Research Article

METHODOLOGY FOR THE DIAGNOSIS OF THE IMPLEMENTATION OF LEAN MANUFACTURING SYSTEM TOOLS IN COMPANIES IN THE AUTO PARTS SECTOR OF THE STATE OF TLAXCALA, MEXICO

Adilene Ivonne Medel Rodríguez[1*]., Ma. Elizabeth Montiel Huerta[2] and Alejandra Torres López[3]

[1]Administrative Engineering Department, Technological Institute of Apizaco, Apizaco, Tlaxcala
[2,3]Division of Graduate Studies and Research, Technological Institute of Apizaco, National Institute of Technology of Mexico, Apizaco, Tlaxcala, Mexico

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ABSTRACT

Under evidence of the clear growth of the auto parts sector in the state of Tlaxcala, Mexico, but without certainty of a long-term sustainable base. A study is carried out to determine the level of implementation of tools of the lean manufacturing system in this sector, since this system, with a good focus and implementation, presents considerable improvements in the growth and stability of companies. Under the established methodology, a fairly consistent result is obtained, although with some deficiencies in some factors, such as innovation and operator participation.

INTRODUCTION

Studies show the difficulty and slowness of some companies to implement lean manufacturing, this may be due to the rush to implement changes, without stopping to make a diagnosis to identify the strengths to be strengthened, in turn the weak parts that need to be corrected. In addition to this problem of implementation of lean manufacturing, was considered the manufacturing sector of auto parts in the state of Tlaxcala, Mexico, as an object of study, due to the growing activity and importance it has gained in the state of Tlaxcala in recent years, but still has no sustainable basis in the long term, therefore, this study aims to know the level of implementation of the tools of lean manufacturing system in the auto parts sector of the state of Tlaxcala, Mexico. This will make it possible to create actions to make it ephemeral in the long run. The importance of this sector for the federal government and for Mexico's development is taken into account. The National Productivity Council is expected to strengthen this sector in order to make it more attractive and attract investment from other countries. The auto parts sector is an essential component of the Mexican manufacturing industry; in recent years it has become one of the most important sectors in terms of employment, with 40% of the automotive sector (Muller, 2014).

Corresponding author: **Adilene Ivonne Medel Rodríguez**
Administrative Engineering Department, Technological Institute of Apizaco, Apizaco, Tlaxcala

METHODOLOGY

The methodology defined for this research consists of the steps shown in the figure "research methodology", which will lead to answers to the above-mentioned research questions.
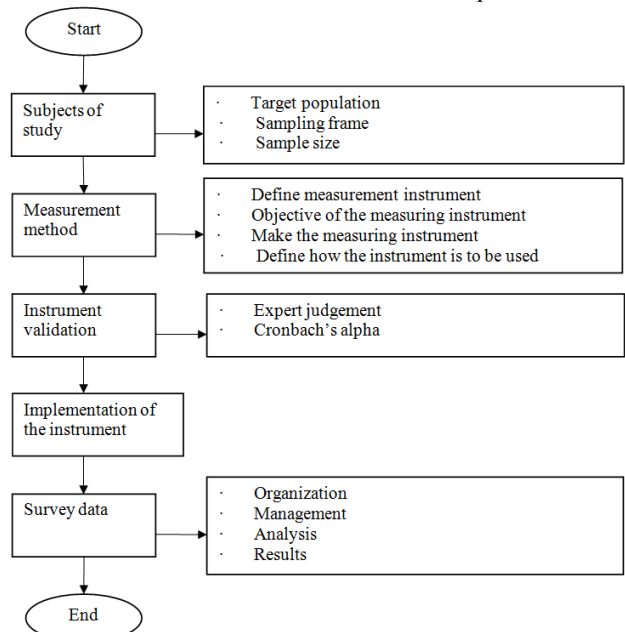

Chart 1 "Methodology for the diagnosis of the implementation of lean manufacturing system tools in companies in the auto parts sector of the state of Tlaxcala, Mexico."(Source: personal collection).

