Artículos científicos

Determinación de mejores prácticas de logística inversa asociadas a la competitividad a través del teorema de Bayes

Determination of Best Practices in Reverse Logistics Associated with Competitiveness Through the Bayes Theorem

Determinação das melhores práticas em logística reversa associadas à competitividade através do teorema de Bayes

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Resumen

Esta investigación se enfoca en analizar las prácticas de las pymes de maquinados de Ciudad Juárez, Chihuahua, México, específicamente los procesos de logística inversa de empresas identificadas como competitivas. Se aplicó un cuestionario para examinar y describir los factores de logística inversa que contribuyen para que una empresa de este ramo sea competitiva. Para determinar las pymes evaluadas se consideró la clasificación del Directorio Estadístico Nacional de Unidades Económicas (Denue). De las 20 empresas seleccionadas, se identificaron que 35 % eran competitivas y 65 % no eran competitivas, de acuerdo con el grado de conocimiento y aplicación de la logística inversa en sus empresas. Las variables más significativas que indican que las empresas son competitivas con 57 % de probabilidad son: la revisión de mercancías devueltas, la clasificación de lo devuelto, el registro que se realiza de las devoluciones, transporte disponible para la distribución de los materiales devueltos, personal disponible para disponer de las devoluciones, tener transporte óptimo, tener un área para las devoluciones y tener un proceso que permita documentar las devoluciones.

Palabras clave: competitividad, logística inversa, pequeña empresa, teorema de Bayes.

Abstract

This research focuses on analyzing the practices of machining SMEs in Ciudad Juarez, Chihuahua, Mexico, specifically the reverse logistics processes of companies identified as competitive. A questionnaire was applied to examine and describe the reverse logistics factors that contribute to the competitiveness of a company in this industry. To determine the SMEs evaluated, the classification of the National Statistical Directory of Economic Units was considered. Of the 20 companies selected, 35% were identified as competitive and 65% as not competitive, according to the degree of knowledge and application of reverse logistics in their companies. The most significant variables that indicate that the companies are competitive with 57 % of probability are: review of returned goods, classification of returned goods, registration of returns, transportation available for the distribution of returned materials, personnel available to dispose of returns, having optimal transportation, having an area for returns and having a process for documenting returns.

Keywords: competitiveness, reverse logistics, small business, Bayes theorem, Bayes' theorem.

Resumo

Esta investigação centra-se na análise das práticas de maquinagem das PMEs em Ciudad Juarez, Chihuahua, México, especificamente os processos de logística inversa das empresas identificadas como competitivas. Foi aplicado um questionário para examinar e descrever os factores logísticos inversos que contribuem para a competitividade de uma empresa neste sector. Para determinar as PME avaliadas, foi considerada a classificação do Directório Estatístico Nacional de Unidades Económicas (Denue). Das 20 empresas seleccionadas, 35 % foram identificadas como competitivas e 65 % como não competitivas, de acordo com o grau de conhecimento e aplicação da logística inversa nas suas empresas. As variáveis mais significativas que indicam que as empresas são competitivas com 57 % de probabilidade são: a revisão das mercadorias devolvidas, a classificação do que é devolvido, o registo que é feito das devoluções, o transporte disponível para a distribuição dos materiais devolvidos, o pessoal disponível para dispor das devoluções, ter um transporte óptimo, ter uma área para as devoluções e ter um processo que permita documentar as devoluções.

Palavras-chave: competitividade, logística inversa, pequenas empresas, teorema de Bayes.

Introduction

Small and medium-sized enterprises (SMEs) represent the main source of income, employability and economic support in most countries, however, the level of these companies is not sufficient to position themselves and integrate as suppliers of large companies (Pavón, 2010). In Mexico, in the industrial sector, micro, small and medium-sized companies represent 99.26% of all companies (Saavedra and Tapia, 2011). However, because they do not have tools to optimize their processes and implement best practices, their level of competitiveness is reduced to the point of putting their survival at risk. These companies require government support, a closer relationship with large companies to be included in supplier development programs and to adjust their internal structure, in addition to

stimulating their ability to innovate and generate competitive advantages (De Fuentes and Dutrénit, 2006).

