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MODEL DETERMINATION FOR THE REDUCTION OF INVENTORY COSTS IN AUTO PARTS MANUFACTURING COMPANIES

DETERMINACIÓN DE MODELO PARA LA DISMINUCIÓN DEL COSTO DE INVENTARIO EN EMPRESAS MANUFACTURERAS DE AUTOPARTES

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ABSTRACT

The supply chain is the set of processes that develop from the request for the product until it is delivered to the final customer, one of the main components of this is the warehouse area, Inventory as a current asset in the balance sheet is a concern for organizations. Because of the above, this research aims to determine a model for reducing inventory costs, based on the identification of factors that influence it. The study is quantitative, non-experimental and cross-sectional; to collect data a measurement instrument was applied to 37 large enterprises, for analysis of the data a multiple linear regression was used, and it was found that, If the staff is competent and appropriate inventory audit policies are applied for the organization, inventory costs will decrease.

Palabras clave:
inventarios, cadena de suministro, costos.

RESUMEN

La cadena de suministro es el conjunto de procesos que se desarrollan desde que se hace la solicitud del producto hasta que se entrega al cliente final, uno de los principales componentes de esta, es el área del almacén, el inventario al ser un activo corriente en el balance general es motivo de preocupación de las organizaciones. Debido a lo mencionado esta investigación tiene como objetivo determinar un modelo para disminuir los costos del inventario, a partir de la identificación de los factores que influyen en este. El estudio es cuantitativo, no experimental y transversal; para recabar los datos se aplicó un instrumento de medición a 37 empresas grandes, para el análisis de los datos se usó una regresión lineal múltiple y se encontró que, si el personal es competente y se aplican políticas de auditorías de inventario adecuadas para la organización, los costos de inventario disminuirán.

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Introduction

The Importance of Inventory Management in the Supply Chain

Supply chain management is a term that has emerged in the last 60 years, covering all activities related to the flow and transformation of goods, from the raw material stage to the end user, as well as the information flows related to the handling and management of demand (Ballou, 2004).

The supply chain is comprised of facilities, inventory, transportation, procurement, demand planning, customer service, as well as pricing.

As mentioned above one of the areas of the supply chain is inventory management; these are material goods found in the supply chain and can be found as raw material, in-process product and finished product (Chopra & Meindl, 2013).

Inventory management consists of determining the quantity to order in order to avoid incurring unnecessary costs, such as obsolescence, damaged material, as well as costs generated by inventory management. On the other hand, inventory management within the warehouse consists of securing stock within the warehouse, avoiding having discrepancies in inventory that could affect production, and thus incurring material dispatch costs (Chang, 2017) (Chase, 2009).

Inadequate inventory management and valuation can contribute to business failure, while good inventory valuation, management and control contribute to business success. Until the 1980s, holding large volumes of inventory was interpreted as a sign of economic strength and good management, and sometimes the strength of a company was even measured by the amount of inventory it was able to store. The economic benefits that can be derived from reducing inventories are clear just by looking at the following statistics: in the United States, the average cost of an inventory represents between 30 and 55% of its value. These costs are derived from obsolescence, insurance, opportunity costs and others (Duque Roldán, Osorio Agudelo, & Agudelo Hernández, 2010).

Izar (2011), focused on identifying a model that would decrease inventory costs, in his research he posed two questions: How much of a given item should be ordered when placing a new order? When is it time to place a new order? to solve these questions I use the hybrid method, which considers the economic quantity of the order and the discounts for buying larger volumes of items, in addition to considering the financial opportunity cost of having inventories in the warehouses that do not generate any profit and in turn the cost of the shortage that they defined as that which is not earned by not having the item in stock, on the other hand the cost that they did not consider was associated with the quality; in the research concluded that the quantity and time of order significantly influence the reduction of inventory costs.

