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The influence of maintenance on process innovation and business performance

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Abstract

Scientific literature reveals that maintenance is a key strategy for a firm's success, as it is a factor that improves business performance. For this reason, the present study aimed to analyze the influence of maintenance on process innovation and business performance, based on a sample of 288 micro, small and medium enterprises (MSMEs) from the industrial sector of Guanajuato. The results obtained through the statistical technique of Linear Regression under the stepwise method reveal that there is sufficient empirical evidence of the influence of maintenance on process innovation and business performance. For this reason, decision makers must include within their business strategies the maintenance strategy, which will be reflected in a greater efficiency of their equipment and reduction of costs, in order to comply with the requirements of their clients and with it achieve higher levels of business performance.

Maintenance, Process innovation, Bussines performance, MSMEs

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Introduction

From the industrial revolution that occurred initially in England in the eighteenth century, caused companies to focus and pay more attention to standardization. In the case of Mexico, due to various circumstances, this process of industrialization did not begin until the end of the 19th century (Chavez Palacios, 2004). And it was because of the need to mass-produce that the standardization of processes was adopted, so that maintenance became a fundamental part of the corporations, aimed at equipment repair activities (Vilarón Vázquez, Pineda Domínguez, & Pérez Rodríguez, 2007).

Currently, companies consider the maintenance area as a strategic activity that is related to innovation and productivity needed in the globalized world of today (Vilarón Vázquez et al., 2007).

The costs of manufacturing within the companies have caused that it is to improve the maintenance, reason why it demands greater degree of talent, skill and training of the personnel that repairs the equipment. It is here where innovation in the processes is created, giving way to the reduction of costs in the productive processes and stimuli of creativity in the manufacturing processes (Vilarón Vázquez et al., 2007).

It has been found in scientific literature that maintenance is crucial compared to the ability of a corporation to compete against its rivals with quality, delivery and cost, since this must be seen as an investment to improve business performance (Fredendall, Patterson, Kennedy, & Griffin, 1997).

In this sense, maintenance from the strategic point of view, promises to improve the performance of a company, with the commitment, training, resources and integration that this requires (Swanson, 2001).

So the purpose of this research is to determine the influence of maintenance on process innovation and business performance of MSMEs in the state of Guanajuato.

Justification

There is theoretical and empirical evidence that states that there are several variables involved in process innovation and business performance, but there are few studies that deepen to know if maintenance is a facilitator for process innovation and performance within the corporations, mainly in smaller companies in an emerging country such as Mexico.

Most of the work has focused on the many external and internal factors that are associated with generic innovation, but more recently attention has been given to innovation in maintenance management (Pitt, Goya, & Sapri, 2006).

Therefore, the present study intends to contribute empirical evidence on the relationship that exists between maintenance with process innovation and business performance in the industrial MSMEs of an emerging country such as Mexico.

An additional contribution is that not only the impact of maintenance on process innovation and business performance is evidenced, but also maintenance activities that significantly influence both process innovation and business performance are identified.

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Problem

Because of globalization and the demand of the current market, a pattern has been set in the competition, which has led organizations, specifically MSMEs (micro, small and medium enterprises) to rethink their strategies and improve their business performance, in order to comply with market requirements, offering innovative products and / or services that reinforce its competitiveness (Cuevas-Vargas, Aguilera Enríquez, & González Adame, 2015).

In this sense, after the theoretical support that exists of the relationship between maintenance with process innovation and business performance, there is a need to know if the maintenance performed in the industrial MSMEs of Guanajuato affects the level of innovation of processes and performance improvement within organizations.

For this reason it is important to know how important maintenance is within the MSMEs of an emerging country and how maintenance activities help them to innovate in their processes and improve their business performance.

Hyphoteses

H1: Maintenance significantly influences process innovation.

H2: Maintenance significantly influences business performance.

Objectives

General objective

To determine the influence of maintenance on process innovation and business performance of industrial MSMEs.