Machining SMEs are responsible for manufacturing metal parts for machinery and equipment in general. Gómez, Meléndez, Cárdenas and Salcido (2019) investigated the level of competitiveness of these companies in Ciudad Juárez, Chihuahua, Mexico, and adhering to the classification of the competitiveness analysis of the Inter-American Development Bank (IDB), they identified that 43% have a low level, 24% with a medium level and 33% with a high level. These companies focus on generating value to the product, but they require strategies so that their internal processes in other areas also increase their level of competitiveness. According to Cure, Meza and Amaya (2006), the logistics function is essential for companies to be competitive. Among the most common definitions of logistics is the one that characterizes it as the flow that materials follow from their manufacture to the consumer. But there may also be an alteration of said flow, when the consumer returns the merchandise to the producer, by not meeting the producer's expectations; these goods require further treatment and that is where reverse logistics or reverse logistics functions come into play.

Reverse logistics issues have become relevant, although there are still not enough studies to improve the practice and its results (Ramos, 2017). By participating in a globalized environment, it is necessary for companies to seek new ways to be competitive. In this line, the management of the supply chain allows managing customer returns, which generates an impact on the service and the recovery of product value. (Gómez, Correa y Vásquez, 2012).

This article addresses aspects of reverse logistics such as handling returns, customer service, disposition, transportation, and inventory storage. Applying Bayes' theorem, it seeks to shed light on the following question: how do reverse logistics practices implemented in machining companies contribute to competitiveness? To structure the problem in question, as well as the interrelationships inherent to the subject, statistical tools are used.

Literature review

Reverse logistics

Reverse logistics refers to the process that products follow, not from the producer to the consumer, but, on the contrary, from the consumer to the producer. The latter must generate the necessary processes to enter the product back into its warehouse and dispose of it properly. Reverse logistics manages and ensures that the return of the merchandise to the producer is successful and that the associated expenses are not high. For this, recovery and recycling are considered, including the management of hazardous waste, as well as tools to be able to handle excess merchandise in warehouses, merchandise returned due to data or that do not fulfill their function, or that become products that they are no longer useful for the market and which the company must dispose of (Bastos, 2007).

Reverse logistics activities not only refer to how to recycle or reuse packaging, but also the processes to collect used, damaged, unwanted products or obsolete products and those used to send products to the customer, such as packaging. , containers and packaging. Therefore, once a product has been returned, it is necessary to consider the following activities (see table 1):

Table 1. Common reverse logistics activities.

Materiales	Actividades de Logística Inversa
Productos	Regresar al proveedor
	Revender
	Vender vía ofertas
	Salvar
	Reacondicionar
	Restauración
	Remanufactura
	Reclamo de materiales
	Reciclar
	Basura

Empaque	Reutilizar
	Restaurar
	Reclamo de materiales
	Reciclar
	Salvar

Source: Rogers y Tibben-Lembke (1999)

With the application of reverse logistics in companies, the result is a reduction in costs, a projection of an image of environmental responsibility and the proper use of new technologies (Santos and Santos, 2010). When there is commitment to the client and their disagreements are addressed, greater trust is generated in the company, this interaction improves the service. Hence the importance of applying reverse logistics in any company, since the way in which the customer perceives his supplier is added value and is an important point when deciding to make his purchase (Cure et al., 2006).

Cespón and Feitó (2009) mention that companies, if they apply the techniques or taxonomies related to reverse logistics, can generate an impact on business competitiveness, by adding recovery strategies, waste reuse and returns, and also achieve a decrease in the costs. Thus, reverse logistics is a practice of social responsibility due to the potential economic, environmental and productivity impacts, if companies conscientiously consider its application (Gómez et al., 2012). In this sense, Bustos (2015) analyzes the incorporation of reverse logistics as one of the competitive priorities in the Mérida business ecosystem and assigns it a moderately important label.

Campoverde et al. (2020) determine that there is a significant difference when knowing and using reverse logistics in companies, since when performing the Mann Whitney hypothesis test they were able to verify that there is significant statistical evidence. They conclude that if companies pay attention and focus on developing reverse logistics strategies in companies, they could obtain better income, in addition to usefully contributing to the reduction of pollution: not knowing the reverse logistics processes represents a disadvantage over companies. yes. For his part, Izarra (2022) adds that reverse logistics, by participating in the creation of awareness and reducing pollution through its strategies, contributes directly in three dimensions: society, economy and environment.

Cisneros and Hidalgo (2022) confirm that the implementation of reverse logistics models where waste can be reused gives companies the opportunity to have an economic recovery. The review of the literature on reverse logistics allows us to know that despite the

fact that the term is not new, its application strategies in companies and the benefits it represents are not widely known; Organizations apply certain aspects of reverse logistics to their processes and only when studies are carried out in companies can they be detected.