On the other hand, for inventory management already in the warehouse, policies should be established for the classification of materials according to their importance, according to the literature this classification is usually in three ABC categories, where class A are very important because they represent 80% of inventory costs, class B are moderately important, representing 15% and class C represent 5%, it can be said that they are the least important, however, they should be audited, to avoid affecting production by the loss of them, in case they have not yet been marked as obsolete (Park, 2014) (Sucky, 2005).

The inventory classification policy is in turn supported by cycle counting policies, which are designed to guarantee the accuracy of the inventory. The frequency of these audits is based on how it is established in the organization, some organizations state that it is necessary to audit Class A materials four times a year, Class B materials three times a year and Class C materials once a year (Kok & Shang, 2014) (Wiffels, Giannikas, Woodall, McFarlane, & Lu, 2016).

The Auto Parts Manufacturing Sector in Nuevo León

The population selected for this research was the large auto parts manufacturing companies; this is because they are firmly established and are generally the ones that invest in strategies and technologies to make their processes efficient.

According to INEGI (2023), the automotive industry is delimited as follows: branch 3361 manufacture of cars and trucks, branch 3362 manufacture of bodies and trailers, branch 3363 manufacture of parts for motor vehicles, and branch 3369 manufacture of other transportation equipment.

It can be noted that according to figures from the monthly manufacturing industry survey (2019), Mexico's northern border accounts for 50.6% of Mexico's auto parts manufacturing industry, while the Bajío accounts for 29.8%.

By the year 2022, Nuevo Leon was the third entity with the largest automotive investment, generating 7689 jobs and a construction area of 259,332 square meters during the year mentioned (Cluster Industrial, 2023).

Research Objective

The population selected for this research was the large auto parts manufacturing companies; this is because they are firmly established and are generally the ones that invest in strategies and technologies to make their processes efficient.

Justification of the Study

Due to the importance of inventories and their costs, this research addresses the problem of inventory cost from a perspective that evaluates the perception of the leaders of the organizations with respect to the identification of the variables that have an impact on the management and cost of the inventory, as mentioned in the previous section, Nuevo Leon was selected because it is one of the main states that is dedicated to the mentioned sector.

Theoretical Framework

Due to the cost importance of inventory management, numerous studies have been conducted to determine which factors have an impact on inventory management.

Demand Management

To reduce the costs associated with inventories, it is necessary to have a correct demand management, which consists of developing activities that allow managing the sources of demand between customer and supplier, in order to buy what is necessary and thus stop incurring inventory management costs (Vollman, Matzke, Grunewald, & Spengler, 2013).

Demand management for production can vary according to the organization, mainly the demand for the final product (independent demand) must be known, in other words, the one that will be sold to the target market, and from there request the materials according to the bill of materials (independent demand) (Leal & Olivia, 2012) (Gutierrez & Vidal, 2008). After identifying the dependent and independent demand, it is determined which method will be used for the correct inventory planning, which can be a simple rolling forecast, batch by batch production, economic order quantity, simple linear regression or only producing what is needed; the latter with the objective of reducing the costs generated by inventories (Bustos & Chacon, 2012).

Information Technology

On the other hand, other authors indicate that the use of information technologies such as Enterprise resource planning, material requirements planning, warehouse management

system, radio frequency identification, bar code or qr code, have a savings of 16% in the cost generated by the handling of materials in the supply chain (Byrne & Heavey, 2006).

Human Resource Competence

Similarly, other authors indicate that employees are considered as the source of value creation in inventory management, but for this to happen it is necessary to mention the concept of competence focused on inventory management (Palsaitis, Ciziuniene, & Vaiciute, 2017).

Qualitative studies have also been carried out focused on the analysis of the just-in-time methodology, where a survey of a total of 30 items was applied to managers and engineers. The survey aimed to analyze the impact between human resources and production processes, the impact of human resources and inventory management, the impact of human resources and economic performance, as well as inventory and its impact on economic performance, the impact of production processes on inventory and economic performance. To conduct the research, structural equations were used and it was determined that there is an impact by the human resource on production processes, inventory management and organizational performance (Garcia, et al., 2015).