Subject of study: defined for this research in the following points.

- Target population: it is specified according to concepts and variables defined in the research problem, that is, the auto parts sector of the state of Tlaxcala.
- Sampling frame: defined by the size of the company in this sector.

Enterprise size sampling frame			
Large	Medium	Small	Total
10	23	14	47

Chart 2 Sampling frame by company size. (Source: personal collection).

- Sample size: defined using the statistical formula for population ratios:

$$n = \frac{k^2(p*q)*N}{(e^2*(N-1))+k^2*p*q}$$

As a result, a total of 28 companies, however, refused to open their doors in the field, under the variation of confidentiality of the information. Therefore, a total of 12 openings were obtained, of which 3 correspond to small companies, 4 medium companies and 5 large companies, which correspond to the sector under study.

The measurement method is described below in the points

- Define the instrument: Structured interview of a personal nature, this implies the direct participation of the interviewer, who raises the questions to the interviewed subjects.
- Definition of the objective: The objective of this interview is to know the current situation of the implementation of the lean manufacturing system of the companies of the auto parts sector in the state of Tlaxcala.
- Elaboration of the instrument: It begins with a presentation message, specifying who carries out the survey and the objectives pursued in the research. Identification and general data of the company and the main informant. Instructions for completing the interview and body of the instrument (structured set of statements), which consists of a total of 43 statements, with 5 possible answers under the Likert scale.

Validation methods: carried out by expert judgement and the Cronbach's alpha

Instrument validation by expert judgment, is described in the points shown below in chart 3.
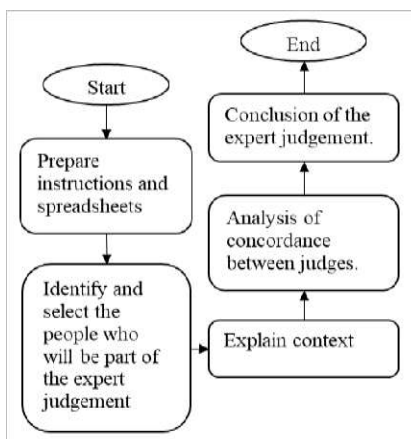

Chart 3 Instrument validation process by expert judgment. (Source: Skjong and Wentworht, 2000,).

Instrument validation by Cronbach's alpha: Using the SPSS statistical software, 0.93 was obtained, which indicates that the validity of the instrument is excellent, according to the Cronbach's alpha internal consistency scale. (Darren & Mallery, 2016).

Instrument (structured interview) applied to companies established in various industrial zones, such as industrial corridors, industrial parks, industrial areas and industrial cities located in different parts of the state of Tlaxcala, which are shown below.
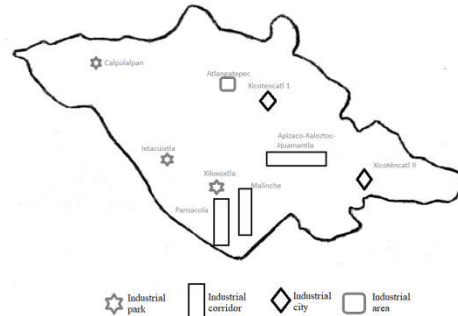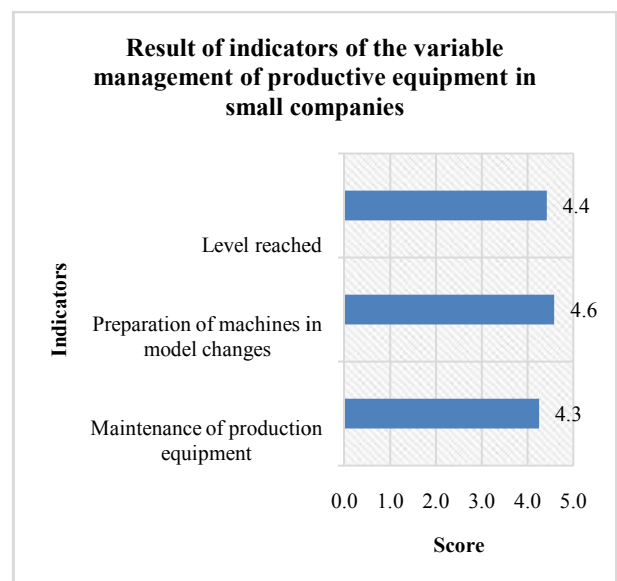