Bayes theorem

Bayes' theorem is applicable to probability theories, although it raises concerns about the type of probabilities it uses (Peña and Fernández, 2019). This is because for traditional statistics (Mesa et al., 2011) only the probabilities based on experiments generated through constant repetitions and that have a confirmation based on experience are important; while for Bayesian statistics probabilities that are merely subjective can also be useful. The theorem allows us to know how the subjective probabilities that have information that is added to the experiment should be handled (Díaz, Beltrán and Cueva, 2018). This approach, which reinforces Bayesian statistics, exhibits its usefulness in certain estimates based on subjective knowledge, which is issued before having any result, and which allows these estimates to be revised based on evidence. In this way, new ways of understanding knowledge are opened (Rendón, Riojas, Contreras and Martínez, 2018).

This theorem is one of the best known and most important theorems related to probability (Lamothe et al., 2017). And despite having its beginnings in the medical field, it can be applied in many branches of science such as genetics, epidemiology, engineering, forensic science, ecology, psychology, among others (Araujo, 2012). Bayes' theorem allows us to be optimistic if a certain analysis in the branch of social and administrative sciences indicates that it is possible to be competitive in some area.
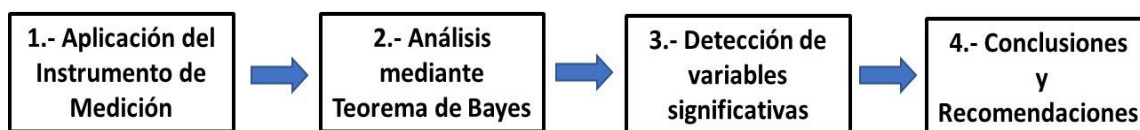
Materials and methods

The research problem led to formulate the following question: how do reverse logistics practices implemented in machining companies contribute to their competitiveness? In such a way that the objective was to analyze the reverse logistics practices carried out by a sample of companies. This research presents a study based on a questionnaire that was applied to machining SMEs in Ciudad Juárez, Chihuahua, Mexico, to examine and describe the reverse logistics factors that contribute to a company in this field being competitive. To determine the SMEs evaluated, the classification of the National Statistical Directory of Economic Units (Denue) was considered; the economic activity was: manufacturing

industries for the manufacture of metal products, which carried out machining of metal parts and screw manufacturing, specifically machining of metal parts for machinery and equipment in general. Thus, a total of 20 companies were obtained.

The applied questionnaire was taken from the research carried out by Alvarado, Argueta and Fuentes (2008). The questionnaire was adapted to the characteristics and terms used by the manufacturing companies in Ciudad Juárez, Chihuahua, which were previously determined. For this instrument, the level of reliability was determined by means of Cronbach's Alpha, which allowed knowing the internal consistency of the instrument and verifying that the items measured the same construct and their relationship (Welch and Comer, 1988). In this regard, values greater than 0.9 were observed, which indicates a high level of reliability of the instrument.

Taking into account the works of Mendenhall, Beaver and Beaver (2015), Lynch (2007) and Correa and Barrera (2018), Bayes's theorem was applied and the data were analyzed. The objective of carrying out an analysis using Bayes' theorem was to detect which were the best practices of the companies analyzed and the probability that these practices used by the companies in question achieve greater competitiveness in the market with the use of reverse logistics. . The method performed is summarized in Figure 1, which consists of four stages.

Figure 1. Research method developed

Source: self made

The first stage was the application of the measuring instrument. This application was made to all the machining companies in Ciudad Juárez, Chihuahua, that were identified. In the second stage, the analysis of the information was carried out using the Bayes theorem, based on the results obtained from the application of the instrument, by means of which the competitive companies and those that were not according to the level of competitiveness of the IDB were classified. and thus be able to obtain a control group and an experimental group. Of the 20 companies, 35% were identified as competitive and 65% were not competitive, according to the degree of knowledge and application of reverse logistics in their companies. Table 2 shows an example of how the results of each variable were determined by category

with its corresponding percentage, which was done with the support of the Minitab version
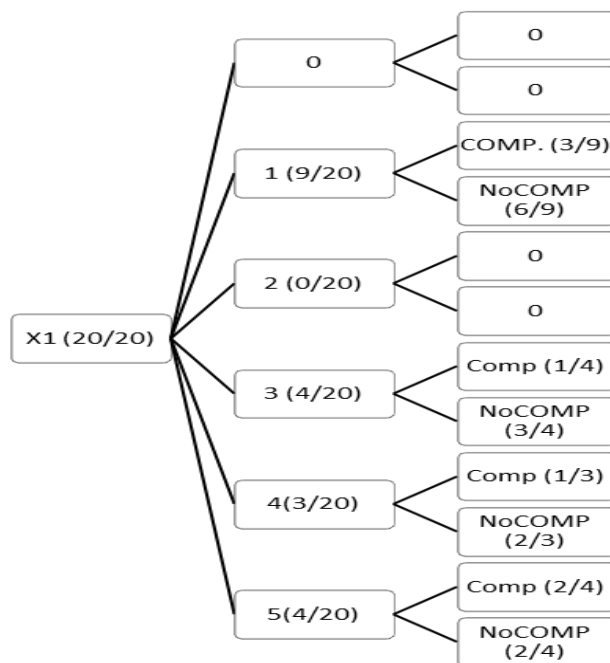2018 software.