Operationalization of Variables and Hypotheses

Table 1 shows the definitions of the variables that will be used in this research.

Table 1
Types of Variables

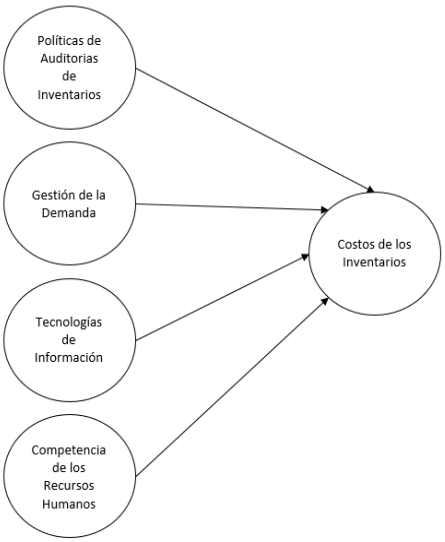
	Variable	Definition	Author
X1	Competence of the human resources involved in inventory management.	A competency is a set of skills to be developed.	Palsaitis, Ciziuniene, & Vaiciute, (2017)
X2	Information systems involved in inventory management.	Information systems not only support the flow of information, but also improve the performance of the supply chain.	Garcia, et al., (2015)
X3	Demand management	It consists of optimally determining the production of external demand and the quantity of materials to be ordered.	Vollman (2013)
X4	Inventory audit policies	These tools are intended to ensure the accuracy of the inventory.	Wiffels, Giannikas, Woodall, McFarlane, & Lu, (2016)
Y1	Inventory Costs	Refers to all costs incurred in maintaining inventory.	Gutierrez & Vidal , (2008)

Hypothesis

According to the literature presented in the introduction and in the theoretical framework, it can be highlighted that there are four variables that have an impact on the reduction of inventory management costs. The following are the hypotheses of the research that will be tested by means of multiple linear regression in order to establish the model mentioned in the research objective. The decision was made not to place the direction of the impact on the hypotheses, since it is known that a negative impact would generate a recommendation as well as a positive one; Figure 1 shows the interaction of the hypotheses.

- Inventory audit policies have an impact on inventory costs.
- Demand management has an impact on inventory costs.
- Information technology has an impact on inventory costs.
- Human resource competency has an impact on inventory costs.

Figure 1
Graphical model of the hypotheses



Method

The selected population were the large auto parts companies, which according to INEGI (2018) are those with more than 250 workers having as a result 47 companies in Nuevo León Mexico. To carry out the application of the measurement instrument, a 95% confidence level was used, which indicates that there is a 5% margin of error, with the result that the survey should be applied to 31 companies. The type of sample was not probabilistic since the companies to which the instrument was sent were selected by the authors.

The type of research for this study is qualitative, correlational, explanatory, non-experimental, cross-sectional and causal.

Following the literature review presented in the introduction and in the theoretical framework, a measurement instrument was developed called "Variables that impact inventory costs from the perspective of supply chain leaders", the measurement instrument was divided into two sections, where the first section was questioned by data such as gender, age and schooling of the person answering the questionnaire, this in order to give a description of the subject of study; the second section, composed of 36 items, consisted of the questionnaire that would gather the information for the elaboration of the model with the variables that have an impact on the costs generated by inventory management. Table II shows the type of variable, how it is measured, as well as the number of items per variable and the scale used, which in this case was a Likert scale of 1-7.

Table 2
Types of Variables

Dependent / Independent Variable	Variable	Type of Variable.	Measurement	Items
X1	Human Resource Competence	Ordinal Variable, Discrete	Likert scale 1-7	CRH1 - CRH11.
X2	Information Technology	Ordinal Variable, Discrete	Likert scale 1-7	SI12- SI17
X3	Inventory audit policies	Ordinal Variable, Discrete	Likert scale 1-7	PAI18-PAI23
X4	Demand Management	Ordinal Variable, Discrete	Likert scale 1-7	GD24 - GD30
Y1	Inventory Costs	Ordinal Variable, Discrete	Likert scale 1-7	CI35 - CI41

Pilot Test

On the other hand, to check the reliability of the study, which refers to the degree to which its repeated application to the same individual or object produces the same results (Hernández, 2014). To evaluate the reliability of the measurement instrument, Cronbach's Alpha was used, obtaining the results shown in Table III, where it can be noted that the variables meet the aforementioned requirement.

