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Research Article

Productivity in the Sugar Industry: Method to Identify Work Groups

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Abstract

Background and Objective: The international sugar industry has a current production of 160 million t and requires the improvement of worker productivity to reach its full potential. This cross-sectional study allowed to analyze productivity as perceived by workers and propose a methodology to identify work groups. **Materials and Methods:** It was designed a measuring instrument with 6 variables, 3 based on constructs of productivity, training and ISO standards as well as three direct variables such as age, age and level of study. **Results:** We analyzed the productivity variable using structural equations (PLS) with XLSTAT software and used SPSS to measure the reliability of the measuring instrument as well as the integration of working groups using k-means statistics. The optimal group number was three. The variables that determined the integration of homogenous work groups are age, seniority and level of education. **Conclusion:** Training has a positive relationship with productivity and is a determining factor in selecting work groups, since workers with a better disposition towards training are more productive. The statistical analysis by means of k-means identified an inverse relationship between productivity and seniority, that is as the worker's seniority in the company increases, his productivity decreases. The age and knowledge of the variables of the ISO 22000 standards indicated a minor impact on productivity.

Key words: Productivity, training, ISO norms, XLSTAT, sugar industry

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

The sugar industry is the industrial sector dedicated to the production of sugar through the transformation of sugarcane. The process begins with the cutting of cane, a heating process to achieve evaporation follows and then the resulting product is filtered, clarified and dried to turn it into sugar¹. The sugar industry is seeking to become more efficient in these processes to increase both production and profit.

The sugar industry in the Mexican Republic has 57 mills distributed in 12 states, which have similar operating conditions. The industry in Mexico is part of an international market with a total production of 160 million t, for both sugarcane and beets². The manufacturers involved in this agro-industrial process use productivity indicators such as harvested area, sugar produced, factory yield, sucrose extraction, purity of the juice mixed and total sucrose losses. Productivity classified from low to medium and medium to high. These mills compete with those in countries with lower production costs such as Brazil, Mauritius, India and South Africa, Malawi, Swaziland, Guatemala, Ethiopia, Sudan, Argentina and Australia³.

Internal factors determine the productivity and profitability of sugar mills, namely the interaction with sucrose, days of harvest, time losses, efficiency in use of installed capacity, sucrose recovery and efficiency in fuel consumption. These actions largely depend on the efficiency and skills of workers. Productivity calculated as the ratio between used resources and results obtained. In terms of efficiency and effectiveness, human resources are considered a determining factor to achieve productivity objectives^{4,5}. As the productivity of a company increases, it becomes more competitive. To support this process, learning, experience as well as the skills and knowledge of workers are crucial⁶.

As such, to improve productivity in the sugar industry, it is necessary to identify all determinants, including the human factor. Therefore, the perception of the individual productivity of workers is essential for increasing production. However, workers do not often share their opinions, although these would be valuable for their companies. This study has two objectives:

- Determine whether Training and knowledge of ISO 22000 influence on the productivity perceived of the worker
- Propose a methodology to identify work groups evaluating age, seniority, educational level, training, knowledge in ISO 22000 standards and productivity

MATERIALS AND METHODS

Theoretical background and research hypothesis

Productivity: The improvement of productivity should begin with the efficient participation of employees as well as good labor relations, since the human factor is present in each part of the process. In this context, productivity is an indicator of organizational efficiency, in the sense that the ability of human capital to incorporate new knowledge and skills supports this process⁷. Human resources also have an important role in the administration of costs and in increasing productivity. To better identify this relationship, business growth should connect to personal growth⁸.

With greater productivity, higher income is generated, leading to the economic growth of the company and achieving its objectives^{9,10}. In this process, workers' performance is subject to external factors such as health, well-being and emotions. As such, for workers to be more productive, they must be able to concentrate, so they can work at 100% capacity¹¹.

The foundation of productivity lies in theories such as marginal productivity theory and Maslow's pyramid of needs theory^{12,13}. According to these theories, companies need to manufacture their products with greater intensity, be more competitive, improve their productivity and strengthen their training. This will allow them to have better financial stability¹⁴. The training as a strategy to improve productivity of company was employed and presented the following hypothesis:

- Training positively influences the perception of productivity

For Baumann *et al.*¹⁵ propose a theoretical model to improve pragmatic competitive individual productivity (ICP). As indicated by the theories for each of them that include theoretical aspects for education Mudrack *et al.*¹⁶ and Pellerin¹⁷, for motivation Fulop¹⁸, for personality Collier *et al.*¹⁹ and Ryska²⁰, the life experience Judge *et al.*²¹. Performance evaluation is important to measure productivity, Management process allows a better integration of the strategies implemented by human resources²².

