>, < 15>, and <20>. Finish the validity with 20 epochs, an error of: 0.055 and 30 input data (see figure 13). Finally, <Clear Plot> is chosen.

v. As a result, we obtain the ANFIS system (see figure 14) whose layered architecture is similar to figure 6. We also obtain the list of the nine fuzzy rules (see figure 15) and the new ANFIS fuzzy rule (see figure 16), which includes the SVM algorithm.

vi. The ANFIS architecture delivers an ANFIS SVM Surface Viewer map (see figure 17). It is different from the FIS SVM Surface Viewer (see figure 10) especially in the elimination of the sharp edges typical of ANFIS:

vii. Finally, the ANFIS SVM is exported to the file for use in Simulink. The ANFIS SVM algorithm will be used in the SVM application to simulate the scenarios of the five exporting companies involved.

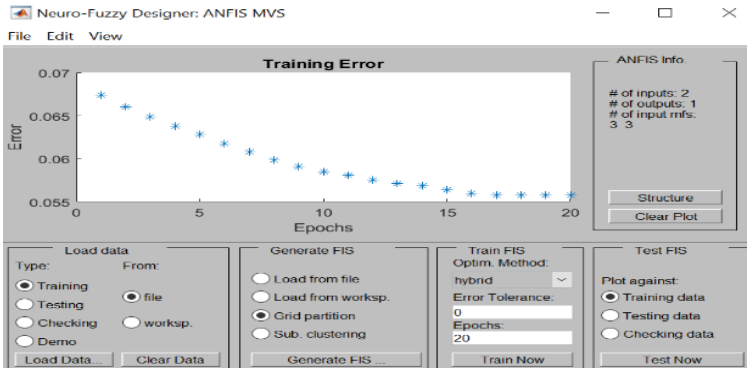

Figure 11. ANFIS SVM-Training error. 2020

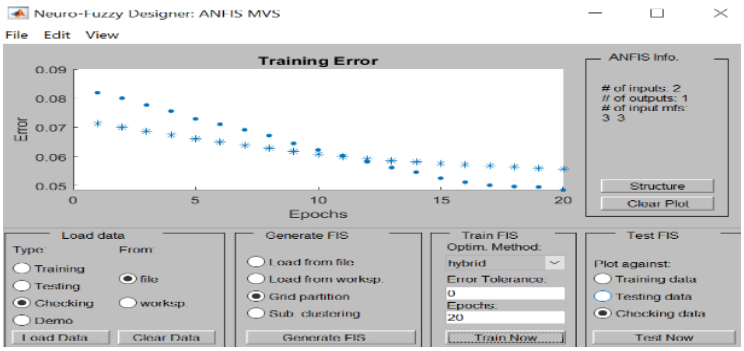

Figure 12. ANFIS SVM-Control error. 2020

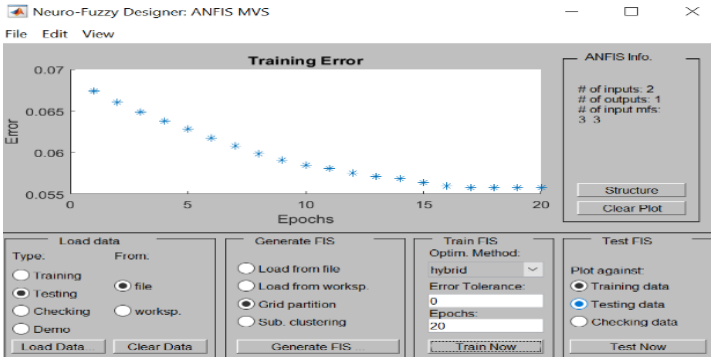

Figure 13. ANFIS SVM-Validity error. 2020

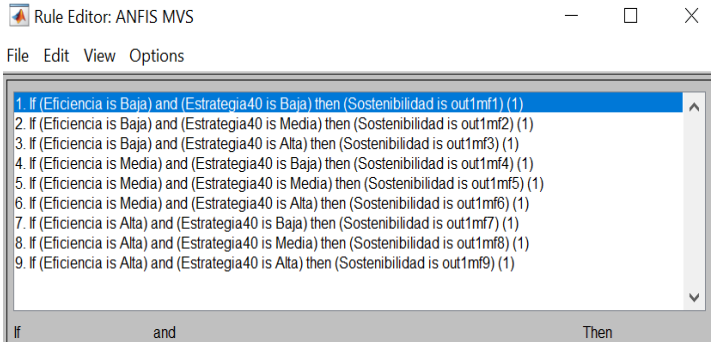

Figure 14. ANFIS-SVM fuzzy rules. 2020

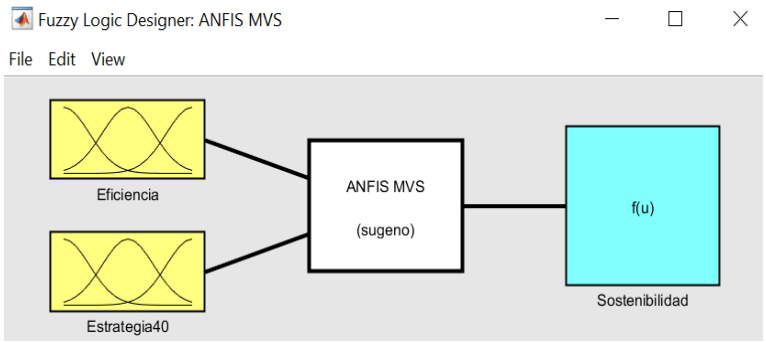

Figure 15. ANFIS-SVM architecture. 2020

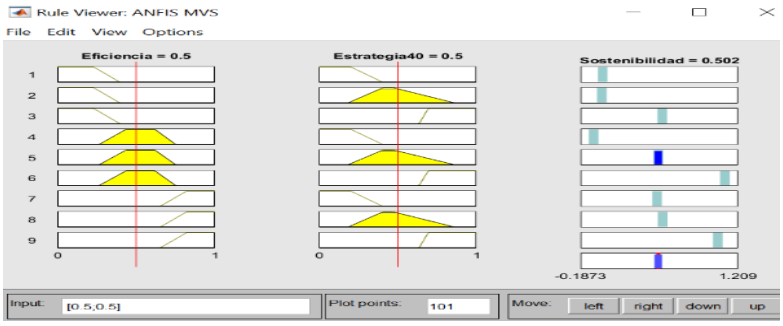

Figure 16. ANFIS SVM rules. 2020

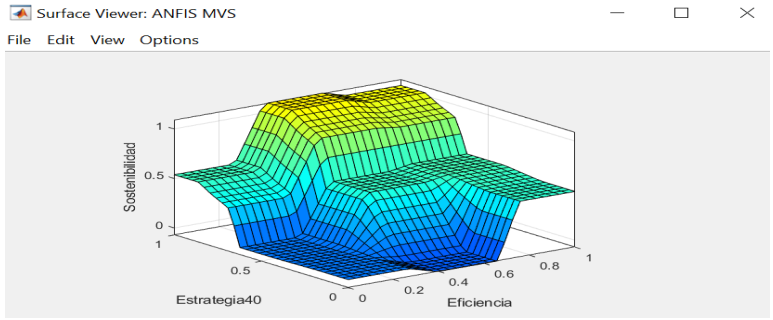

Figure 17. ANFIS SVM surface. 2020

SVM application

The objective is to use the ANFIS SVM algorithm in the Simulink simulator of Matlab version R2020a, for which the following tasks are executed.

i. The virtual interview is conducted with five exporting companies. An advanced skills and competencies scale (HCDA) is filled out for each exporting company. The assessment is carried out with the person in charge of each work position (WP) and values of [0 1] according to the endecaria scale are used. The researcher has defined the values of the "Ideal Profile" (see Table 1).

Table 1
Format of the scale of advanced digital skills and competences (HCDA)

Vectores I4.0	Habilidades y Competencias Digitales Avanzada (HCDA)	VE_1					VE_2					Perfil Ideal
		Eficiencia					Estrategia 4.0					
		PT1	PT2	PT3	PT4	PT5	PT6	PT7	PT8	PT9	PT10	
HD	Computaciòn en la Nube	0.8	0.5	0.7	0.6	0.3	0.4	0.8	0.6	0.3	0.4	0.9
	Realidad Virtual	0.7	0.6	0.3	0.4	0.8	0.6	0.6	0.5	0.7	0.5	0.8
	Robot Industrial	0.1	0.5	0.8	0.5	0.7	0.6	0.3	0.4	0.1	0.6	0.9
	Uso de GIS	0.4	0.7	0.6	0.3	0.4	0.8	0.6	0.6	0.4	0.3	0.8
GD	Internet Industrial (IIoT)	0.3	0.3	0.3	0.7	0.3	0.3	0.5	0.5	0.3	0.7	1.0
	Big Data Industrial	0.6	0.8	0.7	0.6	0.3	0.4	0.8	0.6	0.6	0.1	1.0
	Inteligencia Artificial	0.8	0.6	0.6	0.3	0.8	0.8	0.6	0.7	0.8	0.4	1.0
	Impresiòn 3D	0.2	0.7	0.5	0.1	0.6	0.4	0.5	0.1	0.1	0.3	1.0
SD	Proyectos àgiles	0.7	0.6	0.3	0.4	0.8	0.6	0.3	0.4	0.5	0.6	1.0
	Trabajo colaborativo virtual	0.3	0.3	0.5	0.3	0.7	0.6	0.3	0.3	0.8	0.8	1.0
	Seguridad de Red Industrial	0.6	0.7	0.6	0.3	0.4	0.8	0.6	0.6	0.4	0.5	1.0
	Gestiòn de Redes Sociales	0.6	0.5	0.8	0.7	0.8	0.4	0.5	0.8	0.5	0.4	1.0

Note: WP1 = R&D&I, WP2 = Supply, WP = Manufacturing, WP4 = Logistics, WP5 = Marketing, WP6 = Design, WP7 = Services, WP8 = ICT, WP9 = HR, and WP10 = Management. The Ideal Profile values are recommendations of the researcher based on his experience.
In the position WP1 = R&D&I, it is taken into account if there is agile project management, very useful in Industry 4.0.

ii. From the HDCA scale, the data for each work center (WP1, WP2, ... WP10) is used. The data for each work center is processed using the Hamming Distance and a WP value is obtained. For example: for the management position (WP10) we have:
DH Management = 1/12 ((0.9-0.4) + (0.8-0.5) + (0.9-0.6) + (0.8-0.3) + (1-0.7) + (1-0.1) + (1-0.4) + (1-0.3) + (1-0.6) + (1-0.8) + (1-0.5) + (1-0.4).
DH Management = 1/12 (0.5+0.3+0.3+0.3+0.5+0.3+0.9+0.6+0.7+0.4+0.2+0.5+0.6 = 0.48.

iii. The values for each work center are ordered: (i) with the WPs assigned to efficiency (WP1, WP2, WP3, WP4, WP5) the triangular fuzzy number is constructed and the mean is obtained: $NBT_1 = VE_1$, and (ii) with the WPs assigned to strategy 4.0 (WP6, WP7, WP8, WP9, WP10) the triangular fuzzy number is constructed and the mean is obtained: $NBT_2 = VE_2$. The process is repeated for the other four exporting companies.

iv. The values of VE_1 and VE_2, for each exporting company, are entered into Simulink and VS_1 is obtained as a result. In the 2020 scenario (see Figure 18).

v. Another contribution of the SVM is the simulation of VE_1 and VE_2 in Simulink for a future scenario. In Company 1, the value of VE_1 (2020) = 0.35 is changed to VE_1 (2025) = 0.55 and the value of VE_2 (2020) = 0.42 is changed to VE_2 (2025) = 0.45. Where VS_1 (2020) = 0.325 passes VS_1 (2025) = 0.502 = Sustainability. The increase occurs because of the improvement in each job in the efficiency variable and the 4.0 strategy (see figure 19). The simulation continues with Company 2, 3, 4, and 5 (see table 2).

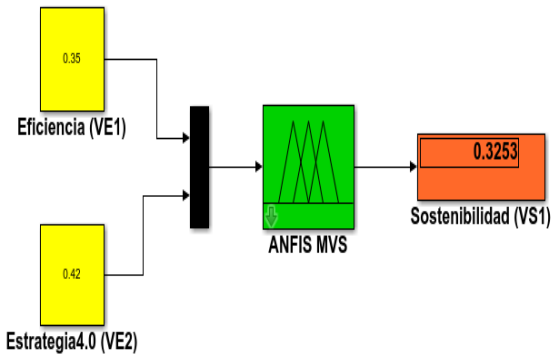

Figure 18. Simulink SVM: scenario year 2020

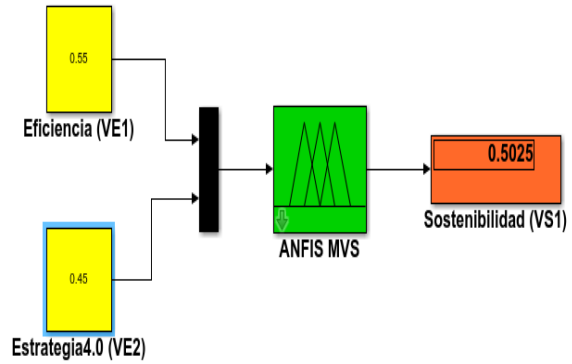

Figure 19. Simulink SVM: scenario year 2025

Table 2
SVM result by exporting company. Scenario year 2020 and 2025.

Empresa Exportadora I4.0	Escenario Año 2020					Escenario Año 2025					Sector Economico de Exportaciòn
	VE1	VE2	VS1			VE1	VE2	VS1			
			Bajo	Medio	Alto			Bajo	Medio	Alto	
Empresa 1	0,35	0,42	**0,325**			0,55	0,45		**0,502**		Agricultura
Empresa 2	0,18	0,55	**0,002**			0,38	0,65		**0,619**		Agro-Industria
Empresa 3	0,39	0,42		**0,487**		0,48	0,66			**0,762**	Medico
Empresa 4	0,41	0,67			**0,824**	0,58	0,75			**0,965**	Electronico
Empresa 5	0.32	0,39	**0,192**			0,41	0,45		**0,502**		Manufactura

Note: The virtual interview was conducted between May, June, and July 2020. In the 2020 scenario, three companies have low sustainability (red). In the 2025 scenario, the three companies moved to medium sustainability (gray). The decision was to reduce the worst-performing Hamming Distance. In other words, the job manager will have to increase his HCDA, which is a different challenge for each company. But the management of the five companies urges them to improve their HCDA.

Discussion and conclusion

The increase in productivity based on data (University 4 Industry, 2013) and the cyber-physical system to achieve the smart factory (Cheng, et al, 2016) are promises of Industry 4.0 that have yet to be validated. Similarly, the VSM is not the panacea to comprehensively solve the sustainability of an exporting company, it is only a model that helps to understand the current state of the company with respect to the reality of Industry 4.0. A model that cannot interpret all the complex and changing reality, but it does allow the *stakeholder to* align digital strategic thinking, digital strategic direction, and digital strategy in an efficient way. The VSM could even be used in model-based systems engineering (MBSE) for the harmonization of information (Marny and Purohit, 2019) and the initiation of a new business model needed in Industry 4.0.

The model provides appropriate knowledge for the *stakeholder to* drive a sustainability strategy under Industry 4.0. Even more so, when companies have to operate with one eye on the short term and the other focused on the long term (Kotler and Caslione, 2010) in times of uncertainty or turbulence. Based on the above, two groups of exporting companies are defined: (i) those that do not have the slightest interest in Industry 4.0, and (ii) those that have digital technology adapted and proven in their processes. But the technology is underutilized or, in other words, complex knowledge is needed to get the most out of it in order to improve the company's sustainability.

The VSM is useful for the second group of exporting companies, as it allows them to operate at three planning levels: short term, intermediate term (three to five years), and long term (Kotler and Caslione, 2010) with which projects and initiatives can be executed simultaneously in three boxes: (i) short term or present: manage the core business with maximum profitability, (ii) medium term or past: abandon ideas that inhibit innovation, (iii) long term or future: convert innovative ideas into new products and businesses (Govindarajan, 2016). Under these two premises, the SVM allows exporting companies to prolong their long-term sustainability, while optimizing the company's performance and value in the short and medium term (Kotler, Caslione, 2010), since the model delivers certain values of [0 1] which is associated with low, medium, and high business sustainability.

The model uses the benefits of the FIS and ANFIS architecture. Both make use of the same input linguistic variable name, output variable, linguistic labels, universe range [0 1], trapezoidal function type, and fuzzy rules. But their three-dimensional surfaces are different, especially, the ANFIS surface has the smoothest transitions. Even though the training was with 110 data and 20 epochs, the error was 0.055. It is necessary to mention that the Neural Networks, which includes the Fuzzy Logic Toolbox, were not used, since it requires a larger training set (Díaz, et al, 2007).

The truth is that the VSM needs more use for the benefit of its adaptive network. This requires a training process with new export ecosystems, face-to-face interviews, and adapting its protocol to another language, since a critical point of view may require training with a larger number of data and a larger number of epochs. All of which will allow the ANFIS SVM algorithm to develop a better predictive scenario, the box of the future, for a goods exporting company; a scenario of the future that will allow the *stakeholder to* develop product innovation, new business models, new working methods, and higher productivity.

The other aspect to improve is the data capture in the HCDA scale. It is necessary that the interview be face-to-face, in order to achieve a better observation of the reality of the exporting company. Also, the values of the "Ideal Profile" could be improved by making them all value 1. But above all, the most delicate aspect is to synthesize the advanced digital skills and competencies in a few items, when the reality is that in the market there are dozens of disruptive technologies.

However, a synthesis was made based on the operational aspects of DT and the use of brands has been avoided, but it will be necessary to review and adjust the HCDA every five-year period.

Finally, SVM was used in a small number of companies in order to monitor, control, and calibrate the model. It was verified that Simulink is agile in delivering the sustainability value that adjusts to the reality of the company in question. Likewise, the simulator allows to deliver a predictive value of the output variable from data of the input variables, which allows to improve in an efficient and effective way the values in each work place through a better use of the DTs and the 4.0 strategy, an aid to the *stakeholder* that allows him to design a specific strategy to increase the values of the variables, better if use is made of the *Fuzzy-Delphi* and R^{+}-Expertones.

In conclusion, the overall objective was achieved. Because with the delivery of the SVM, we have validated a model that allows us to measure the sustainability of a company. Even through the simulator, we obtained results that are in line with reality. In other words, the model is useful for the *stakeholder* who has to make decisions regarding Industry 4.0, without the need to be precise. It is expected to be used in order to take care of the sustainability of the exporting company so necessary and useful in society, since the technological gap that drives the fifth industrial revolution (5IR) is a threat aimed at rendering obsolete the products or goods of the 3IR and 4IR. Future research may consider taking advantage of the results of the VSM and generating *fuzzy clustering* in the exporting sectors of a country.

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Annexes

Annex 1

Training, control, and validity set data

Item	VE_1	VE_2	VS_1	Item	VE1	VE2	VS1	Item	VE1	VE2	VS1	Item	VE1	VE2	VS1
1	0.35	0.55	0.30	51	0.96	0.13	0.50	101	0.38	0.64	0.58	151	0.76	0.15	0.50
2	0.27	0.45	0.00	52	0.89	0.35	0.50	102	0.82	0.16	0.50	152	0.18	0.81	0.50
3	0.15	0.33	0.00	53	0.71	0.65	0.70	103	0.22	0.40	0.00	153	0.11	0.91	0.50
4	0.51	0.37	0.38	54	0.75	0.62	0.57	104	0.14	0.46	0.00	154	0.31	0.56	0.07
5	0.75	0.13	0.50	55	0.73	0.67	0.80	105	0.85	0.92	1.00	155	0.05	0.33	0.00
6	0.91	0.17	0.50	56	0.70	0.70	1.00	106	0.56	0.65	0.70	156	0.25	0.47	0.00
7	0.63	0.31	0.16	57	0.78	0.67	0.80	107	0.54	0.84	1.00	157	0.39	0.73	0.96
8	0.41	0.48	0.50	58	0.92	0.96	1.00	108	0.43	0.73	1.00	158	0.26	0.62	0.07
9	0.43	0.77	1.00	59	0.61	0.36	0.35	109	0.58	0.77	1.00	159	0.46	0.32	0.13
10	0.49	0.90	1.00	60	0.35	0.35	0.68	110	0.39	0.61	0.50	160	0.16	0.72	0.60
11	0.18	0.29	0.00	61	0.35	0.81	0.80	111	0.99	0.29	0.50	161	0.27	0.53	0.00
12	1.00	1.00	1.00	62	0.25	0.77	0.50	112	0.79	0.31	0.50	162	0.07	0.13	0.00
13	0.00	0.00	0.00	63	0.46	0.58	0.50	113	0.75	0.69	0.92	163	0.42	0.79	1.00
14	0.10	0.31	0.00	64	0.62	0.39	0.47	114	0.15	0.75	0.50	164	0.33	0.83	0.69
15	0.05	0.05	0.00	65	0.72	0.37	0.50	115	0.36	0.56	0.34	165	0.98	0.81	1.00
16	0.12	0.51	0.00	66	0.82	0.39	0.50	116	0.14	0.45	0.00	166	0.69	0.59	0.50
17	0.25	0.25	0.00	67	0.27	0.69	0.42	117	0.37	0.42	0.38	167	0.49	0.77	1.00
18	0.45	0.45	0.50	68	0.41	0.74	1.00	118	0.56	0.35	0.30	168	0.45	0.48	0.50
19	0.35	0.35	0.18	69	0.65	0.31	0.24	119	0.51	0.31	0.07	169	0.55	0.85	1.00
20	0.50	0.50	0.50	70	0.95	0.27	0.50	120	0.78	0.65	0.73	170	0.35	0.51	0.30
21	0.76	0.28	0.50	71	0.66	0.49	0.50	121	0.95	0.27	0.50	171	0.35	0.68	0.66
22	0.81	0.19	0.50	72	0.76	0.85	1.00	122	0.66	0.49	0.50	172	0.63	0.26	0.11
23	0.91	0.19	0.50	73	0.81	0.89	1.00	123	0.76	0.85	1.00	173	0.71	0.69	0.92
24	0.94	0.37	0.50	74	0.21	0.91	0.50	124	0.81	0.89	1.00	174	0.22	0.69	0.42
25	0.99	0.29	0.50	75	0.38	0.68	0.79	125	0.21	0.91	0.50	175	0.54	0.46	0.50
26	0.79	0.31	0.50	76	0.55	0.33	0.19	126	0.11	0.84	0.50	176	0.61	0.36	0.35
27	0.75	0.69	0.92	77	0.25	0.47	0.00	127	0.36	0.22	0.00	177	0.35	0.56	0.30
28	0.65	0.67	0.80	78	1.00	0.73	1.00	128	0.05	0.33	0.00	178	0.25	0.25	0.00
29	0.32	0.56	0.13	79	1.00	0.33	0.50	129	0.25	0.52	0.00	179	0.70	0.70	1.00
30	0.34	0.45	0.25	80	1.00	0.12	0.50	130	1.00	0.73	1.00	180	0.78	0.67	0.81
31	0.37	0.42	0.38	81	0.66	0.52	0.50	131	1.00	0.33	0.50	181	0.42	0.46	0.60
32	0.56	0.35	0.30	82	0.69	0.59	0.50	132	1.00	0.12	0.50	182	0.85	0.16	0.50
33	0.58	0.21	0.00	83	0.49	0.77	1.00	133	0.66	0.52	0.50	183	0.45	0.71	1.00
34	0.78	0.62	0.57	84	0.45	0.48	0.50	134	0.71	0.42	0.50	184	0.66	0.45	0.50
35	0.11	0.84	0.50	85	0.55	0.85	1.00	135	0.21	0.37	0.00	185	0.15	0.75	0.50
36	0.19	0.96	0.50	86	0.35	0.51	0.30	136	0.41	0.81	1.00	186	0.27	0.53	0.00
37	0.67	0.71	1.00	87	0.81	0.31	0.50	137	0.31	0.91	0.57	187	0.07	0.13	0.00
38	0.81	0.21	0.50	88	0.11	0.47	0.00	138	0.35	0.68	0.66	188	0.42	0.79	1.00
39	0.91	0.31	0.50	89	0.73	0.57	0.50	139	0.63	0.26	0.11	189	0.33	0.83	0.69
40	0.31	0.81	0.65	90	0.50	0.59	0.50	140	0.50	0.58	0.50	190	0.98	0.81	1.00
41	0.41	0.71	1.00	91	0.38	0.81	0.92	141	0.55	0.50	0.50	191	0.18	0.61	0.03
42	0.35	0.68	0.66	92	0.37	0.75	0.88	142	0.15	0.50	0.00	192	0.21	0.69	0.42
43	0.63	0.26	0.11	93	0.71	0.69	0.92	143	0.89	0.15	0.50	193	0.11	0.29	0.00
44	0.45	0.57	0.50	94	0.22	0.69	0.42	144	0.70	0.45	0.50	194	0.38	0.68	0.79
45	0.05	0.45	0.00	95	0.54	0.46	0.50	145	0.29	0.31	0.00	195	0.55	0.33	0.19
46	0.15	0.55	0.00	96	0.59	0.71	1.00	146	1.00	0.45	0.50	196	0.25	0.47	0.00
47	0.89	0.15	0.50	97	0.70	0.79	1.00	147	0.41	0.34	0.25	197	1.00	0.73	1.00
48	0.70	0.45	0.50	98	0.15	0.37	0.00	148	0.65	0.31	0.24	198	1.00	0.33	0.50
49	0.29	0.31	0.00	99	0.14	0.57	0.00	149	0.55	0.27	0.00	199	1.00	0.12	0.50
50	1.00	0.45	0.60	100	0.35	0.00	0.00	150	0.66	0.45	0.50	200	0.66	0.52	0.50

Note: Light blue color: training data; Orange color: control data; Green color: validity data.

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G SUITE AS A SOLUTION IN COLLABORATIVE, ACADEMIC AND PROFESSIONAL WORK TOOLS

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Abstract. The wonders brought by innovations from cloud computing help collaborative productivity and work management processes, revolutionize the way we learn and work, mitigate boundaries, in addition to expanding services and reducing costs for companies and people globally. In this perspective, the objective of the present research is to present the G Suite functionalities as a productivity, storage and cooperation tool. In order to achieve the proposed objective, an investigation was carried out on the Google Docs application, understood as an essential tool in the creation, edition, management and sharing of office-type documents - office applications, which is part of the G Suite solution. This study was carried out exploring the Google Docs tool, as well as books, articles, websites, blogs and technical documents. The following was concluded, among other things: G Suite is a powerful and complex tool for productivity, storage and collaborative work, with Google Docs as its greatest exponent; the G Suite is the evolution of Google Apps, the latter representing free tools, including Google Docs; and, access to office type tools requires the user to have an active Gmail account.

Keywords: G Suite, Google Docs, Google Apps, Collaborative work.

G SUITE COMO SOLUÇÃO EM FERRAMENTAS DE TRABALHO COLABORATIVAS, ACADÊMICAS E PROFISSIONAIS

Resumo. As maravilhas trazidas pelas inovações a partir da computação em nuvem auxiliam nos processos de produtividade e gerenciamento de trabalho colaborativos, revolucionam a forma como aprendemos e trabalhamos, atenuam fronteiras, além de ampliarem os serviços e reduzirem custos para empresas e para pessoas à nível global. Nessa perspectiva, o objetivo da presente pesquisa é apresentar as funcionalidades do G Suite enquanto ferramenta de produtividade, de armazenamento e de cooperação. Para atingir o objetivo proposto, foi realizada uma investigação sobre o aplicativo Google Docs, entendido como ferramenta essencial na criação, na edição, no gerenciamento e no compartilhamento de documentos do tipo office – aplicativos de escritório, sendo este uma vertente da solução G Suite. Este estudo foi realizado explorando a ferramenta Google Docs, bem como livros, artigos, sites, blogs e documentos técnicos. Concluiu-se, entre outras coisas, o seguinte: (1)o G Suite é uma poderosa e uma complexa ferramenta de produtividade, de armazenamento e de trabalho colaborativo, tendo no Google Docs seu maior expoente;

(2)o G Suite é a evolução do Google Apps, este último representante das ferramentas de caráter gratuito, incluindo o Google Docs; e, (3)o acesso às ferramentas tipo office exigem que o usuário tenha uma conta Gmail ativa.

Palavras-chaves: G Suite, Google Docs, Google Apps, Trabalho colaborativo.

G SUITE COMO SOLUCIÓN EN HERRAMIENTAS DE TRABAJO COLABORATIVAS, ACADÉMICAS Y PROFESIONALES

Resumen. Las maravillas que traen las innovaciones de la computación en la nube ayudan a la productividad colaborativa y a los procesos de gestión del trabajo, revolucionan la forma en que aprendemos y trabajamos, mitigan los límites, además de ampliar los servicios y reducir los costos para las empresas y las personas a nivel mundial. En esta perspectiva, el objetivo de la presente investigación es presentar las funcionalidades de G Suite como una herramienta de productividad, almacenamiento y cooperación. Para lograr el objetivo propuesto, se llevó a cabo una investigación sobre la aplicación Google Docs, entendida como una herramienta esencial en la creación, edición, gestión y uso compartido de documentos de tipo office, aplicaciones de oficina, que forma parte de la solución G Suite. Este estudio se llevó a cabo explorando la herramienta Google Docs, así como libros, artículos, sitios web, blogs y documentos técnicos. Se concluyó lo siguiente, entre otras cosas: (1) G Suite es una herramienta poderosa y compleja para la productividad, el almacenamiento y el trabajo colaborativo, con Google Docs como su mayor exponente; (2) G Suite es la evolución de Google Apps, esta última representa herramientas gratuitas, incluidos Google Docs; y, (3) el acceso a las herramientas de tipo oficina requiere que el usuario tenga una cuenta de Gmail activa.

Palabras clave: G Suite, Google Docs, Google Apps, trabajo colaborativo.

Introduction

Cloud technology has revolutionized communication and transactional ways between individuals across borders. It enables collaborative work in a variety of ways, including the formation of high-performance remote work teams. It is not limited to this, of course, but encompasses functionalities that go beyond the business environment, through scientific academies and on to the individual working and/or studying alone. Regardless of the environment in which this technology is inserted, it is responsible for satisfying a diverse range of demands that extends from businesses to governments to individuals.

An appropriate conceptualization of cloud technology is that it is Internet-based computing in which shared resources (such as hard disks for storage) and applications are offered to multiple devices (such as a computer and/or PDA, for example) on demand, as a public utility (Turban and Volonino, 2013). In other words, it is the distribution of computing services-servers, storage, databases, networking, software, analytics, intelligence, and more-over the Internet, providing faster innovation, flexible resources, and economies of scale (Microsoft, 2018).

The idea of cloud computing is to store applications and information in the providers' data centers instead of on the company's local servers. This cloud concept refers to data sources stored outside the customers' internal network (Turban and Volonino, 2013). The concept of cloud computing is a type of RIA - Rich Internet Application,

which is nothing more than software that has the functionality and complexity of traditional application software but runs in a web browser and does not require local installation (Stair and Reynolds, 2011). Google Apps - redesigned as G Suite and the subject of this research -, for example, provides common business applications online, accessed via the web, while the software and data are stored on servers (Turban and Volonino, 2013).

The way in which this technology has emerged converges with the new labor and educational needs and realities that transform the means and methods of learning and the working relationships of individuals as a society. Coupled with the tangential advance of information, media, and technological tools that support decision making in increasingly complex and dynamic environments, these technologies are capable of transforming the way we communicate, learn, and work in such a way that distance becomes merely a negligible element. The move to cloud computing, especially provider-provided distributed hosting, is increasing with the introduction of new applications (Turban and Volonino, 2013). This means that these advances break traditional paradigms and open space for the new to emerge and reveal itself from emerging innovations, generating new paradigms.

For this research, the focus will be on the type of service known as SaaS -*software as a service*-, which is a method of distributing software applications over the Internet on demand and generally subscription-based (Microsoft, 2018; Turban and Volonino, 2013). In other words, SaaS is a type of solution dubbed software-as-a-service, in which cloud providers host and manage the software application, its underlying infrastructure, and perform maintenance, such as software updates and security *patches* (Microsoft 2018; Turban and Volonino, 2013). Access to this service is remote, and the user only needs to connect through the browser (Google Chrome, Mozilla Firefox, Safari, or Microsoft Edge, for example) from any device (computer, *tablet,* or *smartphone*, for example) connected to the internet. In the case of G Suite, the subject of this research, the target will be the free service provided by the company Google®, although the focus of this tool is directed, more explicitly, to the corporate branch.

Therefore, the object of inquiry of this research is: what is G Suite, how can it contribute to collaborative work, whether in the academic or professional environment? Pointing out that the main focus will be on the free version of this tool, although the payment option of this business technology solution will be detailed. Thus, the functionality of this integrated solution of technological resources will be presented, highlighting Google Docs as part of this solution and emblem of collaborative work, both academic and professional.

Methodology

This research is characterized as applied in nature, since its objective is to generate knowledge for practical application aimed at solving specific problems, involving local truths and interests (Prodanov and Freitas, 2013). From the point of view of the objectives, this study is characterized as exploratory because it aims to give more knowledge to the problem in order to make it explicit or build hypotheses (Gil, 1988 *apud* Bertucci, 2012). As for the technique used in this research, it is defined as a case study because it is an empirical research that ascertains a contemporary phenomenon within its real context, especially when the boundaries between the phenomenon and the context are not clearly defined (Yin, 2001 *apud* Prodanov and Freitas, 2013). Thus, the objective of this research

is to describe the use of the G Suite tool as a solution in collaborative, academic, and professional work.

To achieve this objective, the literature review as a structuring object of the foundation of the proposed topic focused on documentary research, consisting of the search for diverse information, both technical and qualitative, according to the reading of books, articles, specialized websites, blogs, and specific documents, for the purpose to analyze and interpret the existing paradigm (Bertucci, 2012). In order to develop the topic in alignment with the objective already qualified as exploratory, the present research was outlined in synchrony through the use of the technological tool G Suite, in order to test it. That is, this work was written entirely through the Google Docs application. The latter, being one of the essential tools that incorporates the platform of technological solutions for productivity, development, and collaborative work known as G Suite and offered by the company Google®.

It is worth noting the lack of informative sources on the subject, something that is noticeable even in the few manuals on the concept and its operation within the Google® site itself. Although technological themes and innovations have a habit of reaching the market at an ever-increasing speed, this does not mean that their potential for use can be fully exploited. This is something that happens, recurrently, with the use of free software - which has its shortcomings due to its defective or even nonexistent documentation (Amorim, 2015). It is in this sense that the present research conditions the possibility of discussing the use of this technological tool nicknamed as G Suite, describing its operation and disclosing its usefulness.

Results

Introductory procedures

Google® can be characterized as an Internet *Service Provider* (ISP) that provides individuals and organizations with access to a robust set of services. It has free and paid commercial and non-commercial services (Stair and Reynolds, 2011; Baltzan and Phillips, 2012). In other words, it is a service-oriented company with a complete infrastructure (servers, *storages*, *software*, *datacenters*). Web services encompass all the technologies used to transmit and process information over a network, more specifically the Internet (Baltzan and Phillips, 2012).

In the specific case of the object of this research, in order for the user to have access to the basic services offered by the Google® company, it is necessary to create an email account - specifically a Gmail account. This is the company's official email and is the basic procedure for the user to enjoy the set of productivity tools offered by the company. Once logged in, the user has access to a broad platform of services including office applications, storage, and collaborative work. For this research, in particular, G Suite as a platform of integrated solutions and Google Docs as a specific tool for collaborative work will be detailed. These technological tools are described below.

G Suite

G Suite can be defined as a suite of solutions in productivity tools (office automation) based on cloud technology, i.e. a diverse set of Google® products aimed at both businesses and individuals. It replaces the former Google Apps and has a set of web-based applications with features similar to traditional office suites, such as Microsoft *Office*® and Libre*Office*, for example. It contains a set of integrated online productivity

tools, such as email, calendar, *office*, storage, video calls, etc. Based on cloud technology, such a service is active 24/7 and can be accessed from anywhere, anytime, and from any device connected to the Internet (Wikipedia, 2018; Rhous, 2018).

G Suite offers cloud storage solutions, productivity tools, and collaborative work, being a diverse set of applications (software) developed by Google® with very popular free versions, such as Gmail, Google Drive, and Google Docs, for example, in addition to the paid version, which accumulates a set of additional features oriented to commercial use. The commercial G Suite trial is free for 14 days. After that, the most basic service package is paid and has a fee of $6 per user/month (Wikipedia, 2018; Rhous, 2018). The prices of the service packages are illustrated in Figure 1.