Specific objectives

- To identify maintenance practices that have a significant influence on process innovation.
- To identify maintenance practices that have a significant influence on business performance.

Theoretical framework

This research presents the theoretical arguments that sustain the relationship of the analysis variables: maintenance, process innovation and business performance.

Relationship of maintenance with process innovation

Maintenance is defined as the combination of all technical and administrative actions, including control actions, aimed at retaining an element, or restoring it to a state where it can perform a required function. A process such as maintenance can be defined as an activity or a set of linked and ordered activities for the transformation from entry to exit (Rentzhong, 1996).

For his part Teresko (1992) states that maintenance is an investment, that is, one of the functions of a company, which returns quality, safety and reliability.

Likewise, Etienne-Hamilton (1994) defines maintenance as a partner that together with other functions works to achieve the goals or strategic objectives of a company.

Faced with these definitions, we can say that maintenance is a resource that corporations can use to achieve their goals, obtaining advantages from it.

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Over the years entrepreneurs have understood the importance of the proper functioning of the teams that participate in the production systems with respect to the profits of their organizations.

Regarding empirical evidence, in a study conducted with 22 Mexican companies from different sectors, Vilarón Vázquez et al. (2007) found that the role that industrial maintenance plays has been based on both operational and administrative activities; highlighting that maintenance stimulates creativity, generation of technology in the area, increases the effectiveness of companies, reduces costs in the maintenance area, allows companies to be more competitive in their field, provides knowledge to human capital and it gives a pattern to innovation in manufacturing processes.

In their empirical study carried out in Spain with medium and large companies in the industrial sector of machinery and instruments for measurement, analysis and control, Perdomo-Ortiz, González-Benito, & Galende (2006) reveal that there is a link between maintenance practices and the innovation capabilities of a company, that is, the knowledge of a company to make changes in its processes, products and systems. In addition, they found that process documentation and proper and preventive maintenance help to carry out innovation in companies.

On the other hand, Zehir & Sadikoglu (2010) in their study conducted with 373 Turkish companies found that the practices performed by maintenance employees to achieve quality, improves innovation in processes products or services, since they generate innovative ideas.

On the other hand, Pitt et al. (2006) in their research carried out in Malaysia, highlight the importance of a strategic maintenance management system in relation to innovation, that is, it is emphasized that innovation in this process adds value to corporations by the continuous efficiency produced by a Creative environment

The costs of manufacturing within the companies have caused that it tries to improve the maintenance, reason why it demands greater degree of talent, skill and qualification of the personnel that repairs the equipment; it is here where innovation in processes is created, giving way to the reduction of costs in productive processes and stimuli of creativity in manufacturing processes (Vilarón Vázquez et al., 2007).

Process innovation is reflected in the changes in the processes that cover the techniques, equipment and information programs of auxiliary activities, such as purchasing, accounting, IT and maintenance (OECD, 2005). Based on these arguments, the first hypothesis is presented:

H1: Maintenance significantly influences process innovation.

Relationship of maintenance with business performance

Fredendall, Patterson, Kennedy, & Griffin (1997) indicate that maintenance is crucial against the ability of a corporation to compete against its competition with quality, delivery and cost, since maintenance is not an expense, but an investment for better business performance In their study carried out in Singapore with 67 industrial companies, Brah & Chong (2007) found that companies that implement total productive maintenance, that is, maintenance in their processes, machinery and equipment, perform better in contrast to those that do not performed.

For his part Swanson (2001) in his research with 287 North American companies of the metallurgical industry, whose purpose was to explore the different maintenance strategies in relation to the maintenance and performance of the plant, conclude that the maintenance from the strategic point of view, It promises to improve the performance of a company, with the commitment, training, resources and integration that it requires. Assuming that managers or managers of corporations can already feel comfortable when investing in maintenance, due to its positive impact on business performance.