According to Buller and McEvoy²³ they mention that not all work groups carry out activities with the same strategic importance, they are based on their singularities and their capabilities. For Zwick²⁴, a motivation to increase the intensity

of training is favorable to regain competitiveness and is an adequate means to reduce the distance between its main competitors, to improve the productivity of the company.

Training: Training programs bases are on identifying the needs of companies in each work area as to prepare workers to improve their job performance. In other words, accompany trains workers to allow them to acquire new skills and knowledge to improve competitiveness^{25,26}.

Training improves the skills of the personnel in various areas and ultimately helps increase the innovation and productivity levels of the company²⁷. From a psychological perspective, training is the process that identifies relevant aspects of human behavior at work, being necessary to create, make adjustments and intervene in the work process^{28,29}, this is based on the theoretical foundations of the concept.

The foundation of the training construct links to theories such as theory of action, behavioral theory or theory X and Y³⁰⁻³². The hypothesis shows as follows:

- Training increases knowledge of the ISO 22000 standards

Training is an important tool to improve quality, achieve goals and objectives of the company. The different contributions derived from training have addressed new training practices³³⁻³⁶. In total agreement with the works of the mentioned authors.

Human capital according to the OECD has determined the income of the population worldwide. In developed countries the benefits of trade have been directed towards education and growth per capita^{37,38}. In the same proposed sense of this work, training conditions must improve to develop productivity and improve income for workers. For Groot³⁹, the average productivity growth of a worker who received training within the first six months against one who did not receive it indicated a difference of 8%, so it can be seen that there is an increase in the productivity of trained workers.

Knowledge of the ISO 22000 standards: Training strategies take base on quality standards. For instance, the ISO-22000: 2018 standard refers to food safety management, being a requirement for companies in the food sector. Its implementation through the safety management system allows production of safe food items⁴⁰. Further, safety is also a term used in food preparation and indicates no harm will come to the consumer or the manufacturer during preparation process⁴¹. For food safety, the prevention and elimination of potential risks in food consumption are to be considered⁴².

In European agribusiness organizations, competitiveness improves through food certification, which guarantees the quality of manufactured products⁴³. The Food Safety Management System certification offers other benefits, for example, the awareness of employees, improved company image and attracting new clients⁴⁴. Safety Management System requires trained personnel to ensure compliance with the requirements of the standard and achieve its objectives⁴⁵. There are also some theories that support the concept of quality, such as the just-in-time theory, 5s, Ishikawa diagram and Kaizen method⁴⁶⁻⁴⁹, the following hypothesis is:

- Knowledge of ISO 22000 positively influences the perception of productivity

The conceptual framework of productivity determinants presented in Fig. 1.

Worker characteristics: There are different determinants of the job satisfaction of a worker, such as age, health, education level, seniority and family relationships. These manifest in the favorable or unfavorable attitude of the worker towards his/her work^{50,51}. Seniority influences the ability to respond to changes in the environment, with an inverse relationship between seniority and aspects related to technology and competitors⁵².

Work groups: Work groups include workers with individual assignments, entrusted to develop specific short-term tasks and work together for the duration of the assignment. Work teams are part of the organizational structure, share training, experience that favors productivity, decision making and reach their development goals in the medium and long term⁵³. Work groups consist of responsible collaborators in each area of competence, with objectives and particular interests as the developed activities are more complex, the collaboration level of each member must increase to improve the efficiency of the group⁵⁴. Recently, there has been significant theoretical progress in the self-management of equipment, motivated by the interest in analyzing its design, structure and performance⁵⁵.

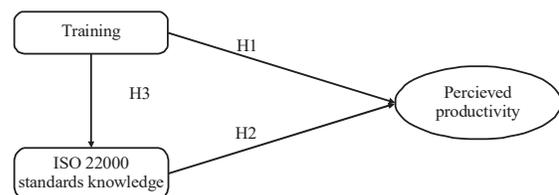


Fig. 1: Conceptual framework of productivity determinants

Method: This is a quantitative cross-sectional study, in which we applied inferential and multi variate statistics to identify the relationships between variables. The complete study took place from October, 2018 to August, 2019 at the sugar mill, located North of Veracruz, Mexico. Human resources authorities granted access to the plant, they provided all the facilities to interview the workers at lunchtime. The contact was personal, so that they felt free to express their perceptions about productivity.