PACOTE	Basic	Business	Enterprise
PREÇO	R$24,30 por usuário/mês	R$48,60 por usuário/mês	R$112,00 por usuário/mês
SOLUÇÕES	e-mail comercial	e-mail comercial	e-mail comercial
	videoconferência e chamada de voz	videoconferência e chamada de voz	videoconferência e chamada de voz
	mensagens	mensagens	mensagens
	agenda	agenda	agenda
	pacote of ce	pacote of ce	pacote of ce
	30gb de armazenamento na nuvem	desenvolvimento de aplicat vos	desenvolvimento de aplicat vos
	suporte 24 horas, 7x7	armazenamento na nuvem ilimitado	armazenamento na nuvem ilimitado
	controle de segurança e administração	suporte 24 horas, 7x7	suporte 24 horas, 7x7
		controle de segurança e administração	controle de segurança e administração
		recurso e-discovery	recurso e-discovery
		def nição de polít cas e relatórios de auditoria	def nição de polít cas e relatórios de auditoria
			prevenção, hospedagem, integração, controle, análise

Figure 1. G Suite pricing by package type
Note: Source: Google® (2020).

On the other hand, the non-commercial version (the most popular) is completely free and offers a solid range of office tools, cloud storage, and collaborative work solutions. The entire suite of applications including search engine, email, calendar, storage, video calling, translator, GPS, and blogging are offered for free up to the 15gb storage limit (Google, 2020). Beyond this limit, Google® charges a fee as shown in Figure 2.

PACOTE DE SERVIÇOS	
ARMAZENAMENTO	PREÇO
15gb	Gratuito
100gb	R$6,99/mês
200gb	R$9,99/mês
2tb	R$34,99/mês
10tb	R$349,99/mês
20tb	R$699,99/mês
30tb	R$1049,99/mês

Figure 2. Price according to the storage to be contracted.
Note: Source: Google® (2020).

To access the package of free services offered by the company, reinforcing what has already been said, the user must create a Gmail account. From a valid username and password, the user has access to all the most basic tools that support productivity, storage, and collaborative work, as already specified. Below we will summarize some of these main tools mentioned that make up the free service package.

Basic tools and Google Docs

From a valid email, when logging into the system, the user can avail a wide range of free and integrated services in a single platform, including connection tools (Gmail, Calendar, Google+, Hangouts Chat, and Hangouts Meet), creation (Google Docs, Google Forms, Google Sites, and Blogger), and access and storage (Google Drive). The system interface is quite intuitive and user-friendly, being easy to use (Botacim and Athayde, 2018).

When it comes to collaborative work, for example, the user can count on tools that will allow an excellent level of information flow, such as chat and video conferencing through the Hangouts application. In it, it is possible to combine voice, video, and audio transmission, reducing steps with travel and time, increasing efficiency in management communication through quick responses, access to more people, and less duplication of efforts due to geographically dispersed locations (Stair and Reynolds, 2011). Figure 3 illustrates some of the designs of some of the G Suite tools.

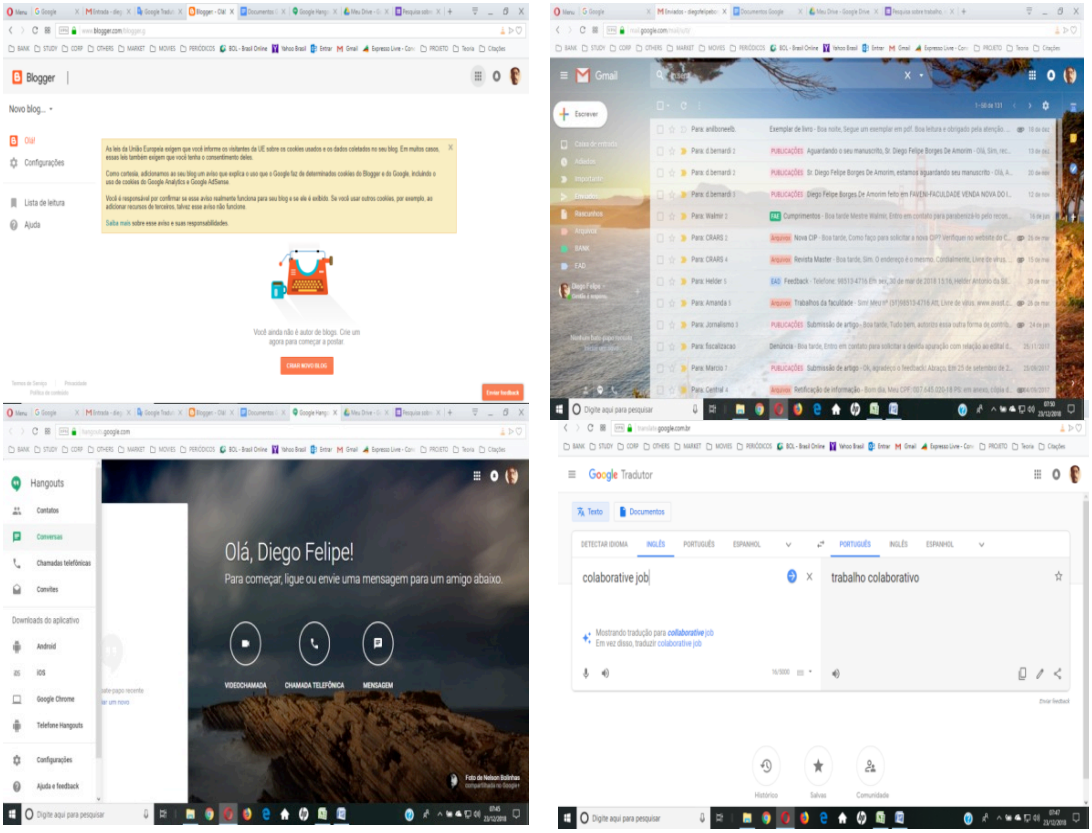

Figure 3. Home pages of some Google Apps tools.
Note: Source: the author.

Google Docs, on the other hand, can be identified as the application most inclined to collaborative work, as it brings together a suite of productivity software such as documents, spreadsheets, forms, and presentations. It is considered a shareable workspace where authorized project members and colleagues can share documents, problems, templates, spreadsheets, photos, and other forms of information to keep up to date on project status or topics of common interest (Stair and Reynolds, 2011). For logical reasons, this optimizes work time and space constraints, facilitating the collaborative creation, organization, sharing, and management of this information. Figure 4 illustrates the concept presented.

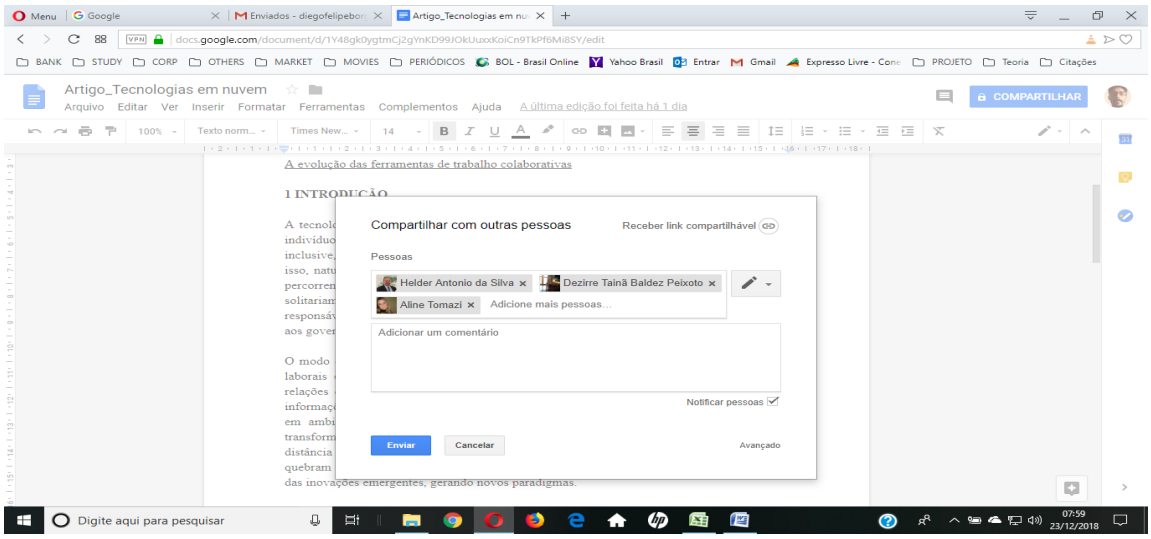

Figure 4. Layout of the Google Docs tool with sharing option.
Note: Source: the author.

By using Google Docs, the user has a complete basic tool for creating, storing, and sharing files in the different possible recording formats, which are compatible with the most traditional commercially available *office* programs, such as Microsoft *Office*® and Libre *Office.* Perhaps the most obvious perceived advantage, among all those already presented, is the possibility of having access to the file on different mobile devices, such as *notebooks, tablets, and smartphones*, as long as the file in question is stored in cloud technology and there is an Internet connection. On the other hand, the clearest disadvantage is the need to be online, since in offline mode there is no possibility to access the files stored in the cloud technology. When connected, the files are automatically opened and saved in the Google Docs application.

Web applications, collaboration and education environment

Online *office-type* applications - word processor, spreadsheet, and presentation creator - make it possible to create, edit, collaborate, and share documents over the Internet, which was previously only possible on the computer (Jorge, 2009). If in the past there were only two options: developing or acquiring the technology, there is now a third option: renting it through a permanent service base (Turban and Volonino, 2013). This leads to the encounter of cloud computing or cloud technology, which provides greater computing capabilities, such as web services that encompass all technologies used to transmit and process information through a network, more specifically, the Internet. (Baltzan and Phillips, 2012; Turban and Volonino, 2013).

In this sense, Google Docs can be identified as a collaborative system, since it allows its users to create, edit, manage, and share documents. A collaborative system is a set of IT-based tools that support the work of teams by facilitating the exchange and flow of information (Baltzan and Phillips, 2012). It has the power to solve various specific tasks such as business or non-business, academic tasks, online meetings, remote projects, etc. (Jorge, 2009; Baltzan and Phillips, 2012; Turban and Volonino, 2013). Another suitable definition says that it is a workgroup application, which is designed to support group work whether people are in the same location or globally dispersed (Stair and Reynolds, 2011).

This type of tool is very useful in the development of collaborative work (Jorge, 2009). Users can create, edit, manage, and share documents. As the content is stored on the Internet (cloud), it will be accessible to the users of the work group at any time and place. Specifically, within the Google Docs application, it is possible to define access parameters (Jorge, 2009; Botacim and Athayde, 2018), i.e., the owner member can define the level of participation of each project member, for example. Each time a group member contributes, it is possible to follow the modifications - Figure 5 - made to the work from the "version history."

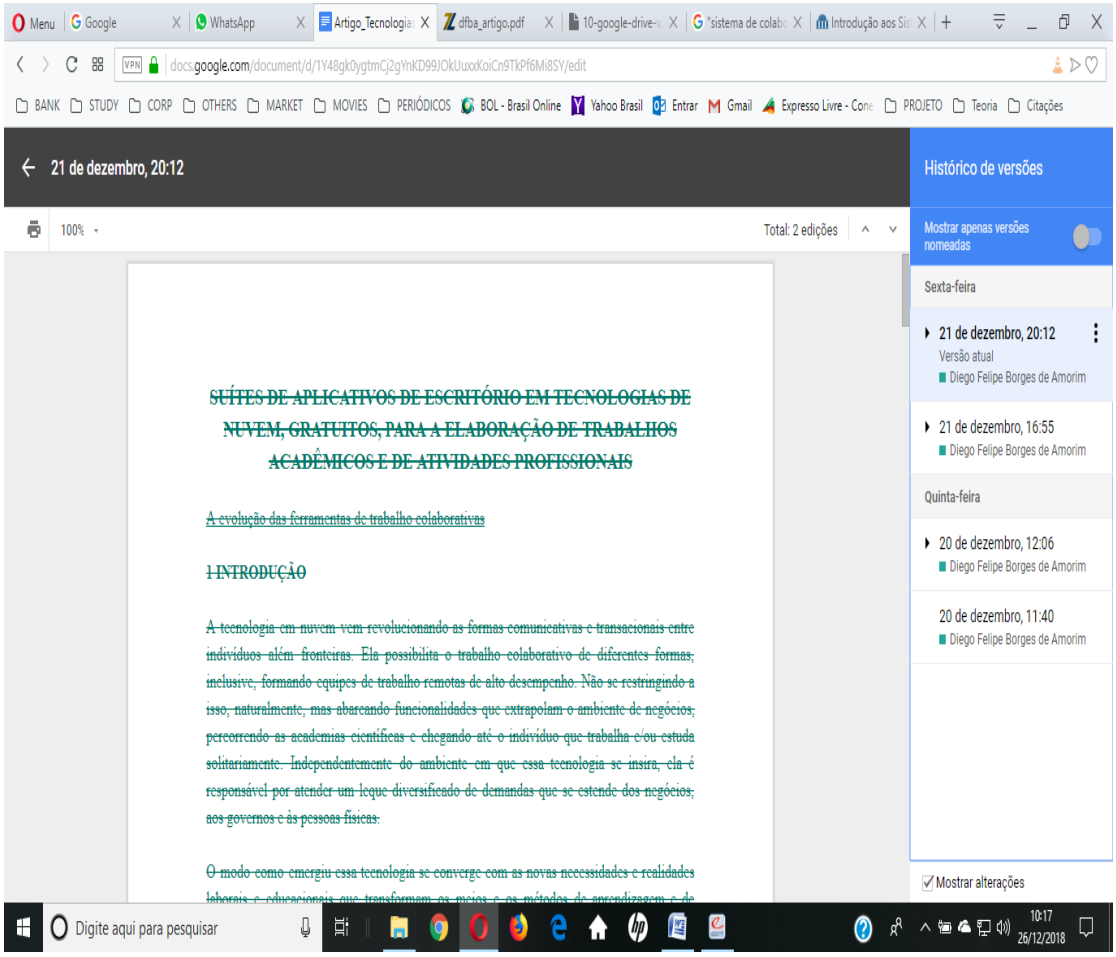

Figure 5. Version management within the Google Docs application.
Note: Source: the author.

The tool keeps track of the versions edited by each member of the working group, and the contributions of the participants are identified by color. Thus, the teacher can monitor the progress of the work and know the contribution of each student (Jorge, 2009). The moderator user (in the case of a teacher, for example), has the possibility of creating evaluation parameters according to the individual contribution of the working group. Each edited contribution to the project (document) is automatically saved by the system and can be retrieved at any time and place through a hyperlink generated by the application itself. Of course, in the case of individual use, the user will perceive the evolution of his work in the same way, because the platform is aimed at both collaboration and individual use by a student or an employee of a company.

The Google Docs package, although with less functionality than traditional software, has a constant updating of the tool, providing it with more and more themes,

options and features (Jorge, 2009). Moreover, an increasing number of software applications rely on online connections to support group documents and information sharing (Stair and Reynolds, 2011). Google® advances innovation in online services by creating robust and diversified web applications, including the sharing of documents, spreadsheets, presentations, calendars, and notes between workgroups. At the educational level, the tool can be used by a group of students working on a common project involving the creation of one or more types of artifacts: documents, spreadsheets, or presentations (Jorge, 2009).

Google Docs is an excellent tool for preparing texts, spreadsheets, and presentations, which can be prepared individually or collectively. Being able to become a collaborative space, the application favors collective work, providing advantages that can be used in an educational and professional context, as mentioned above. With an Internet connection, document creation, editing, management, and sharing are guaranteed. The secret of the success of cloud computing, among other things, perhaps lies in the fact that it maintains a virtuous circle of information that can be accessed anytime, anywhere. And sharing produces experiences capable of promoting ideas and solutions for the most diverse paradigms.

Therefore, the trend of cloud computing responds to the new global realities of learning, which require the insertion of various technologies in the educational process (Jorge, 2009; Stair and Reynolds, 2011). With distance learning programs and systems, teachers can easily create course *homepages* on the Internet. Students can access the list of course topics and books and the instructor's notes on the homepage (Stair and Reynolds, 2011). These are productivity web applications, videoconferencing, e-mails, discussion forums, chats, blogs, social networks, etc., that enhance learning processes and knowledge construction. Teaching and learning strategies that emphasize the importance of collaborative knowledge construction require tools that facilitate the collective production of artifacts in real time and in different places (Kasielewska, 2008 *apud* Jorge, 2009).

Discussion and conclusions

The purpose of this research is to describe the functionality of the G Suite web tool as an integrated application solution for connecting, accessing, creating, and controlling productivity and collaborative work. It focuses on the presentation of the Google Docs application as a tool oriented to cooperative work, both academic and professional. To do this, we followed a path that started with a brief explanation of G Suite and continued in more detail with Google Docs and its contributions to collaborative and educational environments. The elaboration of this study was structured on the restricted material available on the subject and on the use of the application, object of investigation of this research, by this researcher. Reinforcing that it was carried out exclusively within the web application called Google Docs, both for the construction of the text, as well as for the composition of the spreadsheet in which the tables and figures that make up this article were created.

It is understood that the objective of the present investigation has been fulfilled. Therefore, we conclude the following: (1) G Suite is a powerful and complete package of web services oriented to companies, so the products that make up this integrated solution can be customized according to the desired contracting. (2) Google Docs is a G Suite tool, being the most oriented to collaborative work, from the creation, editing, management, and sharing of documents with various recording extensions. (3) G Suite is the evolution

of Google Apps, reinforcing its commercial nature. However, the use of productivity, storage, and collaborative work applications can be accessed for free with some limitations as long as the user creates a Gmail account. (4) Google Docs is an excellent collaborative work tool with an intuitive and simple layout. Although its functionality is modest, it provides what is necessary to carry out work with minimum standards to be followed. On the other hand, it provides the advantage of having several integrated support tools, such as Gmail, Google Forms, Google Drive, Google Translator, and Google Hangouts. (5) This integration and conformity of solutions creates value in learning, education and work processes, collaborative or not. Google Docs becomes an environment for knowledge construction, management, and sharing, oriented to innovation. (6) A possible disadvantage of using cloud computing is the dependence on a continuous Internet connection. These applications cannot be accessed offline and that includes Google Docs.

As the evolution of technologies is becoming faster and more complex, and cloud computing is already a reality that should be better explored, we recommend an in-depth study of the other tools that make up the G Suite or those of the competition, such as Microsoft® Office Online, for example. Something that could be better explored, in addition, is the Google Classroom tool, since it is offered completely free of charge on the Google® portal. This could be a very relevant topic if refined with practical applications of successful cases in the implementation of these educational support tools.

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DEVELOPMENT OF A COMPREHENSIVE SYSTEM OF MATRICES OF THE MARKETING ENVIRONMENT FOR DECISION MAKING AND THE CONTRIBUTION OF THE GROWTH OF SMALL AND MEDIUM ENTERPRISES (PYMES) IN THE REGION OF TEGUCIGALPA, HONDURAS

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Abstract. In Tegucigalpa, Honduras, the PYMES sector is an economic engine due to its proven ability to generate employment and for its contribution to the economy, in general. (INE, 2017). On average, 90% is made up of micro and small companies and only 10% of medium-sized companies. The main objective was to develop an integrated model of strategic matrices for the PYMES of the Central District, Honduras; that allows influencing in optimizing the decision-making of its main managerial indicators. The hypothesis to be demonstrated was whether an integrated model of strategic matrices of the Marketing environment helps decision-making, and allows the organizational growth of PYMES. The research was descriptive in scope, with a type of non-experimental cross-sectional research, the independent variable was an integrated model of strategic matrices of the Marketing environment and the dependent variable growth or business potentialization in PYMES. For the study, the universe of 10,000 PYMES in Tegucigalpa was considered, taking the sample of 155 companies selected using the simple random technique. It was determined how PYMES analyze their environments, be it the macro environment and micro environment, through a system of 6 strategic matrices. The system was developed in a company where the implementation of the matrices demonstrated different strategies, which, depending on the results, can contribute significantly, in how SMEs can face their competitive environment in all areas and the possible solutions both to Short, medium and long term. The work was carried out for the Doctorate in Projects of the Universidad Iberoamericana, with an agreement with Funiber.

Keywords: Strategy, Strategic matrices, environments, PYMES

DESARROLLO DE UN SISTEMA INTEGRAL DE MATRICES DEL ENTORNO DE MARKETING PARA LA TOMA DE DECISIONES Y EL APORTE DEL CRECIMIENTO DE LA PEQUEÑA Y MEDIANA EMPRESA (PYMES) EN LA REGIÓN DE TEGUCIGALPA, HONDURAS

Resumen. En Tegucigalpa, Honduras el sector PYMES (Pequeña y Mediana empresas) son un motor económico por su capacidad comprobada de generar empleo y por su aportación a la economía, en general. (INE, 2017). En promedio el 90% está compuesto entre micro y pequeñas empresas y tan solo un 10% de medianas empresas. El objetivo principal fue desarrollar un modelo integrado de matrices estratégicas para las PYMES del Distrito Central, Honduras; que permita incidir en optimizar la toma de decisiones de sus principales indicadores gerenciales. La hipótesis a demostrar fue si un modelo integrado de matrices estratégicas del entorno del Marketing ayuda a la toma de decisiones, y permite el crecimiento organizacional de las PYMES. La investigación fue un alcance descriptivo, con un tipo de investigación no experimental de corte transversal, la variable independiente fue un sistema integrado de matrices estratégicas del entorno del Marketing y la variable dependiente crecimiento o potencialización empresarial en las PYMES. Para el estudio se consideró al universo de 10,000 PYMES en Tegucigalpa, tomando la muestra de 155 empresas seleccionas mediante la técnica aleatoria simple. Se determinó como las PYMES analizan sus entornos, ya sea el macro entorno y micro entorno, mediante un sistema de 6 matrices estratégicas. El sistema se desarrolló en una empresa donde la implementación de las matrices demostró diferentes estrategias, que, dependiendo de los resultados, puede aportar de manera significativa, en como las PYMES, pueden afrontar su entorno competitivo en todas las áreas y las posibles soluciones tanto a corto, mediano y largo plazo. El trabajo fue realizado para el Doctorado en Proyectos de la Universidad Iberoamericana, con convenio con Funiber.

Palabras clave: Estrategia, Matrices estratégicas, entornos, MIPYME

Introduction

SMEs in Tegucigalpa, Honduras, and throughout the world are categorized as engines that energize the economy in every way, in turn, at least in Honduras. They have not been studied as it should be, although large companies at some point began as SMEs. They are not given relative importance they should have; the truth is that this sector of commercial and productive infrastructure, travel an arduous road with many difficulties to face every day.

Marketing is not indifferent to this commercial activity; however, due to the lack of resources, MSMEs operate in an artisanal or wild manner or in other words, without a professional or methodological sense, without the necessary studies and knowledge to be able to compete in a better way and therefore operate in the long term. The capital is the backbone of the country's submerged economies, which generates employment and cash flows, making Tegucigalpa increasingly attractive to investment. By identifying strategic marketing variables according to the different environments in Honduras, models will be provided to generate strategies to compete and thus help generate profitability.

The objective of the study was to develop an integrated model of strategic matrices for SMEs in the Central District, Honduras. The different marketing environments were taken as factors, as well as other models such as Porter's five forces, SWOT matrices, and micro and macro environment variables.

Background

According to the criteria of Barba and Martínez (2006), cited by Guevara, (2016) who point out that the birth of new companies can be grouped under perspectives attributed to the entrepreneur, based on the importance of generating diverse relationships to organize their businesses or companies.

According to González (2014), the genesis of MSMEs is considered to have arisen in two ways: The large company, one that has a stable structure and organization and the other that is of a family nature and seeks its permanence in the market.

Kerkhoff, (2012) in his study Competitiveness of MSMEs in Honduras explains that, despite the different initiatives to support micro, small, and medium-sized enterprises in Honduras, it is evident that these efforts are not clearly linked to a policy framework for the country's development in general, nor to the competitiveness of the business sector in particular.

According to Ochoa (2016) there are a total of 1,578 medium-sized enterprises in Honduras, covering the production of food, beverages and tobacco, textiles and clothing, wood and furniture, metalworking and chemicals, rubber and plastics. With respect to the collection of information, despite the fact that there is not enough baseline information, there is clarity in the definitions regarding MSMEs in Honduras, as evidenced by the organizations that have collected information on this topic over the years.

Specifically in studies carried out in Honduras, one on the competitiveness of the business sector, Cevallos (2008) quoted by Amaya (2015) indicates that SMEs have been increasingly the subject of numerous investigations and analyses, both in industrialized and developing countries. Their progressive importance in the economic growth process of countries is mainly due to the employment they generate in a context where two situations coexist.

According to Kerkhoff (2012), MSMEs play a fundamental role in the subsistence and development of the country. However, this situation has changed over the course of the last decades of the last century, as the sector went from representing a poverty survival mechanism to being a business segment that fights poverty. Kerkhoff (2012) states that in the seventies and eighties, not much importance was given to the formulation of the MSMEs' situation in Honduras.

For Amaya (2015), the Honduran small businessman continues to be the basis of the economy; more than 70% of the employment generated in the country is the product of micro, small, and medium-sized enterprises that already a total -only in the transformation area- of 170,000 organizations that contribute more than 30% of the country's GDP.

In a study published by Orueta (2016) according to the Law for the Promotion and Development of the Competitiveness of Micro, Small, and Medium Enterprises. Small enterprises are defined as those that have a better combination of productive factors and commercial positioning, which allow the business unit to accumulate certain surplus margins, have a more defined business organization than microenterprises, and greater formalization in their management and registration.

On the other hand, there are authors who have contributed to the growth of marketing theories in order to have a better understanding of the subject. In 1914, Professor Lewis Weld presented the research "Market Distribution" at the American Economic Association, a work that has been considered the first scientific research in

marketing Bartels, (1988). In 1914, Butler defined marketing as a combination of factors, a work of coordination, planning, and administration of the complicated relationships that a distributor must consider before carrying out his campaign Bartels, (1988).

Alexander in his book Marketing (1940), quoted by Munuera Alemán (1992, p. 130), lists the following functions: Merchandising, Buying, Selling, Standardization, Risk, Concentration, Financing, Control, and Storage.

Porter (1991) cited by Estrada Sánchez and Vargas-Hernández (2015) mention that understanding the concept of competitiveness in its full dimension is important, given its value in explaining and addressing the problems posed by the creation of the factors required for development processes to be viable in underdeveloped economies, or at least for some sectors to grow.

Method

A quantitative research was conducted, which as evidenced by (Sampieri, 2014) "in quantitative studies data collection is used to test hypotheses, based on numerical measurement and statistical analysis, to establish patterns of behavior and test theories" a descriptive scope, with a non-experimental cross-sectional design, where the variables were *integrated system of strategic matrices of the Marketing environment,* as independent, *Growth or business potency in SMEs* as dependent. The sample was probabilistic, simple randomized, and according to the results of the sample size calculation, the instruments were applied to 155 SMEs in Tegucigalpa, Honduras.

The instrument used was a structured questionnaire created by the author in order to supply variables to feed the different matrices, filled out by the owners, administrators, or managers of the companies, it consisted of several parts to be developed, the first focused on determining general descriptive aspects, such as seniority, gender, academic level, position of the interviewee, number of employees, and the category to which it belongs.

The second section of the instrument collected information on the dependent and independent variables, with emphasis on collecting the variables of the micro environment to determine the known weaknesses and strengths, as well as those of the macro environment to identify opportunities and threats of the competitive environment.

A pilot test was carried out to validate the instrument, which represented 15 companies representing 10% of the sample, with a statistical coefficient of 0.943 reliability as a result, which was considered correct, in order to continue with the study as a whole. For the analysis of the general information, frequency tables were used, using the SPSS program version 24.

Hypothesis

The hypothesis proposed for the research was: *An integrated system of strategic matrices of the marketing environment helps decision making, and allows the organizational growth of SMEs.*

Results

It was observed that of the total number of SMEs interviewed, 50.32% represented owners, 29.03% administrators and 20.65% managers, which gave a good indication of good criteria, since they are the ones who concretely manage the availability of company resources. All of them represent 38.06% with permanence from 1 to 3 years and 34.19% from 4 to 8 years and 27.74% 9 years or more. The average age with 42.58% is from 26 to 35 years, which is considered a young population, 18.06% the age is 18 to 25 years, and from 36 years and older is 39.35%, which represents an equitable distribution of the ages.

The educational level had interesting results, observing that 56.77% of the interviewees have undergraduate studies, which is considered very good given the skills needed to manage a business, 24.52% have high school, 16.77% have postgraduate studies, and only 1.94% have barely completed elementary school.

In the business gender, 60.65% are headed by men and 39.35% are headed by women.

On the other hand, 47.10% had 1 to 5 employees, 21.29% had 5 to 10 employees, 14.19% had 10 to 15 employees, and 17.42% had more than 15 employees. In terms of the sectors interviewed, the highest percentage was credited to the commercial sector with 41.29% and the service sector with 28.39%, followed by 19.35% of the food sector, but we tried to have a representative sample of all sectors, 51.61% are sole traders, 23.23% represent 23.23%, and 25.16% represent Limited Liability Companies, that is to say, the sample represents fully constituted SMEs.

The 32.90% of the sample said they did not know that whether their company or business was centralized or decentralized, 41.29% said it was centralized and 25.81% decentralized. It is observed that the model generates confidence in the people interviewed, as seen in previous analyses, the majority are the owners, and only a small number do not feel confidence in the model with 2.58%. It is observed that the managers of SMEs believe that the implementation of the strategic matrix model would improve their business, only a small 1.29% consider that it would not contribute anything to the management of their business, hence there is a good acceptance of the model.

In order to have a clearer picture of the data obtained, this section presents the crossing of variables of the main general data, with the main findings.

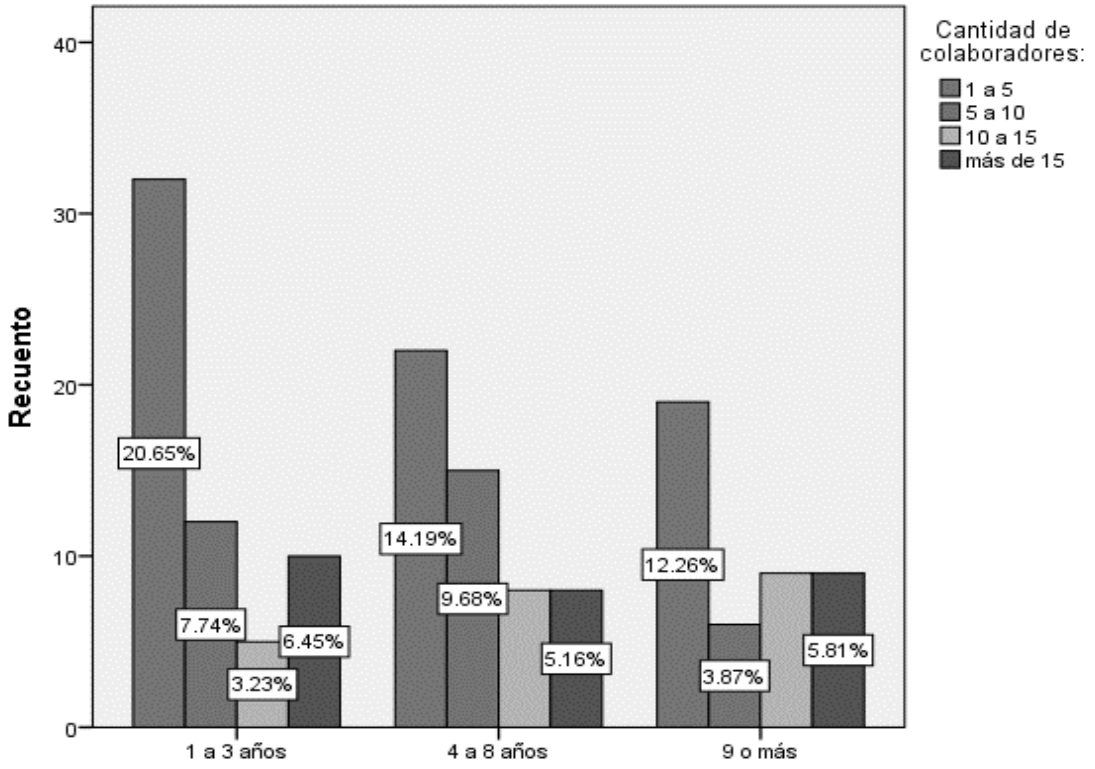

Figure 1. Crossing of variables number of employees with years of permanence in the company

Note: It can be observed that in the three levels of the range of years of permanence, the companies have from 1 to 5 collaborators. An interesting fact is to see the companies with a duration or more than 15 years, they are represented in the companies with permanence from 1 to 3 years and in the case of 5 to 10 collaborators, it is maximized in the companies with 4 to 8 years.

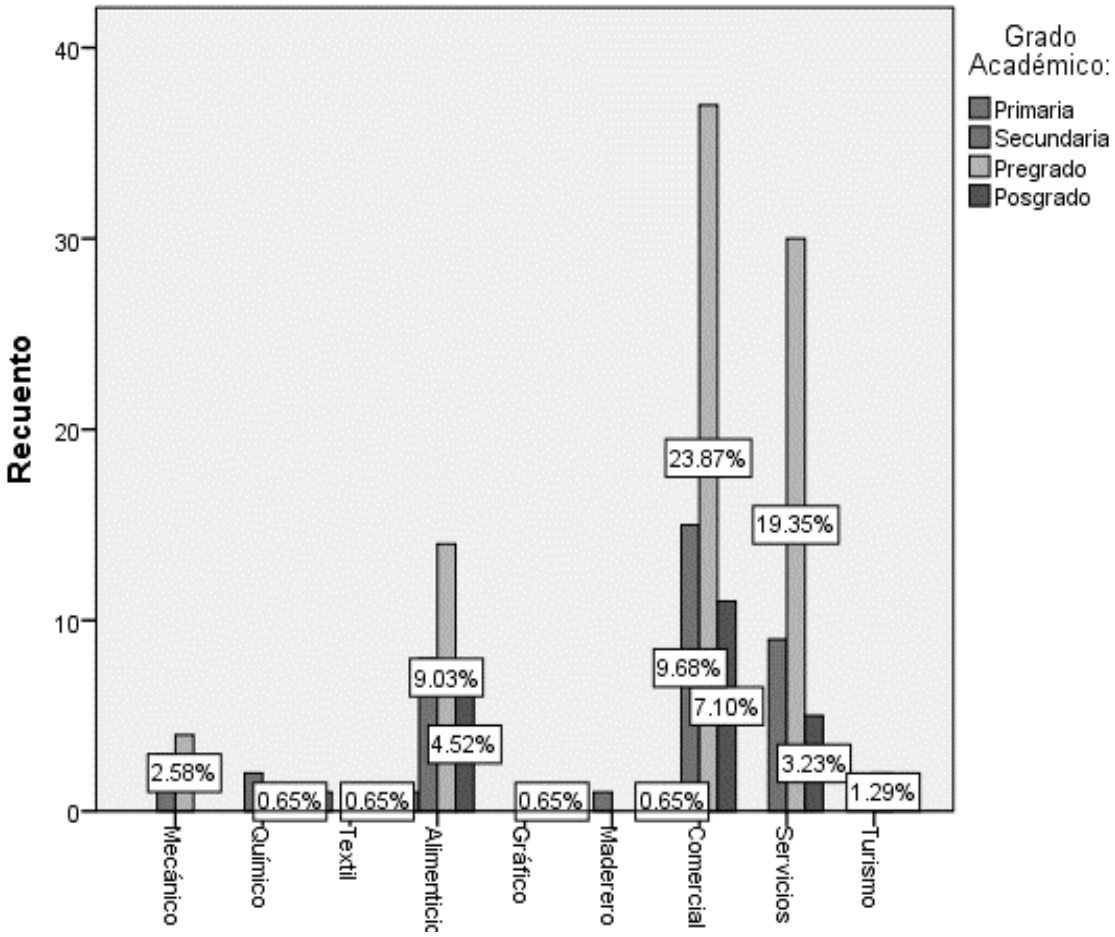

*Figure 1*Crossing of academic degree variables with productive sector

Note: This crossover clearly shows that the commercial sector is managed by management personnel with undergraduate degrees, as is the service sector and also the food, commercial, and service sectors are managed by personnel with Master's degrees and possibly even doctorates.