Another empirical study conducted by Ahuja & Kumar (2009) in India, reveals that properly applied maintenance influences the improvement of the companies' performance and leads them to build the capacity to be competitive, since a well-executed maintenance contributes to the compliance with organizational goals and objectives. For his part, Solís Coria (2012) in his study conducted in Mexico concludes that the maintenance and participation in the planning of the product process are positively related to performance, because it is a tool that provides the confidence that the productivity will not be affected while it is being implemented. So we can say that there is a link between the maintenance that takes place in a company and the performance that is obtained. Based on these arguments, the second hypothesis is presented:

H2: Maintenance significantly influences business performance.

Next, in figure 1, the theoretical research model is shown.

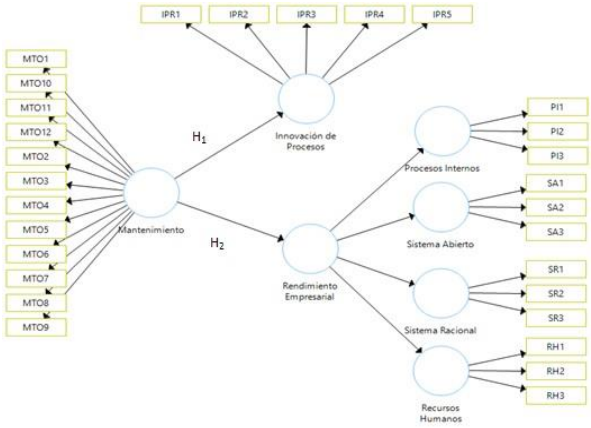

Figure 1 Theoretical model of research.

Research Methodology

Sample design and information gathering

The present empirical study of explanatory type, had a quantitative approach, with a non experimental design and transveral cut, through the Multiple Linear Regression under the method of successive steps. Considering as a reference the database of the Mexican Business Information System (2017), in which 3,123 economic units of the industrial sector in the State of Guanajuato, from one to 250 employees, were registered.

In this sense, a survey was designed to be answered by the managers or owners of this type of company, which was applied randomly to 342 entrepreneurs, using a confidence level of 95% and a margin of error of 5%, obtaining a response rate of 84%, counting on a final sample of 288 surveys. In Table 1, detailed information is shown.

characteristics	Description
Kind of investigation	Empirical, explanatory, descriptive and transversal
Focus	Quantitative
Analysis unit	Mipymes of the state of Guanajuato from 1 to 250 workers
Geographic area	State of Guanajuato, Mexico
MiPymes Universe	3,123 micro, small and medium industrial companies
Method of information gathering	Personal survey to managers or owners of the company
Sampling method	Simple random sampling
Sample size	342 mypymes
Final Sample	288 mipymes
Sampling error margin	± 5% error, 95% confidence level (p = q = 0.5)
Data analysis	Multiple Linear Regression

Table 1 Research data sheet.

Measurement of the variables

Maintenance variable

The measurement scale of the maintenance variable was adapted from Quickview 3.0 Manufacturing Assessment (TDO Solutions for Manufacturing and Technology, 2001), measured with 12 items, with a Likert scale of 1 to 5 points, where 1 refers the total disagreement and 5 total agreement.

Being a latent variable that can not be observed directly, it was necessary to create a new variable that would take on the role of an exogenous variable, based on the arithmetic mean of its 12 manifest variables, as pointed out by Cuevas-Vargas & Estrada (2017).

Variable process innovation

Process innovation variable was taken from Cuevas-Vargas et al. (2015), adapted from Pinzón (2009), which was measured with five items, using a Likert scale of 1 to 5 points, where 1 refers the total disagreement and 5 the total agreement.

Given that this variable took on the role of an endogenous variable, as shown in the theoretical model, it was necessary to generate a new variable, as Cuevas-Vargas & Estrada (2017) point out, based on the average arithmetic of its five manifest variables.