Chart 4 Map of industrial zones established in the state of Tlaxcala, Mexico. (Source: personal collection).

Survey data: This part consists of the organization, management and analysis of data: by developing a framework for the appropriate management of information at all stages of the survey. The data collected in the interviews were processed in the Excel statistical software, grouped according to the variables proposed in this research, by company and grouped by company size.

The data are analyzed with the Likert's scale points assigned to each answer, defined by the researcher, which range from 5 to 1, where 5 is the maximum score to be obtained for each statement and 1 the minimum score. Since some indicators have more than 1 statement, the arithmetic mean of the data set is used for this analysis, so the values will only go from 5 to 1.

RESULTS

The results are presented as follows: analysis by indicator, analysis by variable, general analysis of the lean manufacturing system. Results of the general analysis of the indicators of the operations infrastructure variable

Result of indicators of the variable management of production equipment in medium-sized companies

Indicator	Score
Level reached	4.3
Preparation of machines in model changes	4.3
Maintenance of production equipment	4.3

Result of indicators of the variable management of productive equipment in large companies

Indicator	Score
Level reached	4.4
Preparation of machines in model changes	4.6
Maintenance of production equipment	4.3

Result of indicators of the variable management of productive equipment in the auto parts sector of the state of Tlaxcala

Indicator	Score
Level reached	4.4
Preparation of machines in model changes	4.5
Maintenance of production equipment	4.3

Chart 5 Result of the general analysis of the indicators, of the operations infrastructure variable.(Source: personal collection).