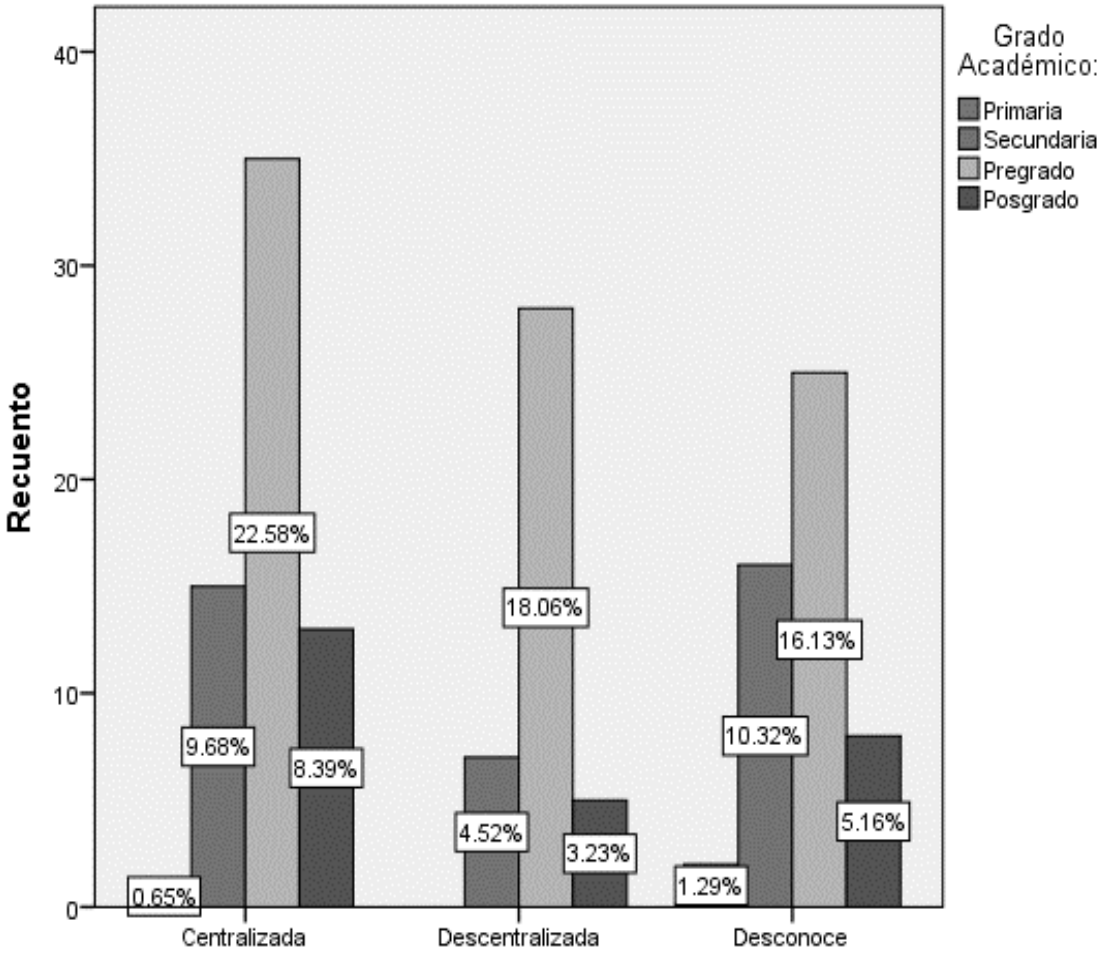

Figure 3. Crossing of academic degree variables with the type of company.

Note: The importance of this crossover lies in the fact that the degree of centralization and decentralization is high in the area of undergraduate, high school, and even doctorate, and as expected in those who had only completed elementary school.

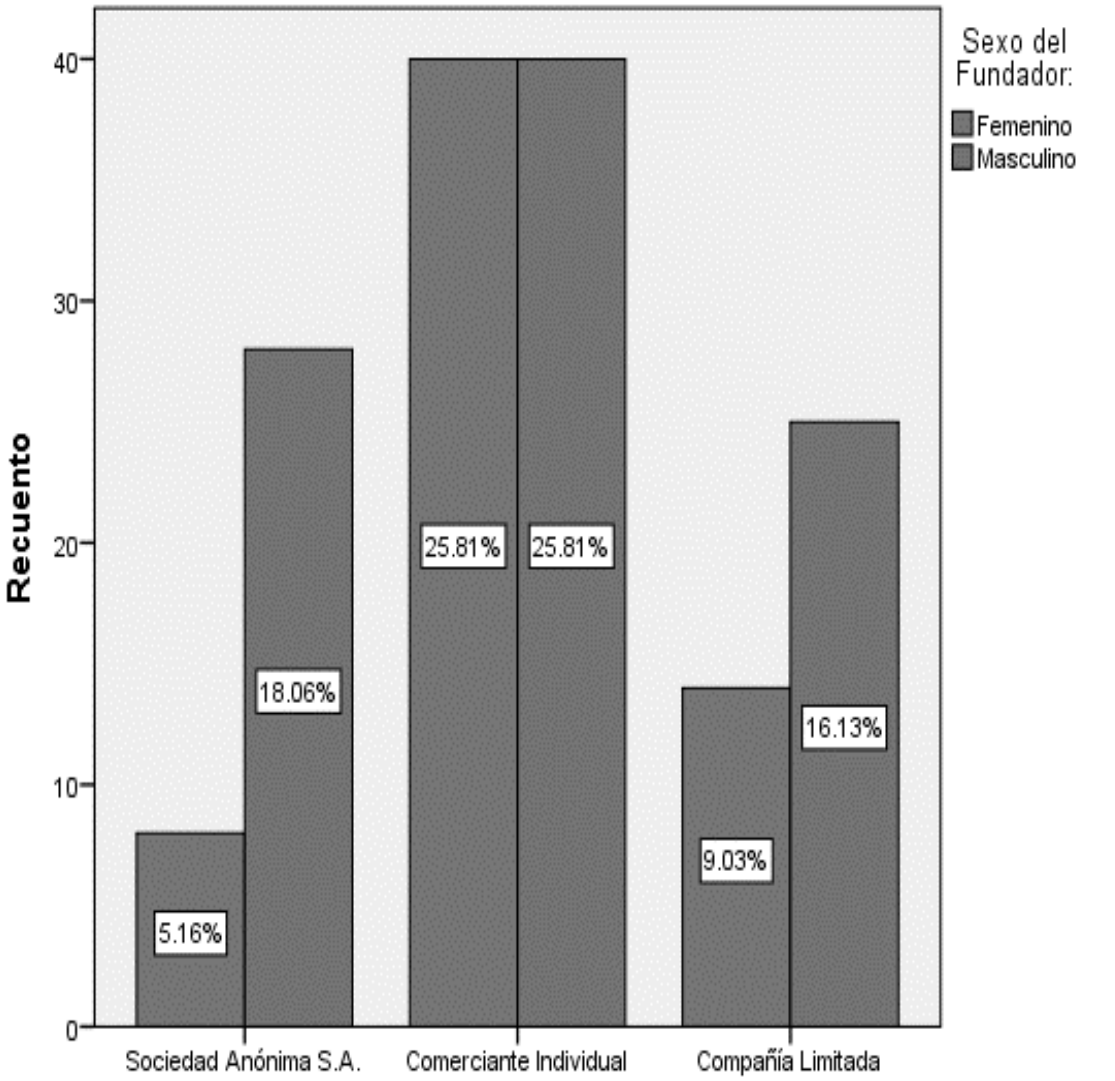

Figure 4. Crossing of founder's gender variables with the type of organization

Note: It was found that the male sex constituted more Corporations in the SME sector, the same trend is maintained in the Limited Liability Company sector, the interesting thing is that in both sexes the trend is even to be constituted as a sole trader with 25.81% for both sexes.

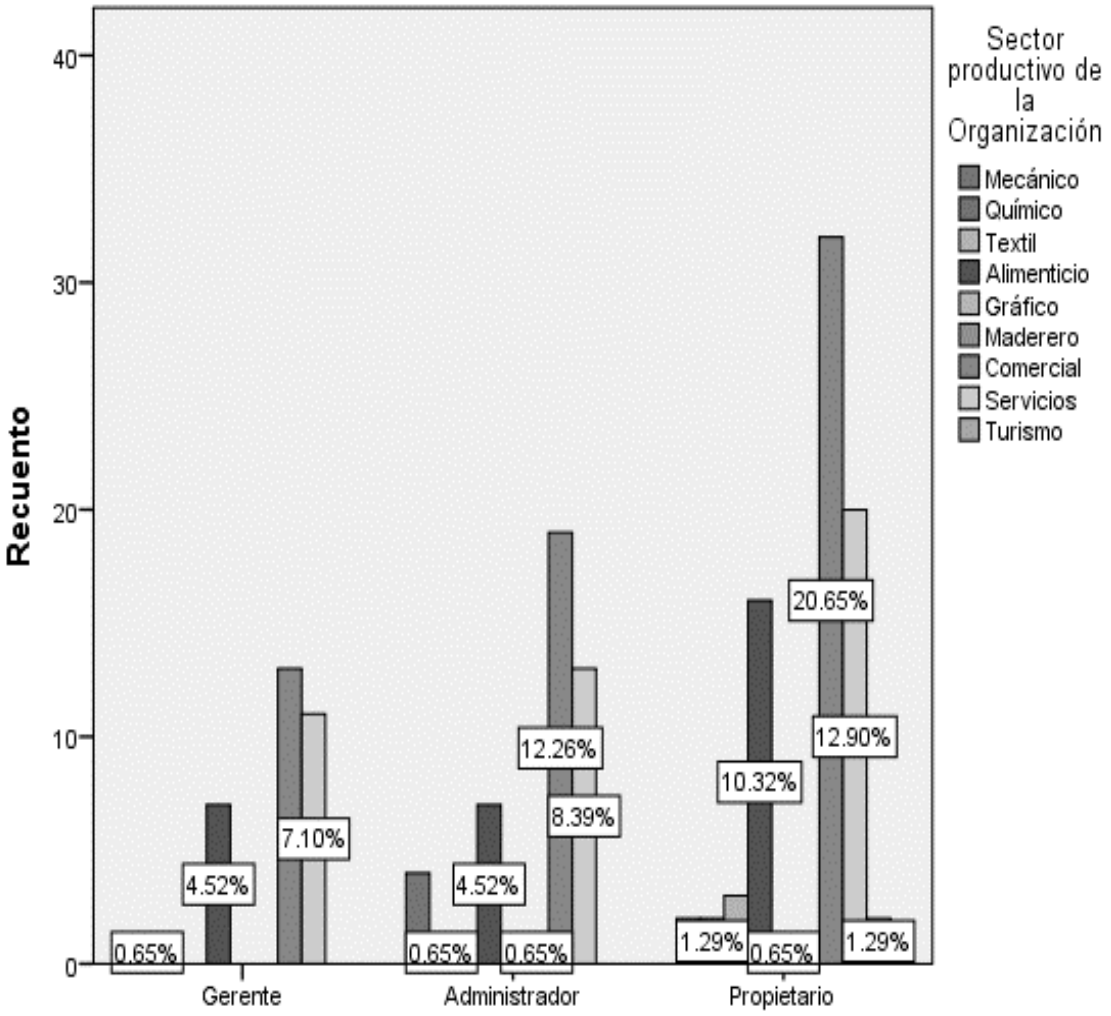

Figure 5. Crossing of productive sector variables with the interviewee's position

Note: It was found that the commercial sector is the most identified sector for managers, administrators, and owners, in second place was the service sector, and in third place was the food sector, an interesting fact is that a high percentage of the interviews were conducted with the owners of SMEs, which generates veracity in the information obtained.

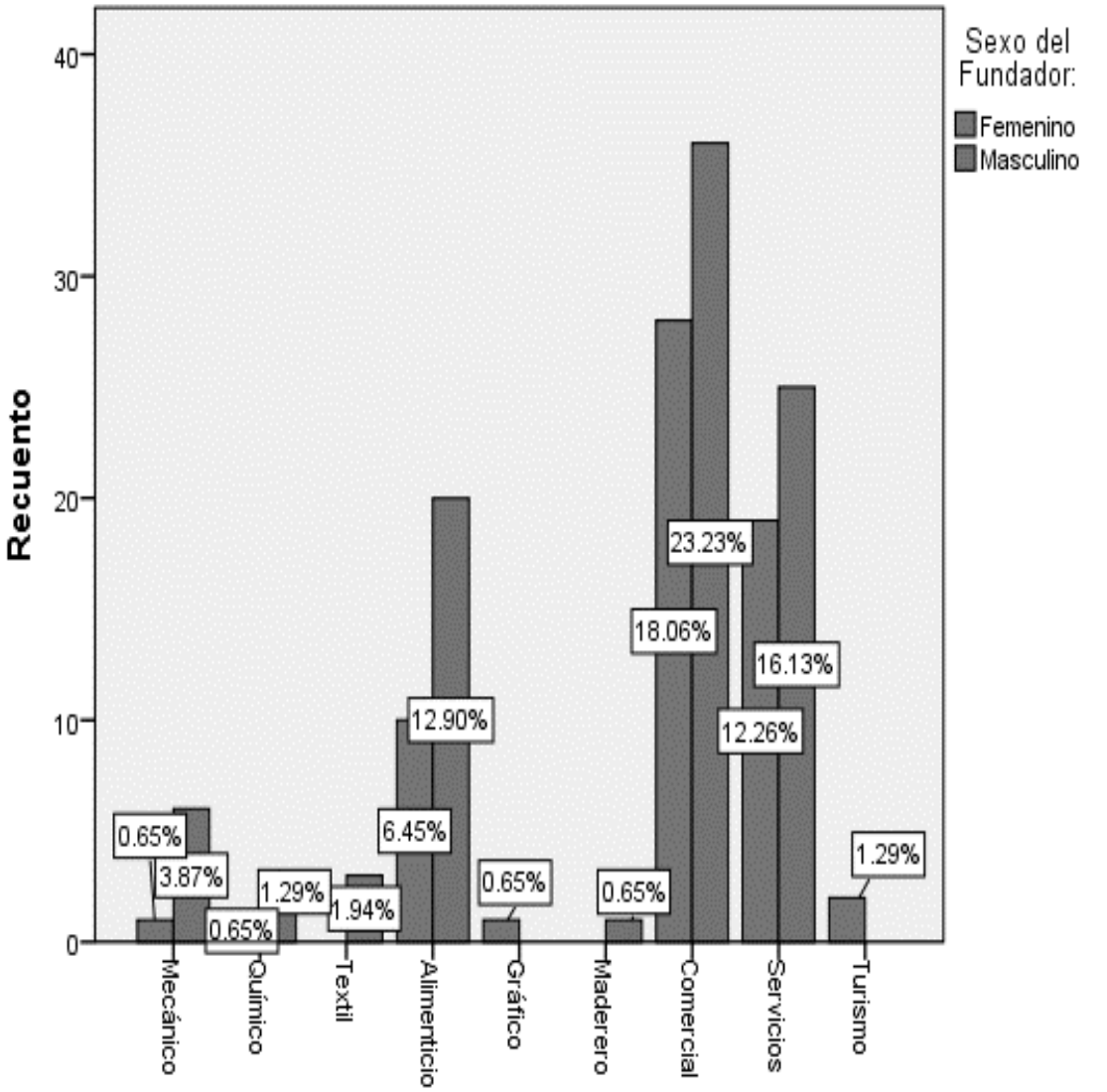

Figure 6. Crossing of founder's gender variables with productive sector

Note: The male sector stands out in the founding of companies in the different productive sectors, only in the chemical sector, graphic design, and tourism the sex of the founder is female, but there is an important participation in the commercial, food, and service sectors.

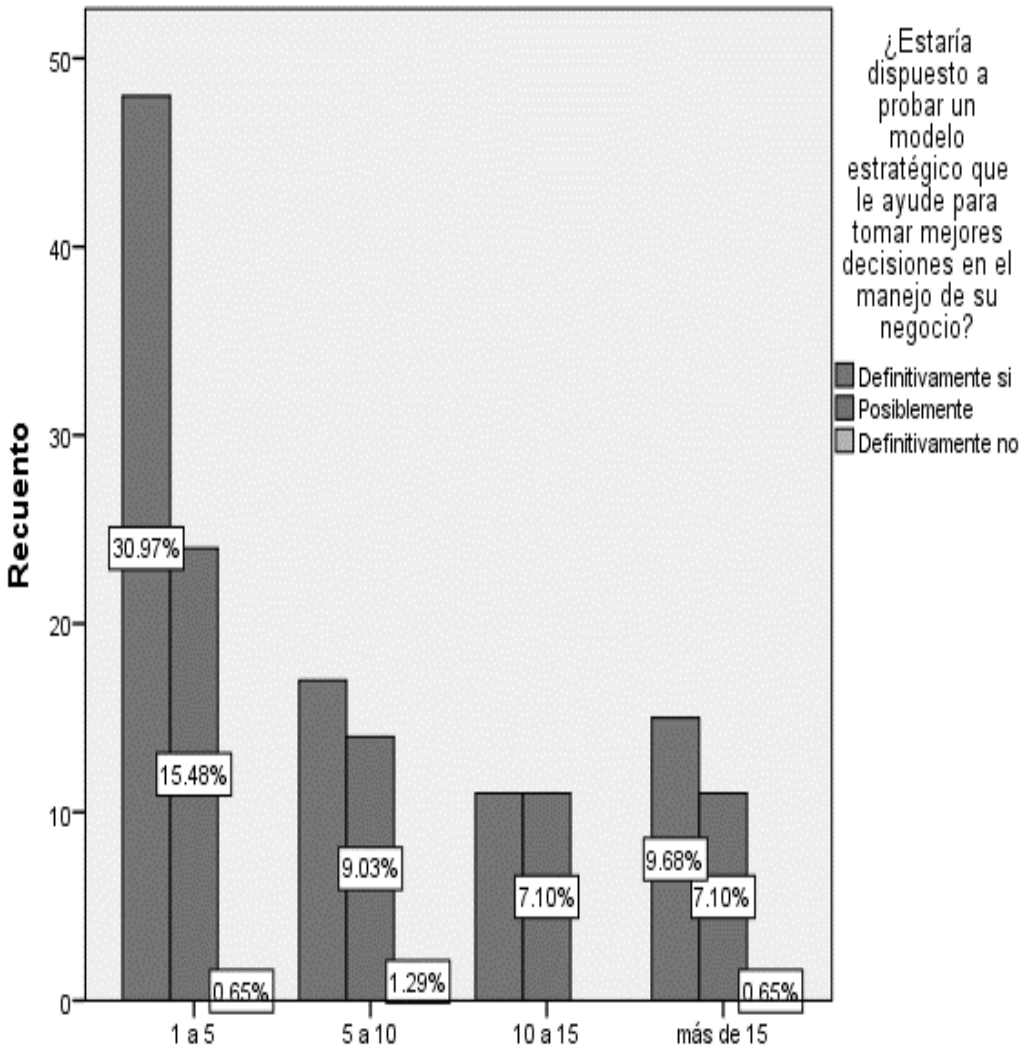

Figure 7. Crossing of number of collaborators variables, with would be willing to test the model

Note: In all categories of number of employees, there was good acceptance to test the model, because they see it as a good opportunity to improve the management and strategic processes of their businesses.

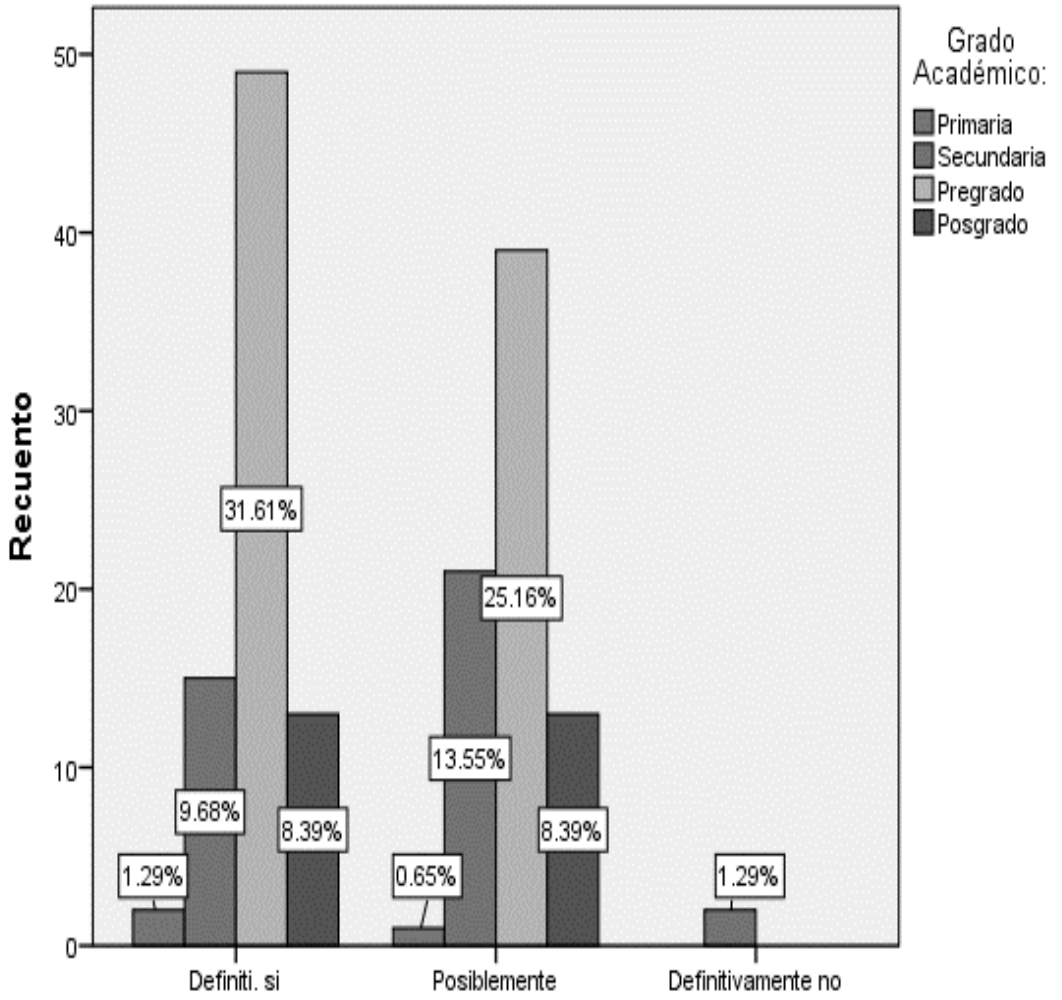

Figure 8. Crossing of academic degree variables with belief that with the help of the model

Note: Good acceptance of the model is observed in the academic grades; however, a slight percentage is observed in the secondary grade who believe that it would definitely not help them, which could be due to the lack of academic knowledge, but from there, there is a good perspective in all academic grades.

Results of environment analysis

Speaking of the macro-environment, political, and economic environment, according to the criteria of the different SME managers, there is a tendency to determine that in the Honduran context it is negative for the organizations, the cultural environment is more favorable in relation to the political and economic environments, and the technological environment is favorable to the political and economic environments.

In the Honduran context, the psychographic and environmental environment is more favorable in relation to the political and economic environments, according to SME managers.

In the micro environment, analyzing towards the internal part of the organizations, in the planning and administration variable, the managers consider that they have strengths in administrative management, which is considered positive; in the control variable, they

do not have a tendency towards positive or negative, it can be said that they are equal in terms of their strengths and weaknesses; in the marketing variable, they have a negative tendency, which is considered weak in almost all the variables under study, especially in the research area.

In the Human Resources variable, they have a negative trend, which is considered weak in almost all the variables under study; in the Technical and Technological capabilities variable, they have a negative trend considered weak in almost all the variables under study.

Regarding the bargaining power of suppliers, they consider that there is a moderate risk that suppliers may affect them with different actions; regarding the bargaining power of buyers, whether for B2B or B2C channels, they consider that there is a low risk, since buyers do not have much decision-making power.

In the opinion of the managers, the power of substitute products is considered a high risk, which means that there is a risk that a customer will change their product for one similar to that of the competition. As for the entry of new competitors, they consider that there is a high risk, due to the great amount of competition in the capital's competitive market.

Evaluating the strength of the SMEs' current competitors, according to their criteria, they consider that there is a high risk, due to the large amount of competition in the capital's competitive market.

In order to have a better criterion for this research work, proposals of strategic matrices were made for the SME, Innovación Creativa, a company dedicated to the elaboration of stamps and digital printing in Tegucigalpa, having the following results: Proposal of marketing strategy matrices for the Innovación Creativa company.

Table 1

Macro Environment Analysis. Opportunities identified for the Innovación Creativa company

NIVEL	OPORTUNIDADES	IMPACTO 1 LEVE 2 MEDIADO 3 FAVORABLE 4 MUY FAVOR	PROBABILIDAD 1 LEVE 2 MEDIANA 3 ALTA 4 MUY ALTA	TENDENCIA 1 DECRECE 2 ESTABLE 3 INCREMENTA	PUNTOS	CALIFICACIÓN A B C	JUSTIFICACIÓN	ESTRATEGIA DE APROVECHAMIENTO
Económico	Regulaciones comerciales	4	4	1	16	B	Dispocisión del gobierno en la apertura comercial	
	Aumentos salariales	4	4	2	32	C	cada año se revisa el aumento a los salarios	Oportunidad de los clientes en aumentar sus ingresos lo
	Costos de materias primas	4	4	2	32	C	reducción de algunas materias primas	Identificar las oportunidades de negociar
	Aumento generalizado de precios (Inflación)	3	2	2	12	B	existe poco crecimiento inflacionario	
	Tasa de interés para préstamo	3	3	2	18	C	baja en las tasas de interés para capital de	Aprovechar el incentivo de los bancos para capital de
	Inversión del gobierno en el sector PYME	4	4	3	48	C	Propuestas de apoyo a la PYME	Identificar las actividades del gobierno para capital de
	Acceso a préstamos	4	4	2	32	C	por medio del banco estatal se promueve el	Identificar programas gubernamentales para

Note: Due to space constraints, only the structure is shown, but the analysis of opportunities is much broader, using categories of the letters A, B, and C, with the letter C being the most challenging opportunity. Source: Own authorship adapted from (Ramos, 2004, p. 122).

Table 2

Opportunities identified for the Innovación Creativa company

NIVEL	OPORTUNIDADES	IMPACTO 1 LEVE	2 MEDIADO	3 FAVORABLE	4 MUY FAVOR	PROBABILIDAD 1 LEVE	2 MEDIANA	3 ALTA	4 MUY ALTA	TENDENCIA 1 DECRECE	2 ESTABLE	3 INCREMENTA	PUNTOS	CALIFICACIÓN A	B	C	JUSTIFICACIÓN	ESTRATEGIA DE APROVECHAMIENTO
Político - legal	Credibilidad internacional				**4**			**3**			**2**		**24**		**C**		Aparente buen manejo por parte del gobierno	Crear alianzas con distribuidores en el exterior
	Programas de apoyo gubernamental				**4**		**2**					**3**	**24**		**C**		Programas de apoyo a la PYME	Identificar y monitorear programas eventuales por parte del gobierno
	Credibilidad legal o protección legal de la empresa				**4**			**3**				**3**	**36**		**C**		Entes encargados del cumplimiento legal empresarial	Legalizar por completo la estructura de marca de la empresa
	Leyes de seguridad social				**4**				**4**			**3**	**48**		**C**		Diversos medios de protección social	legalizar la estructura de seguridad social empresarial
	Leyes de propiedad intelectual				**4**				**4**		**2**		**32**		**C**		Entes encargados de Propiedad intelectual	Legalizar nombre, marca, logo por protección de patentes
	Leyes de promoción y competitivad				**4**				**4**		**2**		**32**		**C**		Aparente vigilancia en temas de competitivad	Supervisar las leyes y prohibiciones en las principales leyes de competitividad

Note: Due to space constraints, only the structure is shown, but the analysis of opportunities is much broader, using categories of the letters A, B, and C, with the letter C being the most challenging opportunity. Source: Own authorship adapted from (Ramos, 2004, p. 122).

Table 3

Threats identified for the Innovación Creativa company

NIVEL	AMENAZAS	IMPACTO 1 LEVE	2 MEDIADO	3 GRAVE	4 MUY GRAVE	PROBABILIDAD 1 LEVE	2 MEDIANA	3 ALTA	4 MUY ALTA	TENDENCIA 1 DECRECE	2 ESTABLE	3 INCREMENTA	PUNTOS	CALIFICACIÓN A	B	C	JUSTIFICACIÓN	ESTRATEGIA DE BLOQUEO
Político - legal	Inestabilidad política				4				4			3	48			C	En Honduras se vive tención politica en los últimos años	Monitoreo constante de las decisiones politicas para realizar planes B
	Incertidumbre electoral				4				4			3	48			C	Este año es de crear estructura politicas	Realizar campañas de educación electoral con marketing interno
	Decisiones políticas en el comercio				4				4			3	48			C	No han sido acertadas las decisiones en torno a lo politico	identificar leyes que puedan perjudicar los actos de comercio
	Leyes tributarias			3			2				2		12		B		Ha existido incremento en el pago de los tributos	
	Déficit Fiscal			3				3				3	27			C	Cada año el gobierno invierte menos en el emprendedurimos	Gestionar estrategias de ahorro interno para disminuir costos ante el incremento de bienes
	Deuda política				4				4			3	48			C	Los partidos politicos cada año exigen mayores ingresos	Incentivar cultura de ahorro operativa y en la producción de bienes
	Régimen político				4		2				2		16		B		Existe incertidumbre entorno al continuismos del actual presidente	
	Nivel de corrupción				4				4			3	48			C	Los niveles de corrupción aumenta cada año en Honduras	Incentivar campañas en redes sociales para evitar el mal manejo de fondos del gobierno
	Oposición al gobierno				4				4			3	48			C	Cada año aumenta la opisición del gobierno que genera incertidumbre	Monitorear los acontecimientos que se generan en manera de protestas
	Afiliación política				4			3		1			12		B		Se ha incrementado la participación de nuevos partidos políticos	
	Falta de programas sociales				4			3			2		24			C	El gobierno no ha invertido en programas sociales	Desarrollar campañas para donar viveres y de apoyo a aspectos sociales
	Fuerte lucha por el poder del gobierno				4				4			3	48			C	Conflictos internos generan pleitos por el poder, genera incertidumbre	Monitoreo constante de protestas por actos políticos

Note: Due to space constraints, only the structure is shown, but the analysis of opportunities is much broader, using categories of letters A, B, and C, with the letter C being the most challenging threat. Source: Own authorship adapted from (Ramos, 2004, p. 120).

Table 4

Threats identified for the Innovación Creativa company

NIVEL	AMENAZAS	IMPACTO 1 LEVE	2 MEDIADO	3 GRAVE	4 MUY GRAVE	PROBABILIDAD 1 LEVE	2 MEDIANA	3 ALTA	4 MUY ALTA	TENDENCIA 1 DECRECE	2 ESTABLE	3 INCREMENTA	PUNTOS	CALIFICACIÓN A	B	C	JUSTIFICACIÓN	ESTRATEGIA DE BLOQUEO
	Pago de impuestos			3				3			2		18			C	Peligro al aumento del pago de tributos en condiciones sin inversión	Reestructura el sistema de ingresos y egresos para verificar el control correcto del pago
	Devaluación de la moneda				4			3				3	36			C	La compra de materiales y materia prima se encarece	Generar alianzas estratégicas con proveedores en el extranjero
Económico	Desempleo				4				4			3	48			C	Al no haber inversión se cierran negocios lo que genera desempleo	incentivar programas sociales para incentivar a ser emprendedores
	Operar sin trabas del gobierno	1						3				3	9			A	Los gobiernos cada vez mas no facilitan la incersión de nuevos negocios	
	Baja en el poder adquisitivo			3				3			2		18			C	Al no contar con empleo las personas no pueden comprar lo necesario	Generar estrategias de reducción de costos, para bajar el precio de los productos

Note: Due to space constraints, only the structure is shown, but the analysis of opportunities is much broader, using categories of letters A, B, and C, with the letter C being the most challenging threat. Source: Own authorship adapted from (Ramos, 2004, p. 120).

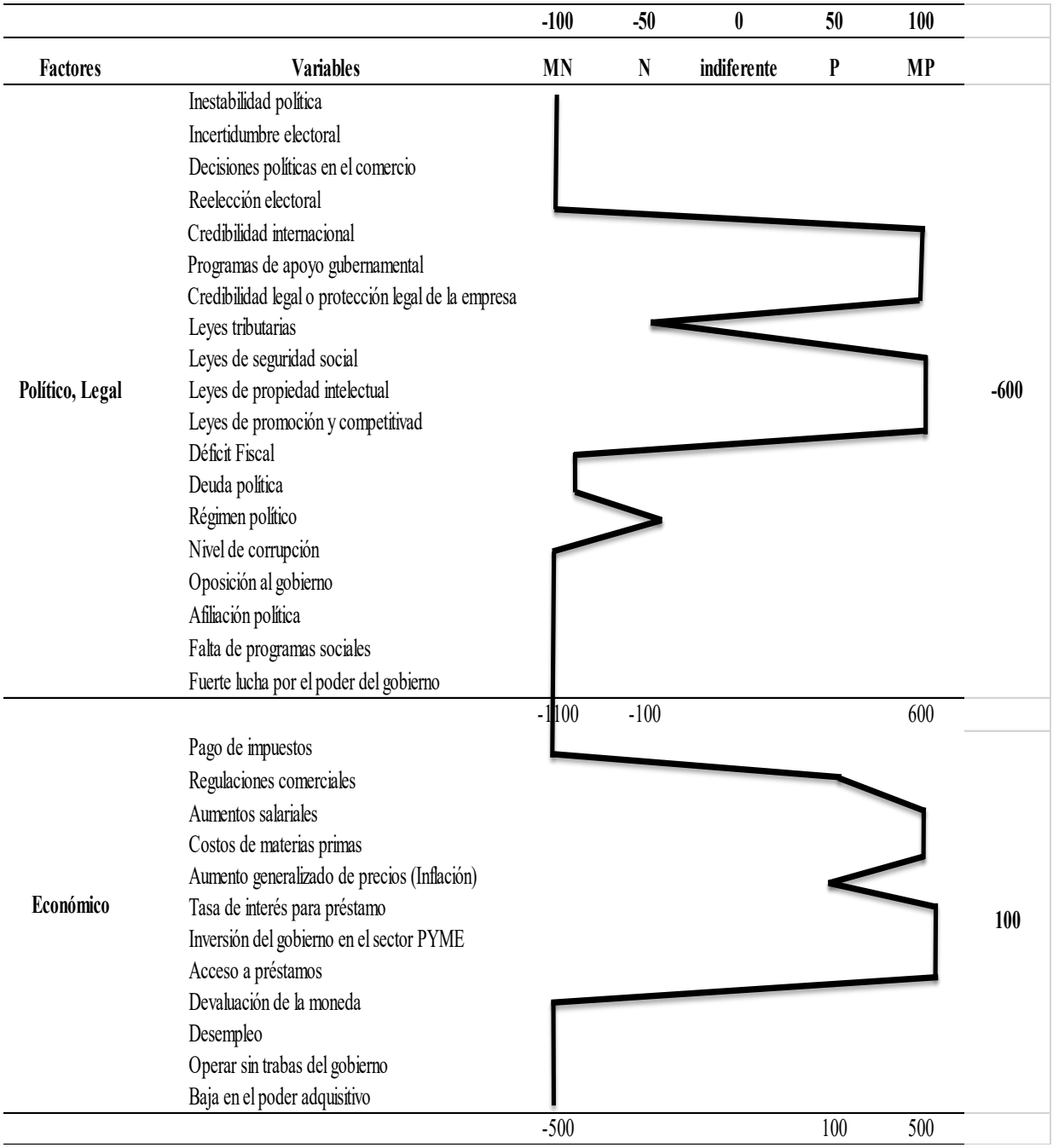

Figure 9. PESTEL matrix, opportunities, and threats by categories

Note: The origin of the PEST analysis dates back to 1968 with the publication of an essay on marketing entitled "Macro-environmental analysis in strategic management." This model was modified to have measurable indicators as positive and negative, being fed by the matrices of opportunities and threats in tables 1 and 2 as methods to measure the business macro-environment. The idea of the indicators is to be able to measure at which levels there are more opportunities or more threats to be able to generate competitive strategies. Source: Own authorship with data from the applied instrument, adapted from theorists Liam Fahey and V. K. Narayana.