Table 2. Percentages by category

Variable	Competitiva		No competitiva	
X_1	N = 7	%	N = 13	%
0				
1	6	46	3	42
2	0	0	0	0
3	3	26	1	15
4	2	14	1	15
5	2	14	2	28
	13	100	7	100

Source: self made

Subsequently, and following the Bayes theorem methodology, a probability tree was
created (see figure 2) to determine the conditional probabilities of the study; this was done
the same for each variable.

Figure 2. Tree diagram

Source: self made

With the following procedure, the Bayes theorem was applied to each classification of variables to identify which factor has the greatest impact:

$$P\left(1/COMP\right) = \frac{P(COMP/1)P(1)}{P(COMP)} = \frac{(3/9)(9/20)}{(7/20)} = \frac{3}{7} = .42 = 42\%$$

$$P\left(2/COMP\right) = \frac{P(COMP/2)P(2)}{P(COMP)} = \frac{(0/9)(0/20)}{(7/20)} = 0 = 0 = 0\%$$

$$P\left(3/COMP\right) = \frac{P(COMP/3)P(3)}{P(COMP)} = \frac{(1/4)(4/20)}{(7/20)} = \frac{1}{7} = .14 = 14\%$$

$$P\left(4/COMP\right) = \frac{P(COMP/4)P(4)}{P(COMP)} = \frac{(1/3)(3/20)}{(7/20)} = \frac{1}{7} = .14 = 14\%$$

$$P\left(5/COMP\right) = \frac{P(COMP/5)P(5)}{P(COMP)} = \frac{(2/4)(4/20)}{(7/20)} = \frac{2}{7} = .28 = 28\%$$

This methodology was applied to the 34 variables that were analyzed on the competitive companies in this research and which will be delved into in the following section.

Results

Tables 3 and 4 summarize the results of each of the 34 variables, according to the preponderant factor for companies considered competitive. These results show the percentage of factors associated with the competitiveness of the machining SMEs studied, according to the application of the reverse logistics processes that they implement in each of them, which are shown below:

Table 3. Summary of significant probabilities X1 to X17

Variable	Respuesta	Porcentaje %
X1 = Previsión de devoluciones	1	42
X2 = Revisión de mercancía devuelta	5	57
X3 = Clasificación de productos devueltos	5	57
X4 = Recolección de productos devueltos	5	42
X5 = Registro de devoluciones	5	57
X6 = Indicadores de devolución	5	42
X7 = Políticas de devoluciones	1 y 5	28
X8 = Revisión de inventario	2 y 5	28
X9 = Sistema de inventarios	3, 4 y 5	28
X10 = Estrategias para la disminución de devoluciones	1 y 5	42
X11 = Documentación de reclamo	5	42
X12 = Clasificación de reclamos	5	42
X13 = Documentación de órdenes de devolución	5	42
X14 = Documentación de reposiciones	5	42
X15 = Tipos de devolución y disposición final	5	42
X16 = Identificación del destino de la devolución	5	42
X17 = Indicadores de materiales y materia prima devueltos	5	42

Source: self made

The analysis of the results showed that for the variables X2 to X6, X11 to X19, X20 to X26, X28 to X30, X33 and X34, SMEs generally put the processes into practice and control the returns and disposition of these to thus achieve be competitive in your field. Interestingly, it was also found that the variables X7 to X10, X27, X31 and X32 are not essential, since they do not generate or reduce a higher or lower level of competitiveness; X1 and X20 are also not essential to generate competitiveness.

Table 4. Summary of significant probabilities X17 to X34.