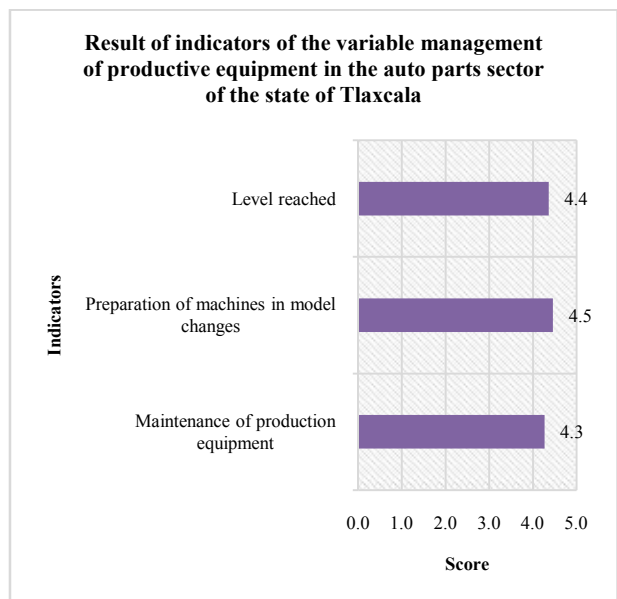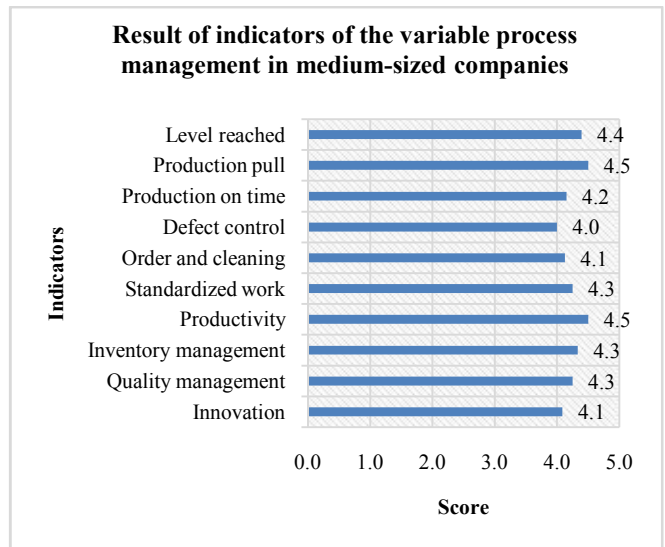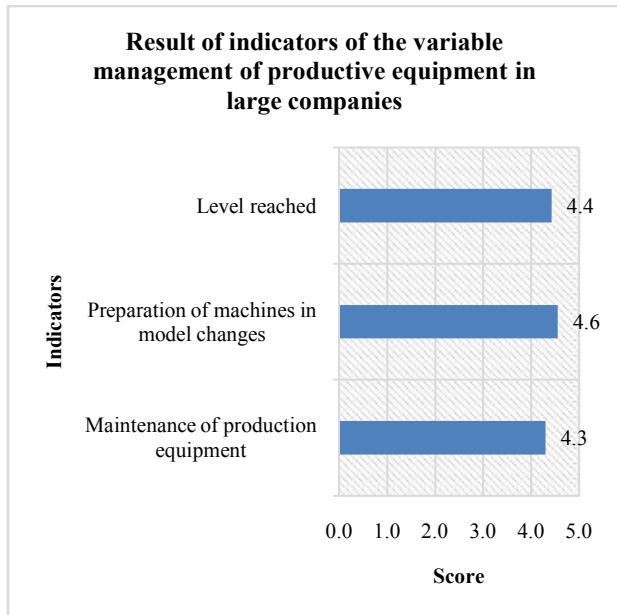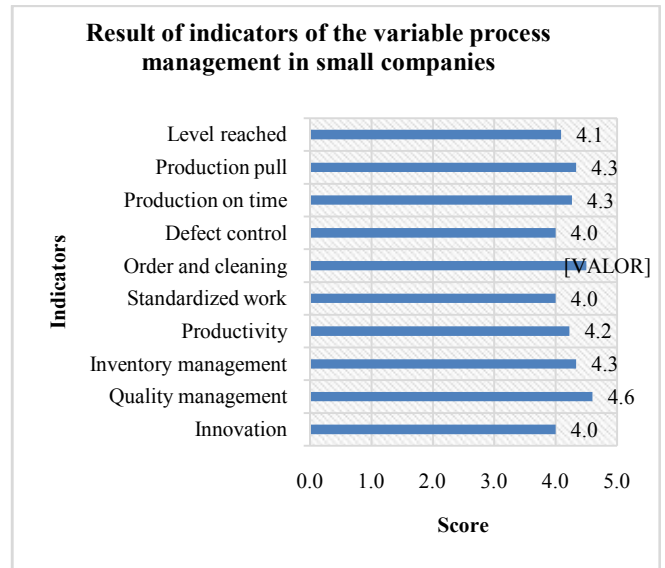Results of the general analysis of the indicators of the process management variable:

Result of indicators of the variable process management in small companies

Indicator	Score
Level reached	4.1
Production pull	4.3
Production on time	4.3
Defect control	4.0
Order and cleaning	[VALOR]
Standardized work	4.0
Productivity	4.2
Inventory management	4.3
Quality management	4.6
Innovation	4.0

Result of indicators of the variable process management in medium-sized companies

Indicator	Score
Level reached	4.4
Production pull	4.5
Production on time	4.2
Defect control	4.0
Order and cleaning	4.1
Standardized work	4.3
Productivity	4.5
Inventory management	4.3
Quality management	4.3
Innovation	4.1

Result of indicators of the variable process management in large companies

Indicator	Score
Level reached	4.4
Production pull	4.6
Production on time	4.4
Defect control	4.4
Order and cleaning	4.6
Standardized work	4.6
Productivity	4.5
Inventory management	4.3
Quality management	4.6
Innovation	3.6