Sixty-two line workers were object of the measurement instrument during the morning shift at the sugar mill, Veracruz. This instrument's focus was to measure the individual perceptions of productivity in the company and consists of six variables: productivity, training, ISO standards, age, seniority and education level. The number of items for the productivity variable is 13, 10 for the training variable and three for the ISO standards, totaling 26 items. The variables of age, seniority and level of study applied directly. Available in Appendix 1.

The designed instrument allowed approaching the workers in the production area to identify their perceptions on the company's productivity. To validate the instrument, test on pilot trial was conducted, yielding a Cronbach's alpha of 0.893. The value exceeded the recommended threshold of 7.0, indicating that all elements in the scale comply with the underlying constructions⁵⁶. Classification of answers was on a five-point Likert scale. Subsequently used the variance inflation factor(VIF) and average variance extracted (AVE) to test the reliability and validity of the measurement instrument. AVE values must be at least 0.50, which indicates that the construction explains at least half of the variance of its observed variables⁵⁷.

The process to obtain permission for the application of the instrument, its revision by the administrative personnel and its application were due over a period of ten months, which included the training of the support staff for the instrument application. The surveys carried on during meal breaks, since the operability levels are too high to allow workers to answer questionnaires during their shifts. Ten trained researchers applied this instrument.

To analyze perception of productivity of the respondents, implemented a three-group k-means technique to determine the similarities between them in terms of productivity, training, ISO standards, age, age and education level (years). The groups were determined by ANOVA, considering the highest number of significant F-tests ($p < 0.05$). The data were analyzed using k-means, productivity was the dependent variable. We employed SPSS V25 for all statistical analysis⁵⁸.

Characterization of variables: In terms of training, a worker is required to perform daily activities correctly, consider that the training received from the company helps improve skills, ask for work advice, has been trained for a new position in the company, perceive that training improves labor competence, consider training allows reaching objectives and manifest the openness and availability to training.

Regarding ISO 22000 standards, the worker considers that the company's facilities are suitable for manufacturing its products, identifies if the company has a system that locates and removes production waste, the work area is considered adequate to keep the process isolated and not contaminate the product. Suppliers trained and complied with the standards and the company maintains control of the water, air and energy in the production area for product safety.

Productivity identifies if the worker is aware of the manufacturing process in the company, considers incentives that motivate productivity, identify appropriate tools and materials to improve tasks. Identifies communication with superiors, perceives control over inputs and raw materials, consider quality adequate in its performance, identify opportunities and professional development in the company, if the company has indicators to measure quality and productivity, the workers are included in work meetings and they perceive that the company takes advantage of internal talent.

RESULTS

Descriptive statistics: The workers in the production area of sugar mill, mostly men are between 21 and 59 years old, some with long tenures in the same position. Education expresses as the number of years of study and ranges from 6 years of elementary school to professional qualifications (17 years), with most workers having first and secondary education. Seniority is between 10 months and 38 years, with all respondents unionized, which offers them greater benefits. The factory is located 30 min from the city center and they travel by public transport, similar to most mills in different cities. The mean and standard deviation show in Table 1.

The variables (productivity, training and ISO standards) show characteristics of homogeneity and one-dimensionality based on the factor analysis test with Varimax rotation, this test is considered to increase the variance of the squared factorial loads for each factor and most charges tend to approach 1, while the others approach 0.

The statistical tests used to assess the reliability of the measuring instrument are Cronbach's alpha, average variance extracted (AVE) and variance inflation factor (VIF). The