Business performance variable

The scale of measurement of the business performance variable was adapted from Quinn & Rohrbaugh (1983), which was measured based on its four approaches: the internal processes approach, measured with a 3-item scale, the open-system approach , measured with a scale of 3 items, the rational system approach, measured with a scale of 3 items, and the human resources approach, measured with a scale of 3 items, all of them measured with a Likert scale of 1 to 5 points, where 1 is total disagreement and 5 is total agreement.

Similarly, to measure this endogenous variable according to the theoretical research model, it was necessary to create the four variables of the different approaches, starting from the arithmetic mean of its manifest variables, as Cuevas-Vargas & Estrada points out. (2017), and subsequently created the variable business performance, from the arithmetic mean of its four variables representing the four approaches proposed by Quinn & Rohrbaugh (1983).

Reliability

In order to demonstrate the reliability of the scales, the Cronbach's Alpha (Cronbach, 1951) was used, obtaining values much higher than the 0.7 suggested by Nunally & Bernstein (1994), which are shown in Table 2.

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Construct	Cronbach's Alpha >0.7
Maintenance	0.932
Process Innovation	0.903
Performance with focus on internal processes	0.855
Performance with open system approach	0.872
Performance with rational system approach	0.912
Performance with a human resources approach	0.854

Table 2 Reliability of the scales.

Therefore, it can be concluded that the different scales with which each of the variables was measured have reliability, which indicates that there is internal consistency between the variables with which each of the constructs was measured.

Results

First, the descriptive statistics are presented in Table 3, where it can be seen that the industrial Mipymes of Guanajuato, according to the perception of the managers or owners, give greater attention to their operators being responsible for cleaning and organizing their tools, equipment and work area, with an average of 3.95, followed by the variable equipment is cleaned, maintained and and lubricated on a regular basis, with an average of 3.90, however, although they claim to have a program of maintenance for the workshop team, with an average of 3.46, it has been found that what they have paid less attention to is documenting this maintenance program, with an average of 2.82, followed by documentation of the time invested in the maintenance of the teams, with an average of 2.88.

ID	Variable	Mean
MT1	There is a maintenance program for the workshop team	3.46
MT2	That maintenance program is documented	2.82
MT3	The measuring devices are calibrated periodically	3.17
MT4	There is a traceable calibration record for each device	2.93
MT5	The cutting tools are stored and clearly identified	3.45
MT6	The time invested in the maintenance of the equipment is documented	2.88
MT7	Operators perform equipment maintenance repairs	3.43
MT8	The equipment is cleaned, maintained and lubricated on a regular basis	3.90
MT9	The condition of the pieces of mobile equipment is evaluated on a regular basis to verify that it works within the tolerances	3.65
MT10	The measuring devices mounted on machines are checked and / or balanced on a regular basis to ensure operation within the tolerances	3.55
MT11	Operators are responsible for cleaning and organizing their tools, equipment and work area	3.95
MT12	Operators are responsible for cleaning their own machines, lubricating them and maintaining them on a regular basis	3.74

Table 3 Maintenance descriptive statistics.

With regard to process innovation, it was found that the managers or owners of the industrial MSMEs have bet more to introduce new equipment with the purpose of automating their processes, with an average of 3.36, followed by the incorporation of new or improved methods of creation and provision of services, with an average of 3.09, however, managers give less importance to the use of computer programs and techniques for the supply of inputs, with an average of 2.82, as shown in the Table 4, which is presented below.

ID	Variable	Mean
IP 1	New equipment has been introduced to automate the company's processes	3.36
IP 2	Computer programs and techniques are used for the supply of supplies, allocation of supplies in the company or the distribution of final products	2.82
IP 3	New or improved methods of creation and provision of services have been incorporated	3.09
IP 4	Significant changes are introduced in the equipment and software used in the procedures or techniques for the provision of services	2.95
IP 5	New or improved techniques, equipment and computer programs are introduced that are used in auxiliary support activities (purchasing, accounting, calculation, maintenance)	3.04

Table 4 Descriptive statistics of process innovation.