Result of indicators of the variable process management in companies in the auto parts sector in the state of Tlaxcala

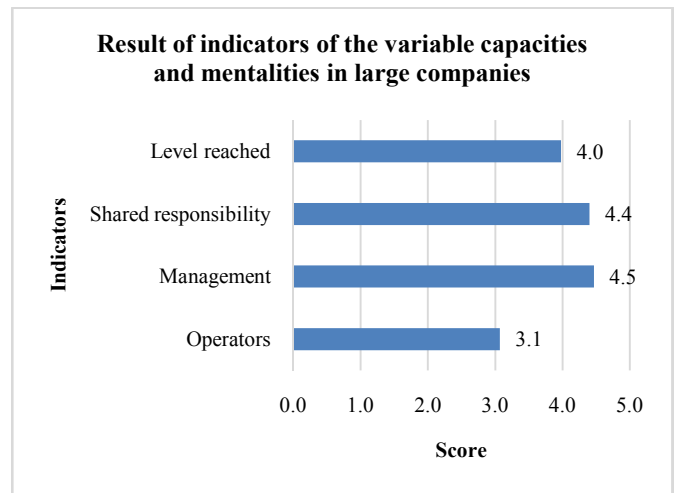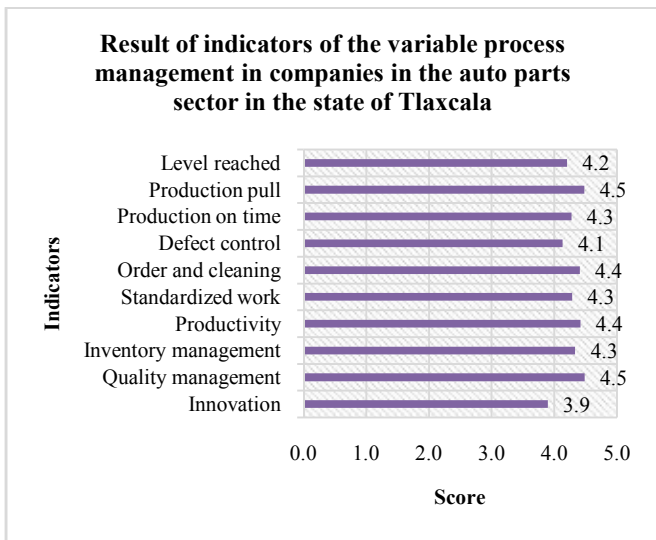| Indicator	Score
Level reached	4.2
Production pull	4.5
Production on time	4.3
Defect control	4.1
Order and cleaning	4.4
Standardized work	4.3
Productivity	4.4
Inventory management	4.3
Quality management	4.5
Innovation	3.9

Illustration 3.17 Result of the general analysis of the indicators of the process management variable.(Source: personal collection).