Variable	Respuesta	Porcentaje %
X18 = Documentación de identificación	5	42
X19 = Disposición de acuerdo con la normativa de devoluciones	5	42
X20 = Subcontratación para disposiciones	0	71
X21 = Transporte disponible para distribución	5	57
X22 = Personal para la disposición de devoluciones	5	57
X23 = Transporte para recolección de devoluciones	5	42
X24 = Transporte óptimo	5	57
X25 = Indicadores de averías en transporte	5	42
X26 = Documentación para personal de transporte	5	42
X27 = Comunicación con proveedores	1 Y 5	28
X28 = Área de devoluciones	5	57
X29 = Clasificación de productos devueltos	5	42
X30 = Reutilización de empaques y embalajes	5	42
X31 = Personal de almacenamiento y clasificación	1 Y 5	42
X32 = Verificación física de devoluciones	1 Y 5	42
X33 = Almacenamiento adecuado de devoluciones	5	42
X34 = Proceso documentado de devoluciones	5	57

Source: self made

The most significant variables that indicate that the companies are competitive with a 57% probability are: the review of returned merchandise, the classification of what is returned, the registration that is made of returns, transportation available for the distribution of returned materials, personnel available to dispose of returns, have optimal transportation, have an area for returns and have a process that allows returns to be documented.

Discussion

Applying reverse logistics processes for the control of returns and disposal of these reflects on the part of any company a concern to satisfy the client and a concern for the environment; thus, indirectly, reverse logistics turns SMEs into socially responsible companies and helps to concentrate efforts on activities that really benefit competitiveness and a longer life in the market.

According to the analysis carried out, the most competitive companies are those that review the returned merchandise, classify it, have a record of the returns and have transportation available, that is, they carry out the entire merchandise return process. This shows the relevance of having a well-established process for the return of products and their final disposal. So much so that Buendía, Chanamé, Meza and Paz (2019), López (2010) and Hernández (2009) agree that good reverse logistics practices are essential to control the return of goods and the losses generated by a company, in short, to successfully manage your resources. It is necessary for these organizations to work on establishing recovery strategies for products that do not meet their objective or when their useful life ends and thus eliminate the impact generated by residues and waste to the environment. Considering strategies for product returns, reuse and recycling could ensure product quality and favorable customer opinion.

Noé (2015) found that organizations with sustainability strategies achieved better performance; and noted that, in many cases, although small and medium-sized companies do not know the concepts, they do apply them. Likewise, companies that apply reverse logistics are more likely to increase their profits and increase their productivity (Vega, Marrero and Pérez, 2017). The relevance detected is the focus on the environmental impact derived from the concern that the population and companies have to be friendlier to the environment and to seek solutions so as not to continue damaging it, which would be interesting to measure under the decision-making analysis tool. decisions applied in our study, and carry out qualitative and case study research into practice to analyze probabilities and make timely decisions in favor of the companies analyzed.

Conclusions

The procedure to determine the prevailing factors that determine whether a company is competitive using Bayesian statistics was very useful, since this approach makes explicit use of probability to quantify the uncertainty of the inference. In the case of machining SMEs analyzed in this research, the predominant factors are the classification, collection and registration of returns; documentation, classification of claims; identification, destination and disposition of returns; the transfer of returns and reuse of packaging and packaging. Indeed, developing these reverse logistics activities will increase the ability of companies to be competitive. It is an iterative learning process in which conclusions are reached about a phenomenon (a posteriori probability) from prior knowledge about the system (a priori probability) and new evidence (data information). In other words, the results of a new study could be used to update knowledge on the subject and include it in subsequent studies. Bayes's theorem applied in reverse logistics specifically for this procedure could be put into practice correctly, using simple computer resources for the analysis of other areas of the company.

Some of the advantages over frequentist statistics are: the adjustment to complex models not accessible by frequentist methods due to the restrictions of these models; it allows more exact estimations of the parameters when the sample size is small, the interpretation of the results is simple and direct since they indicate the probability that a parameter takes a certain value; measures of uncertainty, missing data and different levels of variability can be included; allows propagation of the error; it also allows to specify the distributions of the parameters (depending in turn on other parameters) when it is known a priori how they are distributed and minimizes the use of arbitrary limits to make decisions. The return of products and the process for handling them, in addition to the materials discarded by consumers, represent opportunities for organizations. Undoubtedly, SMEs can become competitive and sustainable through proper management of the resources or products that are recovered.

Future lines of research

The research carried out made it possible to identify important aspects as a complement to the work presented and in turn shed light on SMEs to increase knowledge about reverse logistics and its impacts when applying it. As it is a strategy that allows reducing the waste used by companies and correctly handling returns, research on the

environmental impact of the application of reverse logistics in companies is recommended and, in turn, how it contributes to their competitiveness. , because expenses can be recovered if reverse logistics strategies are applied properly. However, as the research focused on machining SMEs in the region, it is recommended to carry it out in other fields such as commercial, the rest of the industrial, agro-industrial, and service branches, and also take into consideration the other internal processes of the organization such as administration, production, finance, among others.

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