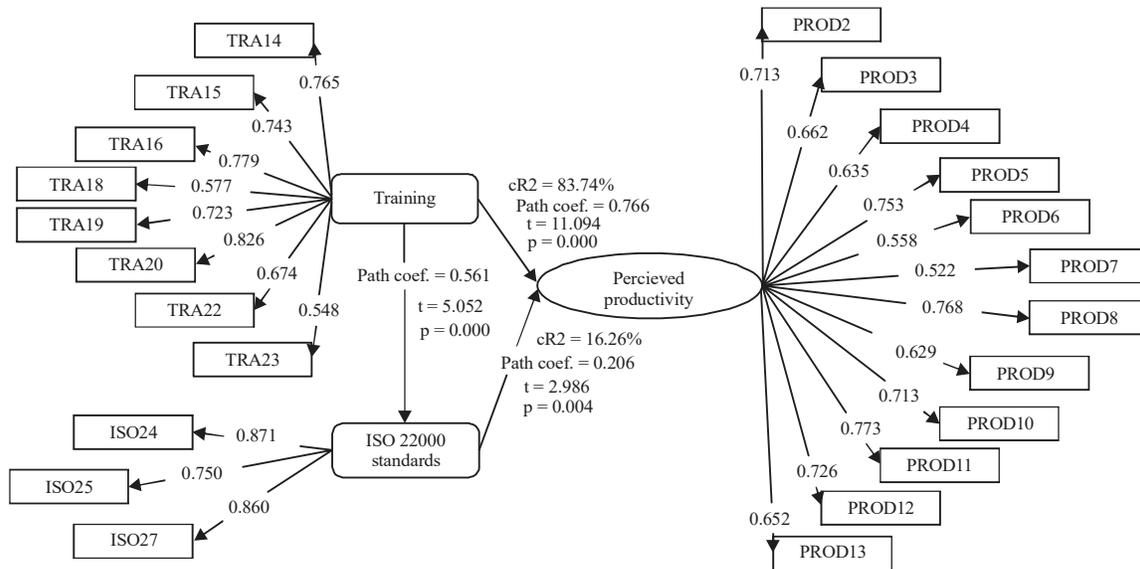


Fig. 2: Path modelling and factor loading results

Table 1: Means and standard deviations

Variable	Questions	Mean	Standard deviation
Productivity (V1)	PROP1-PROP13	1.782	0.771
Training (V2)	CAPP14-CAPP23	1.532	0.809
ISO standards (V3)	NORP24-NORP27	1.766	0.952
Age (V4)	P28	42.140	11.056
Seniority (V5)	P29	11.270	11.663
Education (V6)	P30	10.250	2.981

Table 2: Validity of instrument reliability using Cronbach's alpha, AVE and VIF tests

Variables	Cronbach's alpha		Average variance extracted (AVE)		Variance inflation factor (VIF)			
	Factor	Total	AVE	CR	T	Significant	Tolerance	VIF
Productivity (V1)	0.886	0.893	0.544	0.544	Dependent variable			
Training (V2)	0.844				3.222	0.003	0.719	1.391
ISO standards (V3)	0.684				1.469	0.151	0.771	1.296

variables analyzed are productivity, training and ISO standards. Cronbach's alpha values for each variable are productivity (0.886), training (0.844) and ISO standards (0.684), accepted values for this test. The AVE value for three variables analyzed is (0.544). The VIF is statistically significant (T = 3.222, p = 0.003) for the training variable only. Data presented in Table 2.

Path model results and factor loadings: The PLS estimation results for the structural model as well as the item loadings for the research constructs are shown in Fig. 2. The model did not consider the value of the element PROD1 for the productivity variable. In the training variable the elements TRA17 and TRA21 were also eliminated as for the ISO 22000 variable, the ISO26 element was eliminated, because the factor loads of

these elements were less than 0.500, which means that they explained less than 50% of the variance and did not reach the threshold equal to or greater than 0.500. The lowest item at the total load observed was the productivity variable PROD7 with 0.522 and the highest was the variable ISO22000 with the item ISO24 with 0.871.

Outcome of hypotheses testing: In this study, the tests performed on the hypotheses are determined by the values of the trajectory coefficient as well as by t values of the structural model obtained from the bootstrapping algorithm.

For the hypothesis test the results indicate, Hypothesis 1: The training has a positive impact on the Perceived Productivity of the workers. The results can be seen in Fig. 2, the training had a positive impact (Path coefficients = 0.766)

Table 3: Results of the groups derived by the k-mean test and the characterizations of variables

Variables	Groups		
	1	2	3
Productivity	2.3	1.8	1.40
Training	1.9	1.4	1.30
ISO standards	1.7	1.6	1.30
Age	47.93	29.71	53.11
Seniority	5.16	6.67	32.56
Education	9.00	12.53	8.00

Table 4: ANOVA

Variables	Cluster		Error			
	Mean square	Df	Mean square	df	F	Significant
Training	1.29	2	0.68	37	1.90	0.16
ISO standards	0.32	2	0.72	37	0.45	0.63
Productivity	0.91	2	0.70	37	1.286	0.288
*Age	2077.87	2	26.41	37	78.66	0.000
*Seniority	2470.50	2	37.67	37	65.57	0.000
*Education	77.87	2	7.08	37	10.98	0.000

*Variables that determine the groups are derived from the k-means test

and was statistically significant ($t = 11.094$) when predicting its positive influence on the perceived productivity.