Regarding business performance, according to the perception of the managers of this type of company, it was found that their organizations have had an increase in the satisfaction of their clients, with an average of 3.90, followed by the improvement of the quality of their products. , with an average of 3.73, and in third place the improvement of the image of the company and its products / services, with an average of 3.63, however, the lowest ratings on average are shown in the human resources approach with the reduction of staff turnover, an aspect that should be considered to improve the work environment, as shown in Table 5 presented below.

ID	Variable	Mean
PI 1	Improvement of product / service quality	3.73
PI 2	Increase in the efficiency of internal operational processes	3.55
PI 3	Improvement in the organization of staff tasks	3.53
SA 1	Increase in customer satisfaction	3.90
SA 2	Rapidity of adaptation to the needs of the markets	3.54
SA 3	Improvement of the image of the company and its products / services	3.63
SR 1	Increase in market share	3.43
SR 2	Increase in profitability	3.45
SR 3	Increase in productivity	3.52
R H1	Improvement in worker motivation / satisfaction	3.47
R H2	Reduction of staff turnover (voluntary abandonment of workers)	3.33
R H3	Reduction of work absenteeism	3.42

Table 5 Descriptive statistics of business performance

Subsequently, it was necessary to show the linearity between the independent variables, finding that there is linearity between the observable variables with which the exogenous maintenance variable was measured. In this sense and according to what was pointed out by Hair, Black, Babin, & Anderson (2010), it is feasible to apply multiple linear regression analysis, which was applied under the method of successive steps and whose results are shown in the Table 6.

Hypotheses	β	t-value	R^2 Adjusted	F- value
Maintenance → Process Innovation	0.526***	10.446	0.274	109.11 ***
Maintenance → Business Performance	0.647***	14.366	0.417	206.39 ***
Significance: ***=p<0.001; **= p<0.01				

Table 6 Results of the linear regression.

Based on the findings found, previously shown in Table 6, with regard to H1, the results obtained (β= 0.526, p<0.001), they indicate that the maintenance influences positively and significantly in the innovation of processes, when impacting the maintenance in a 52.6% in this type of innovation of the industrial SMEs of the state of Guanjauato, and that the innovation of processes is explained in a 27.4% for maintenance, therefore, H1 is accepted, confirming the findings found by Perdomo-Ortíz et al. (2006) in Spain, since maintenance practices are related to the innovation capabilities of a company in its processes, products and systems. It also coincides with the results of Zehir & Sadikoglu (2010) in Turkey, where the practices of maintenance employees to achieve quality improves process innovation.

Regarding H2, the results indicate that maintenance significantly influences business performance (β= 0.647 p<0.001), when impacting the maintenance of business performance by 64.7% and that the business performance of MSMEs under study is explained by 41.7% for maintenance, therefore, H2 is accepted, and confirms the results obtained by Ahuja & Kumar (2009) in India; Brah & Chong (2007) in Singapore, and Swanson (2001) with American companies, who found that the maintenance carried out properly within the company, improves their performance and allows them to build the capacity to be competitive.

Finally, in order to identify the maintenance activities that have a significant influence on process innovation and business performance, a new multiple linear regression was applied under the same method of successive steps, and the results are shown below in the following section. Table 7.

Variable	Innovation Processes	Business Performance
The measuring devices are calibrated periodically.	0.177** (2.192)	0.218*** (3.578)
The maintenance program is documented.	0.218*** (3.314)	N.S.
The measuring devices mounted on machines are checked and / or balanced on a regular basis to ensure operation within the tolerances	0.138** (2.188)	N.S.
The cutting tools are stored and clearly identified	0.138** (2.029)	N.S.
There is a maintenance program for the workshop team	N.S.	0.268*** (4.161)
The equipment is cleaned, maintained and lubricated on a regular basis	N.S.	0.152** (2.225)
Operators are responsible for cleaning and organizing their tools, equipment and work area	N.S.	0.146** (2.248)
R^2 Adjusted	0.296	0.418
F-value	30.449***	52.521***
Highest VIF	2.671	2.302

Table 7 Multiple linear regression results.