		-100	-50	0	50	100	
Factores	**Variables**	**MN**	**N**	**indiferente**	**P**	**MP**	
Socio – cultural - Demográfico	Tradiciones culturales						**-50**
	Valores y creencias						
	Creación de fuentes de empleo						
	Edad promedio de la población						
	Creencias religiosas						
	Tasa mortalidad						
	Recreación pública						
	Abandono de la niñez						
	Seguridad familiar						
	Tasa de crecimiento poblacional						
	Inmigración del campo a la ciudad						
	Migración hacia otros países						
	Seguridad poblacional						
	Estado civil de la población						
	Crecimiento poblacional						
	Inseguridad poblacional						
	Violencia doméstica						
	Nivel educativo						
	Diversidad de género						
	Migración						
	Conflictos sociales						
	Protestas y destrucción de la propiedad						
		-1100			50	1000	
Tecnología	Inversión en equipo tecnológico						**800**
	Introducción de nuevas tecnologías						
	Crecimiento tecnológico de la competencia						
	Crecimiento de las redes sociales digitales						
	Crecimiento en el uso de internet						
	Nuevas formas de comunicación						
	Comercio electrónico						
	Implementación de normas ISO						
						800	
Psicográfico	Nuevos estilos de vida						**350**
	Comportamiento de compra de la población						
	Motivación a la compra de un producto						
	Clase social						
	Gustos y preferencias de los consumidores						
					50	300	
Geográfico / Ambiental	Contaminación ambiental						**-700**
	Contaminación sónica						
	Cambio climático						
	Escasez de agua						
	Inundaciones						
	Ubicación del negocio						
	Urbanismo y población						
	Ubicación y crecimiento de barrios y colonias						
	Escasez de alimentos						
	Pandemias						
	Desarrollo de nuevas enfermedades						
		-800				100	
	TOTALES	-3400	-200		400	3300	
				100			

Figure 10. Continued PESTEL matrix opportunities and threats by categories

Note: Continuation of the PESTEL analysis. Source: Own authorship with data from the applied instrument, adapted from theorists Liam Fahey and V. K. Naraya.

Table 5

Porter's 5 Forces Matrix as Microenvironment analysis. Rivalry among the company's competitors

	Valuation	AVERAGE
Tendency to follow the competitor	5	Very High
Its competitors are quite balanced	5	Very High
Slow growth of the industrial sector	3	moderate
There is similarity in the products and services offered by the competitors	5	Very High
Increases in installed capacity	5	Very High
There is a diversity of competitive strategies	4	high
Rivalry between competitors is:	**5**	Very High

Note: It is a strategic model adapted from the engineer and professor Michael Eugene Porter of Harvard Business School, in 1979, a system of indicators from 1 to 5 was designed to measure the intensity of each of the forces, and the variables were conditioned to the Honduran market. These matrices are complements to identify the micro business environment. Source: Own authorship with data from the applied instrument.

Table 6

Threat of entry of new competitors

	Valuation	AVERAGE
Competitor contribution level	5	Very High
Risk of entry of new competitors	5	Very High
Investment level	5	Very High
Uninnovative products	3	moderate
Access to distribution channels	3	moderate
Easy procurement of raw materials	5	Very High
Ease of learning how to manage the market	5	Very High
The impact of the competence is	3	moderate
The threat of entry of new competitors is:	**4**	high

Note: Indicator 4 shows that the company is under strong threat from the entry of new competitors. Source: Own authorship with data from the applied instrument.

Table 7

Threat of substitute products

	Valuation	AVERAGE
Substitute products are present	3	moderate
Substitute products have competitive quality and services.	2	under
Substitute products have lower prices.	3	moderate
They provide improvement trends in the market.	4	high
Competitors offer better quality at the same price	3	moderate
They offer excellent performance to the user.	4	high
The threat of substitute products is:	**3**	moderate

Note: Indicator 3 shows that the company moderately has products that can substitute it. Source: Own authorship with data from the applied instrument.

Table 5

Bargaining power of the supplier

	Valuation	AVERAGE
The risk of raising prices is	3	moderate
The risk of diminishing quality and service is:	1	Very low
The risk that changes the negotiations is:	1	Very low
Having a diversified portfolio of suppliers is:	3	moderate
There is a risk of shortages of vital production materials	4	high
Supplier sells differentiated inputs	5	Very High
Their supplier generates confidence	3	moderate
Supplier facilitates alliances with competitors	4	high
The bargaining power of the supplier is:	**3**	moderate

Note: The influence that suppliers have is moderate for the Innovación Creativa company. Source: Own authorship with data from the applied instrument.

Table 6

Buyer's bargaining power (B2C, B2B)

	Valuation	**AVERAGE**
Influence on pricing:	5	Very High
Demand for quality and service at constant prices.	5	Very High
Possibility to sell large volumes.	2	low
They consume standard, non-differentiated products.	3	moderate
Distribution channels meet business needs	5	Very High
Low consumer loyalty	3	moderate
The bargaining power of its customers or distribution channels is:	**4**	**high**

Note: Customer power generates a 4 indicator which says that customers do have influence on product and price decisions. Source: Own authorship with data from the applied instrument

Table 7

Strengths and Weaknesses Matrix

CRITICAL FACTORS BY AREA	LEVEL					IMPACT					TREND			COMBINATION	CLASSIFICATION			CRITERIA			PROPOSED STRATEGY
	1	2	3	4	5	1	2	3	4	5	1	2	3								
	The worst / Very	Below Average /	AVERAGE	OF THE BEST	THE BEST	NONE	LOW	MEDIUM	ALTO	VERY HIGH	DECREASE	STABLE	INCREASE		WEAKNESS	INDIFFERENT	STRENGTH	SWOT MATRIX	CONTINGENCY PLANS	IGNORE	
Administration and Planning																					
It has defined administrative processes				**4**				3					3	4 3 3			**F**	**X**			Encourage continuous improvement
Plan, plans are created on an ongoing basis					**5**			3					3	5 3 3			**F**		**X**		Constant monitoring of the macro environment
They make planned decisions					**5**				4			2		5 4 2			**F**	**X**			Medium-term planning
Has contingency plans for eventualities			**3**					3				2		3 3 2	**D**			**X**			Planning for eventualities
Achieve planned results				**4**			2					2		4 2 2			**F**	**X**			Constant monitoring of performance indicators
Integrating work teams is a daily task					**5**				4				3	5 4 3			**F**	**X**			Planning with the different SBUs of the company
Direct access to soft loans					**5**				4			2		5 4 2			**F**	**X**			Fulfill the commitments

															made to build trust and confidence
Meets the planned times for a given action	**4**		3		2	4	3	2		**F**	**X**				Measure performance indicators by SBU
The company's values are transmitted to employees		**5**	3		2	5	3	2		**I**				**X**	Continuing to improve corporate identity
Generate short-, medium-, and long-term strategic plans		**5**	3		2	5	3	2		**I**				**X**	They are considered to have complied with the planning
The organization makes decisions effectively		**5**	3		2	5	3	2		**I**				**X**	Socialize the processes with all SBUs
It has administrative leadership		**5**	3		2	5	3	2		**I**				**X**	In decision making, generate consensus with the SBUs.
Incentives to motivate staff	**2**			4	2	2	3	2	**D**			**X**			Improving negotiations and rewards to incentivize personnel
Perceives communication capacity		**5**		4	2	5	3	2		**I**				**X**	Improve the flow of continuous communication in the company
Notes an established management style	**4**		2		2	4	2	2		**I**				**X**	Identify a relevant

Decisions are made in a hierarchical fashion		**5**		3		2	5	3	2	**I**	**X**	corporate culture Identify leaders by SBU for continuous improvement
Perceives good coordination of activities	**2**		2		1		2	2	1	**I**	**X**	Plan SBU plans for strategic compliance
Notes smooth communication between departments		**4**	2			2	4	2	2	**I**	**X**	Design internal marketing plans for continuous improvement

Note: This matrix was adapted from (Ramos, 2004, p. 128) and is linked to Porter's 5 forces matrix to make a complementary analysis of the competitive microenvironment, analyzing the weaknesses and strengths that SMEs in particular may present. Source: Own authorship with data from the applied instrument

	EMPRESA INNOVACION CREATIVA			HONDUSELLOS	
	POSICIONES DE VALORACIÓN				
FACTORES DEL DIAGNÓSTICO ESTRATEGICO	Muy debil	Débil	equilibrada	Fuerte	Muy fuerte
	-100	-50	0	50	100
CARACTERISTICAS					
Antigüedad					
ciclo de vida					
tamaño y estructura jurídica					
Estructura financiera					
CAMPO DE ACTIVIDAD					
calidad de productos					
diseño					
imagen de productos					
mercados					
clientes					
canales de distribución					
proveedores					
ESTRUCTURA DE LA ORGANIZACIÓN					
descentralizada					
comunicación e información					
flexibilidad					
ESTILO DE DIRECCION					
Experiencia					
estilo directivo					
cultura empresarial					

	DEBILIDADES			FORTALEZAS	
INNOVACION CREATIVA	-100	-150	0	350	300
HONDUSELLOS	0	-200		250	400

INNOVACION CREATIVA	**400**
HONDUSELLOS	**450**

Figure 11. Internal strategic profile matrix

Note: This model was adapted from (David, 2003, p. 180) and was made by integrating indicators to categorize variables from very weak to very strong. This model is fed from the Porter's 5 forces matrix and the matrix of weaknesses and strengths, making a comparison with the closest competitors to have a stronger competitive criterion according to the strengths and weaknesses of the companies.
Source: Own authorship with data from the instrument applied to the Innovación Creativa company of Tegucigalpa and the Hondusellos company as the main competitor.

Table 8

Creative Innovation Action Plan Model

Justificación	Estrategia de las matrices Bloqueo, Aprovechamiento, contingencia	Corto, medio, Largo Objetivo Smart	Estrategia prevista	Acciones a realizar	Tiempo	Lugar	UEN Responsable	Presupuesto	Medida de Control y seguimiento
POLITICO LEGAL	**APROVECHAMIENTO**			**A LARGO PLAZO**					
Credibilidad internacional	**Crear alianzas con distribuidores en el exterior**	Desarrollar un plan de exportación para los próximos 3 años, con los países fronterizos, exportando el 5% de nuestra producción	**Desarrollo de Mercados**	Verificar los requerimientos legales de cada los países destino. Investigar la oferta y demanda. Investigar gustos y preferencias. Investigar competencia, y hacer contactos con los principales distribuidores	3 años	Guatemala, El Salvador, Nicaragua	DEPTO. MKT, FINANZAS	$5000	Informes semestrales de seguimiento en el mercado destino
TECNOLOGICO	**BLOQUEO**			**A CORTO PLAZO**					
Comercio electrónico	Desarrollar planes para redes sociales	Implementar estrategias para Facebook e Instagran del 1 al 24 de diciembre de 2020 dirigido al mercado juvenil, para alcanzar un 20% de engagement	**Mix Promocional** Ofrecer descuento del 10% para las compras via facebook e instagran	Realizar post promocionales 1 vez por semana, diseñar publicaciones interactivas,	24 dias	Tegucigalpa	DEPTO. MKT REDES DIGITALES	L5,000.00	Metricas de facebook e Instagran y el volumen de ventas
	APROVECHAMIENTO			**MEDIANO PLAZO**					
Comercio electrónico	Desarrollar planes para redes sociales	Implementar estrategias para Facebook e Instagran del 1 al 24 de diciembre dirigido al mercado juvenil, para alcanzar un 20% de engagement	**Mix Promocional** Ofrecer descuento del 10% para las compras via facebook e instagran	Realizar post promocionales 1 vez por semana, diseñar publicaciones interactivas,	24 dias	Tegucigalpa	DEPTO. MKT REDES DIGITALES	L5,000.00	Metricas de facebook e Instagran y el volumen de ventas
RECURSOS HUMANOS	**DEBILIDAD**			**MEDIANO PLAZO**					
Cuenta con procesos de planeación de los RRHH bien definidos	Estructurar planes de marketing interno	Desarrollar un pla de marketing interno, para mejorar el proceso de percepción en los colaboradores para aplicarse en el año 2021	Motivaciones y compensaciones	Realizar estudios de percepción interna de manera semestral	2 años	Tegucigalpa	RRHH y Marketing	L5,000.00	Mejora en el rendimiento de los colaboradores

Note: This matrix is fed from all the previously exposed matrices, the idea is to have a synthesized and categorized summary to have a broad vision of the competitive environment and the different actions that will be carried out in the short, medium, and long term. Source: Own authorship with data from the set of strategic matrices.

Conclusions

SMEs have several arguments that affect them in the progress of their activities, in aspects related to marketing or administration of the same, despite being the subject of many studies within the socio-economic field. However, people who want to start a business look at SMEs as an element of entrepreneurship that will enable them to start their entrepreneurial path, through which their talent can be evidenced if their business becomes consolidated as a company that provides services and/or products for various types of customers.

It is feasible to note that this study, despite having a purely administrative marketing character, combines elements that can be used in the daily work of this type of companies, and performs an analysis from its origin, its advantages, disadvantages, evolution, administrative theories, etc., up to the production and proposal of an integrated model of strategic matrices.

On the other hand, according to the design of the objectives of the thesis, it is concluded that presenting as proposed an integrated matrix model is favorable for SMEs to be able to operate in a practical way in the competitive sector where they are, since it allows to know from the external and internal aspects and to be able to visualize tactical, operational, and strategic aspects in the future.

According to the perception of the SME owners or managers regarding the matrix system, they were open to test the model, taking into account that this process is costly to acquire, and they identified all those internal and external variables that may result as opportunities, threats, weaknesses, and strengths that SMEs may present in the general and specific environment.

The results of the study determined that the working hypothesis is approved because it is feasible to design an integrated system of strategic matrices, so the null hypothesis is rejected.

The research conducted by this doctoral work described very relevant aspects of SMEs in Tegucigalpa, Honduras, describing all those variables from administrative processes to operational processes, using and innovating matrices that will give much contribution to knowledge and concentrated value in competitive markets.

Among the major findings, it was discovered that companies face many threats at the political, economic, social, cultural, and psychographic levels, which were found in the instrument applied to 155 SMEs and had agreement with the model applied to the company under study. In turn, companies are committed to take advantage of many opportunities that the same macro environment can generate, using the tool called PESTEL can have a clearer picture in which environments should be taken care of and in which others can be taken advantage of.

The study of the specific or internal environment identified that on average SMEs have greater weaknesses in relation to their strengths due to the complexity of their operation, especially in obtaining working capital, technical knowledge, and all those variables such as suppliers, competitors, and customers. To complement the internal analysis, Porter's 5 forces tool was used to design a matrix to assess the established weaknesses and strengths.

Since most SMEs do not have innovation and development, they are pleased that these strategic matrices can significantly support them in improving their processes, especially in the marketing and administrative areas, which in the end leads to better income generation, hiring of more personnel, which combats unemployment and therefore contributes to improvements in society.

For these reasons, it was evident the satisfaction of the SME that provided their data at the time of running the respective simulations using the integrated model of strategic matrices.

Thus, this company knows in advance its possible results, if they continue to be managed in the same way as they are currently and do not make any changes in their ways or techniques to manage and control their activities.

Taking into account the above, one of the alternatives for SMEs is to look for ways to increase their competitiveness and respond to the business environments that they face on a daily basis in relation to their competition, to the substitute products that are present, and in relation to the loss of customers. SMEs, according to the findings of this work, must make changes, which will help them to be competitive in each of the sectors where they develop their daily work and will be able to remain in time, despite external factors that are currently affecting them and internal factors that can take their toll if interesting control measures are not taken in the short, medium, and long term.

With the complete matrix model, which in total consists of 8 strategic, adapted, created, and innovated matrices, it is now possible to plan in the short, medium, and long term using a dynamic action plan, easy to assimilate and that can provide a critical overview of how to compete in all aspects. The action plan will help determine which strategies are the most appropriate depending on what is found in the different environments either internal or external.

Among the main limitations encountered during the study were the following:

- The lack of confidence that SMEs in Tegucigalpa have in providing data to generate information, both for the interviews and for filling out the instrument.
- Unfortunately, in the year 2020 the whole world was in pandemic, in the case of Honduras, it was in confinement since March, which made it difficult to access interviews and to request meetings to fill out the instrument, so we proceeded to conduct interviews by video call and the questionnaire virtually.

It should be noted that SMEs in Tegucigalpa are the main promoter of sources of employment, but unfortunately, they are little supported and stimulated by the government sector in order to generate more employment, tax payments, and healthy competition at a general level, especially in the tourism, services, and manufacturing sectors in general.

As for the recommendations, it is emphasized that SMEs in Tegucigalpa should put this integrated matrix model into practice, so that they can plan strategically, in an orderly, planned manner and above all with a vision of the aspects they want to improve on a daily basis, at all levels.

On the other hand, it is suggested to follow up on the results of this doctoral thesis in order to continue identifying variables from both the external and internal sectors, as well as possible improvements and innovations to the matrix system.

It is also suggested that more research be conducted on SMEs, not only in Tegucigalpa but also in Honduras, in order to strengthen this sector, which is so important not only for Honduras but for the world in general.

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EFFECT OF EICHHORNIA CRASSIPES COMPOST ON THE QUALITY OF THEOBROMA CACAO NURSERY PLANTS

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Abstract. The study consisted of determining the effect of *E. crassipes* compost on the quality of *T. cacao* nursery plants, knowing the appropriate compost percentages for its addition as sustrate and determining levels of lead (Pb), arsenic (As) and mercury (Hg) in *E. crassipes* plants, compost and *T. cacao* plants. A completely randomized design was used, with 5 treatments, 5 repetitions with 48 plants each, in an experimentation period of 4.5 months. Compost of *E. crassipes* was used in percentages of 10%, 20% and 40% mixed with soil in 90%, 80% and 60%. The treatments were identified as: T1 (T10: 90), T2 (T20: 80), T3 (T40: 60), a relative treatment T4 (TR, 100% soil and chemical fertilization) and a control treatment T5 (TT, 100 % land). The results of the ANOVA show that there is a statistically significant difference of the treatments in the quality of *T. cacao* plants for the diameter, Dickson's Quality Index (DQI) and total dry weight. The T1, T2, T3 and T4 were statistically superior to the control treatment T5 (TT). Plant height, slenderness index, and aerial dry weight-root dry weight ratio did not present statistically significant differences. The translocation of Pb to *T. cacao* plants was non-existent. The plants of T3 (T40: 60), showed chlorotic yellowing and symptoms of diseases in the 45 to 90 days of germination. It is recommended to use percentages of compost of *E. crassipes* not greater than 20%, for *T. cacao* plants in the nursery.

Keywords: *E. crassipes* compost, Cerrón Grande, quality of the *T. cacao* plants, heavy metals.

EFECTO DEL COMPOST DE EICHHORNIA CRASSIPES EN LA CALIDAD DE PLANTAS EN VIVERO DE THEOBROMA CACAO

Resumen. El estudio consistió en determinar el efecto del compost de E. crassipes en la calidad de las plantas en vivero de T. cacao, conocer los porcentajes de compost apropiados para su adición como sustrato y determinar niveles de plomo (Pb), arsénico (As) y mercurio (Hg) en plantas de E. crassipes, compost y plantas de T. cacao. Se utilizó un diseño completamente al azar, con 5 tratamientos, 5 repeticiones con 48 plantas cada uno, en un período de experimentación de 4.5 meses. Se usó compost de E. crassipes en porcentajes de 10%, 20% y 40%

mezclados con tierra en 90%, 80% y 60%. Los tratamientos se identificaron como: T1 (T10:90), T2 (T20:80), T3 (T40:60), un tratamiento relativo T4 (TR, 100% tierra y fertilización química) y un tratamiento testigo T5 (TT, 100% tierra). Los resultados del ANOVA demuestran que existe diferencia estadística significativa de los tratamientos en la calidad de las plantas de T. cacao para el diámetro, Índice de Calidad de Dickson (ICD) y peso seco total. Los T1, T2, T3 y T4, fueron estadísticamente superiores al tratamiento testigo T5 (TT). La altura de planta, índice de esbeltez, y relación peso seco aéreo-peso seco radicular, no presentaron diferencia estadística significativa. La traslocación de Pb a plantas de T. cacao fue inexistente. Las plantas del T3 (T40:60), mostraron amarillamiento clorótico y síntomas de enfermedades en los 45 a los 90 días de germinadas. Se recomienda usar porcentajes de compost de E. crassipes no mayores al 20%, para plantas de T. cacao en vivero.

Palabras clave: *compost de E. crassipes, Cerrón Grande, calidad de Theobroma cacao, metales pesados*.

EFFECT OF EICHHORNIA CRASSIPES COMPOST ON THE QUALITY OF THEOBROMA CACAO NURSERY PLANTS

Abstract. The study consisted of determining the effect of *E. crassipes* compost on the quality of *T. cacao* nursery plants, knowing the appropriate compost percentages for its addition as sustrate and determining levels of lead (Pb), arsenic (As) and mercury (Hg) in *E. crassipes* plants, compost and *T. cacao* plants. A completely randomized design was used, with 5 treatments, 5 repetitions with 48 plants each, in an experimentation period of 4.5 months. Compost of *E. crassipes* was used in percentages of 10%, 20% and 40% mixed with soil in 90%, 80% and 60%. The treatments were identified as: T1 (T10: 90), T2 (T20: 80), T3 (T40: 60), a relative treatment T4 (TR, 100% soil and chemical fertilization) and a control treatment T5 (TT, 100 % land). The results of the ANOVA show that there is a statistically significant difference of the treatments in the quality of *T. cacao* plants for the diameter, Dickson's Quality Index (DQI) and total dry weight. The T1, T2, T3 and T4 were statistically superior to the control treatment T5 (TT). Plant height, slenderness index, and aerial dry weight-root dry weight ratio did not present statistically significant differences. The translocation of Pb to *T. cacao* plants was non-existent. The plants of T3 (T40: 60), showed chlorotic yellowing and symptoms of diseases in the 45 to 90 days of germination. It is recommended to use percentages of compost of *E. crassipes* not greater than 20%, for *T. cacao* plants in the nursery.

Keywords: *E. crassipes* compost, Cerrón Grande, quality of the *T. cacao* plants, heavy metals.

Introduction

Water hyacinth (*E. crassipes*) is an aquatic plant that grows rapidly in water reservoirs (Alvarado, 2013). It is considered a perennial aquatic weed (Madsen and Robles, n.d.), and ranked among the 100 most harmful invasive alien species in the world (Lowe et al., 2004). According to the Food and Agriculture Organization of the United Nations (FAO, 1996), *E. crassipes* globally causes more serious and widespread problems than any other floating aquatic weed. Rzedowski and Rzedowski (2005) mention that *E. crassipes* spreads in such a way that it covers the mirrors of canals and other water reservoirs. Its abundance and volume in these bodies of water makes fishing and navigation impossible. According to Barrett and Forno (1982), the origin of *E. crassipes* seems to be the Brazilian Amazon with natural spread to other areas of the South American continent and introduced by human action to Central America and the Caribbean. The Aquatic Ecosystem Restoration Foundation (AERF, 2014), indicates that *E. crassipes* has been widely introduced in all tropical regions of the world, most recently in Lake Victoria, East Africa.

In El Salvador, the Cerrón Grande reservoir (with geographical coordinates 14° 03" N and 89° 04" W), constitutes the largest continental freshwater body (Ministry of Environment and Natural Resources [MARN], 2016), with a covered area of 135 km^2, built for the Cerrón Grande Hydroelectric Power Plant dam, with a nominal capacity of 135 MW, and an average

annual generation of 488 GWh (Hydroelectric Executive Commission of Río Lempa [CEL], n.d.). One of the preponderant problems in the Cerrón Grande reservoir is the presence and expansion of *E. crassipes*, which affects various economic sectors such as the fishing industry, tourism, and navigation (Alas, R. March 25, 2016). Also, it could affect the turbines for hydroelectric generation of the Cerrón Grande dam ("Endangered natural treasures, Cerrón Grande reservoir", 2016). MARN (2019) calculated a coverage of 3,000 hectares of *E. crassipes*, which is equivalent to 22.22% of the reservoir.

Sonter et al. (2018) mention that compost has recently gained acceptance for integrated solid waste and aquatic weed management, labeled as an environmentally friendly product and a sustainable solution for urban waste and aquatic weed management. In this regard, Mashavira et al. (2015), evaluated the effect of *E. crassipes* on tomato (*Lycopersicon esculentum*), on growth attributes, yield potential, and the accumulation of heavy metal levels of lead (Pb), copper (Cu), nickel (Ni), and zinc (Zn) in tomato fruit; while Enriquez (2013), studied the effect of compost based on *Eichhornia crassipes* on lettuce "*Lactuca sativa,"* on the variables survival, yield in weight (kg), lettuce head diameter and concentration of the heavy metals, lead (Pb) and arsenic (As). As part of the control of *E. crassipes* in the Cerrón Grande reservoir, in the period from November 2019 to March 2020, 17.34 hectares were manually and mechanically harvested using *E. crassipes* harvesting barges (CEL, 2020). The Local Economic Development Agency and the Environmental Investment Fund of El Salvador (ADEL-FIAES, 2014) proposed making compost from *E. crassipes* plants extracted from the Cerrón Grande reservoir as one of the alternatives for its sustainable use and management.

In this context, this study was developed by preparing compost of *E. crassipes* from the Cerrón Grande reservoir, and its effect on the quality of cocoa plants (*Theobroma cacao*) in the nursery stage was evaluated. *T. cacao* is one of the species with high ecological and economic potential that CEL produces in the forest nurseries of its hydroelectric power plants to reforest the Lempa River basin. According to the Ministry of Agriculture and Livestock (MAG, 2018), due to the socio-environmental importance that this crop represents, in El Salvador, there is a "policy for the development of the cocoa chain." Therefore, the production of quality *T. cacao* plants in nurseries is essential for the success of the plantation.

According to Arteaga et al. (2003) the type of soil or substrate used in plant production is one of the factors that most influences the quality and cost of plant production in nurseries, so it is necessary to have alternatives to reduce costs, guaranteeing a certain plant quality. Prieto (2004), points out that an appropriate nursery process requires cultural practices related to substrates, containers, fertilizers, mycorrhizae, irrigation, prevention and control of pests and diseases.

Plant quality depends on the genetic characteristics of the germplasm and the techniques used for its reproduction (Prieto et al., 2009). The parameters height and diameter are considered estimators of plant performance after planting (Mexal and Landis, 1990) and can be easily quantified (Birchler et al., 1998). In addition, morphological attributes such as the slenderness index, which relates plant height and diameter, the ratio of the dry weight of the aerial and root parts, and the Dickson quality index, which is calculated by the ratio between the total dry weight of the plant and the sum of the slenderness index and the aerial part-root part ratio (Navarro et al. , 2006, Birchler et al., 1998, Dickson et al., 1960, cited by Mateo-Sánchez et al., 2011), are also used.

The objectives of the research were to determine the effect of compost from *E. crassipes* plants extracted from the Cerrón Grande reservoir on the quality of *T. cacao* plants at the nursery stage, through the parameters of plant height, diameter, slenderness index, ratio of the dry weight of the aerial part, and dry weight of the root part (PSa/PSr), as well as the Dickson Quality Index (DQI); in addition, to determine the percentages of *E. crassipes* compost most appropriate to mix with soil for T. cacao production at the nursery stage and finally, to evaluate

the levels of heavy metals such as As, Pb ,and Hg in fresh *E. crassipes* plants, in the compost obtained, and in the *T. cacao* plants to analyze the existence of translocation of these metals.

Method

The extraction of *E. crassipes* plants from the Cerrón Grande reservoir was carried out on December 06 and 07, 2018, in the Santa Teresa canton, municipality of Potonico, department of Chalatenango, at the location coordinates 13°57'48.10" N and 88°54'36.51" W, at a distance of 3.0 km in a northwest direction from the Cerrón Grande Hydroelectric Power Plant. For its extraction, quadrats of 1 m long x 1 m wide (1 m^2) were made with PVC pipes of 1" diameter. The number of plants per m^2 recorded in the quadrats in each extraction was counted, they were left to drain for 3 minutes and then the plant mass of each quadrat was weighed. Next, parts of stems, leaves, and roots were taken from 100 fresh *E. crassipes* plants obtained from the quadrats by random sampling, for analysis of the heavy metals Pb, As, and Hg, and taken to the laboratory of the Salvadoran Foundation for Social and Economic Development (FUSADES). Pb and As were analyzed using the atomic absorption spectrophotometry method with a graphite furnace, and Hg was analyzed using the atomic absorption spectrophotometry method with a hydride generator. After extraction, the *E. crassipes* plants were transferred for composting to the site where the experimental design was implemented, located at coordinates 14° 05' 44.28" N and 89° 15' 20.08" W, in the sub-basin of the Jayuca River, in the village of La Cruz, canton Santa Rosa, municipality of Nueva Concepción, department of Chalatenango. Then, at the composting site, the *E. crassipes* plants were chopped in an agricultural machine used to chop grass. The chopped plant material was placed in the form of a mound 5.70 m long, 1.90 m wide, and 0.90 m high, on a 5 cm thick layer of unchopped *E. crassipes* plants to avoid contact with the soil, then the mound was covered with a plastic sheet. During the first six weeks, the mound was turned by hand to provide aeration twice a week, and then once a week for the following eleven weeks. During the last two weeks, the composted material was spread in a 30 cm thick layer, leaving it without a cover during the day, and at night it was placed again. At the end of this process, the *E. crassipes* compost was weighed and stored in sacks for the maturation process for 5 months before being used as a substrate for the production of *T. cacao* plants in the nursery stage, and a chemical analysis of Pb was performed. During the composting process, the temperature of the material and the relative humidity of the environment were measured daily. The composting period was from December 09, 2018 to April 21, 2019. The cultivation of *T. cacao* in the nursery stage was implemented from September 29, 2019 to February 23, 2020. Figure 1 shows the extraction of *E. crassipes* and composting.

Figure 1. A) Extraction of *E. crassipes* from the Cerrón Grande reservoir. B) Composting.

For the implementation of the study, a completely randomized experimental design was used with five treatments, five replications, and 48 plants per replication. The sample size of *T. cacao* plants for destructive analysis in the laboratory to determine the dry weight (g) was estimated with the formula:

$$n = \frac{t^2 * S^2}{e^2}$$

Where:

n: sample size.

S^2: variance.

t^2 = Student's t at 95% confidence.

e^2= error (5%). The error value is multiplied by the average, before being squared, thus increasing the number of samples to be processed.

The result showed a minimum of 121 plants to be sampled using the height variable; however, a total of 250 plants were sampled (50 for each treatment and 10 plants per replication), thus ensuring a representative sampling. Statistical analyses were performed with Statistix 8.1 software, student version. One-way analysis of variance (ANOVA), with a significance level of 0.05 was used. Significant differences in the means of the treatments were obtained with Tukey's statistical test.

In the test, compost made from *E. crassipes* from the Cerrón Grande reservoir was used in percentages of 10%, 20%, and 40%, mixed with soil in 90%, 80%, and 60% to complete 100% of the volume of the bags (8"x12") where the *T. cacao* seeds were planted. The 5 treatments were identified as follows: T_1 (10:90), T_2 (20:80), T_3 (40:60), a relative treatment T_4 (TR, 100% soil, and 3 chemical fertilizations with triple formula fertilizer 15 N-P-K, at 15, 45, and 90 days after germination, using two grams in the first fertilization and five grams in the second and third fertilization) and a control treatment T_5 (TT, 100% soil) without any additive.

Pest and disease control was carried out preventively. For soil insect control, Imidaclopid WG 0.8% was used, applied to the soil 15 days before planting *T. cacao* seeds. For foliar pest control, the insecticides Abamectin (1.8 EC) and Lambdacyhalothrin (2.5 EC) were used. Prevention of fungal diseases was done with Difenoconazole, Azoxystrobin (32.5 SC) applied every 10 days. The *T. cacao* plants in the nursery were protected with shade using 73% saran mesh. They were arranged in 4 rows at a width of 0.50 m and 12 plants per row at a length of 1.56 m for each repetition. The width of the rows was 0.60 m x 0.65 m.

When the *T. cacao* plants reached 4 months and 15 days after germination, a destructive analysis of the plants, stem, leaves, and roots was carried out to measure the dry weight (g). Following the methodology of Fernandez, et al. (2010), the plants in the center of each replicate were sampled to avoid edge effect. Each plant was measured for diameter at the base of the stem (mm) with a vernier and height (cm) with a tape measure. The soil was separated from the plants using water to leave the root bare. The root was cut and the stems with leaves and roots were placed separately in plastic bags, identified for each treatment and each repetition, obtaining 25 samples of stems with leaves and 25 samples of roots. They were put to dry for 72 hours through the oven method at 50 °C. Once dried, the weight of the stem with leaves, root dry weight, and total dry weight were measured. This test was carried out at the Agricultural Chemistry Laboratory of the National Center for Agricultural and Forestry Technology "Enrique Álvarez Córdova" (CENTA), located in San Andrés, La Libertad, El Salvador. Taking as a reference the methodology of Fonseca et al. (2002), described by Piña and Arboleda (2010), the slenderness index (SI) was estimated with the data obtained from the laboratory, according to equation 1, and the Dickson Quality Index (DQI), with equation 2, as detailed below:

$$SI = \frac{Height\ of\ the\ aerial\ part\ (cm)}{Stem\ diameter\ (mm)} \quad \text{Eq. 1.}$$

$$DQI = \frac{Total\ dry\ weight\ (g)}{\frac{Height\ of\ the\ aerial\ part\ (cm)}{Stem\ diameter\ (mm)} + \frac{Aerial\ dry\ weight\ (g)}{Root\ dry\ weight\ (g)}} \quad \text{Eq. 2.}$$

According to Prieto et al. (2009) the slenderness index is an indicator of the plant's resistance to wind desiccation, its survival and growth in dry sites. Its value should be less than six; higher values indicate that the plant has a thinner stem in relation to its size. The Dickson Quality Index (DQI) groups variables related to plant quality. The higher the index value, the better the plant quality. Biomass correlates with plant survival and growth in the field. The ratio of aerial part to root part was calculated as the quotient between the dry weight of the aerial part in grams and the dry weight of the root in grams (PSa/PSr). Ratios above 2.5 indicate disproportion and the existence of an insufficient root system to provide energy to the aerial part of the plant (Prieto et al., 2009). In addition, *T. cacao* plants grown at T_3 (T40:60) were sampled to evaluate if there was translocation of Pb from the substrate to the nursery plants.

Due to the fact that during the cultivation process of *T. cacao* plants it was observed that in the 5 replicates of T_3 (T40:60) and at a non-significant level in T_2 (T20:80) some *T. cacao* plants first presented a progressive leaf discoloration turning chlorotic yellow and then showed symptoms of disease in the foliage, it was decided to perform a foliar analysis on plants of the T_3 treatment (T40:60) taken from the 5 replicates. The analysis was carried out at the FUSADES laboratory, San Salvador, El Salvador. On the other hand, in the Plant Parasitology laboratory of CENTA, an analysis of the presence of pathogens in *E. crassipes* compost was carried out in T_5 (TT) and T_3 (T40:60) in order to determine the pathogens that caused the disease. The Potato Dextrose Agar (PDA) method was used as culture medium, under strict asepsis in a laminar flow chamber with ultraviolet light. Soil and substrate were homogenized and 10g were taken. Dilutions of 1/10,000 and 1/100,000 were prepared and 1 ml of each dilution was taken and placed in glass petri dishes sealed with parafilm tape containing PDA culture medium. The petri dishes were placed in an incubator at 22°C for 5 to 8 days, until fungal and bacterial growth was observed. For the identification of the microorganisms present, a sample of each of the fungi and bacteria grown in the petri dish was taken with a deception needle through a stereoscopic microscope and placed on a slide containing a drop of sterile water, covered with a coverslip and placed in a compound microscope where each of the fungal genera present in the samples was identified (R.F. de Serrano, personal communication, May 24, 2021).

Results

The overall mean plant height of *T. cacao* plants was 42.92 cm and a coefficient of variation of 13.35. T_1 reached the highest mean with 46.34 cm, followed by T_4 with 44.46 cm, T_2 with 43.37 cm, and T_3 with 41.78 cm. The control or T_5 registered the lowest mean with 38.65 cm (Table 1). The analysis of variance showed no statistical difference between the means at a significance level of 0.05 (Table 2).

Table 1
Results of Tukey's test for statistical differences of means.

	Variables studied		
Treatment	Height (cm)	Diameter (mm)	Slenderness index
T1 (T10:90)	46.34±4.28 $_{a}$	5.00±0.32 $_{ab}$	9.62±0.71 $_{a}$
T2 (T20:80)	43.37±4.39 $_{a}$	4.97±0.35 $_{ab}$	8.98±0.43 $_{a}$
T3 (T40:60)	41.78±8.98 $_{a}$	5.07±0.50 $_{a}$	8.39±1.22 $_{a}$
T4 (TR)	44.46±3.72 $_{a}$	4.71±0.42 $_{ab}$	9.82±0.92 $_{a}$
T5 (TT)	38.65±5.64 $_{a}$	4.18±0.59 $_{b}$	9.45±0.85 $_{a}$

Note: Means with different letters within a column are significantly different. ($p<0.05$), according to Tukey's test.

The overall mean plant diameter was 4.78 mm and a coefficient of variation of 9.45. T_3 recorded the highest mean with 5.07 mm, followed by T_1 with 5.00 mm, and T_2 with 4.97 mm. Treatments T_4 and T_5 recorded the lowest means with 4.71 mm and 4.18 mm, respectively (Table 1). A statistical difference was found at a significance level of 0.05 between the means of the treatments (Table 2). Tukey's test shows that the means of treatments T_1, T_2, and T_4 are statistically equal, T_3 and T_5 are different, where T_3 is the best and T_5 of least quality.