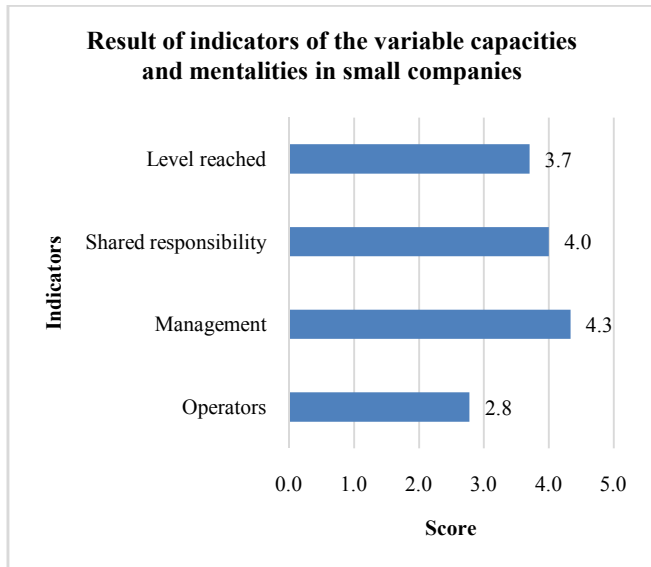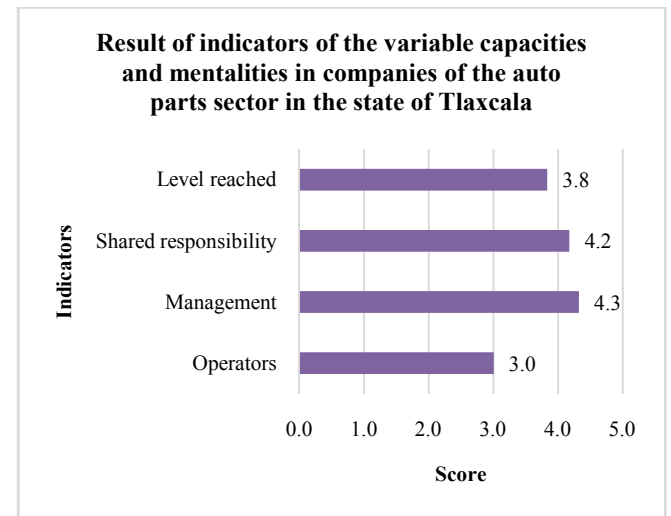Result of the general analysis of the indicators of the mentalities and capacities variable:

Result of indicators of the variable capacities and mentalities in small companies

Indicator	Score
Level reached	3.7
Shared responsibility	4.0
Management	4.3
Operators	2.8

Result of indicators of the variable capacities and mentalities in medium-sized companies

Indicator	Score
Level reached	3.8
Shared responsibility	4.1
Management	4.2
Operators	3.2

Result of indicators of the variable capacities and mentalities in large companies

Indicator	Score
Level reached	4.0
Shared responsibility	4.4
Management	4.5
Operators	3.1

Result of indicators of the variable capacities and mentalities in companies of the auto parts sector in the state of Tlaxcala

Indicator	Score
Level reached	3.8
Shared responsibility	4.2
Management	4.3
Operators	3.0

Illustration 3.18 Result of the general analysis of the indicators of the variable mentalities and capacities.(Source: personal collection).

Results of general analysis of the variables and level of implementation of the lean manufacturing system in companies in the auto parts sector in the state of Tlaxcala, Mexico.

Score obtained from the variables of the lean manufacturing system in the auto parts sector of the state of Tlaxcala, Mexico.

Variable	Score
Operations Infrastructure	4.0
Process Management	4.1
People Management	3.8

Level of implementation of the lean manufacturing system in the auto parts sector in the state of Tlaxcala, Mexico.