Where it can be seen that the companies that calibrate their measuring devices periodically, see the impact of this maintenance activity in a significant way both in their process innovation and in their business performance, influencing 17.7% and 21.8% respectively.

Likewise, the results indicate that documenting the activities of its maintenance program significantly impacts on 21.8% in process innovation; that when they periodically balance machine-mounted measuring devices to ensure operation within tolerances they see a positive effect at 13.8% on process innovation; that the fact of saving the cutting tools and having them clearly identified has a significant influence of 13.8% on the innovation of their processes. On the other hand, it was found that having a maintenance program for the workshop team has a significant impact on business performance of 26.8%; that when the equipment is cleaned, maintained and lubricated on a regular basis it significantly impacts a 15.2% on the business performance; and that having operators responsible for cleaning and organizing their tools, equipment and work area has a significant effect on business performance.

Conclusions

Based on the objective of the research, it is concluded that maintenance has a positive and highly significant impact on both process innovation and business performance, so it is essential that the decision makers of this type of companies consider its business strategies maintenance management, since it will allow them to reduce their costs, streamline their processes and improve their level of innovation. That is why having the equipment that is given maintenance continuously, will guarantee the company greater durability and likewise will allow it to meet the requirements of its customers and thereby obtain better business performance.

On the other hand it has been found that document your maintenance program, periodically calibrate your devices, save and clearly identify the cutting tools, as well as regularly check or calibrate the measuring devices mounted to the machines and scales to ensure its operation within tolerances, significantly influences the innovation processes of this type of companies.

In the same sense, it was found that having a maintenance program for workshop equipment, calibrating the measuring devices periodically, cleaning, maintaining and lubricating the equipment on a regular basis, as well as the fact that the workers are responsible for cleaning and organizing their tools, equipment and work area has a positive and significant impact on business performance.

Therefore, decision makers should pay special attention to having a maintenance program and document the types of maintenance that are being done to the teams to have a history for decision making. In the same way, they should inculcate in their workers and workers the culture of equipment maintenance, in which cleaning, lubrication and calibration of tools and devices, the care and organization of their tools and equipment, as well as their own work area. Within the limitations of this study, it can be highlighted that the surveys were answered from the point of view of the MiPymes managers, which can be lent to subjectivities.

In future investigations, it is recommended to identify whether the size and age of the company influence maintenance management. Similarly, it is suggested to carry out a comparative study with another geographical area of the country to see how maintenance is found in industrial SMEs.

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Analyze the relationship of maintenance with other variables such as knowledge management, technology, prevention of pollution and waste reduction, financing, competitiveness, etc., in order to expand the results and compare them with the conclusions set out in the present study. Finally, it is suggested to apply an exploratory factorial analysis to the scale in order to identify if it is feasible for the maintenance variable to pass from that large number of manifest variables to a smaller one of explanatory elements (factors), which allow explaining in a more simple maintenance.

References

Ahuja, I. P., & Kumar, P. (2009). A case study of total productive maintenance implementation at precision tube mills. *Journal of Quality in Maintenance*, 15(3), 241-258. doi:10.1108/13552510910983198

Brah, S.A., & Chong, W.K. (2007). Relationship between total productive maintenance and performance. *Internal Journal of Production Research*, 42(12), 2383-2401. doi:http://dx.doi.org/10.1080/00207540410001661418

Chavez Palacios, J. (2004). Desarrollo Tecnológico en la Primera Revolución Industrial. *Revista de Historia*, 17, 93-109.

Cronbach, L.J. (1951). Coefficient alpha and the internal structure of tests. *Psychometrika*, 16, 297-334.

Cuevas-Vargas, H., Aguilera Enríquez, L., & González Adame, M. (2015). La relación de la innovación de procesos y el rendimiento empresarial de las MiPymes industriales de Guanajuato. *IX Congreso de la Red Internacional de Investigadores en Competitividad*, 11-13.