In the slenderness index, lower values reflect better quality plants. The overall mean of the slenderness index, which is the result of dividing the height and diameter at the root collar, was 9.25 and a coefficient of variation of 9.40. T_4 with a mean of 9.82, T_1 with a mean of 9.62, and the control T_5 with a mean of 9.45 presented the highest slenderness index. While treatments T_2 and T_3 reached the lowest means, with 8.98 and 8.39 individually (Table 1). The analysis of variance showed that there was no statistical difference between the means at a significance level of 0.05 (Table 2).

Table 2
Analysis of variance to determine statistical differences in the variables studied.

Variable	Source of variation	GL	Sum of squares	Mean square	F	P
Height (cm)	Treatment	4	169.01	42.25	1.29	0.30NS
	Error	20	656.57	32.82		
	Total	24	825.58			
Diameter (mm)	Treatment	4	2.66	0.66	3.26	0.03*
	Error	20	4.09	0.20		
	Total	24	6.75			
Leanness Index	Treatment	4	6.52	1.63	2.15	0.11NS
	Error	20	15.14	0.75		
	Total	24	21.67			

Note: NS= Statistically non-significant and, *= Statistically significant.

Figure 2 shows the measurement of the height, diameter, and samples of *T. cacao* plants for dry weight analysis to determine the quality variables of the plants.

Figure 2. A) Height measurement of *T. cacao* plants. B) Diameter measurement.

The overall mean of the dry weight (g) aerial part-dry weight (g) root part (PSa/PSr) ratio was 10.11 and a coefficient of variation of 18.37. The treatments with the highest mean were T4, T1, and T5, which recorded a mean of 10.86, 10.26, and 10.10 g, respectively. Treatments T3 and T2 had the lowest means with 9.86 and 9.51 g, each (Table 3). Values above 2.5 indicate disproportion between the aerial part and the root part; therefore, according to these results, there is no balance among the relationship between these two variables. According to the analysis of variance, there is no statistical difference between the means at a significance level of 0.05 (Table 4).

Table 3
Results of Tukey's test for statistical differences of means.

	Variables studied		
Treatment	PSa/PSr (g)	PSt (g)	ICD
T1 (T10:90)	10.26±1.13 $_{a}$	91.20±13.36 $_{a}$	4.57±0.37 $_{a}$
T2 (T20:80)	9.51±2.00 $_{a}$	83.51±12.33 $_{ab}$	4.52±0.51 $_{ab}$
T3 (T40:60)	9.86±2.11 $_{a}$	83.91±12.98 $_{ab}$	4.63±0.65 $_{a}$
T4 (TR)	10.86±2.11 $_{a}$	84.73±13.31 $_{ab}$	4.15±0.90 $_{ab}$
T5 (TT)	10.10±1.74 $_{a}$	62.36±15.10 $_{b}$	3.22±0.86 $_{b}$

Note: Means with different letters within a column are significantly different ($p<0.05$), according to Tukey's test.

The overall mean of the total dry weight variable was 81.14 g and a coefficient of variation of 16.58. Plant biomass is associated with plant survival and growth in the field. T_1 registered the best mean with 91.20 g. In second order are the treatments T_4, T_3, and T_2 that recorded means of 84.73 g, 83.91 g, and 83.51 g, individually. Lastly, there is T_5 with a mean of 62.36 g (Table 3). According to the analysis of variance, there is a significant statistical difference between the means of the treatments. According to Tukey's test, the means of treatments T_2, T_3, and T_4 are statistically equal, T_1 is statistically different from the other treatments, being the best, and T_5 is the worst with the lowest mean, so that the plants of T_1 with the best mean weight may have a higher percentage of survival in the plantation than those of T_5, which had the lowest mean weight.

The overall mean of the Dickson Quality Index was 4.22 and the coefficient of variation was 16.40. This index integrates the variables of plant quality, total plant dry weight (g), slenderness index (SI), and the ratio of aerial part dry weight - root dry weight (PSa/PSr); higher

values denote better quality plants, which may have more success in surviving in the sites where they are established in the field. T_3 registered the best mean with 4.64 DQI, followed by treatments T_1 with 4.57 DQI, and T_2 with 4.52 DQI. Fourth place was occupied by treatment T_4 with a mean of 4.16. The lowest mean was recorded by T_5 with 3.23 (Table 3). The results of the analysis of variance show that there is a significant statistical difference between the means of the treatments (Table 4). According to Tukey's test, the means of treatments T_2 and T_4 are statistically equal, as well as T_1 and T_3, with the best averages and T_5 with the lowest average.

Table 4
Analysis of variance to determine statistical differences in the variables studied

Variable	Source of variation	GL	Sum of squares	Mean square	F	P
Ratio of aerial part-root part (g)	Treatment	4	5.07	1.26	0.37	0.82NS
	Error	20	69.07	3.45		
	Total	24	74.15			
Total dry weight (g)	Treatment	4	2400.26	600.06	3.32	0.03*
	Error	20	3620.02	181.00		
	Total	24	6020.28			
Dickson Quality Index (DQI)	Treatment	4	6.86	1.71	3.58	0.02*
	Error	20	9.59	0.47		
	Total	24	16.45			

Note: NS= Statistically non-significant and, *= Statistically significant.

Regarding the heavy metals evaluated, Pb recorded an average of 3.54 ppm in fresh plants of *E. crassipes*. Hg and As were not detectable (Figure 3). For this reason, only Pb was analyzed in the *E. crassipes* compost, but it was no longer detectable (0.00 ppm). In spite of not detecting it in the compost samples analyzed, in order to fulfill the objective related to analyzing whether there is translocation of Pb, an analysis of this element was carried out in the *T. cacao* plants grown in treatment T_3, with a higher percentage of *E. crassipes* compost; according to the tests, it was not detectable either.

Due to the problems of progressive leaf discoloration turning chlorotic yellow and then symptoms of disease in *T. cacao* plants at T_3, a foliar analysis of nutrients was performed on the plants of that treatment. The results were compared with the reference levels used in the Agricultural Chemistry Laboratory of CENTA for the cultivation of *T. cacao*, based on Methods of Analysis of Soil Plants, Water, and Fertilizers. Fertilizer Development and Organization, 1999 (G. L. Enriquez, personal communication, 24 May 2021). N registered 3.18%, P 0.16%, K 1.32%, Ca 0.55%, Mg 0.20%, and S 0.24%. Fe presented 90.63 ppm, Cu 3.55 ppm, Mn 55.78 ppm, Zn 18.91 ppm, and B registered 67.52 ppm. N presented a higher level than recommended between 2.00% - 2.50%. The nutrients P, Mg, Cu, and Zn presented low levels, being the sufficient level 0.18% for P, 0.45% for Mg, between 8.0 ppm - 12.0 ppm for Cu, and between 20.0 - 100.0 ppm for Zn; while the nutrients K, Fe, Mn, and B presented sufficient levels: 1.30% - 2.2%, 60 - 200 ppm, 50 - 300 ppm, and 25 - 70 ppm, respectively (Table 5).

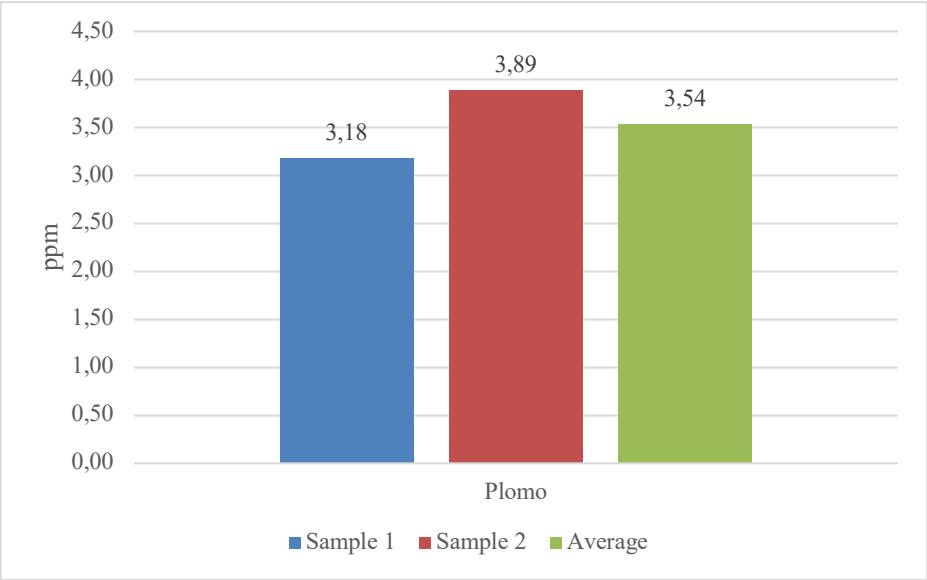

Figure 3. Results of Pb analysis in fresh *E. crassipes* plants.

Table 5
Foliar analysis of nutrients in T. cacao plants of the T_3 treatment (T40:60).

Element	Results	Unit	Low level	Sufficient level	High level
Total nitrogen	3.18	%	1.8 - 1.99	2.0 - 2.5	> 2.5
Phosphorus	0.16	%	0.13 - 0.18	> 0.18	
Potassium	1.32	%	1 - 1.29	1.3 - 2.2	> 2.2
Calcium	0.55	%	0.3 - 0.49	> 0.40	-
Magnesium	0.20	%	0.2 - 0.49	> 0.45	-
Sulfur	0.24	%	-	-	-
Iron	90.63	ppm	50 - 59	60 - 200	> 200
Copper	3.55	ppm	4 - 7	8 - 12	> 12
Manganese	55.78	ppm	22 - 49	50 - 300	> 300
Zinc	18.91	ppm	18 - 19	20 - 100	> 100
Boron	67.52	ppm	12 - 24	25 - 70	> 70

Note: Source: Results obtained at the FUSADES laboratory and reference level data used by the CENTA Agricultural Chemistry laboratory for cocoa cultivation, based on Methods of Analysis of Soil Plants, Water, and Fertilizers, Fertilizer Development and Organization, 1999 (G. L. Enriquez, personal communication, May 24, 2021).

Pathogens in E. crassipes compost at T_5 (TT) and T_3 (T40:60).

In the *E. crassipes* compost, four genera of fungi were found: *Aspergillus sp*, *Penicillum sp*, *Rhizopus sp*, *Sclerotium sp*; and one species of bacteria, which was not identified (Table 6). In T_5, two genera of fungi *Aspergillus sp* and *Fusarium sp*; and one bacterial species, which could not be identified, were recorded. On the one hand, in the substrate of T_3 (T40:60), seven genera of fungi *Aspergillus sp*, *Penicillum sp*, *Fusarium sp*, *Pythium sp*, *Cladosporium sp*, *Rosellinia sp,* and *Tricoderma sp* were found (Table 6). On the other hand, *Pythium sp* was found in the stem of the plants grown in T_3, and unidentified bacteria were present in the root and leaves. According to the results, the fungi that affected *T. cacao* plants in T_3 were *Fusarium*

sp, *Pythium sp,* and *Rosellinia sp*, the latter being the one with the highest incidence and the one that caused the most damage. In advanced stages, it manifested in the aerial parts causing yellowing, wilting, leaf drop, and dieback. This is consistent with that described by Phillips-Mora and Cerda (2011) and Alarcón et al. (2012), on the symptoms of the fungus *Rosellinea pepo* on *T. cacao* plants.

Table 6
Pathogens identified in E. crassipes compost, T_5 (TT), T_3 (T40:60), and in plants.

Fungal/bacterial genera	*E. crassipes* compost	T_5 (TT)	T_3 (T40:60) and plants	Observation
Aspergillus sp	*x*	*x*	*x*	Contaminant
Penicillum sp	*x*		*x*	Contaminant
Fusarium sp		*x*	*x*	
Pythium sp			*x*	
Cladosporium sp			*x*	
Rosellinia sp			*x*	Principal damage
Trichoderma sp			*x*	Antagonistic
Rhizopus sp	*x*			Contaminant
Sclerotium sp	*x*			
*Bacteria**	*x*	*x*	*x*	

Note: Source: Results from CENTA parasitology laboratory.
The x indicates the presence of the pathogen. *without identifying its genus.

Discussion and conclusions

Total plant height (cm). Although the results of *T. cacao* plant height was superior in the percentages of *E. crassipes* compost substrate (T_1, T_2, and T_3), no significant difference was found compared to the control treatment T_5. Similar results were reported by González (2018), who found no statistical difference for the height of *T. cacao* clones in his study where he tested treatments of organic fertilizers, bokashi, and earthworm humus, at 15, 45 and 90 days after planting. Lliuya (2015) found a significant difference in the same variable in the treatments where he used guinea pig manure, compost, and chicken manure in the cultivation of *T. cacao* seedlings. Likewise, Ramírez et al. (2013) presented better results for the treatment with a mixture of soil, sand and guinea pig manure, where *T. cacao* plants reached 34 cm in height in the saran cover and 35 cm in the plastic cover after 120 days.

Diameter (mm). In the present investigation, the diameter means were statistically superior in the treatments with percentages of *E. crassipes* compost substrate (T_1, T_2, and T_3), with respect to the control treatment T_5, with T_3 being the best. These data coincide with those reported by Lliuya (2015), who found significant difference in the diameter of *T. cacao* plants at 120 days for the organic fertilizer treatments compost, chicken manure, and guinea pig manure. Ramirez et al. (2013) also present better results for the treatment with a mixture of soil, sand, and guinea pig manure, where *T. cacao* plants recorded 6.89 mm of thickness in the saran cover and 8.72 mm in the plastic cover at 120 days. The opposite case revealed by González (2018), where the diameter of plants of *T. cacao* clones showed no statistical difference in the treatments of organic fertilizers, bokashi, and earthworm humus, at 15, 45 and 90 days after planting.

Slenderness index. Lower values of this index indicate better quality plants. The means of treatments T_2 and T_3 presented the lowest values; in spite of this, there was no significant difference between treatments, including the control T_5. Similar results were found by Tut Si (2014), in his study with nursery plants of *Tabebuia donnell-smithii* (cortez blanco) produced in the substrates lombri-composite, sand, soil, and chicken manure, in different proportions and mixtures, where no significant difference was found among treatments.

Total dry weight (g). A significant difference was found in the treatments with percentages of *E. crassipes* compost T_2 and T_3 and the relative treatment T_4, obtaining similar effects among them; T_1 was superior to all the treatments, and T_5 was the one with the lowest weight. Mateo-Sánchez et al. (2011) found a significant difference ($p<0.05$) for total dry weight in the production of Cedrela *odorata (*cedar) plants in nursery based on raw sawdust substrate mixed with peat moss-agrolite-vermiculite, registering the best result in plants grown with the 60% sawdust treatment, followed by the 70% sawdust treatment.

Dickson Quality Index (DQI). The treatments with *E. crassipes* compost T_3 with a mean of 4.63 DQI, T_1 with 4.57 DQI, and T_2 with 4.52 DQI, presented the best means of Dickson quality index (DQI), compared to T_5, finding a significant statistical difference. Mateo-Sánchez et al. (2011) obtained a significant difference ($p<0.01$) for the DQI in an experiment for the production of Cedrela *odorata (*cedar) plants in nursery based on raw sawdust substrate mixed with peat moss-agrolite-vermiculite. The best values were recorded for the treatments with 70%, 90%, and 60% sawdust. These data agree with those found in this study, where the treatments with a higher percentage of compost were superior to the control T_5.

Chemical analysis of heavy metals Pb, As, and Hg in E. crassipes plants prior to composting, Pb in compost, and in T. cacao plants. Pb recorded an average of 3.54 ppm in *E. crassipes* plants. Meanwhile, Hg, and As were not detectable; agreeing with those reported by ADEL-FIAES (2014), in samples of *E. crassipes* in 3 locations of the Cerrón Grande reservoir, which found between 2.41 and 3.0 ppm of Pb and also did not detect Hg and As. In turn, MARN (2012) in a leaf analysis sample of *E. crassipes* in the Metapán lagoon found 0.81 ppm of Pb, 2.26 ppm of As, and did not detect Hg. Coinciding in the presence of Pb, and the non-detection of Hg, in the plants of *E. crassipes* in both water bodies. According to NCh2880 (2004), the maximum level of trace elements in raw material for composting (mg/kg dry basis) for Hg is 10 mg/kg and for Pb 800 mg/kg. Therefore, the *E. crassipes* plants sampled in the Cerrón Grande reservoir meet the requirements for use as raw material for composting, with regard to Pb, which registered 3.54 ppm, and Hg, which was not detectable.

Foliar analysis and pathogens. According to the results of the foliar analysis and presence of pathogens, it is possible that when using a greater amount of *E. crassipes* compost, certain nutrients by excess or deficiency may cause a negative effect on plant development, as was observed in T_3 where 40% of *E. crassipes* compost was used, showing chlorotic yellowing of the leaves of *T. cacao* plants at the beginning of their development and then the presence of diseases. This could also be due to the presence of a greater number of pathogen species in this treatment, contrary to what was observed in the decrease of affected plants as less *E. crassipes* compost was used in treatments T_2 and T_1; therefore, it is recommended to use percentages of *E. crassipes* compost that do not exceed 20%. The symptoms of wilting or chlorosis that generally appear in cocoa nurseries are mainly due to fungal attack (Suárez, et al., cited by Pérez-Martínez, et al., 2017). On the other hand, it is common to find symptoms not caused by phytopathogens, but to nutritional deficiencies, excesses, or imbalances, manifested as chlorosis in whole plants, mottled chlorosis of the interveinal spaces of the leaves, deformation of the leaf lamina, decrease in leaf size, among others (Enriquez, 1985; Hardy, 1961, cited by Perez-Martinez, et al., 2017), which agrees with the findings of this study.

A positive effect of the use of *E. crassipes* plant compost on the quality of *T. cacao* plants in the nursery stage was observed for diameter, total dry weight and Dickson Quality

Index (DQI). This last index is the most comprehensive of all, it was found that treatments T_1 and T_3 recorded the highest means, being statistically equal to each other and superior to the control treatment T_5, which obtained the lowest average and, therefore, plants of lower quality. In the variables height, slenderness index, aerial dry weight/root dry weight ratio, there was no statistical difference between the means of the treatments.

The treatment with the highest percentage of compost, T_3, obtained the highest mean with respect to the Dickson Quality Index. However, from 45 to 90 days of development of *T. cacao* plants in the nursery, plants were affected by chlorosis at the beginning and then by disease, possibly when using a greater amount of *E. crassipes* compost, certain nutrients caused by excess or deficiency caused this effect. It could also be due to the presence of more species of pathogens in this treatment, being the fungi *Fusarium sp*, *Pythium sp*, and *Rosellinia sp,* which most affected the plants; contrary to what was observed in the decrease of affected plants as less compost was used. Considering that T_3 presented symptoms probably due to the attack of phytopathogens, or due to nutritional imbalances, or both, it is recommended that the percentage of *E. crassipes* compost most appropriate to be used for the production of *T. cacao* in the nursery phase should not exceed 20%, according to this research.

According to the findings, no translocation of lead (Pb) to *T. cacao* plants was found. Likewise, *E. crassipes* from the samples in the Cerrón Grande reservoir complies with the requirements of the NCh2880 standard (2004) for use as raw material for composting, with respect to the trace elements Pb, which registered 3.54 ppm, and Hg and As, which were not detectable.

The results obtained from the research show that the use of *E. crassipes* compost from the Cerrón Grande reservoir has a positive effect on the quality of *T. cacao* plants in the nursery stage; and it was determined that the most appropriate percentages of *E. crassipes* compost to be mixed with soil for the production of *T. cacao* in the nursery stage should not exceed 20%. It was also determined that the heavy metal lead (Pb) recorded in the fresh plants of *E. crassipes* was not identified in the compost, nor in the *T. cacao* plants, so there was no translocation of this metal.

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LEADERSHIP AND ORGANIZATIONAL SUCCESS WITH THE ISO 9001 MODEL

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Abstract. Given the growing adoption of the ISO 9000 model by the Industrial Companies of Cotton Textile Products in Bolivia (EIPAT), to effectively address a dynamic context and, as they are unable to visualize representative changes in their performance; furthermore, considering the impact of a solid Leadership on the collaborators and its repercussion on the processes and the organization, and finally, being one of the principles of quality management the Leadership; It was sought to establish the relationship between it and Organizational Success (EO). Two objectives were established: (1) Determine if the management levels exercise the Leadership actions recommended by the ISO 9000 model and, (2) Determine the relationship that exists between the Leadership exercised at each of the management levels and the EO. The alternative hypothesis was "The actions to exercise Leadership positively influence the Success of organizations with ISO 9001 certification"; and the null "Actions to exercise Leadership do not positively influence the Success of organizations with ISO 9001 certification". The information collection instrument was validated by experts in research methodology and Cronbach's Alpha statistic. In the data analysis, the measures of central tendency and variability were used for the descriptive and the Spearman correlation coefficient for the correlational; This made it possible to determine that there is a strong and moderate positive relationship between the study variables; as well as, that the middle management levels exercise these practices more frequently.

Keywords: Leadership, ISO 9001, Organizational Success.

LIDERAZGO Y ÉXITO ORGANIZACIONAL CON EL MODELO ISO 9001

Resumen. Ante la adopción creciente del modelo ISO 9000 por las Empresas Industriales de Productos Algodoneros Textiles en Bolivia (EIPAT), para abordar eficazmente un contexto dinámico y, al no poder visibilizar cambios representativos en su desempeño; además, considerando el impacto de un Liderazgo sólido en los colaboradores y su repercusión en los procesos y la organización, y por último, siendo uno de los principios de gestión de la calidad el Liderazgo; se buscó establecer la relación entre éste y el Éxito Organizacional (EO). Se establecieron 2 objetivos: (1) Determinar si los niveles de dirección ejercen las acciones de Liderazgo

recomendadas por el modelo ISO 9000 y, (2) Determinar la relación que existe entre el Liderazgo que se ejerce en cada uno de los niveles de dirección y el EO. La hipótesis alterna fue "Las acciones para ejercer Liderazgo influyen positivamente en el Éxito de las organizaciones con certificación ISO 9001"; y la nula "Las acciones para ejercer Liderazgo no influyen positivamente en el Éxito de las organizaciones con certificación ISO 9001". El instrumento de recolección de información fue validado por expertos en metodología de la investigación y el estadístico Alfa de Cronbach. En el análisis de los datos se utilizó las medidas de tendencia central y variabilidad para lo descriptivo y el coeficiente de correlación de Spearman para lo correlacional; lo cual permitió determinar que existe una relación positiva fuerte y moderada entre las variables de estudio; así como, que los niveles de dirección medios ejercen con mayor frecuencia dichas prácticas.

Palabras clave: Liderazgo; ISO 9001, éxito organizacional, sistemas de gestión de la calidad.

Introduction

The quality of products and services has ceased to be seen as an added value and has become a minimum expected by consumers, who are increasingly more and better informed due to the ease of access to technical and legal information, as well as to know multiple options before making a purchase decision. This situation has led organizations to be concerned about maintaining quality in order to satisfy the needs and expectations of their customers and, through this, to achieve the expected financial and market results. This has led to strong competition among companies, pushing them to adopt, implement, and maintain ISO 9001 quality management systems (QMS) to achieve high quality standards in order to meet the demands of the environment and differentiate themselves from the rest (Gonzáles, 2015).

Since its publication in 1987, this standard has had 5 versions in which modifications have been incorporated to suit the needs of users and other stakeholders (Manders, de Vries and Blind; 2016), becoming a referential tool to enable the growing internationalization of business and the need for common QMS standards (Fonseca, 2015). According to the report published by ISO (2019), worldwide, the number of certifications in force with ISO 9001 reached 883,521 in 1,217,972 sites; and in Bolivia a total of 241 (ISO, 2019b).

This standard, published by the International Organization for Standardization (ISO), and approved as a Bolivian Standard (NB) by the Bolivian Institute for Standardization and Quality (IBNORCA), establishes a series of generic requirements for designing and implementing a QMS in any type and size of organization, aimed at improving the ability to deliver products and services that meet technical and legal specifications, as well as customer satisfaction (Medina, López and Ruiz, 2017). Having, according to Rodriguez (2012), a favorable impact on efficiency, productivity, competitiveness, profitability, customer satisfaction, and overall performance in organizations providing those who adopt this standard, achieve superior financial and non-financial metrics in relation to others that do not (Fontalvo, Mendoza and Morelos, 2011; Marin, 2013; Benzaquen and Convers, 2015).

Focusing on the management principles of the ISO 9000 model, Leadership is the only one that has an exclusive chapter in the ISO 9001 (2015) standard, inferring the importance that the model gives to it since it states that leaders, at all levels of the organization, create the conditions in which people are involved in achieving the objectives, understanding the achievement of an objective as Success for this model. At the same time, it also specifies that *Leadership* must start with the creation of unity of purpose, and the direction and management of people, so that the organization can align its strategies, policies, processes, and resources towards the achievement of the objectives.

From the review carried out, referring to ISO 9001 and *Leadership*, it can be considered a strategy to implement a QMS under this model to address the complex and dynamic environment, which not only depends on meeting a series of generic requirements but also on

principles where, according to the contribution of different authors (Summers, 2006; Iqbal, Anwar and Halder, 2015; Robbins and Judge, 2017; Benavides, 2017; Chiavenato, 2018; Palazzeschi, Bucci and Di Fabio, 2018; Sousa & Rocha, 2019) can play a key role in the achievement of objectives and, therefore, of Organizational Success (EO) since, additionally, the same authors associate it with the ability to influence people, while according to Rachma (2014) it is a practice that transcends a simple control task because it also understands a focus on interpersonal relationships and motivation (Godoy & Bresó, 2013; Bester, Stander, & van Zyl, 2015; Qian, Song, Jin, Wang, & Chen, 2018). With the background of these investigations and considering what was exposed by Bass and Avolio (1994, 1997), it is possible to affirm that managing an adequate *Leadership* promotes the good functioning of any organization.

Therefore, it is feasible to infer that the more influence the leader has to improve employee practices, the more effective will be the development of a shared vision among the company's collaborators (Blanchard, 2016). Recognizing also that Leadership, in an increasingly dynamic environment and generator of growing uncertainty, is key to generate synergy in work teams in favor of achieving organizational results to survive in the highly competitive market (Youssef and Luthans 2012; Mendoza, García and Uribe, 2014; Tysen Wald and Heidenreich, 2014).

Despite the positive effects of implementing an ISO 9001 QMS, the researcher's experience has shown that it has not made a significant difference to date in the management results obtained by the EIPATs in Bolivia, which have adopted this model in an attempt to deal more effectively with an increasingly complex and dynamic environment. In addition to the above, the exercise of a weak *Leadership* by the different levels of management in this sector can be perceived during the processes of design, implementation, and maintenance of the QMS. ISO 9000 (2015) presents a series of actions to exercise *Leadership* within the QMS that would allow the creation of the unity of purpose and direction and management of people that would facilitate an organization to align its strategies, policies, processes, and resources to achieve the objectives and, seen in this way, it is convenient to intervene in a study on Leadership in organizations that have obtained the certification since it is assumed that the intention and the *know how* that the standard guides exist. Among the possible actions, and as mentioned by ISO 9000 (2015), are: (1) continuous training by management levels (FR), (2) communication the purpose, strategies, policies, and quality processes (CPEPP), (3) participation in teams or continuous improvement projects (PPEC), (4) recognition of personnel who promote and/or effectively apply quality principles and standards (RPPEC), (5) active participation in QMS performance monitoring and evaluation activities (PAED), (6) promotion and development of positive leadership at different levels (FDLP), (7) prioritization of the treatment of issues related to product and service quality (PTTR), (8) promotion and provision of resources, training, and authority required to act with responsibility and accountability (FPFARORC).

Being the supplier of choice is an increasing challenge in different sectors. Competition becomes more intense as new competitors emerge unexpectedly. Customers are more demanding and have many options available to them. Therefore, they expect to get what they want, when they want it, and they want their needs to be fully satisfied (Blanchard, 2016). In addition to the above, smuggling and increased imports of products of Chinese origin at lower prices add to the complexity of the context. This reality specifically describes the current environment in which the EIPATs are developing. This has led organizations in the sector to rely on ISO 9001 to meet the needs and expectations of the market in order to improve their business results. However, beyond the improvement in the image in general, there has not been a direct impact associated with greater customer satisfaction, profits or increase in sales during the period 2017-2019 as shown by the documented information related to management and QMS results in the organizations of the sector; aspects that for the management levels are synonymous with management *Success*. The aforementioned motivated to investigate if the

management levels were exercising the *Leadership* actions promoted by the adopted model; and if these have a relationship with the EO. In this sense, the hypothesis was based on the assumption that *Leadership* actions do not have a positive influence on the *Success* of ISO 9001 certified organizations.

Method

The research, conducted during the period August-December 2020, was framed in the non-experimental-transversal, descriptive, and correlational typology according to the classification presented by Hernández, Fernández and Baptista (2014). The study applied empirical methods and sought to determine the relationship of the exercise of Leadership of the management levels - as an independent variable -, based on the actions suggested by the ISO 9000:2015 standard, with *Success in Organizations* - as a dependent variable - within a certified QMS of the EIPATs during the 2017-2019 fiscal managements. In turn, the following specific objectives were raised: (1) to determine whether the management levels exercise the Leadership actions recommended by the ISO 9000 model and; (2) to determine the relationship that exists between the Leadership exercised at each of the management levels and Success in ISO 9001 certified organizations. To this end, the following research hypotheses were formulated:

(H_1) Alternative hypothesis: Leadership actions positively influence the success of ISO 9001 certified organizations.

(H_0) Null hypothesis: Leadership actions do not positively influence the success of ISO 9001 certified organizations.

The unit of analysis of the research was the EIPAT, where a population of 43 management positions divided into managers (10), department heads (13), and supervisors (20) was recognized. A percentage of 100% of them were administered an Ad Hoc questionnaire of ordinal scales validated under expert judgment and Cronbach's Alpha statistic with a value of 0.9078, which inquired about the participation of management levels in: (1) training related to ISO 9001 (FR); (2) communication of quality purpose, strategies, policies, and processes (CPEPP); (3) participation in continuous improvement teams or projects (PPEC); (4) recognition to promotion and application of quality principles and standards (RPPEC); (5) participation in QMS performance evaluation activities (PAED); (6) encouragement and development of positive leadership (FDLP); (7) prioritization of the treatment of quality-related issues (PTTR) and; (8) encouragement and proportion to act responsibly and be accountable (FPRRC).

Subsequently, after a process of socialization and staff training, the self-assessment questionnaire was applied. Following this, the instrument was prepared in the Google Forms application to facilitate its application, collection, and tabulation and was sent by e-mail. It was given 7 days to be completed, but it was 100% completed within 72 hours. Next, authorization was requested from the Senior Management (SM) of the organizations in the study sector, in order to have access to the documented information to collect the necessary data through the check sheet to corroborate the results of the questionnaire; as well as, those related to customer satisfaction, profits, and sales corresponding to the period 2017-2019. The organizations provided temporary access to this data through virtual folders such as OneDrive, Dropbox, and Google Drive.

The data analysis was performed taking into account the levels of measurement of the variable and using descriptive statistics according to the classification of Hernández at al. (2014). The measures of central tendency and variability were used for the descriptive and the parametric test of Spearman's correlation coefficient to determine whether the Leadership actions promoted by the 9000 model are related to *Organizational Success* in the sector. For

those that had a coefficient between 0.5 < X < 7.5 recognized as Moderate Positive and Strong Positive for those with 5,701 < X.

Results

After analyzing and interpreting the information obtained from the measures of central tendency and variability in each of the dimensions of the independent variable of *Leadership* globally and by level of management, the following results were obtained:

From the consultation on the participation in FR actions with ISO 9001, either managed at personal request or being part of the general training program, to keep updated and strengthen their skills in the subject continuously, it was observed that most managers *almost never* participate in these, as can be seen in Figure 1. There is a high dispersion in the exercise of this activity and a tendency to do it with some regularity as can be seen in Table 1.

However, as can be seen in the DM levels, they tend to do it more frequently and have a more homogeneous exercise of this *Leadership* action; in comparison with the AD and DO who do it *almost never*, as shown in Figure 2 and Table 2.

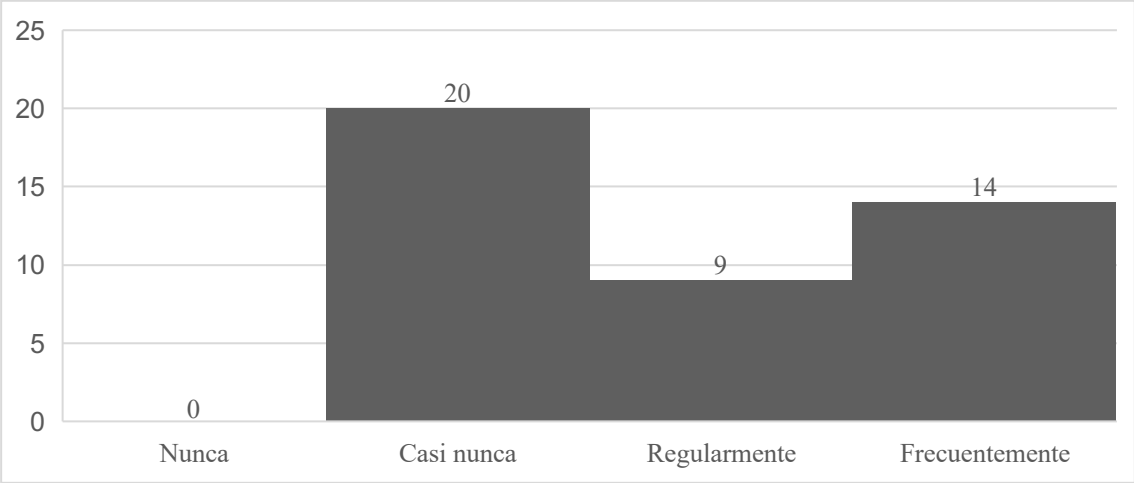

Figure 1. General participation in ISO 9001 training activities
Note: Own elaboration.

Table 1
Participation in ISO 9001 training activities

Tendency and variability	Data
Mean	2,860465116
Median	3
Mode	2
Range	2
Standard deviation	0,8885889

Note: Own elaboration.

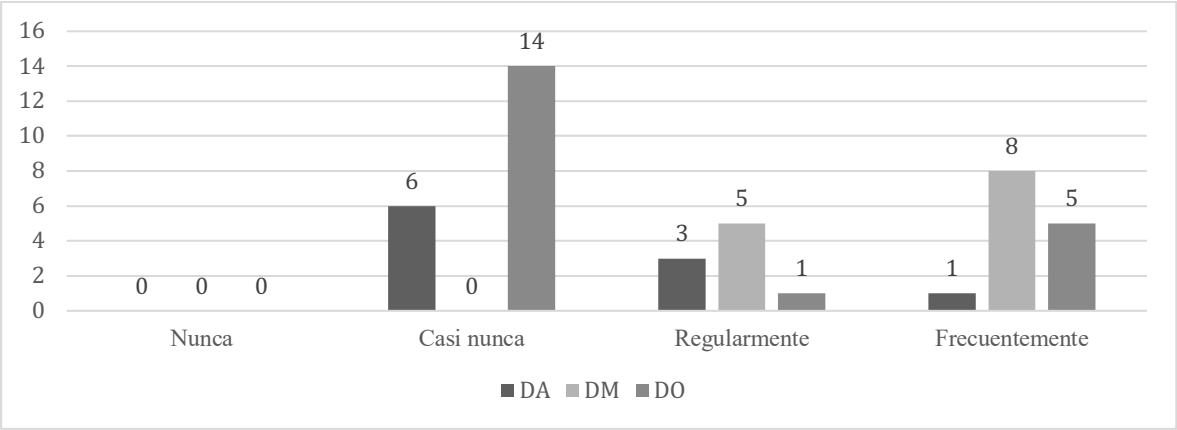

Figure 2. Participation in ISO 9001 training actions by level of management
Note: Own elaboration. Represents all management levels to which the instrument was applied. AD = Senior Management, DM = Middle Management, DO = Operational Management

Table 2
Participation in ISO 9001 training activities by management level

Tendency and variability	Senior Management	Middle Management	Operational Management
Mean	2,5	3,6153	2,55
Median	2	4	2
Mode	2	4	2
Range	2	1	2
Standard deviation	0,7071	0,5053	0,8870

Note: Own elaboration.

The second variable associated with *Leadership* for this study is related to the CPEPP. From the consultation on the execution and participation in these activities through different spaces such as meetings, messages, training actions, among others, it was observed that most of them do it *regularly* as shown in Figure 3. General communication of quality purpose, strategies, policies, and processes

; there is a high dispersion in the exercise of this activity and a slight tendency to do it *almost never* as can be seen in Table 3. However, as shown in Figure 4 and Table 4, the DM and DO levels tend to do it more *regularly*, compared to the AD that do it *almost never*; at the same time, in the three levels, the deviation is high average.