In the hypothesis 2 test, the results indicate: that knowledge of ISO 22000 Standards has a positive impact on the perceived productivity of workers. The results can be seen in Fig. 2, ISO 22000 standards exerted a positive impact (Path coefficients = 0.206) and was statistically significant ($t = 2.986$) when predicting its positive influence on perceived productivity.

In the hypothesis 3 test, the results indicate: that the training has positive influence on knowledge about ISO 22000 standards. The results can be seen in Fig. 2, the training had a positive impact (Path coefficients = 0.561) and was statistically significant ($t = 5.251$) when predicting its positive influence on ISO 22000 standards.

Subsequently, k-means statistical test used six variables to integrate homogeneous work groups: productivity, training, ISO standards, age, seniority and education. The optimal number of groups identified was three, they indicated in the following relationships. For Group one, the values are productivity (2.3), training (1.9), ISO standards (1.7), age (47.93), seniority (5.16) and education (9.0). Group two, the values are productivity (1.8), training (1.4), ISO standards (1.6), age (29.71), seniority (6.67) and education (12.53). For group three, the values are productivity (1.4), training (1.3), ISO standards (1.3), age (53.11), seniority (32.56) and education (8.0). Values indicated in Table 3.

From the variables training, ISO standards, productivity, age, seniority, education, only three were important to

determine the grouping by means of the statistical test of k-means. Which are age ($F = 78.66$, $p = 0.000$), seniority ($F = 65.57$, $p = 0.000$) and education ($F = 10.98$, $p = 0.000$). Data indicated in Table 4.

DISCUSSION

The variables that explain the group with the highest productivity are training, knowledge on ISO 22000 standards and seniority. The evaluated training factors are the worker feels integrated in the work, is qualified to perform tasks well and identifies that the training contributes to achieve the objectives established by the company. As training is a strategy for continuous training and the acquisition of technological tools improves productivity^{59,60}, companies seek to create work teams that are more efficient and effective, for this they use models such as input-process-output, Core or input-mediator-output-input. Our theory considers the integration of teams as complex, since multiple variables are involved, including age and educational training. The characteristics of the workgroup models in our study are consistent with the results of Gil *et al.*⁶¹. There is an emerging scientific field that identifies key processes that allow individuals to combine their skills and abilities to have better performance in work teams⁶².

The seniority of the worker shows to have a negative relationship with productivity, that is, a worker with more seniority produces less than a less senior worker. The human factor is a competitive advantage for a company and informal

leaders can influence behaviors and affect productivity levels⁶³. The influence of informal groups can negatively affect the productivity of the company as workers reduce their performance and production. It is thus necessary to identify the sources of disagreement so that work groups continually increase their performance and the company avoids future conflicts⁶⁴. Informal groups are typically organized by affinities of human relationships rather than tasks and have greater individual autonomy due to being self-managed. Therefore, it is important to consider different options to integrate working groups, namely based on the existing diversity of objective and subjective differences of the individuals that make up each group⁶⁵.

Finally, the age and education variables were not very relevant to explain the variations in workers' perceived productivity.

CONCLUSION

The proposed methodology to identify homogeneous work groups aimed at improving the productivity of the company. Aspects such as age, seniority, educational level, knowledge about ISO 22000 standards and training are considered. The relationship between these aspects allows identification of groups with possibilities to improve results. Training has a positive relationship with productivity and is a determining factor for selection of work groups, workers with a better disposition towards training are more productive. We could identify an inverse relationship between productivity and seniority as the person's time in work increases, his productivity decreases. Knowledge about ISO 22000 standards has low impact on productivity. Finally, companies are currently looking for different ways to increase productivity, this proposal considers the characteristics of the worker in relation to aspects of training and quality standards.

SIGNIFICANCE STATEMENT

This study discovers the perception of worker productivity, which can be beneficial for companies in this field. This study will help the researcher to uncover the critical areas of the relationship between productivity and training and the implementation of quality standards, which many researchers could not explore. Thus, the method of identifying work groups with the aim of increasing productivity may lead to new theory.

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