Table 3
Cronbach's Alpha Analysis

Variable	Cronbach's Alpha
Competencies of the Human Resources involved in inventory management.	0.856
Information Systems involved in inventory management.	0.743
Inventory Audit Policies.	0.796
Demand Management	0.766
Cost of Inventories	.741

As mentioned above, the multiple linear regression method was used to analyze the data collected through the survey, which allows us to determine the correlation between the independent and dependent variables (Montgomery, 2004).

Results

The study consisted of 42 surveys conducted to large companies dedicated to the manufacture of auto parts in the metropolitan area of Monterrey; According to INEGI (2018) a large industry is one that has more than 250 workers; Of these 42 companies only 37 surveys were considered for the study, because when analyzing them in the IBM SPSS 21 software five of them were answered in an atypical way.

Table IV shows the distribution by sex of the leaders who answered the measurement instrument; 64.864% are men and 35.13% are women.

Table 4
Gender distribution of the surveyed sample. Inventory Cost

Sex	Quantity	%
Women	13	35.13
Men	24	64.864
Total	37	100%

Multiple Linear Regression with Sample Data.

The type of research for this study is qualitative, correlational, explanatory, non-experimental, cross-sectional and causal.

As mentioned above, multiple linear regression was used for data analysis, which is a statistical technique used to study the relationship between independent and dependent variables. On the other hand, multiple linear regression must meet the following assumptions: linearity, independence, homoscedasticity, and normality (Baños, Torrado, & Alvarez , 2019).

The IBM SPSS Statistics 21 software was used for the data analysis, where the method by successive steps was chosen, this technique consists of analyzing each independent variable and introducing it in the equation if its probability of F is sufficiently small, in case there are variables already introduced in the equation and the F is large, they are eliminated. The process ends when there are no more variables to be included or eliminated (IBM, 2023).

For this research, several analyses were carried out, in which atypical cases or outliers were detected, which are those observations that have significantly different characteristics from the others. The main problem with outliers is that they are elements that are not representative and can distort the result of the investigation. The outliers located were surveys 14, 23, 34, 26 and 38. For the five outliers eliminated, it can be observed that those who answered the surveys did not have extensive experience as leaders in the supply chain.

In order to test the adequacy of the model in Table V, it can be observed that an R square of .567 was obtained, which indicates that 56.7% of the variability in the dependent variable can be explained by the independent variables in the proposed model, while the rest is due to other causes not explained in the model.

Similarly in Table V, the Durbin Watson is used to test the independence of the data, this indicator has allowed values between 1.5 and 2.5, for this study a value of 1.509 was obtained, which indicates that there is no auto correlation between the residuals.

Table 5
Summary of models with 37 data

Model	R	R^2	Standard error	Durbin Watson
1	.753	.567	.6628	1.509

According to the summary of the ANOVA analysis of variance presented in Table VI, we can observe the significance of the model $p<0$ and an F of 22.26, which means the contrast of the null hypothesis that the population value of R is zero and, therefore, allows us to decide if there is a significant linear relationship between the dependent variable and the set of independent variables.