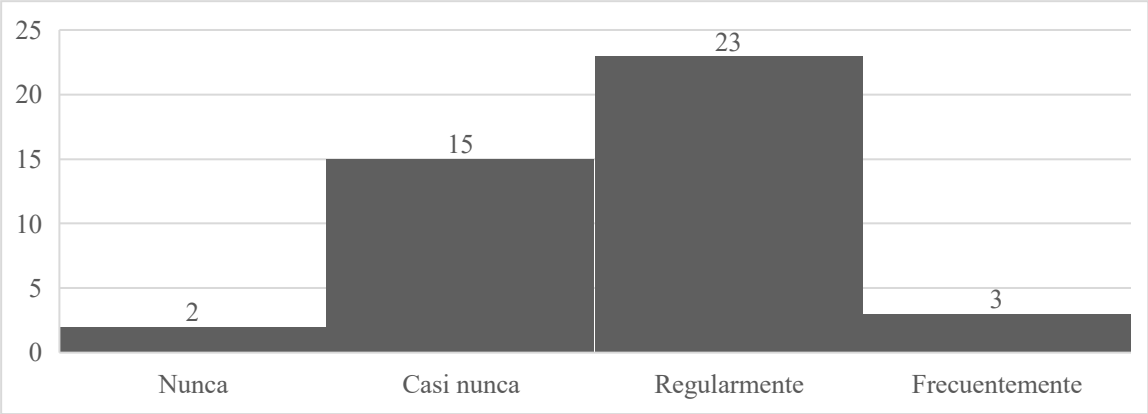

Figure 3. General communication of quality purpose, strategies, policies, and processes
Note: Own elaboration.

Table 3
Communication of quality purpose, strategies, policies, and processes

Tendency and variability	Data
Mean	2,6279
Median	3
Mode	3
Range	3
Standard deviation	0,6908

Note: Own elaboration.

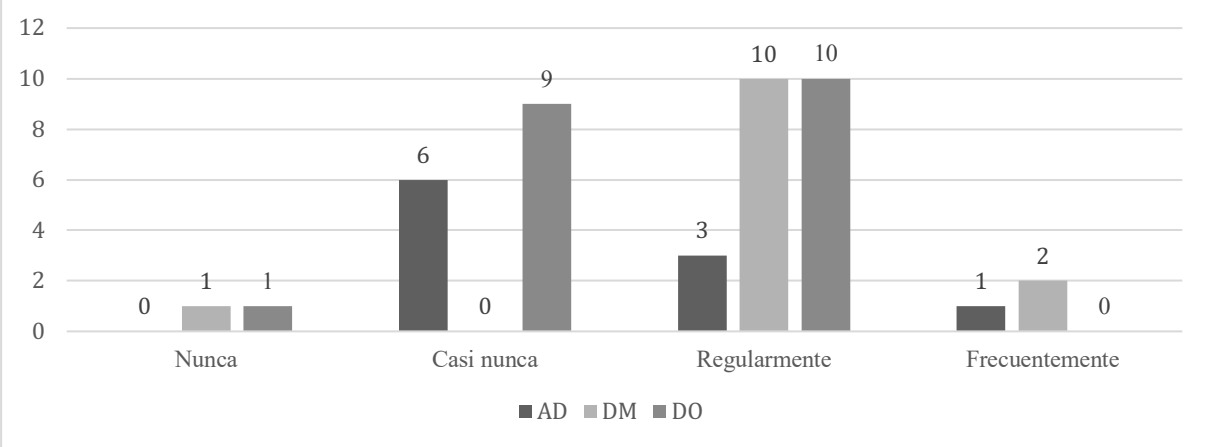

Figure 4. Overall communication of quality purpose, strategies, policies, and processes
Note: Own elaboration. Total number of management levels to which the instrument was applied. DA = Senior Management, DM = Middle Management, DO = Operational Management

Table 4
Communication of quality purpose, strategies, policies, and processes by management level

Tendency and variability	Senior Management	Middle Management	Operational Management
Mean	2,5	3	2,45
Median	2	3	2,5
Mode	2	3	3
Range	2	3	2
Standard deviation	0,7071	0,7071	0,6048

Note: Own elaboration.

The third associated variable, which is related to the PPEC by management levels, it was observed that taking part *frequently* is the most repeated, as shown in Figure 5, with a high average dispersion in the exercise of this activity as can be seen in Table 5. However, as shown seen in Figure 6 and Table 6, the DM levels tend to do it more *frequently* and are more homogeneous in their exercise, compared to the AD who do it *regularly* and the DO who do it *almost never.* In turn, in the latter two the deviation is high.

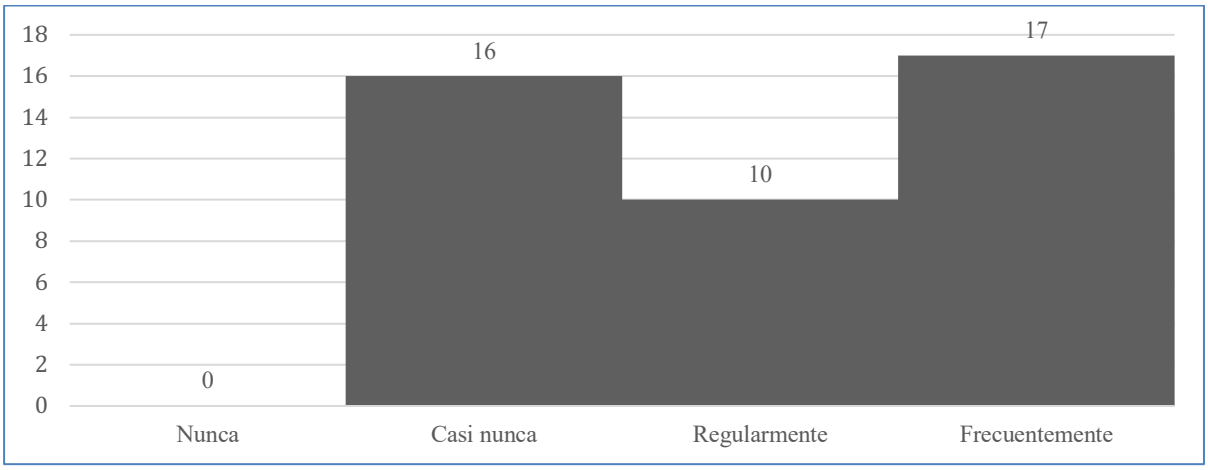

Figure 5. Participation in improvement teams or projects
Note: Own elaboration. Represents all management levels to which the instrument was applied.

Table 5
Participation in improvement teams or projects

Tendency and variability	Data
Mean	3,0232
Median	3
Mode	4
Range	2
Standard deviation	0,8860

Note: Own elaboration.

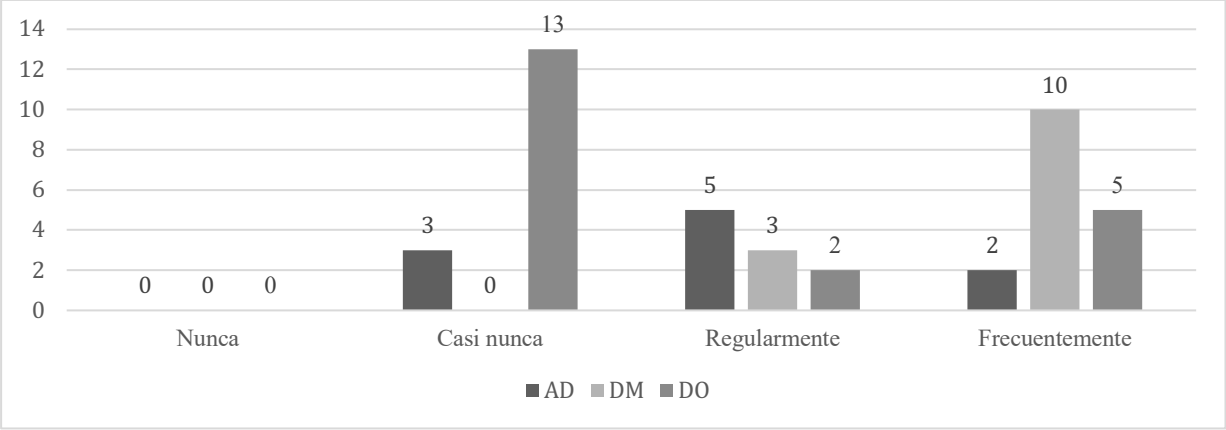

Figure 6. Participation in improvement teams or projects by level of management
Note: Own elaboration. Total number of management levels to which the instrument was applied. AD = Senior Management, DM = Middle Management, DO = Operational Management

Table 6
Participation in improvement teams or projects by management level

Tendency and variability	Senior Management	Middle Management	Operational Management
Mean	2,9	3,7692	2,6
Median	3	4	2
Mode	3	4	2
Range	2	1	2
Standard deviation	0,7378	0,4385	0,8825

Note: Own elaboration.

The fourth variable associated with leadership is related to the RPPEC. It was observed that taking part regularly is the most repeated, as shown in Figure 7, with a high average dispersion in the exercise of this activity as can be seen in Table 7.
However, as shown in Figure 8 and Table 8, the AD and DM levels tend to do it more regularly, compared to the DOs who do it almost never. The behavior of DMs and DOs are more homogeneous with respect to their performance in this Leadership action.

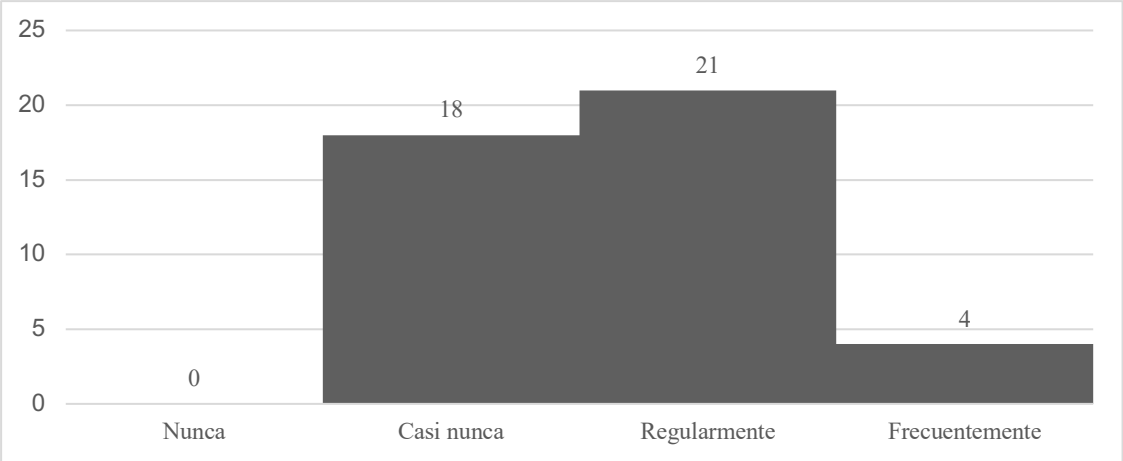

Figure 7. Recognition of personnel who promote and apply quality principles and standards

Note: Own elaboration. Total number of management levels to which the instrument was applied.

Table 7
Recognition of the promotion and application of quality principles and standards

Tendency and variability	Data
Mean	2,6744
Median	3
Mode	3
Range	1
Standard deviation	0,64442

Note: Own elaboration.

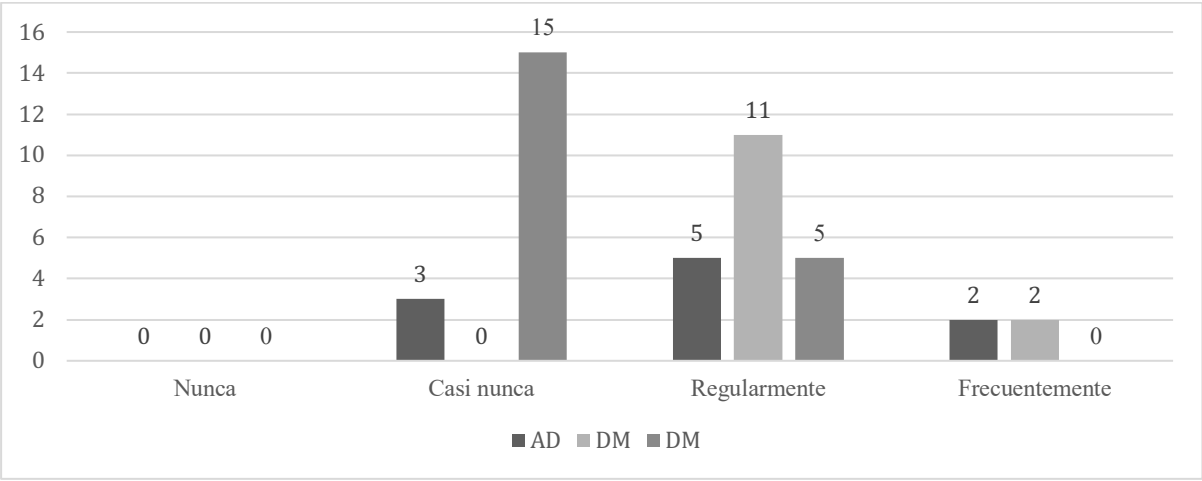

Figure 8. Recognition to promote and apply quality principles and standards
Note: Own elaboration. Total number of management levels to which the instrument was applied. AD = Senior Management, DM = Middle Management, DO = Operational Management

Table 8
Recognition for promoting and applying quality principles and standards by management level

Tendency and variability	Senior Management	Middle Management	Operational Management
Mean	2,9	3,1538	2,25
Median	3	3	2
Mode	3	3	2
Range	2	1	1
Standard deviation	0,7378	0,3755	0,4442

Note: Own elaboration.

The fifth associated variable is related to the PAED of the QMS. It was observed that *frequent* participation is the most repeated, as shown in Figure 9, with a high dispersion in the exercise of this activity, as can be seen in Table 9. However, as shown in Figure 10 and Table 10, the DM levels tend to do it more *frequently* compared to the AD levels that do it regularly, and the DOs that do it *almost never.* The behavior of the higher levels is more homogeneous with respect to their performance in this *Leadership* action, while that of the DMs and DOs is more dispersed.

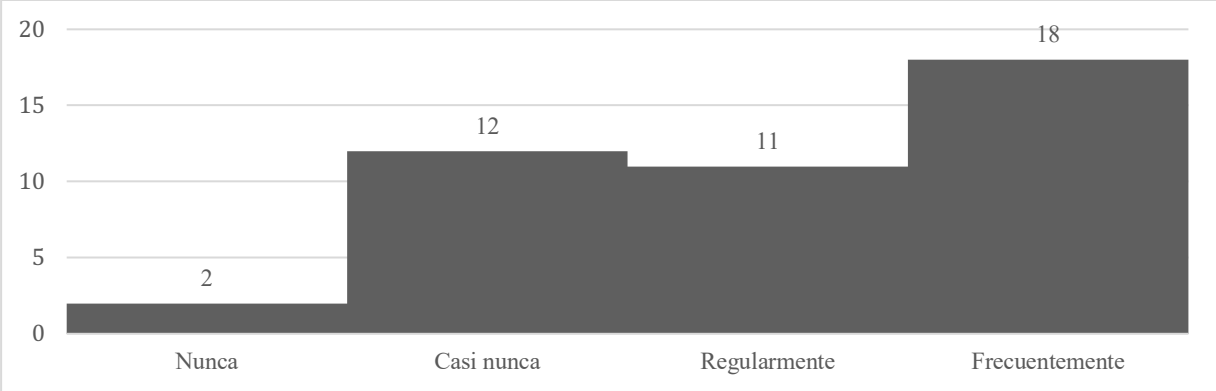

Figure 9. Participation in QMS performance evaluation activities

Note: Own elaboration. Represents all management levels to which the instrument was applied.

Table 9
Participation in QMS performance evaluation actions

Tendency and variability	Data
Mean	3,0465
Median	3
Mode	4
Range	3
Standard deviation	0,9500

Note: Own elaboration.

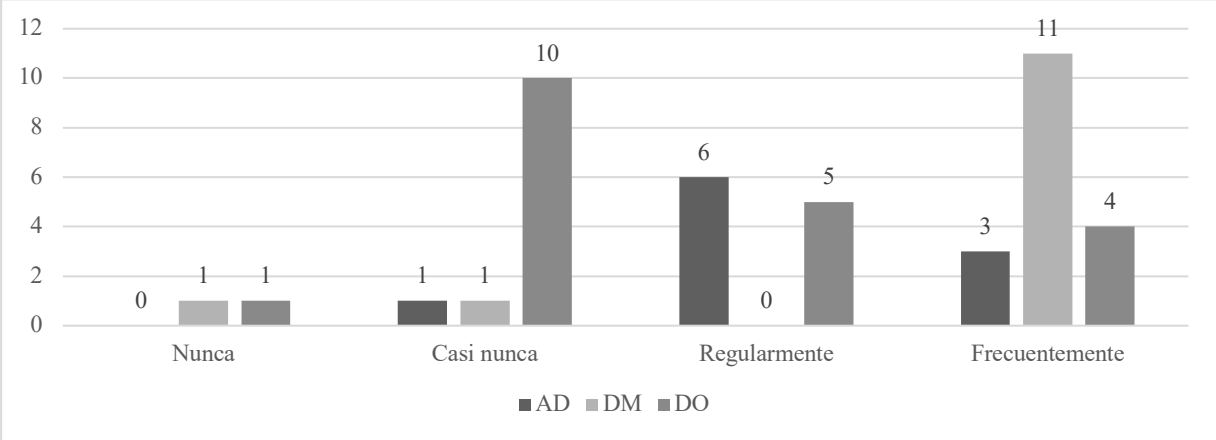

Figure 10. Participation in QMS performance evaluation actions by level of management

Note: Own elaboration. Total number of management levels to which the instrument was applied. AD = Senior Management, DM = Middle Management, DO = Operational Management

Table 10
Participation in QMS performance evaluation actions by management level

Tendency and variability	Senior Management	Middle Management	Operational Management
Mean	3,2	3,6153	2,6
Median	3	4	2
Mode	3	4	2
Range	2	3	2
Standard deviation	0,6324	0,9607	0,8825

Note: Own elaboration.

The sixth associated variable is related to FDLP. It was observed that taking part *regularly* is the most repeated, as shown in Figure 11, with a high average dispersion in the exercise of this activity as can be seen in Table 11. However, as shown in Figure 12 and Table 12, the DM levels tend to do it more *frequently* compared to the AD and DO levels that do it *regularly.* The

behavior of DMs and DOs are more homogeneous with respect to their performance in this *Leadership* action, while AD have a high average deviation.

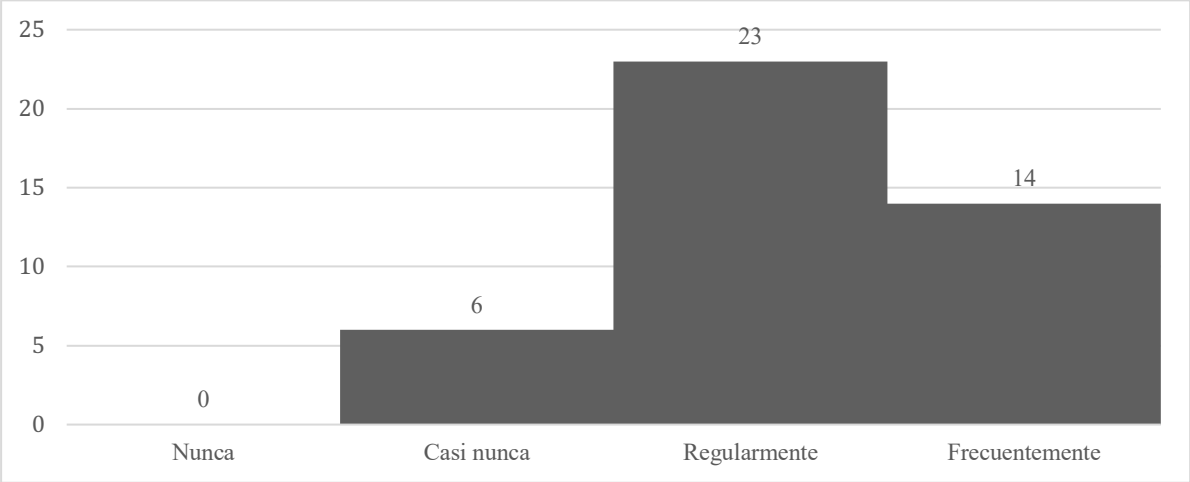

Figure 11. Encouragement and development of positive leadership
Note: Own elaboration. Represents all management levels to which the instrument was applied.

Table 11
Fostering and developing positive leadership by management level

Tendency and variability	Data
Mean	3,1860
Median	3
Mode	3
Range	2
Standard deviation	0,6638

Note: Own elaboration.

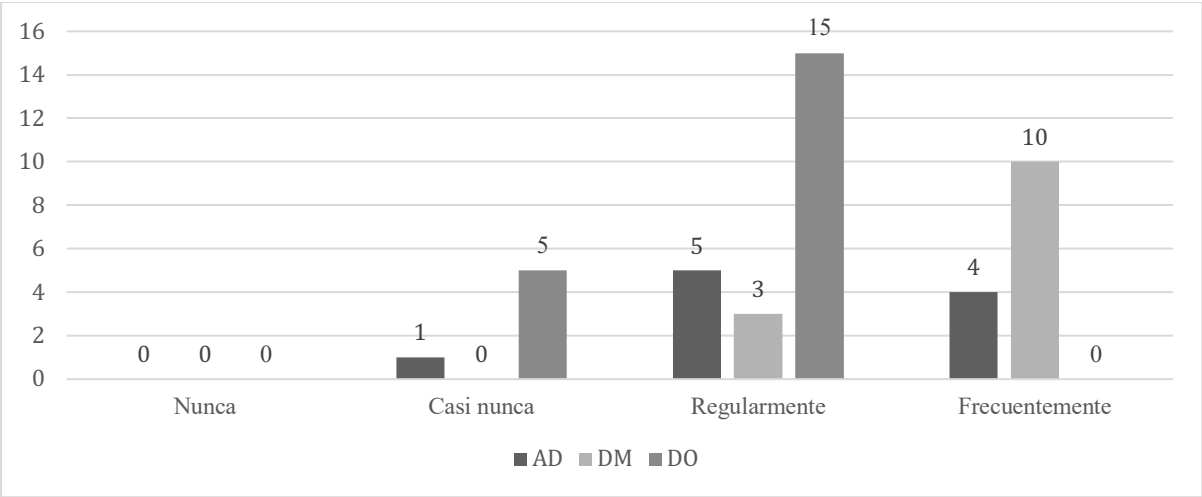

Figure 12. Fostering and developing positive leadership by level of management
Note: Own elaboration. Total number of management levels to which the instrument was applied. DA = Senior Management, DM = Middle Management, DO = Operational Management

Table 12
Encouragement and development of leadership by management level

Tendency and variability	Senior Management	Middle Management	Operational Management
Mean	3,3	3,7692	2,75
Median	3	4	3
Mode	3	4	3
Range	2	1	1
Standard deviation	0,6749	0,4385	0,4442

Note: Own elaboration.

The seventh variable associated with Leadership is related to PTTR with the quality of products and services. It was observed that taking part regularly is the most repeated, as shown in Figure 13 and Table 13. Prioritization of issues related to product or service quality, with a high dispersion in the exercise of this activity as can be seen in Table 13. As shown in Figure 14 and Table 14, the DM levels tend, in greater quantity, to do it *regularly.* The behavior of the DMs is more homogeneous with respect to their performance in this *Leadership* action, while the ADs and DOs have a high deviation.

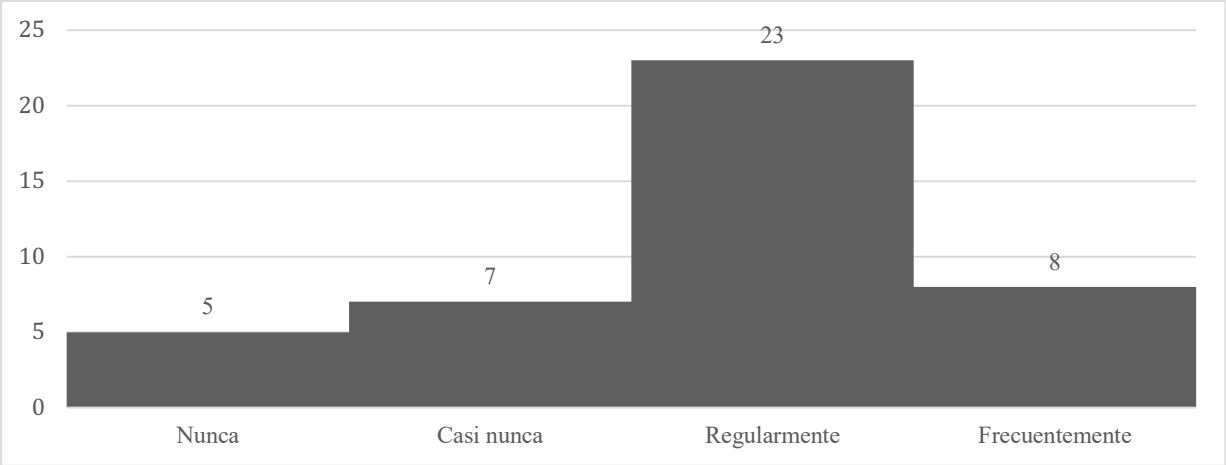

Figure 13. Prioritization of issues related to product or service quality.
Note: Represents all management levels to which the instrument was applied.

Table 13
Prioritization of issues related to product and service quality.

Tendency and variability	Data
Mean	2,7906
Median	3
Mode	3
Range	3
Standard deviation	0,8879

Note: Own elaboration.

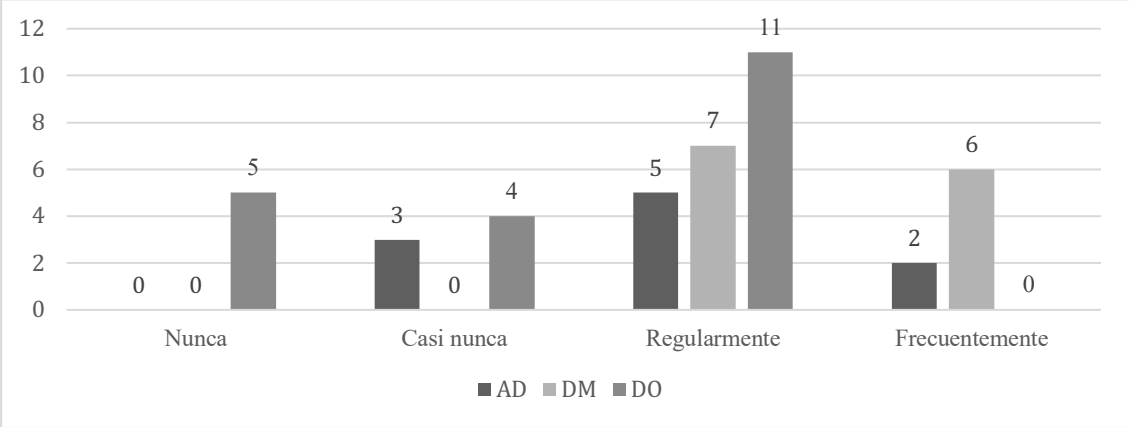

Figure 14. Prioritization of product and service quality issues by management level.

Note: Own elaboration. Total number of management levels to which the instrument was applied. AD = Top Management, DM = Middle Management, DO = Operational Management.

Table 14
Prioritization of issues related to the quality of products and services.

Tendency and variability	Senior Management	Address Media	Operational Management
Mean	2,9	3,4615	2,3
Median	3	3	3
Mode	3	3	3
Range	2	1	2
Standard deviation	0,7378	0,5188	0,8645

Note: Own elaboration.

The last variable associated with *leadership* is related to the FPFARORC. It was observed that taking part *regularly* is the most repeated, as shown in Figure 15, with a high dispersion in the exercise of this activity as can be seen in Table 15. As shown in Figure 16 and Table 16, the AD and DM levels tend, in greater numbers, to do it *regularly*, while the DOs *almost never*. The behavior of the DMs is more homogeneous with respect to their performance in this Leadership action, while the ADs and DOs have a high deviation.

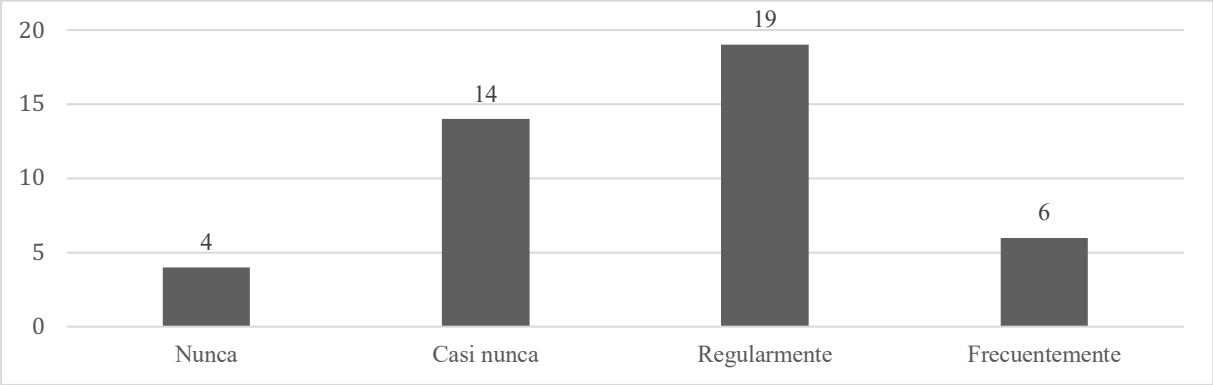

Figure 15. Encouragement and proportion of training for responsible and accountable action
Note: Own elaboration. Total number of management levels to which the instrument was applied.

Table 15
Encouragement and provision of training and resources for responsible and accountable action and accountability

Tendency and variability	Data
Mean	2,6279
Median	3
Mode	3
Range	3
Standard deviation	0,8458

Note: Own elaboration.

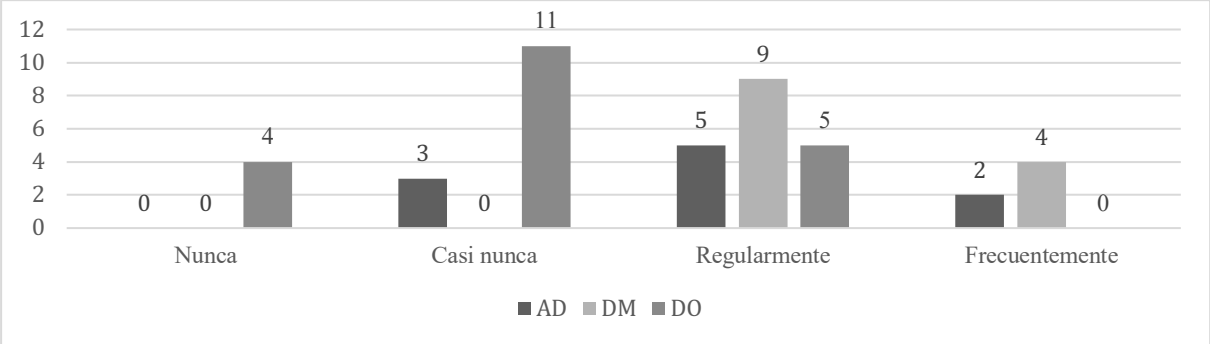

Figure 16. Encouragement and proportion of resources and training for accountability and responsibility by level of management
Note: Own elaboration. Represents all management levels to which the instrument was applied. DA = Senior Management, DM = Middle Management, DO = Operational Management.

Table 16
Encouragement and provision of resources and training to act responsibly and accountably by levels of management

Tendency and variability	Senior Management	Middle Management	Operational Management
Mean	2,9	3,3076	2,5
Median	3	3	2
Mode	3	3	2
Range	2	1	2
Standard deviation	0,7378	0,4803	0,6863

Note: Own elaboration.

After performing the individual analysis of the results of each variable associated with *Leadership*, which represent the actions proposed by the 9000 model for this purpose, it can be seen that in the PPEC and PAED of the QMS, the category that is most repeated globally is *frequently.* While in the CPEPP, the RPPEC, the FDLP, the PTTR, and the FPFAFRORC, the category that is most repeated globally is *regularly.* Finally, the category that is most repeated globally as related to FR is *almost never.* It can be observed that none of the actions recommended by the 9000 model for the exercise of *Leadership* shows a mode in the category *never.* Therefore, it can be said that none of the *Leadership* actions is not executed by most of the study subjects. Figure 17 shows the overall data for the overall measures of central tendency.

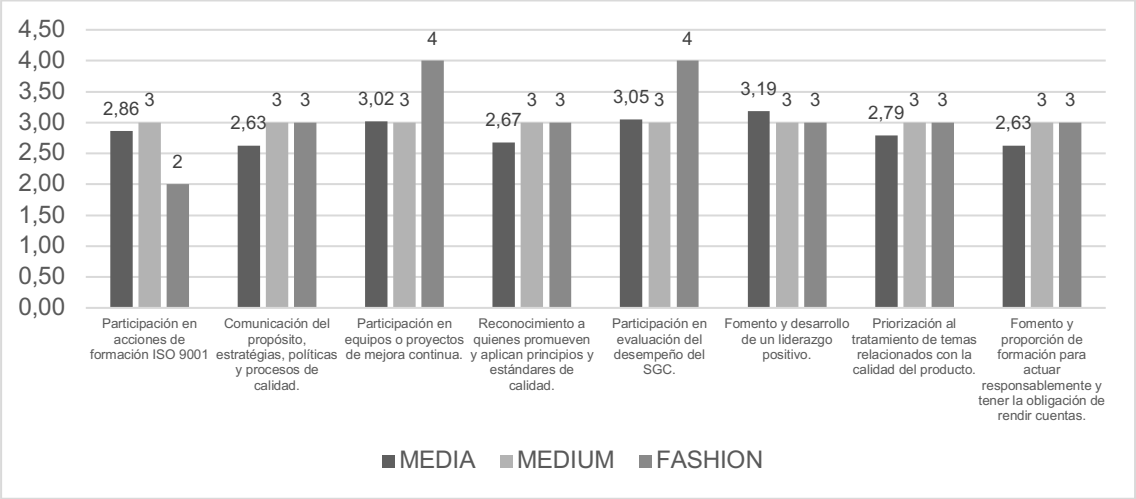

Figure 17. Overall tendency measures
Note: Prepared by the author. Summary of the measures of central tendency obtained for each of the dimensions of the independent variable. Although the three main ones (mean, median, and mode) were presented, the reference measure used as the main one is the mode, considering that the data are not normal.

In turn, Figure 18. Measures of global variability shows the overall ranges and standard deviation in the data for each of the dimensions of the *Leadership* independent variable.

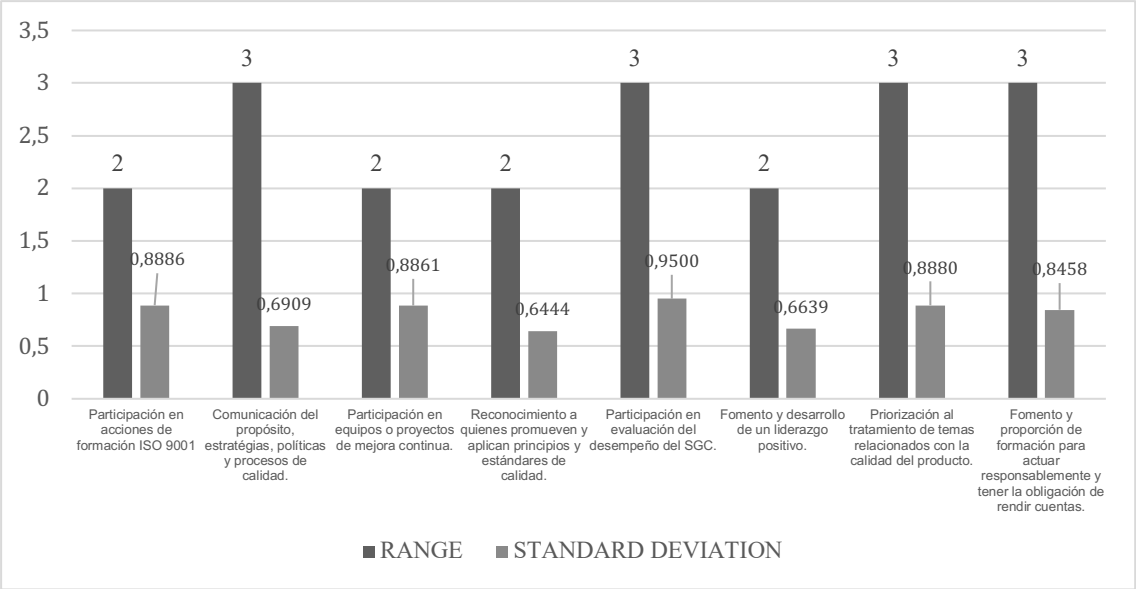

Figure 18. Measures of global variability

Note: Prepared by the author. The range and standard deviation were determined as measures of variability, variance was not used in the analysis because "for descriptive purposes, the standard deviation is preferably used" (Hernández, Fernández and Baptista, 2014).