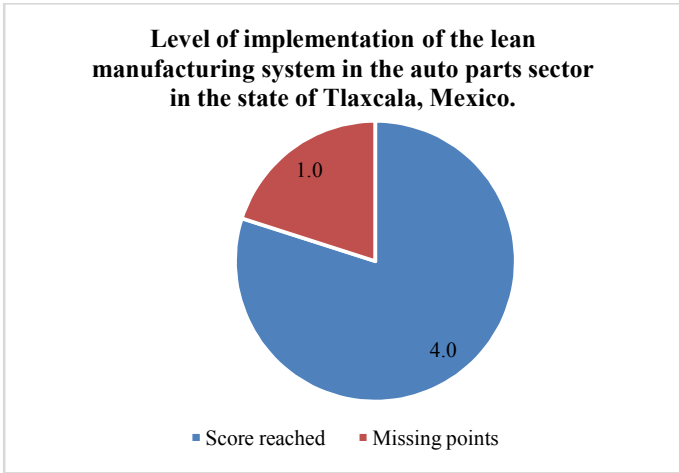

■ Score reached   ■ Missing points
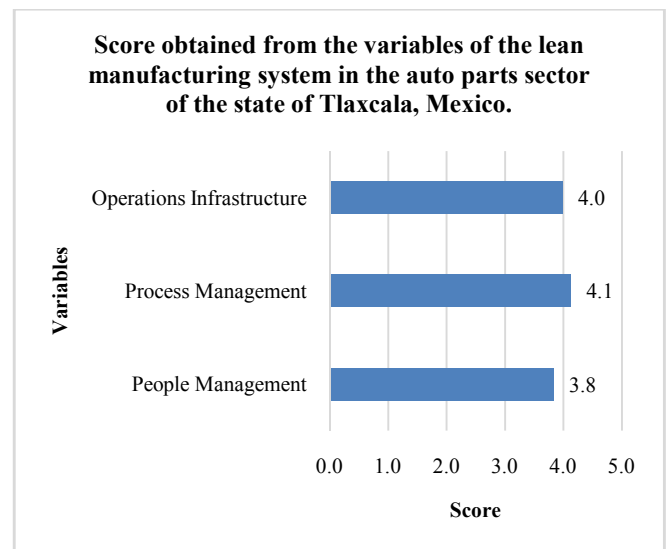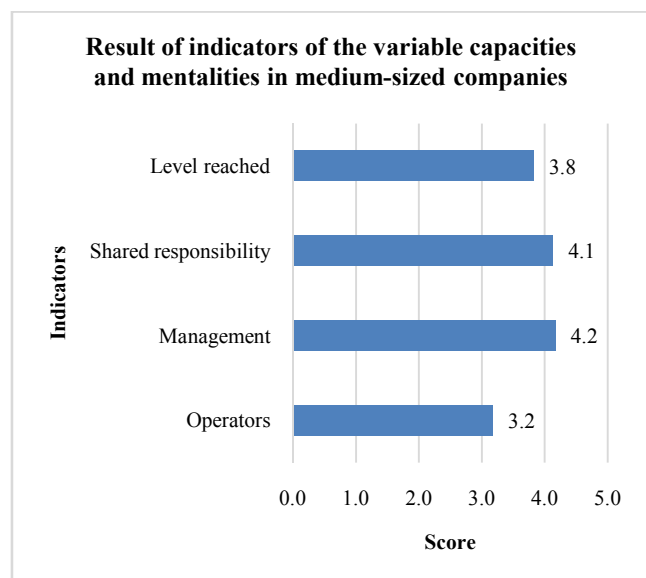
Illustration 3.19 General result of the variables and level of implementation of the lean manufacturing system in the auto parts sector in the state of Tlaxcala, Mexico.(Source: personal collection).

The previous tables show the score obtained, which range from 1 to 5, where 1 means that the system is not known, therefore there is no system, 2 means the system startup therefore is a new system, 3 is a proven system which means there is already a system, 4 means system with a certain maturity and 5 is excellence in the system. The overall result of the lean manufacturing system in the state of Tlaxcala is a level 4. The analysis is presented in the table below.

Chart 9 Analysis of results. (Source: personal collection).

	System	Lean manufacturing	Diffusion	Application	Results
Level 4	System Maturation	Adjustment system	Strong implementation	Good integration	Above industry average
		High standardization	All major areas and many support areas	Few communication cases	Good to excellent in main areas

CONCLUSIONS AND RECOMMENDATIONS

The level of lean manufacturing that is implemented in the auto parts sector of the state of Tlaxcala, has a certain level of maturity, without reaching excellence, although there are still determining factors to take into account to reach maturity, later on the excellence in the level of such implementation, these factors are the lowest score obtained in the interviews conducted with companies: One of them is the human factor, specifically in the low participation of operations personnel in decision-making and initiatives, which may be due to the fact that people management is still preserved in a traditional way, another relevant factor is innovation, factors that the Lean Manufacturing system considers essential for successful implementation. Therefore, it is necessary to consider initiatives, steps and actions that lead to the improvement of these.

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