Cuevas-Vargas, H., & Estrada, S. (2017). La modelización de la conducta innovadora con ecuaciones estructurales. Una técnica de segunda generación. En E. Larios-Gómez & A.C. Giuliani (Eds.), *Administración. Un enfoque latinoamericano México-Brasil* (pp. 299-313). México: Pearson Educación.

Etienne-Hamilton, E.C. (1994). *Operations Strategies for Competitive Advantage: Text and cases*. Texas, USA: Dryden Press.

Fredendall, L. D., Patterson, J. W., Kennedy, W. J., & Griffin, T. (1997). Maintenance: Modelin Its Startegic Impact. *Journal of Managerial Issues*, *9*(4), 440-453. Obtenido de http://www.jstor.org/stable/40604159

Hair, J.F., Black, W.C., Babin, B.J., & Anderson, R.E. (2010). *Multivariate Data Analysis* (7th Edition). New Jersey: Prentice Hall.

Nunnally, J.C., & Bernstein, I.H. (1994). *Psychometric Theory*, 3ª Ed. New York: McGraw-Hill.

OCDE. (2005). *Oslo Manual: Guidelines for Collecting and Interpreting Innovation Data* (3ra ed.). Paris. Obtenido de http://www.oecd-ilibrary.org/docserver/download/9205111e.pdf?expires=1498615819&id=id&accname=guest&checksum=561EE97A21EB6F0B391F5DCE6EBA057B

Perdomo-Ortiz, J., González-Benito, J., & Galende, J. (2006). Total quality management as a forerunner of business innovation capability. *Technovation*, 26(10),1170-1185. doi:https://doi.org/10.1016/j.technovation.2005.09.008

Pinzón, C.S.Y. (2009). Impacto de la Orientación a Mercado en la Innovación en Empresas de Aguascalientes. Tesis Doctoral, Universidad Autónoma de San Luis Potosí, México.

Pitt, M., Goyal, S., & Sapri, M. (2006). Innovation in facilities maintenance management. *Building Services Engineering Research and Technology,* 27(2), 153-164.

Quinn, R., & Rohrbaugh, J. (1883). A spatial model of effectiveness criteria: Towards a competing values approach to organizational analysis. *Management Science, 29*(3), 363-377. http://dx.doi.org/10.1287/mnsc.29.3.363

Rentzhog, O. (1996). *Core Process Management*. *Department of Menichal Engineering, Division of Quality and Technology*. Linköping: Linköping University.

Sistema de Información Empresarial Mexicano. (Abril 12, 2017). Retrieved from Directorio de Empresas: http://www.siem.gob.mx/siem/estadisticas/estadotamanoPublico.asp?tam=3&p=1

Solís Coria, R. (2012). Diseño de un sistema de mantenimiento centrado en confiabilidad, en el área de manufactura, mediante el análisis estadístico de fallas y criticidad en los equipos. *Congreso Internacional de Investigación: Vol. 4. Academia Journals* (pp. 1400- 1405).

Swanson, L. (2001). Linking maintenance strategies to performance. *Journal of Production Economics,* 70(3), 237-244.

TDO Solutions for manufacturing & Technology (2001). Quick View 3.0 Manufacturing Assestment Questionaire.

Teresko, J. (1992). Time bomb or profit center? *Inductry Week*, 241, 52-71.

Vilarón Vázquez, J., Pineda Domínguez, D., & Pérez Rodríguez, E. Y. (2007). La innovación tecnológica en el área del mantenimiento y sus resultados. Estudio de casos. *International Journal of Production Research*, 37, 849-869.

Zehir, C., & Sadikoglu, E. (2010). Investigating the effects of innovation and employee performance on the relationship between total quality management practices and firm performance: An empirical study of Turkish firms. *Journal of Production Economics*, 127(1), 13-26.

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