Regarding whether *Leadership* has a relationship with *EO*, based on the actions suggested by the ISO 9000 model for its exercise by determining the Spearman Correlation Coefficient, we proceed to reject H_0 and, therefore, accept H_1. It can then be affirmed that there is a relationship between the exercise of *Leadership*, under the actions suggested by the ISO 9000 model, and *EO*. The results of the hypothesis test are shown in Table 17. Table 18 shows the relationship coefficients by variable. In turn, Tables 19, 20, and 21 show the categorization of the current leadership exercise performed by each of the management levels in relation to the variables associated with the *EO* in which the correlation is considered to be high positive.

Table 17
Hypothesis test results

Hypothesis	Decision
(H1) Alternative hypothesis: Leadership actions positively influence the success of ISO 9001 certified organizations.	Accepted
(H0) Null hypothesis: Leadership actions do not positively influence the success of ISO 9001 certified organizations.	Rejected

Note: Prepared by the author.

Table 18
Correlation between Leadership and EO

Leadership Dimensions	EO Period 2017-2019		
	Customer satisfaction	Profitability	Sales
FR	0,769933555	0,765176684	0,644707037
CPEPP	0,769933555	0,765176684	0,644707037
PPEC	0,802023558	0,745092117	0,771858955
RPPEC	0,749546965	0,682195711	0,686348535
PAED	0,750302024	0,778918756	0,702091513
FLPD	0,692804289	0,753737542	0,630738448
PTTR	0,73480444	0,72763138	0,701279825
FPDPARORC	0,741430082	0,686084265	0,713002114

Note: Own elaboration. The coefficients in dark lead color represent a strong positive correlation between both dimensions of the variables. The coefficients in light lead color represent a moderate positive correlation.

Table 19
Leadership and its positive and strong relationship with Customer Satisfaction

Leadership Actions based on ISO 9000 model	Period 2017-2019		
	Senior Management	Middle Management	Operational Management
FR	Weak	Very Good	Weak
CPEPP	Weak	Good	Good
PPEC	Good	Very Good	Weak
PAED	Good	Very Good	Weak

Note: Prepared by the author. To facilitate the analysis, Table 4.18 is used considering the dimension of the dependent variable being addressed. In turn, to facilitate its interpretation, the following terms are used according to the category where the identified mode is found for each dimension: Never= Null contribution, Almost never= Weak contribution, Regularly= Good (a), and Frequently= Very good (a).

Table 20
Leadership and its strong positive relationship with Profitability

Leadership Actions based on ISO 9000 model	Period 2017-2019		
	Senior Management	Middle Management	Operational Management
FR	Weak	Very Good	Weak
CPEPP	Weak	Good	Good
PAED	Good	Very Good	Weak
FDLP	Good	Very Good	Good

Note: Prepared by the author. To facilitate the analysis, Table 4.18 is used considering the dimension of the dependent variable being addressed. In turn, to facilitate its interpretation, the following terms are used according to the category where the identified mode is found for each dimension: Never= Null contribution, Almost never= Weak contribution, Regularly= Good (a), and Frequently= Very good (a).

Table 21
Leadership and its strong positive relationship with Sales

Leadership Actions based on the ISO 9000 model	Period 2017-2019		
	Senior Management	Middle Management	Operational Management
PPEC	Good	Very Good	Weak

Note: Prepared by the author. To facilitate the analysis, Table 4.18 is used considering the dimension of the dependent variable being addressed. In turn, to facilitate its interpretation, the following terms are used according to the category where the identified mode is found for each dimension: Never= Null contribution, Almost never= Weak contribution, Regularly= Good (a), and Frequently= Very good (a).

Discussion and conclusions

The DM levels have a greater and more frequent participation in the exercise of *Leadership* in the QMS, from the perspective of the actions suggested by the 9000 model. Due to the correlation identified between the independent and dependent variables, the exercise of *Leadership* in the DM and OD should be strengthened.

With respect to whether the *Leadership* actions suggested by the ISO 9000 model are exercised at the different management levels; it is evident that they are, although not with the same performance and prominence in each one of them.

The null hypothesis is rejected; therefore, the alternative hypothesis is accepted, establishing that there is a relationship between the exercise of *Leadership* and the EO of those who certify ISO 9001; which leads to the awareness of the importance of developing and maintaining strong leadership to influence the expected organizational results.

The *Leadership* actions suggested by the 9000 model that have a strong positive relationship with respect to customer satisfaction are the FR, the CPEPP, the PPEC, and the PAED of the QMS.

The *Leadership* actions suggested by the 9000 model that have a strong positive relationship with respect to customer satisfaction are the FR, the CPEPP, the PAED of the SGC and the FDLP.

The only *Leadership* action, of those suggested by the ISO 9000 model, which has a strong positive relationship with sales is the PPEC by management levels.

Due to the strong positive correlation that exists between FR with respect to customer satisfaction, a greater exercise of the actions suggested by the ISO 9000 model should be encouraged for the *Leadership* of the AD and DO levels, which are found in greater numbers in the category of *almost never*.

Due to the strong positive correlation that exists between CPEPP with respect to customer satisfaction, a greater exercise of the actions suggested by the ISO 9000 model should be encouraged for the *Leadership* of the AD and DO levels which are found in greater numbers in the category of *almost never*.

Due to the strong positive correlation that exists between PPEC with respect to customer satisfaction, a greater exercise of the actions suggested by the ISO 9000 model should be encouraged for the *Leadership* of the AD and DO levels, which are found in greater numbers in the category of *almost never*.

Due to the strong positive correlation that exists with the FR, with respect to profits, a greater exercise of the actions suggested by the ISO 9000 model for *Leadership* should be encouraged by the AD and DO levels, which are found in greater numbers in the category of *almost never*.

Due to the strong positive correlation that exists with the CPEPP with respect to profits, a greater exercise of the actions suggested by the ISO 9000 model should be encouraged for the *Leadership* of the AD and DO levels, which are found in greater numbers in the category of *almost never*.

Due to the strong positive correlation that exists between PAED with respect to customer satisfaction, a greater exercise of the actions suggested by the ISO 9000 model for *Leadership* should be encouraged at the DO levels, which have a mode of *almost never*, in contrast to the DM levels with a mode of frequently and the AD of *regularly*.

Due to the strong positive correlation that exists between PAED with respect to profits, a greater exercise of the actions suggested by the ISO 9000 model for *Leadership* should be encouraged at the DO levels, which have a mode of *almost never*, in contrast to the DM levels with a mode of frequently and the AD of *regularly*.

Due to the strong positive correlation that exists between FDLP with respect to profits, a greater exercise of the actions suggested by the ISO 9000 model for *Leadership* should be encouraged at the AD and DO levels, which have a mode of *regularly*, in contrast to the DM levels with a mode of *frequently*.

Due to the strong positive correlation that exists between PPEC with respect to sales, a greater exercise of the actions suggested by the ISO 9000 model for Leadership should be encouraged at the AD and DO levels, which have a mode of *regularly* and *almost never*, in contrast to the DM levels with a mode *of frequently*.

This research has allowed an approach to the study of leadership in the QMS proposed by the ISO 9000 model and its impact on the success of the organizations that adopt it. However, it is also necessary to recognize the existence of a series of limitations, as well as to propose some recommendations for future studies.

An important limitation of the work revolves around the main data collection instrument used. The number and length of the questions included in the questionnaire, since in order to motivate the response, it was considered appropriate not to add more items than the specific ones related to the actions to exercise *Leadership* according to the ISO 9000 model. This did not allow us to ask some other questions that could have enriched the work. At the same time, due to the global pandemic and the restrictions on circulation, it was not possible to collect data (from the application of the questionnaire) in person, which would have facilitated the explanation and complementation of a greater number of questions. Since the instrument had

to be self-administered, it should be simple and short. For this reason, it is recommended that this study be improved with more extensive instruments when the global situation allows it and that it be complemented with qualitative studies to deepen the perception and behaviors related to *Leadership*.

Another important limitation is the fact that the data collection instrument was applied only to the management levels of the organizations in the sector under study. In order to know the perception on the part of the leaders and to contrast this information, it should be a study that complements this one later on. Because workers in this type of sector do not use computer equipment or have access to the Internet to carry out their work, it was necessary to collect information directly in situ. This was not done for biosafety reasons.

Although the universe of the EIPATs was considered, in order to generalize the conclusions reached in this study, it is important to expand to a more representative number of companies, starting with sectors with a certain similarity in the way they work.

Leadership was approached from the perspective and actions suggested by the 9000 model, under the premise that it influences the success of the QMS; however, it was limited to identify and analyze whether or not the actions of the management levels are consistent with those established in the standard, and to determine whether or not there is an influence on success. However, it did not consider the other six principles of quality management, which could also influence the *EO*, as well as other actions to exercise *Leadership* complementary to those established in the 9000 model.

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PROPOSAL OF A DESCRIPTIVE ENERGY MODEL APPLICABLE TO THE INSTALLATION OF SOLAR PHOTOVOLTAIC SYSTEMS INTERCONNECTED TO THE GRID THROUGH DISTRIBUTED GENERATION: CASE STUDY IN NUEVO LAREDO

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Abstract. World energy consumption continues to increase due to population growth and technological development; however, 73 % of the energy used comes from fossil sources highly polluting for the planet, whose world reserves are being rapidly reduced. Using at least a smaller percentage of renewable energy could mitigate global warming and climate change and ensure global energy sustainability. Aware of this national and global problem, a descriptive energy model is proposed that methodologically includes the steps to follow to determine the viability of installing photovoltaic solar systems in any region of the world, through the analysis of the renewable energy resource available, of the environmental and electrical variables and, human, material and financial resources. The proposed model is developed and designed to collect, integrate, and analyze various sources and research work related to the joint subject as a comprehensive system that graphically displays and describes the information blocks to be obtained. As a particular case study, the model is applied in Nuevo Laredo, concluding that the necessary conditions exist to install photovoltaic systems. The measurement of variables in situ using special instruments and those obtained from databases or special software is considered. They are analyzed and compared with standards, manufacturer specifications, regulations, and reference parameters, making it possible to determine the region's viability to install photovoltaic solar systems. Finally, the application of the model requires preparing a technical report of the results obtained.

Keywords: photovoltaic system, distributed generating, energetic model, solar radiation, meteorological variables.

PLANTEAMIENTO DE UN MODELO ENERGÉTICO DESCRIPTIVO APLICABLE A LA INSTALACIÓN DE SISTEMAS SOLARES FOTOVOLTAICOS INTERCONECTADOS A LA RED MEDIANTE GENERACIÓN DISTRIBUIDA: CASO DE ESTUDIO EN NUEVO LAREDO

Resumen. El consumo de energía a nivel mundial continúa incrementándose debido al aumento demográfico y desarrollo tecnológico, sin embargo, el 73 % de la energía utilizada proviene de fuentes fósiles altamente contaminantes para el planeta y cuyas reservas mundiales se reducen aceleradamente, utilizando únicamente un porcentaje menor de energías limpias o renovables que mitiguen el calentamiento global, el cambio climático y aseguren la sustentabilidad energética mundial. Conscientes de esta problemática nacional y mundial, se propone un modelo energético descriptivo que incluya metodológicamente los pasos a seguir para determinar la viabilidad de instalar sistemas solares fotovoltaicos en cualquier región del mundo, mediante el análisis del recurso energético renovable disponible, de las variables medioambientales y eléctricas y, de los recursos humanos, materiales y financieros. El modelo propuesto se desarrolla y diseña mediante la recopilación, integración y análisis de diversas fuentes y trabajos de investigación relacionados al tema, conjuntado como un sistema integral que muestra gráficamente y describe los bloques de información que deben considerarse. Como un caso particular de estudio el modelo se aplica en Nuevo Laredo, para demostrar que existen las condiciones necesarias para instalar sistemas fotovoltaicos. Se considera la medición de variables in situ mediante instrumentos especiales y las obtenidas de bases de datos o software especial, se analizan y se comparan con normas, especificaciones de fabricantes, regulaciones y parámetros de referencia, lo que permite determinar la viabilidad de la región para instalar sistemas solares fotovoltaicos. Finalmente, la aplicación del modelo requiere elaborar un reporte técnico de los resultados obtenidos.

Palabras clave: Sistema fotovoltaico, generación distribuida, modelo energético, radiación solar, variables meteorológicas.

Introduction

Currently, world energy consumption has had a growth of 13,975 Mtoe, where 73% comes from fossil sources and 27% from renewable energies (ENERDATA, 2020), reaching a world energy consumption increase of 2.35% in 2018 (World Energy Markets Observatory, 2019), and in Mexico at the beginning of 2018 there were only 6,464 million barrels of oil as proven reserves (Kühne et al., 2019), which are enough for 9 years according to current consumption. Additionally, the increase in the cost of electricity tariffs over the last 10 years (Flores Contreras, 2018, p. 32), makes it necessary to look for electricity saving alternatives that reduce consumption and CO_2 emissions.

Under these conditions, although some countries in various regions of the world are already implementing programs that contribute to energy sustainability and sustainability through renewable energies, there is still much area of opportunity, particularly in Mexico due to its high levels of solar radiation throughout its territory according to data from the Geographic Information System for Renewable Energy in Mexico and the Solar Radiation Observatory of the Institute of Geophysics of the UNAM (Institute of Electrical Research, 2010). Observing irradiation values in most of the states above 5 kW/m^2 reaching maximum values of 6.89 kW/m^2, reflecting the large amount of solar resource available during most of the year. This competitive advantage of Mexico motivates the generation of electric energy through the implementation of distributed generation photovoltaic solar systems.

In addition, "grid parity" has now been achieved, which means that photovoltaic systems (PVS) are economically and environmentally competitive and superior to conventional energy production systems.

Global warming, environmental pollution, and the growing need for energy demanded by the regions due to population growth and technological development, forces the search for solutions that ensure its availability at competitive prices. Particularly the case of Nuevo Laredo, located in the region of the Burgos basin, where there are large deposits of gas and oil, which to extract it the companies demand a great amount of energy and motivates the development of this type of studies. For this reason the government of Tamaulipas is very interested in training highly qualified human capital to carry out studies and energy projects, provide energy to companies that could be installed in the city with the objective of extracting these resources from the subsoil.

As an answer to the described problem, the development of a descriptive energy model is proposed to determine the feasibility of installing, interconnecting to the grid, and optimizing distributed generation PV systems in any region of the world. This is achieved by analyzing the input/output variables of PV systems with capacities from 1 kW and less than 0.5 MW, identifying the types of photovoltaic (PV) installations, considering the sizing of components, materials, and PV equipment, as well as human, material, and financial resources and the applicable specifications and regulations.

There is currently no methodology that encompasses and describes in a single block the most relevant aspects considered in PVS design, even though there is information from various sources such as studies, projects, technical reports, theoretical models, doctoral theses, and other sources on related topics. Most of them deal with specific topics without a global vision of the factors involved, which makes it possible to exclude important variables or aspects that should be considered, since omitting them would result in an incomplete final design that would affect the operation of the PV system.

Table 1 mentions research works taken as a reference and describes the additional aspects considered in the proposed energy model that are not addressed in these works and that are relevant to consider in the design and commissioning of distributed generation interconnected PV systems (IPVS).

Table 1
Comparison of benchmark studies and the model proposed in this study

Reference models and studies	Problems they address	Additional aspects addressed by the proposed model
Sustainable energy planning model using multi-criteria optimization techniques (Falcón Roque, 2018).	Energy planning of a region with renewable energies applying multi-criteria techniques and considering universal access to energy in isolated rural communities, taking into account economic, social, and environmental aspects, formulating abstract analyses through objective functions to maximize the use of renewable energies over those coming from fossil resources, reducing polluting emissions, minimizing costs, and suggesting the best renewable source for a certain region.	The proposed model considers the analysis of the renewable resource and local environmental variables, whose assessment determines whether or not it is feasible to install renewable energy systems in the region. The energy planning model analyzes in a general way different types of renewable energy resources in the region, emphasizing technological, application, planning, and environmental aspects without considering in situ measurements or detailed and comparative analysis of each variable that affects energy generation according to the available energy resource.
The study "Solar photovoltaic energy, competitiveness and economic evaluation, benchmarking and modeling" (Collado Fernández, 2009).	It analyzes in general terms the current state of solar photovoltaic energy in the world: installed capacity, demand, generation, its contribution to greenhouse gas reduction, regulatory framework, costs vs. gas-based energy, users, and return on investment.	In addition to these aspects, the proposed model considers the detailed analysis of each variable in the region that affects the generation of the PVS, which allows determining the feasibility of its implementation.
The study "Contribution to the integration of grid-connected photovoltaic systems: solar resource and generation output" (Masa Bote, 2014).	Analyzes the prediction of electric power generation in the integration of photovoltaic systems in buildings in urban environments in comparison with centralized systems, considering shading effects and weather prediction models.	The reference model focuses mainly on the analysis of losses due to shading and analyzes radiation, the effect of temperature and the efficiency of the inverter in the generation of electricity, without considering other variables such as wind speed, humidity, precipitation, applicable regulations, and other human, material, and financial resources that are included in the proposed model.
The study "Feasibility analysis for the installation of a clean energy system by means of photovoltaic cells for power supply of building 4 at ITSLV" (Hernández Gallegos, 2017).	To analyze the feasibility of installing a clean energy system using photovoltaic cells to supply electricity to building 4 of the Instituto Tecnológico Superior de la Venta, in order to reduce electricity billing costs, considering the types of photovoltaic cell technologies, energy consumption, available space, and cost-benefit.	Although the baseline study includes aspects indicated in the proposed model, it does not make reference to the detailed analysis of some environmental variables that affect the generation of the PVS such as humidity, rainfall, and hail, but rather emphasizes on the cost benefit of the PVS as a whole. Although it points out aspects of wind speed, it does not make reference to manufacturers' specifications that must be met to ensure continuous operation of the PVS, as indicated in the proposed model.

Note: Source: Own elaboration.

Method

Design

The design and development of the energy model was defined through conceptual research, studies, measurements, and analysis of PV projects, integrating all this information into a single functional block. The model relates various aspects and input/output variables involved in the generation of PV electric energy, describing how each variable affects the PV generation process, allowing to reduce the effects and improve the overall efficiency of the PV system.

The orderly and methodological application of the model allows obtaining, plotting, analyzing, and comparing the values of the variables of the region under study, with the applicable standards and the specifications of PV component manufacturers, including the sizing of such components and interconnection regulations.

The model methodology involves preparing a technical report with the results obtained, which allows inferring whether or not it is feasible to install PVS in a particular region, or if it is possible to optimize the generation of energy from PVS in case it is operating.

As a particular case, the model is applied to demonstrate that in Nuevo Laredo, Tamaulipas, Mexico, the solar resource, meteorological parameters, and other components included in the model, are adequate to install distributed generation PVS, also promoting the use of renewable energy and mitigating the environmental pollution of the city, due to the daily crossing between Mexico and the United States of more than 12,930 cargo trucks (Duarte, 2017) that consume highly polluting diesel. Nuevo Laredo is located on the southern bank of the Rio Bravo border boundary between Mexico and the United States of America, with 405,000 inhabitants according to the 2018 census. The climate is the driest and most extreme in the state, an average annual temperature of 22.6 °C with large oscillations ranging from 2.5 °C in winter, to 40.50 °C in summer; its average annual rainfall is 472.5 mm and the prevailing winds come from the south.

For the study, two PV systems are considered, one of 3 kW and the other of 4 kW located in different parts of the city; both PV systems use polycrystalline technology and central inverters of the mentioned capacities.

Participants.

The human resources, composed of research professors, students, and through the support of some government agencies to provide information and private owners of the PVS used in the study. Additionally, the facilities of the Universidad Tecnológica de Nuevo Laredo to perform tests on the PVSs and measurements with laboratory equipment.

Instruments.

The variables defined in the model are collected using ad hoc formats and tested with the instruments shown in Table 2:

Table 2
Instruments for data collection

Equipment	Description	Operating range
Use of ad hoc tables or existing official formats.	For the collection of data measured in situ and those obtained from software or databases.	Applicable to all variables.
Two PVSs used as samples.	With polycrystalline technology, for on-site measurement of electrical input/output variables.	PVS of 3 kW and 4 kW.
Fluke Multimeter.	For voltage and electric current measurements.	CAT III, 600V, ACV ± (1.0 %+3), DCV ± (0.5 %+2).
Solar radiation meter.	Amprobe Solar-100 model.	Range: 1999 W/m2; accuracy ± 5-10 W/m2; resolution 0.1W/m2.
Fluke 434-II Power Quality Analyzer (ACE-Fluke 434-II).	To measure the variable harmonic distortion, power, and electrical energy generated by the PVSs.	Accuracy: Voltage: 0.5 % of rated voltage, Current: 0.5 %, Power: 1 %, Frequency: 0.01 Hz).
Weather station.	Model PCE-FWS 20 with remote data access from a PC.	Resolution 0.1 ºC (0.2 ºF); temperature range -40 ºC - +65 ºC, wind speed range 0 - 240 km/h (0 ~ 100 mph).

Note: Source: Own elaboration.

Data analysis

The data of each variable measured in situ are plotted for comparative analysis and interpretation, observing monthly and annual trends, inferring the degree of affectation in the generation of PVS and proposing actions for improvement of the system under study, the analysis allows:

a. Observe trends, behaviors, averages, ranges, and limits.

b. Establish comparisons with applicable standards and manufacturers' specifications to optimize the PVS.

c. Suggest improvement actions, proposing equipment and materials that will withstand the climatic conditions of the region, ensuring a good performance during the PVS's useful life.

d. Issue recommendations or redesign the PVS to operate optimally.

Variables

The variables described in the model are analyzed and plotted to determine their impact on PV generation, the data obtained with measurement instruments and those obtained from official sources such as RetScreen, Meteonorm, CONAGUA, or other sources available on the internet, are recorded in ad hoc tables.

The variables defined in the model are of the quantitative type (Hernández Sampieri et al., 2010), multiple measurements are taken at various times, being analyzed graphically to know their impact and take actions to optimize PV generation, as mentioned in related studies (Caamaño Martín, 1998) and (García Barrios, 2018). Similar studies analyze environmental variables and their effects on PVS (Vigil Galán et al., 2018).

PVS input variables

These are meteorological and solar irradiation variables available in the region under study, analyzed during the design stage of the PV system to know their tendency and that can be determinant to install PV systems in a certain location, refer to Table 3.

Table 3
Photovoltaic system input variables

a. Solar irradiance (G) measured in kWh/m^2, a quantitative and continuous independent variable.
Daily on-site average measurements are obtained by the Apsystem monitoring system from two sample PVSs used during the 12 months of the year and monthly average data from other sources such as RetScreenExpert and Meteonorm V7.1, the average determines whether the region has sufficient solar radiation to ensure optimal PV generation.
b. The ambient temperature (T) measured in °C, a continuous quantitative independent variable.
Daily average measurements are obtained in situ during the 12 months of the year from a meteorological station and from the meteorological station of the Nuevo Laredo International Airport (EMAINL) during a period of 20 years of monitoring. The average of the T measurements is obtained, and the minimum, average, and maximum values are compared to infer the degree of affectation in the generation of PVS.
c. Wind speed (WS) measured in km/h, a continuous and independent quantitative variable.
Daily average measurements taken in situ during the 12 months of the year are obtained from a meteorological station and from the EMAINL during a period of 20 years of monitoring, the average of the WS measurements is obtained, the minimum, average, and maximum values are compared to suggest the degree of robustness that the mounting structures of the PV modules (PVM) should have, and the resistance to wind loads that the PVM installed in the region should withstand.
d. Relative humidity (RH) measured in percent, independent variable.
Daily average measurements taken in situ during the 12 months of the year are obtained from a weather station and from data obtained from the national meteorological system in monthly averages, which are averaged and compared to determine their degree of dispersion. High RH values imply premature corrosion and greater affectation by potential-induced degradation (PID), caused by moisture seepage inside the encapsulation reducing PVS performance by up to 30% in the medium term (Sol Energy, 2018). In places where RH is high, it is recommended to use anodized aluminum structures and PVM approved in PID.
e. Atmospheric pressure (Pa) measured in hPa, a continuous and independent quantitative variable.
Daily average measurements taken in situ during the 12 months of the year are obtained from a meteorological station and from the EMAINL, and the average values are compared to infer possible effects on the PVS performance caused by humidity. Pressures lower than the typical local pressure cause storms and consequently increase humidity, affecting the PVS.
f. Pluvial precipitation (PP), variable measured in mm.
Daily average measurements taken in situ during the 12 months of the year are obtained from a weather station and from the EMAINL, averaged and compared graphically to determine the precipitation levels to recommend the most suitable type of PID PVM, since high rates imply higher humidity and consequently greater possibilities of filtration and corrosion. However, there is also a greater natural cleaning of the PVM reducing the frequency of maintenance due to the accumulation of dust or other debris.
g. Hail and snow (HS), independent variable measured in number of events per year.
Its analysis determines the frequency of occurrence of this phenomenon, which allows the use of PVMs that comply with the IEC 61215 ed.2 standard and avoid irreparable damage.
h. Peak solar hours (PSH), variable measured in h.
The PSH (Pérez Martínez et al., 2017) is a variable obtained from the solar irradiance of the region divided by the standard test value of the PVMs (STC) equivalent to 1,000 W/m^2. Multiplying the PVS capacity by the PSH of the region yields the daily electric power production.

Note: Source: Own elaboration.

PVS output variables

The values are obtained when the PVS is operating, their analysis allows adjustments to be made for optimum performance. These variables are shown in Table 4

indicating their units of measurement, the monitoring period, the source of the measurements, and providing a brief explanation on the interpretation, analysis, and use of the data.

Table 4
Photovoltaic system output variables

a. The generated voltage measured in Volts (V), corresponds to daily measurements taken in periods of 15 minutes during a week.
Variable measured at the point of common coupling (PCC) of the PVS and the network using a multimeter or an ACE-Fluke 434-II. It is verified that the V_{AC} level is within the distortion specifications indicated by the standard for interconnected PVS. The V_{DC} corresponds to the generated voltage measured at the PVM terminals.
b. The generated current measured in Amperes (A), variable measured daily in 15-minute periods during one week.
It is measured at the PCC of the PVS and the network by means of an ammeter or an ACE-Fluke 434-II. It is verified that the I_{AC} signal demanded by the loads is within the harmonic distortion limits allowed by the applicable standard. The I_{DC} corresponds to the generated current measured at the terminals of the PVMs.
c. The electrical power generated (P), measured in Watts (W), corresponds to daily measurements taken in periods of 15 minutes during a week.
Variable measured at the PCC of the PVS and the grid using an ACE-Fluke 434-II. It is verified that the power generated corresponds to the PVS capacity.
d. The electrical energy generated (EE) measured in kWh, corresponds to daily measurements taken in 15-minute periods during a week.
Variable measured at the PVS PCC and the grid using an ACE-Fluke 434-II. The power delivered by the PVS will depend on the loads connected to the circuit, checking that the PVS delivers the electrical power according to the design capacity.
e. The total harmonic distortion (THD) measured in percentage, corresponds to daily measurements taken in periods of 15 minutes during one week.
Variable measured at the PCC of the PVS and the network by means of an ACE-Fluke 434-II, an important parameter that must comply with the applicable standards according to the country, which for Mexico is CFE L0000-45.

Note: Source: Own elaboration.

Results

The design and development of the energy model is based on a series of functional blocks composed of solar irradiation, climatological and electrical variables, sizing of PV components, applicable regulations, manufacturers' specifications, types of users, human, material, financial and technological resources, all compiled from various bibliographic sources and integrated into a single schematic diagram of information shown in Figure 1.

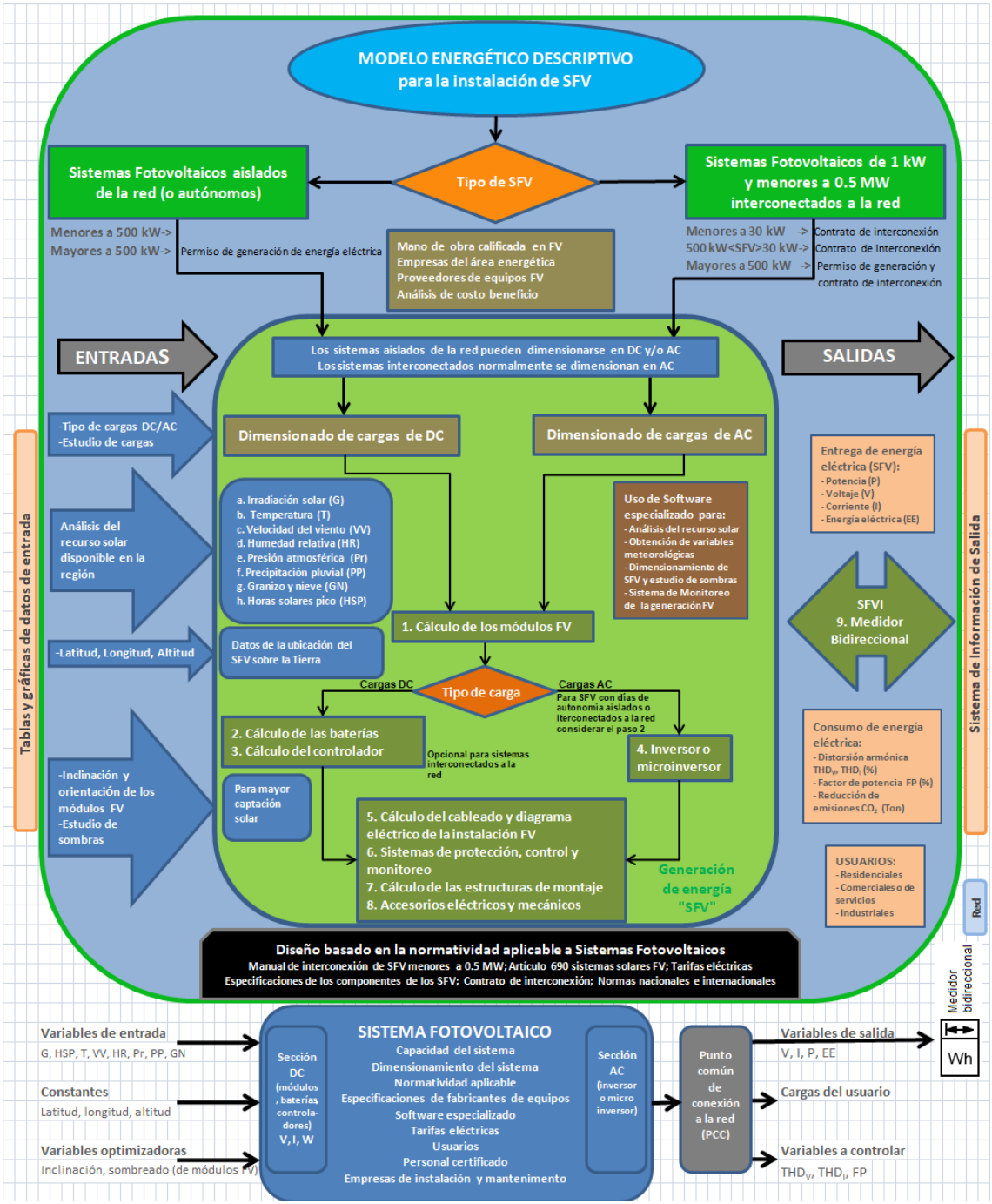
The model developed in addition to considering the analysis of input/output variables, also includes the study of other complementary aspects such as government regulations for grid interconnection, allowing a complete view of the inherent aspects that affect and/or benefit PVS performance coinciding with the study (Masa Bote, 2014) and complementing with the analysis of additional variables such as WS, RH, Pa, and PP.

Through the methodological application of each block and analyzing the trend of the variables referred to in the model, it can be inferred whether the region under analysis located anywhere in the world meets the necessary and sufficient conditions to install PV systems to the distributed generation network. This allows for improvement actions to be taken to the PV systems in operation if the results show vulnerable conditions that were not considered during the design stage of the system or due to the premature degradation of its components. Each block can be broken down according to the flow diagram in

Figure 2 and existing calculation tools or software can be used to facilitate the analysis of the PVS. The function of the main blocks of the proposed model is described in the following sections.

a. Block description of the descriptive energy model

Figure 1 shows all the blocks involved in the solar photovoltaic electric power generation process, describing the function and impact of each one. It is important to point out that the correct application of the model implies considering the analysis of all the blocks avoiding omitting any of them, allowing to obtain a complete result that reflects the reality of the energy conditions of the region and/or the current PV system, which will determine the feasibility of installing new PV systems, or allow improvements to the existing ones.



Descriptive model of a grid-connected solar photovoltaic energy system.
Note: Source: Own elaboration.

b. Type of photovoltaic system

There are two relevant characteristics in every PVS depending on its connection to the installation that will feed the user's loads, being necessary to define whether the system will be autonomous or interconnected to the grid, since the components and sizing of the PVS will be different depending on each case.

c. Skilled labor, companies, and PVS suppliers

The methodology establishes the importance of having specialized labor in the installation of PV systems, and it is convenient to check the availability of certified personnel in the region. Likewise, the local existence of installation service companies or suppliers of PV equipment and materials is relevant in order to obtain a better cost-benefit and post-service during the operation of the PV system and to facilitate the application of guarantees.

d. Use of specialized software

Although the model establishes the measurement of variables in situ, it also considers the use of historical data of these variables obtained from a database using free or licensed software, allowing averages to be obtained between these values and those measured in situ, which is why the model's methodology refers to their use.

e. PVS sizing in alternating current and direct current (AC/DC)

The PV design in commercial, industrial, or residential applications must consider DC or AC loads, since if only DC loads will be fed, it is not necessary to install an inverter because they can be connected directly to the DC circuit. If the PVS will feed AC loads, the inverter must be sized correctly. Using software or manual calculations, the PVS components are sized as listed in Figure 1 (modules, batteries, controller, inverter, wiring, protection systems, electrical and mechanical structures, and accessories).

f. Design based on the regulations applicable to PVS

This block highlights the importance of designing PV systems in accordance with the applicable standards according to the region or country where they will be installed, including both national and international standards applicable to equipment, materials, the level of distortion allowed for electrical variables, including the personal safety standards that must be observed when installing the PV system. The consideration of all applicable standards ensures reliability and functionality of the project, facilitating the registration and connection to the PV system network by complying with all the requirements required by governmental agencies.

g. PVS location data on the Earth (latitude, longitude, and altitude)

It is important to define the place where the VFS will be installed, being necessary to know the geographic coordinates of the place defined by latitude, longitude, and altitude. Particularly for Nuevo Laredo we have the following values:

North Latitude: 27º29'48" (27.43º),

West Longitude: 99º30'01" (-99.56º),

Altitude=138 meters above sea level (masl).

These three parameters are constant values used to locate a point on Earth; however, for the exact choice of the location either at ground level, on the roof, or on facades, it implies considering other factors described in section h.

h. For greater solar gain

The model suggests considering the main variables that affect the capture of solar radiation during the operation of the PVS, some of them being the inclination of the PVM according to the season of the year and user needs, and the orientation towards the south for systems located in the northern hemisphere or oriented towards the north for PVS located in the southern hemisphere.

Another variable that affects the collection is the projection of shadows on the PVM, being necessary to carry out a shadow study to analyze possible affectations. Specialized software is available to estimate the losses caused by shading of the PVMs, in case they cannot be completely avoided due to physical obstacles such as buildings or trees.

i. Type of users

Considering that this research refers to the study of PV systems with capacities of less than 0.5 MW of distributed generation, it is important to distinguish that the largest market of users for the installation of PV systems comes from residential users and small or medium-sized businesses. For this reason, government support programs to promote renewable energies should be focused according to the type of users to which they are directed.

j. Analysis of solar resource and meteorological variables

This relevant block of the model includes the data collection and analysis of each variable of the region under study as indicated in the flow chart in Figure 2, particularly exemplified for Nuevo Laredo.