Table 6
ANOVA

Model	Sum of Squares	Degrees of Freedom	Mean square	F	Significance
Regression	19.56	2	9.783	22.267	.000
Residual	14.937	34	.439		
Total	34.503	36			

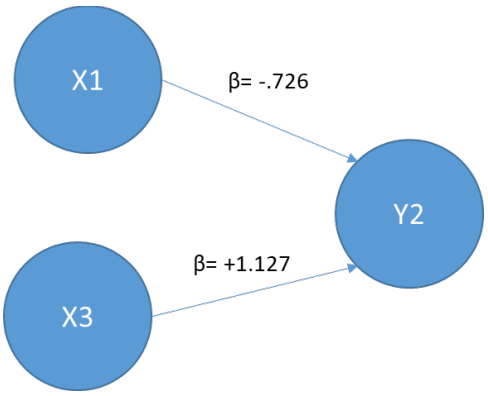
On the other hand, the T student analysis was carried out, where it can be highlighted that of the four variables presented, two of them have a significant impact on the inventory cost variable, this information can be observed in Table VII, where the variable human resource competencies and inventory audit policies are the variables that have significance in the research problem, it is necessary to clarify that this significance can be negative as in the case of human resource competencies, and positive as in the case of inventory audit policies.

Table 7
Model coefficients

	B	Standard Error.	Standard Beta Coefficient	T	Sig.
Constant	.106	.110		.968	.340
Inventory Audit Policies	1.137	.173	1.127	6.586	.000
Human Resource Competence	-.675	.159	-.726	-4.242	.000

Finally, the model resulting from the research is presented in Figure 3. Where X1 is the competence of the human resources used for inventory management, X3 is inventory audit policies and Y2 is inventory cost.

Figure 2
Model proposed in the research



Equation 1 shows the multiple linear regression model. Where Y1 is the dependent variable inventory cost, and the independent variables are X1 Human resource competencies, and X3 Inventory audit policy with an estimated error of .110.

$$Y1 = .110 - .726X1 + 1.127X3. \quad (1)$$

Hypothesis testing.

As can be seen in Table VII, two of the four proposed variables are accepted according to the literature.

Table 8

Acceptance or Rejection

Variables	Beta	T student	P value	Accept or Reject
Competence of human resources	-0726	-4.242	0.00	Accept
Information Systems				Rejects
Inventory Audit Policies	1.127	6.586	.00	Accept
Demand Management	-	-	-	Rejects

Discussion and Conclusions

As can be seen, inventory costs are a major concern in the supply chain. Good inventory management will help to avoid expenses that are not planned by the organization, such as expedited materials, handling of obsolete inventory and surplus inventory. According to the literature analyzed, four variables that impact inventory costs were presented: human resource competencies, demand management, information technology and inventory auditing policies. In this research, based on the statistical analysis of the data collected, it was determined that the variables that have an impact on the problem are the inventory audit policies and the competencies of the human resources, the former having a positive impact and the latter a negative impact, which means that if the organization establishes a policy for inventory management within the warehouse, costs will be reduced, in contrast to the variable of the competencies of the human resources, which had a negative impact. In the case of the variable that had a negative impact, it is considered that it should be developed in greater depth and according to the characteristics of the subject of study, in order to determine which specific competencies would have a positive impact, since each manufacturing sector is different, and it is also necessary to mention that the greater the manipulation by the human resource, the more errors there may be in the processes.

On the other hand, according to the analysis performed, two variables had no impact on the research problem. These variables were information technology and demand management, even though the literature mentions that they are fundamental to inventory management.

It is considered that the subject of the study, having a market with a stable demand, since most of the suppliers have their requirements firm at least two months in advance, makes the opinion of the subject of the study inclined to consider that the demand management variable has no impact; however, if this study is carried out in another market, it could have another perception and thus consider new lines to deepen on this variable and its impact on the cost of inventories. Similarly, information technologies will become relevant with the incorporation of Industry 4.0 in manufacturing practices, not only in the inventory area but also in the entire value chain of

organizations, being key to deepen this variable under different perspectives for future work that will be beneficial for decision making in organizations.

We will seek to develop this topic in specific branches of manufacturing, with the intention of exploring whether companies share organizational factors or whether the nature of these factors makes a difference when it comes to improving their value chains; this work will make it possible to establish a possible path for organizations to improve the performance of their key indicators.

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