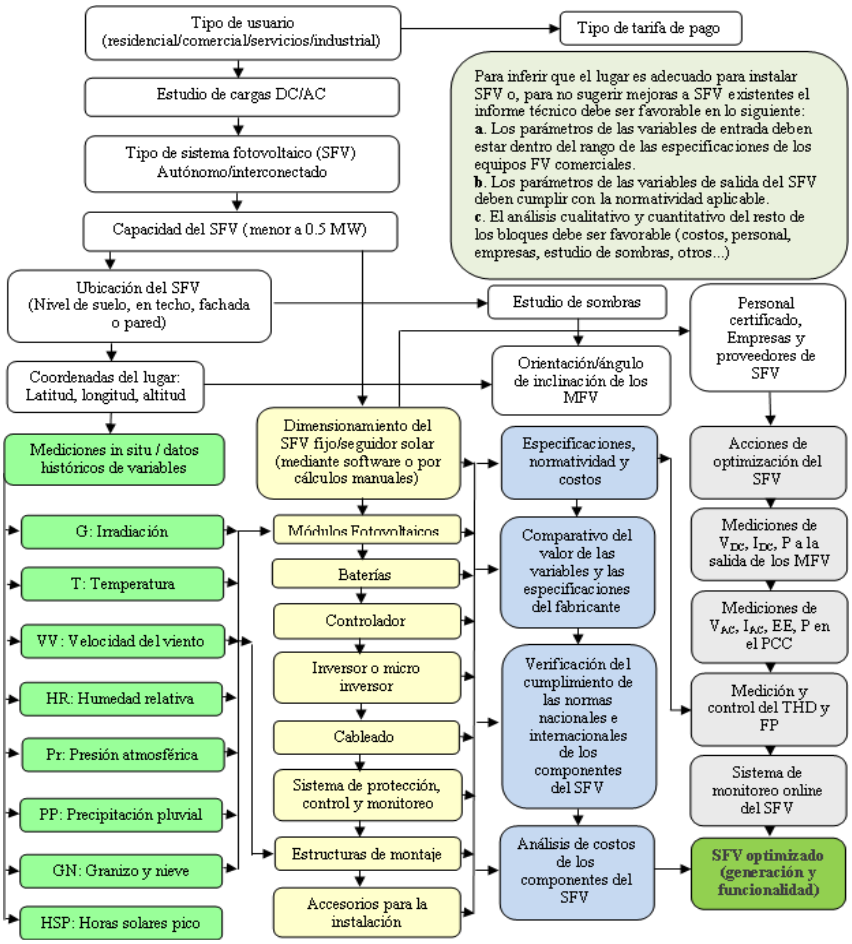


Figure 2. Flow diagram of a grid-connected PV energy system.
Note: Source: Own elaboration.

j1: Solar irradiance (G)

Obtaining this variable according to the methodology described in previous sections shows that Nuevo Laredo has an average irradiation of 4.81 kWh/m^2 during the year, exceeding this value in the months of May to August with values of up to 5.19 kWh/m^2 according to (Electric Research Institute, 2010).

Figure 3 shows the solar irradiation values measured in situ and those obtained using the RETScreen and Meteonorm software in monthly averages, showing a data range of 0.70 kWh/m^2 during the 12 months of the year. Figure 3 shows the congruence of the data from the sources referred to, which can be used to calculate PVS production, reaffirming the great potential for global and diffuse radiation and albedo in the region (De Juana Sardón et al., 2009).

Figure 3 also shows solar radiation readings taken in situ during the 12 months of the year under clear to slightly cloudy sky conditions, using the Amprobe Solar-100 meter. Average values of 940 W/m^2 and 1,163 W/m^2 measured at 27º and perpendicular to the sun respectively were observed, higher than the STC (standard test conditions) parameter of 1,000 W/m^2 used by manufacturers to test the efficiency of the PVMs and a NOCT (nominal operating cell temperature) of 800 W/m^2 (Messenger and Ventre, 2005).

In regions with high solar irradiation, cells with medium performance and affordable cost technologies can be used (Vigil Galán et al., 2018), still maintaining high levels of generation motivating local investment in PV projects by installing PVS with

good performance and of lower cost. PV technologies with high yields are more expensive and are recommended in places with low levels of solar irradiation.

To install stand-alone PVSs, an average solar radiation of 3 kW/m^2/day to 4 kW/m^2/day is required and, for PVSs interconnected to the grid, a solar radiation higher than 4 kW/m^2/day (Vanegas Chamorro et al., 2015), a condition that is met for Nuevo Laredo.

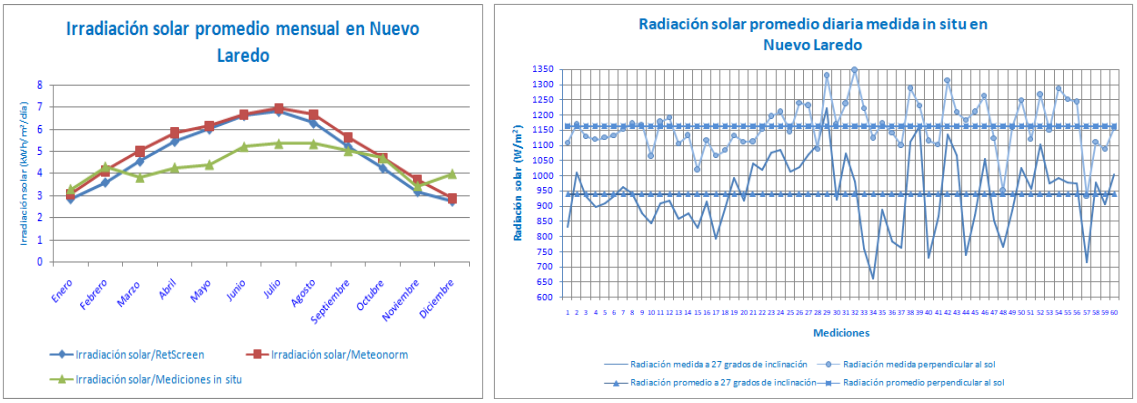


Figure 3. Solar irradiance and radiation measurements

Note: Source: Own elaboration with data from RetScreen software, Meteonorm, and in situ measurements.

j2: Temperature (T)

The obtaining of this variable according to the methodology previously described is shown graphically in Figure 4, reaching maximum average temperatures of 40.50 ºC in the hottest months and 2.5 ºC in the coldest months, causing possible effects on PV generation if the selection of PV components is not adequate, since at operating temperatures above 25 ºC, appreciable losses are generated in the performance of the cells (Mazón Hernández, 2014).

The actual operating temperature of a PVM normally reaches between 15 ºC and 20 ºC above ambient temperature (Pérez Regalado, 2010), making it necessary to use PVMs with high thermal coefficients to withstand the temperature level of the region. High temperatures reduce the voltage and power generated and, at temperatures of zero or below 0 ºC the voltage generated increases according to a factor specified in article 690.7 of the National Electric Code by up to 20%, which can affect the operation of the inverter and cause failures of the entire PVS. There is a wide range of PVM and commercial inverters with temperature coefficients wide enough to be used in every region and affect the performance of the PVS to a lesser degree.

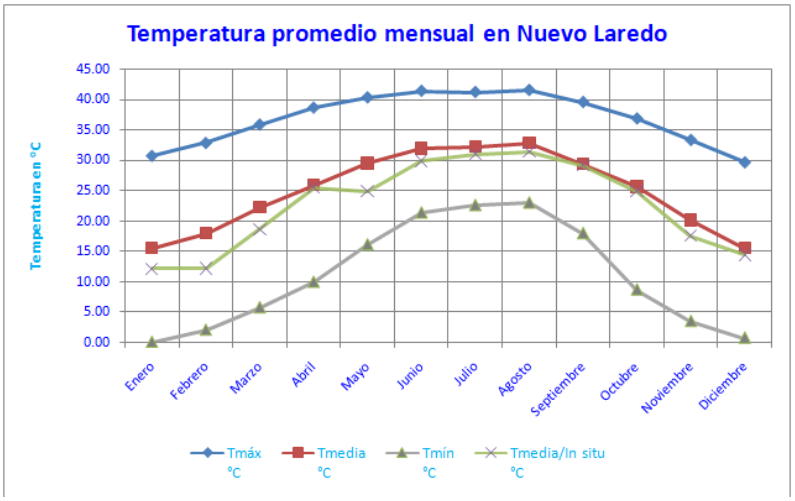


Figure 4. Monthly temperature trend.

Note: Source: Own elaboration with data from EMAINL and in situ measurements.

Figure 5 shows that 47% of 42 PVM manufacturers analyzed have a power temperature coefficient (P_{max}) higher than 0.4%/ºC, meaning that for every degree Celsius above 25 ºC in the cell working temperature, 0.4% of the nominal power generated by each PVM cell is lost.

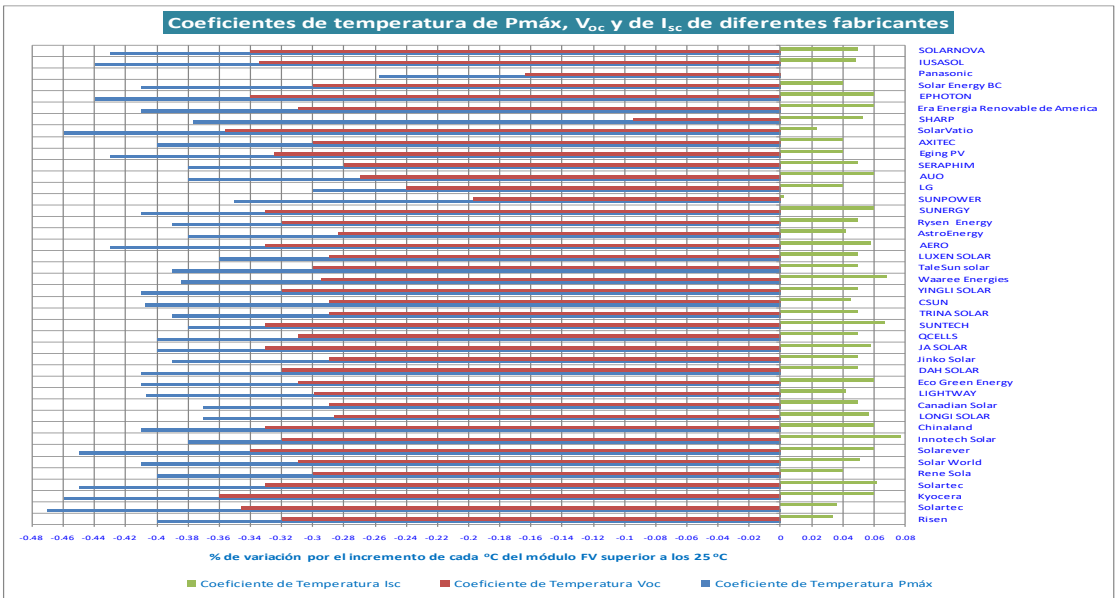


Figure 5. PVM temperature coefficients (I_{sc}: short circuit current; V_{oc}: open circuit voltage)

Note: Source: Own elaboration with data from manufacturer's data sheets.

It is recommended to use modules with low power temperature coefficients, avoiding those with higher coefficients since they present higher losses reducing power. For this reason, it is suggested that modules with temperature coefficients of -0.4%/ºC or lower be used in Nuevo Laredo, guaranteeing better performance. The nominal operating temperature of the PVMs also affects their performance. Figure 6 shows that 78% of the PVMs of the 42 manufacturers mentioned above withstand operating temperatures from -40 ºC to +85 ºC, 5 % from -40 ºC to +80 ºC, and 17 % withstand operating temperatures from -40 ºC to +85 ºC.

According to the temperature analysis shown above, it is observed that the PVMs of the 42 manufacturers comply with the temperature parameter required for Nuevo Laredo, even if the module temperature reaches 60.50 ºC (40.50 ºC +20 ºC), a value within the operating range that any PVM can withstand as shown in Figure 6, a condition that is also widely met for temperatures below zero.

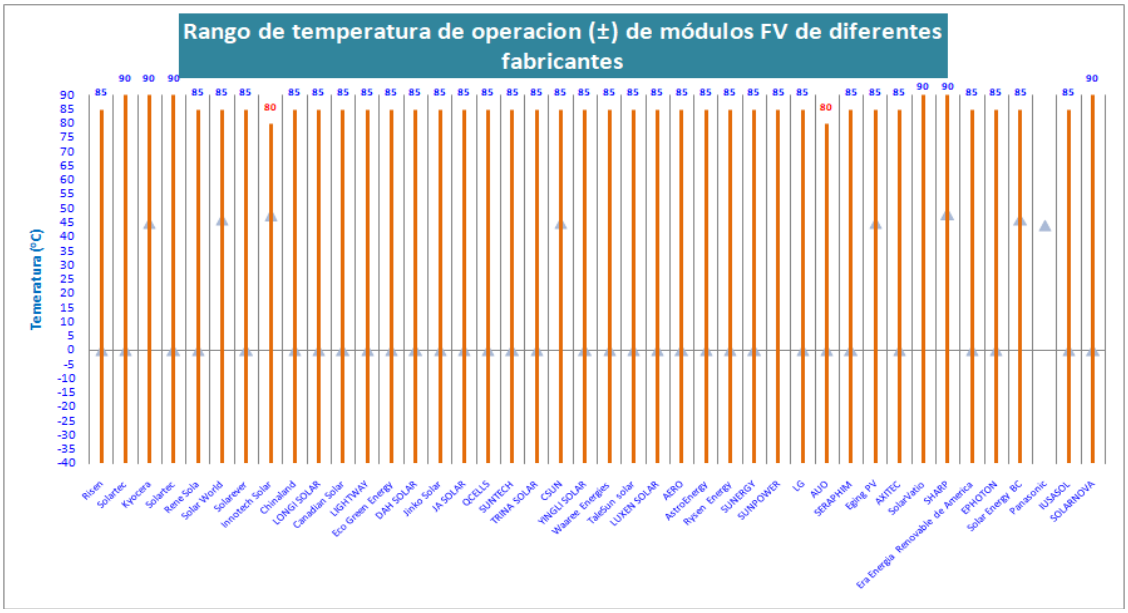


Figure 6. PVM operating temperature

Note: Source: Own elaboration with data from manufacturer's data sheets.

j3: Wind speed (WS)

Wind speed and its mechanical force of impact (Reguera Gil, 2015) is another relevant variable to be considered when planning and developing distributed or centralized photovoltaic generation projects; this variable is obtained according to the methodology previously described in this article. Figure **7** shows that the average maximum WS oscillates between 39 km/h with maximum gusts of up to 55 km/h, still being a moderate speed without major risk as a mechanical force of impact on the PVMs and their structures, since it is within the limits indicated by the manufacturers, acting only as a natural cooling system of the PVS when its speed increases (Mazón Hernández, 2014).

Knowing the average WS and the maximum gusts of the region, in this case for Nuevo Laredo, they are compared with the specifications of different PVMs in terms of their capacity to withstand wind loads. Figure 8 shows the load capacity caused by wind and snow forces supported by the PVMs according to the specifications of 42 manufacturers, showing that they support wind forces from 2,400 Pa to 5,400 Pa, in accordance with the European standard IEC 61215, which indicates a standard value of 2,400 Pa. The maximum value of 5,400 Pa is relevant in areas where the WS is very high during the year, which is not the case for Nuevo Laredo. For these WS, the use of anodized aluminum structures is recommended for mounting the PVMs due to their high resistance to mechanical strength and corrosion.

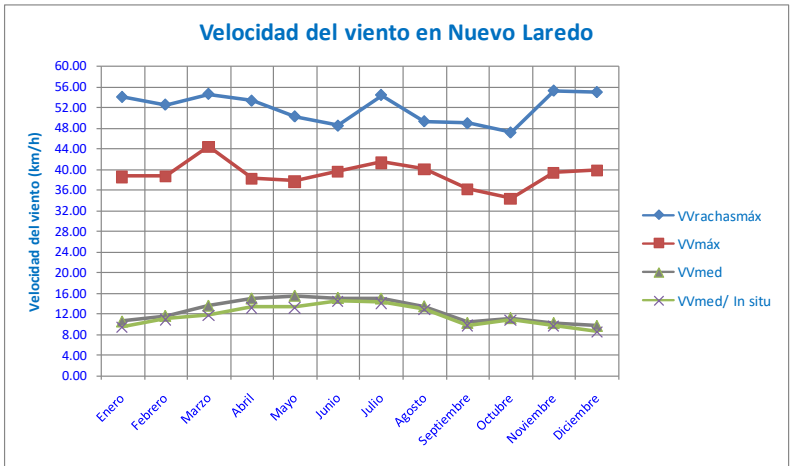


Figure 7. Average, maximum wind speed and maximum wind gusts.
Note: Source: Own elaboration with data from EMAINL and in situ measurements.

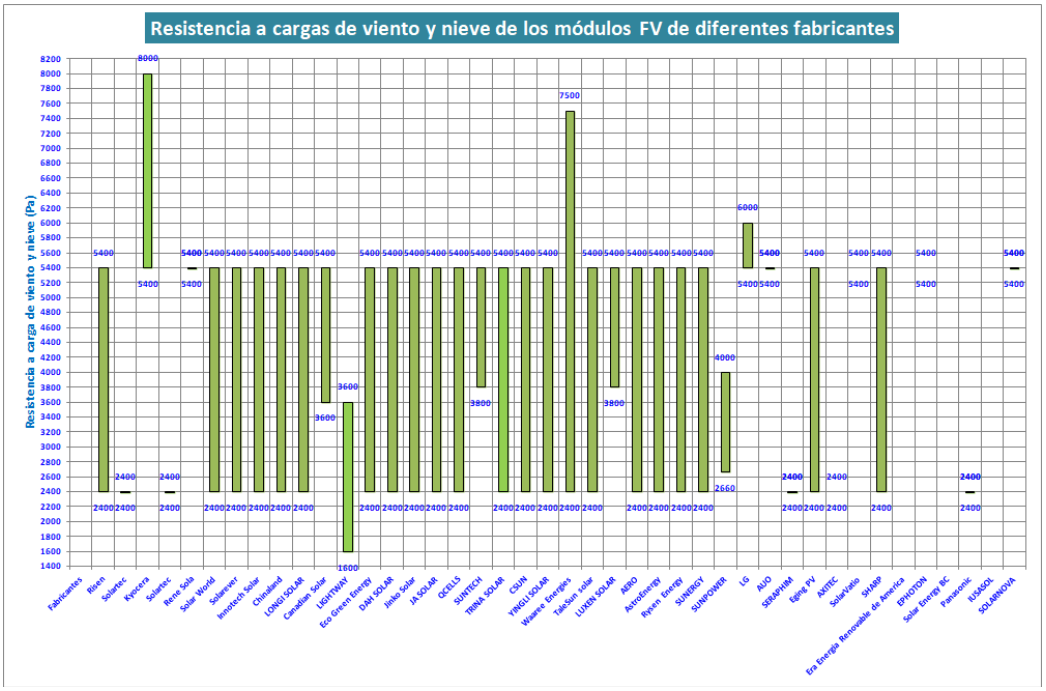


Figure 8. Resistance to mechanical loads of PVMs
Note: Source: Own elaboration with data from manufacturer's data sheets.

J4: Relative humidity (RH)

Figure 9 shows the monthly and annual behavior of relative humidity in Nuevo Laredo with data taken in situ and from the Nuevo Laredo international airport weather station (EMAINL). It is observed that the general average is between 55% to 60%, which is acceptable due to the fact that Nuevo Laredo has an extreme dry climate with large temperature oscillations from -3 ºC in winter to 46 ºC in summer, with August being the hottest month and January the coldest month (Institute for Competitiveness and Foreign Trade of Nuevo Laredo, 2021). Although the maximum humidity value ranges between 85%, the frequency of occurrence per month is from 1 to 3 days and mostly occurs in the coldest months of the year, prevailing average RH values that do not cause premature oxidation or failure of the PVMs by potential induced degradation (PID) caused by moisture seepage in the encapsulated PVMs.

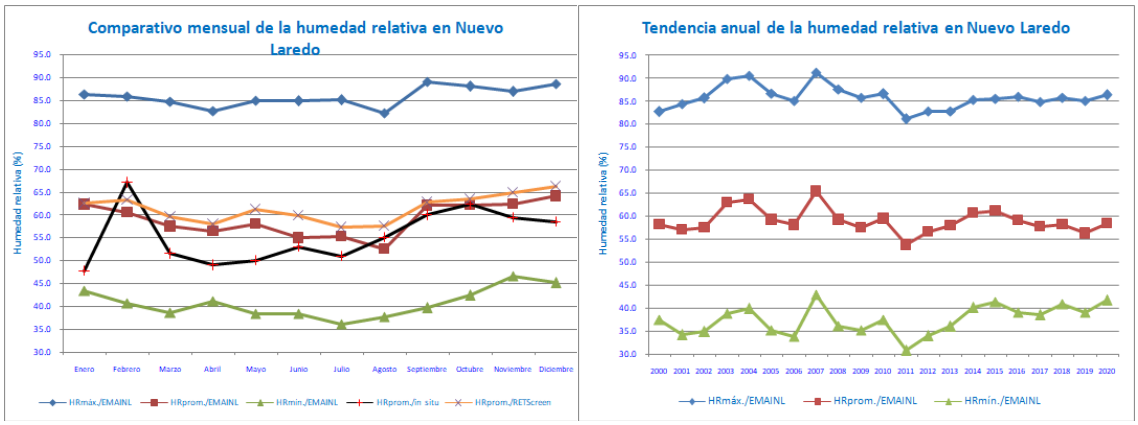
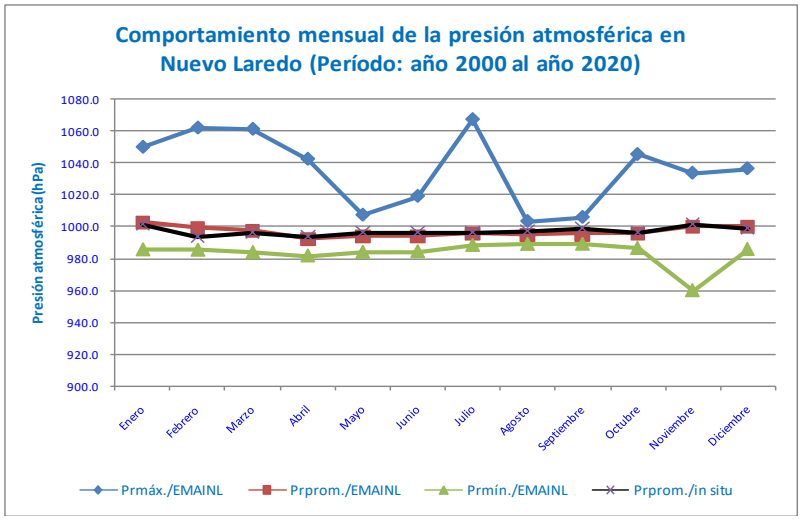


Figure 9. Relative humidity trend in Nuevo Laredo.
Note: Source: Own elaboration with data measured in situ and from EMAINL.

J5: Atmospheric pressure

The atmospheric pressure above sea level is 1,013.25 hPa and at higher elevations is reduced to less than 700 hPa, given that Nuevo Laredo has an altitude above sea level that varies from 138 m to 150 m, the effect is negligible and is not considered to have a major effect on the performance of the PVS to be installed in this region of Tamaulipas. Lowering the pressure below the local atmospheric pressure generates storms or bad weather, which is not typical in Nuevo Laredo where most of the time the weather is dry and with low precipitation.

Figure 10 shows a very stable trend in pressure variation which is largely attributed to the semi-desert climate in Nuevo Laredo, maintaining a monthly average of 997 hPa. This variable is not considered in the manufacturers' specifications because it does not directly affect the PVM, but rather through its effects, especially when it presents a very wide range of variation.



Atmospheric pressure trend in Nuevo Laredo.
Note: Source: Own elaboration with data measured in situ and from EMAINL.

J6: Rainfall Analysis

Precipitation in Nuevo Laredo varies from 550 mm to 600 mm (Tamaulipas Civil Protection, 2011), showing in Figure 11 that during the months of May to October precipitation is higher, reaching an annual average of 553.8 mm. Due to Nuevo Laredo's semi-desert climate, rainfall during most of the year is scarce with a daily average of

approximately 45 days during a 20-year analysis period, i.e., only 12% of the days of the year are rainy.

Rain is a natural way of cleaning the PVMs, but when it is very frequent it causes oxidation in the support structures, for this reason, anodized aluminum is frequently used and, in rare cases, iron structures are used. According to this analysis, precipitation in Nuevo Laredo does not represent a major problem that causes premature oxidation or PID problems in the PVMs. However, to ensure long life, the use of anodized aluminum structures for the attachment of the PVMs is recommended.

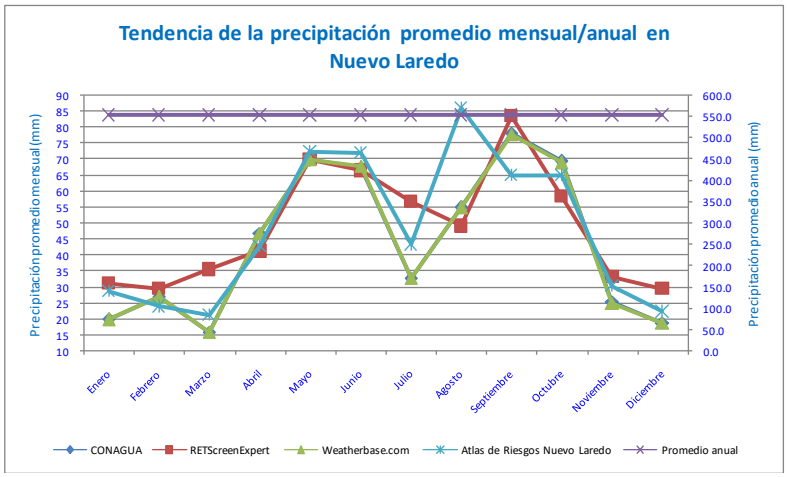


Figure 11. Rainfall trend in Nuevo Laredo.
Note: Source: Own elaboration with data from different database sources.

J7: Hail and snow analysis

Figure 12 shows the trend of hail fall in Nuevo Laredo and the region, showing a low recurrence being a low risk variable; however, it is convenient that the PVMs meet certain standards to the impact force. In the referred figure, an annual maximum of 2 days per year is observed, being normally one day per year, even during several years there is no hail fall.

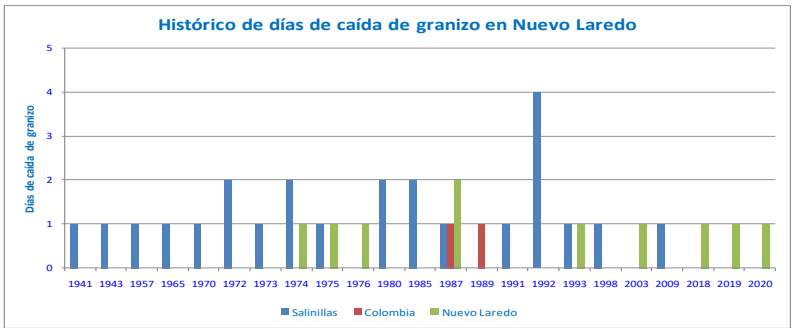


Figure 12. Annual behavior of hail fall in Nuevo Laredo.
Note: Source: Own elaboration with data from the National Meteorological System (SMN).

As a regional reference, the hail fall in 2 neighboring municipalities located less than 50 km away is plotted, showing a similar trend.

Nuevo Laredo is not a snowfall area and on rare occasions a light layer of snow has fallen, so its analysis is irrelevant.

J8: Peak solar hours

The PSH (Pérez Martínez et al., 2017) is a variable obtained from the solar irradiance of the region divided by the STC of the PVMs equivalent to 1,000 W/m^2. The average PSH in Nuevo Laredo is obtained from the average insolation divided by the STC

value resulting in 5.0 h according to monitoring data taken in situ during a period of 18 months and of 5.027 h in annual average according to SAM software (system advisor model) as shown in Figure 13, being both values similar and acceptable for modules with efficiencies higher than 16% to be installed in Nuevo Laredo.

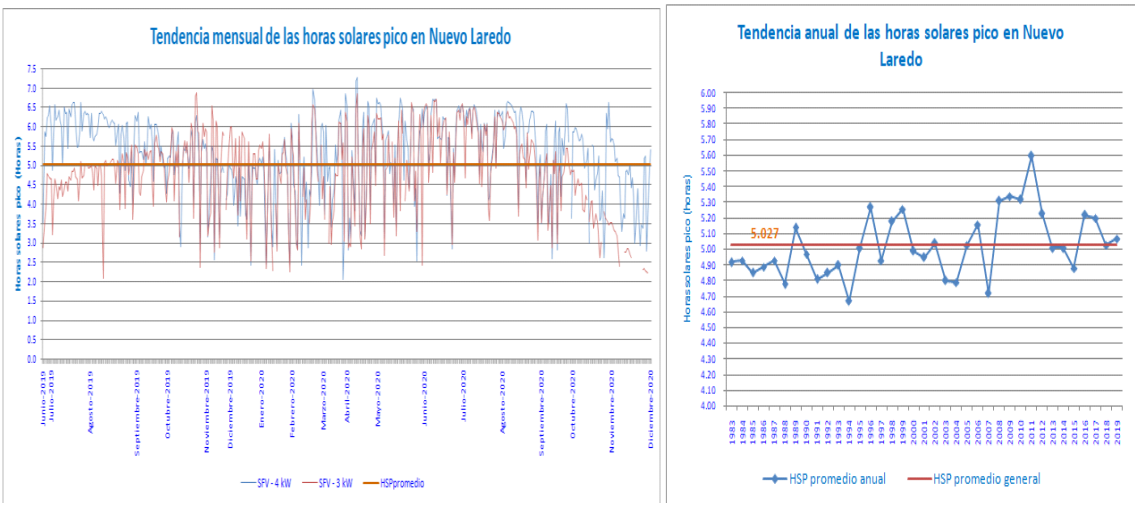


Figure 13. Monthly and annual trend of PSH in Nuevo Laredo.
Note: Source: Own elaboration with data taken in situ and from SAM software.

J9: Correlation analysis between variables

The analysis referred to in the energy model considers reviewing the correlation between variables with the objective of analyzing the behavior of the PVS. Figure 14 shows the hourly electric power generation capacities of two PVSs used as a sample, located at a distance of 25 km from each other, during a sampling period from 31-May to 23-June-2020.

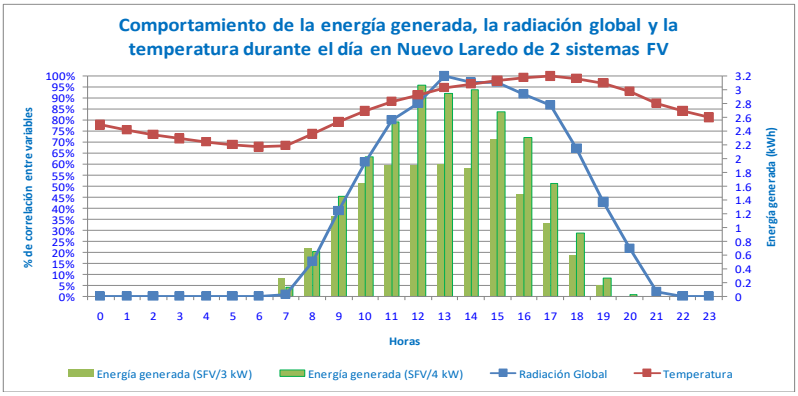


Figure 14. Comparison of meteorological variables and PV-generated energy.
Note: Source: Own elaboration with data from https://www.meteoblue.com/es/tiempo/archive/export/nuevo-laredo and Apsystem.

It is observed that as the irradiation increases so does the temperature and the energy generated in both PVS (Granda Gutiérrez et al., 2013); however, after a certain time of the day, although the temperature still remains high, the radiation is reduced and also the energy generated in both PVS in a proportional way. Proving that the energy generated

depends directly on the radiation and, in this case, the temperature has a minor effect due to the fact that the temperature coefficient of the modules used is less than -0.4%/ºC.

Discussion and conclusions

Discussion

The detailed analysis of the variables referred to in the proposed energy model allows considering the most important parameters when designing a PVS to ensure optimal generation, selecting the materials and equipment with the most appropriate specifications to withstand the environmental conditions of the region under study, and determining whether or not the site is viable for installing PVS.

The model considers most of the variables that affect or optimize PV power generation to ensure a robust, reliable design that guarantees a return on investment for residential, commercial, service, and industrial users through financial analysis (Caamaño Martín, 1998).

Table 5 shows the parameters obtained by applying the methodology according to the proposed model, noting that the site is viable for installing PVS.

Table 5
VFS input variables for Nuevo Laredo

Variable	Average range of the variable	Comment
Irradiance (G)	4.81-5.03-5.19 kWh/m^2	High average value of the Mexican Republic.
Temperature (T)	10 ºC minimum average 25 ºC average 37 ºC maximum average	Although there are occasional extreme values of -3 ºC in winter and up to 45 ºC in summer, the average values are as indicated and are within the specifications of the PVM manufacturers.
Wind speed (WS)	30-39-45 km/h average top speed	Although there are occasional gusts of up to 55-80 and rarely 100 km/h, these values are still within the specifications of the PVM manufacturers.
Relative Humidity (RH)	55 % – 60 %	There are occasional values of 85 %, but the average is 55 %, which is not a risk of high humidity accelerating oxidation or leaching in the PVM encapsulates.
Atmospheric pressure (Pr)	987.1 - 1,012.2 - hPa	Little variation, with no major effect due to the region's low altitude of 138 masl. Monthly average 997 hPa.
Pluvial precipitation (PP)	550 - 553.8 - 600 mm	Low values that do not represent risks for the deterioration of the PVM.
Hail and snow (HN)	20 - 50 mm of ϕ	Diameter of porous hail, occasional fall once a year.
Peak solar hours (PSH)	4.81 - 5.027 - 5.19 h	High insolation value

Note: Source: Own elaboration.

By using this model as a methodological guide for the design and development of PV projects, the risks of system malfunction during its lifetime can be reduced by considering manufacturers' specifications. In the study "Improvement strategies for distributed electricity generation with solar, wind, or hybrid equipment" (Cadena et al., 2012), the feasibility of using renewable resources to cover the demand for electricity is mentioned by analyzing the available resource in the region; however, it only refers to certain variables involved in PV systems, which are already considered in the proposed model.

This model aims to bridge the existing gap between systems that integrate most of the conditions necessary to design and install PVS and the information from various studies that currently exist separately, i.e., the existing information is isolated and is not concentrated or integrated into a single functional block that allows a comprehensive or holistic view of the aspects to be considered.

The use of commercial or free software complements and facilitates the development of each block of the model, resulting in a final technical report that can be used to decide to install or improve the PV project under study.

Conclusions and future work

The analysis of each block of the proposed model applied to Nuevo Laredo, allows inferring that the region meets the necessary and sufficient conditions for the installation of PV systems according to Table 5. It is shown that most of the variables analyzed are within the acceptable ranges when complying with the commercial specifications of PV equipment, ensuring the feasibility of the project.

By breaking down and developing each block of the proposed model, performing the measurements and calculations of the indicated variables, comparing them with applicable standards and regulations according to the region or country, considering the specifications of PV equipment manufacturers, differentiating the types of users to perform demand planning studies (Falcón Roque, 2018), and correctly sizing the system, a robust and complete design that makes the development of the PV project viable will be ensured.

Additionally, the model requires in situ data collection of solar radiation, information that is lacking in most regions of Mexico, relying only on data obtained from measurement stations closer to the study area that are several kilometers away, or satellite data that have certain percentages of error (Grossi Gallegos, 1999). The study (Osseweijer et al., 2017) considers the importance of the involvement of industry (suppliers, consumers), academia (to conduct research and training of skilled labor) and, the government (to establish regulations) as stakeholders in the use and promotion of PVS, conditions that are included in the proposed study.

Currently, in Nuevo Laredo, there are more than 100 PV systems installed with capacities from 1 kW to 202 kW. However, there is still a captive market of 126,127 domestic users, 9161 in PDBT6 tariff (small demand in low voltage), 1754 with GDMTO6 tariff (high demand medium ordinary voltage), and 644 users in GDMTH6 (high demand medium hourly voltage) to implement distributed generation PV projects.

By developing and integrating in a final report all the aspects included in each block of the model and according to the flow diagram in Figure 2 previously mentioned, the results, in addition to being used for the purposes described, could also be used as a reference and complement for the development of future research that requires analyzing

the variables and other characteristics and aspects inherent to PVS, resulting in more complete studies.

As future and complementary work to this research project, an abstract analysis of the variables and their mathematical representation as a function of those that are affected by the behavior of others is proposed, being an example the power generated from the PVS (P) as a direct function of the irradiation (G) incident on the PVMs and of the operating temperature of the system (T), that is, P→ (G, T). Further work should consider the use of equations for both sizing and calculation of meteorological and electrical variables.

The development of mathematical models on the degradation of PVMs (Reguera Gil, 2015), according to the region where they are installed, are also topics of interest and complementary to this project.

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