

System of the Selection of suppliers for the acquisition of goods and services based on the principles of the Analytic Hierarchy Process (AHP)

Jorge Eduardo Manzano Huerta¹, Mauricio Romero Montoya¹, María Guadalupe de la Cruz Altamirano¹, Modesto Raygoza Bello², Fernando Aguirre y Hernández²

¹(Departamento de Ingeniería Industrial, Instituto Tecnológico de Orizaba, México)

²(Department de Estudios de Posgrado e Investigación, Instituto Tecnológico de Orizaba, México)

ABSTRACT: *The suppliers in an organization represent the first link of a supply chain, therefore, the initial factor for the development of activities within the companies, in this sense, the suppliers have the power to lead to success or failure the importance they represent. Knowing the above, it is necessary to pay special attention to the search, selection and evaluation of suppliers, in order to generate good organizational performance and therefore excellent customer service. In the present work, a comprehensive management system for the acquisition of goods and services is disclosed, based on the principles of the Analytic Hierarchy Process (AHP) and the use of Macros programming in the Visual Basic for Applications (VBA).*

KEYWORDS: *AHP, Purchases, Suppliers, Sampling, VBA*

I. INTRODUCTION

The entrepreneurial dynamism in the field of purchasing, that is, the acquisition of supplies and services for business entities is in high demand and involves an intellectual effort of research, comparison and decision making [1] so, if this activities and efforts are not adequate, they can generate important faults in the business supply system, causing malicious problems for the organization, which in extreme cases is the loss of the client and finally the failure of the business [2]. The large companies have managed to handle this problem, therefore, their success and background are based on years of research, practice, trial and error, as well as investment, however, today's organizations cannot give luxurious stories and It is necessary to take the milestones of large companies and work under their empirical knowledge [3]. This document discloses the work from a company dedicated to provide foreign trade services for the importing and exporting community, this project being a case study of the negative economic impact, with respect to the lack of attention in the search, evaluation and suppliers selection. In this sense, an analysis was made of the current company situation, allowing an estimate the loss of the opportunity due to the lack of comparisons of suppliers and lack of inclusion in the basic criteria for the selection of these, leaving in view the poor purchasing system for the acquisition of goods and services, taking as a reference the principles of the Hierarchical Analytical Process (AHP) and Macros programming, together these tools help to study and evaluate the selection criteria of suppliers.

Justification of multi-criteria decision methods: The efforts made to achieve a more efficient system in the evaluation and selection of suppliers are diverse, but the best results are shown in those works where the evaluation mechanisms are made up of multi-criteria methods, such as the AHP method, the weighted sum method, priority assignment, multi-attribute utility (MAUT) among others [4]. In the work developed by Herrera and Osorio, the integration of fuzzy logic to the AHP method represents a very good way to break with the imprecision and preference problems that are usually encountered when evaluating and designating a supplier [5]. A work that presents a good structure in the integration of the QFD and the fuzzy logic for the evaluation and selection of suppliers is the one presented by Lee, in which the designed methodology facilitates the obtaining and management of the information of the evaluated criteria [6]

For Herrera Umaña, the use of AHP and fuzzy logic represented a good source for the judgments issued by the decision makers regarding the alternatives and criteria, which can be converted into fuzzy numbers to calculate the importance of the weights using the AHP; these numbers are used to build the comparison matrix by pairs of AHP. [7] Finally, to Medina the use of the AHP method by means of Expert Choice software as a decision-

making tool in the purchase of WMS platforms (Warehouse Management System) represents a source of competitive advantage within company's logistics development [8].

It is noteworthy that all the authors agree that the insertion of methods such as AHP coupled with the use of new information technologies and communication which are essential tools in the selection and evaluation of suppliers as a source of competitive advantages, cost reduction, less and better times of processing, improvement of service level of both internal and external clients, among other elements.

AHP: The analytic hierarchy process (AHP) includes both the rating and comparison methods. Rationality requires developing a reliable hierarchic structure or feedback network that includes criteria of various types of influence like stakeholders and alternatives decision to determine the best choice. AHP is about breaking a problem down and then aggregating the solutions of all the sub problems into a conclusion. It facilitates the decision making by organizing perceptions, feelings, judgments, and memories into a framework that exhibits the forces which influence a decision. In the simple and most common case, the forces are arranged from more general and less controllable to the more specific and controllable. The AHP is based on the innate human ability to make sound judgments about small problems. It has been applied in a variety of planning decisions and projects in nearly 20 countries [9].

To understand how rationality is there are some main points and consist of:

- Focusing on the goal of solving the problem;
- Knowing enough about a problem to develop a complete structure of relations and influences;
- Having enough knowledge and experience and access to the knowledge and experience of others to assess the priority of influence and dominance (importance, preference, or likelihood to the goal as appropriate) among the relations in the structure;
- Allow differences of opinion with the ability to develop a better commitment.

How to Structure a Hierarchy: The list of suggestions presented by Saaty [10] for the construction of hierarchies, is presented below:

(1) Identify the overall goal. What are you trying to accomplish? What is the main question? (2) Identify the sub-goals of the overall goal. If it is relevant, identify time horizons that affect the decision. (3) Identify criteria that must be satisfied to fulfill the sub-goals of the overall goal. (4) Identify sub-criteria under each criterion. Note that criteria or sub-criteria may be specified in terms of ranges, values, parameters or in terms of verbal intensities such as high, medium, low. (5) Identify the actors involved. (6) Identify the actors' goals. (7) Identify the actors' policies. (8) Identify options or outcomes. (9) For yes-no decisions, take the most preferred outcome and compare the benefits and costs of making the decision with those of not making it. (10) Do a benefit/cost analysis using marginal values. Because we are dealing with dominance hierarchies, ask which alternative yields the greatest benefit; in case costs, which alternative most costly, for risks, which alternative is more risky.

VBA: Microsoft VBA (Visual Basic for Applications) is the macro language used to program Windows applications and is included in several Microsoft applications. VBA allows users and programmers to expand the programs functionality of Microsoft Office suite. Visual Basic for Applications is an almost complete subset of Visual Basic 5.0 and 6.0. [11]

II. DESCRIPTION OF THE SITUATION

The main used tool for an organization in supplier's survey of selection and evaluation is a comparative table which includes only three criteria of decision making; Cost, quality and delivery time. It is important to recognize that to make a good selection it is essential to consider a set of qualitative and quantitative factors [12]. In addition to the mentioned tool, the decision is based on the great extent of the buyer's experience. This situation shows the great deficiency of the suppliers' selection system that it does not have the determining factors for the action; finally, the procedure of selection and evaluation of the company's own suppliers does not contribute to the established levels of customer service. A key element in the suppliers selection and evaluation system of the organization is the number of quotes that must be made in order to make a purchase, which is defined by the amount of the purchase to be made as shown in Table 1.

Table 1. Quotations by amount.

Quotations by amount	
Purchase amount (MXN)	Quotations
Purchase up to \$ 5,000	1 Quotations
from \$ 5,001 to \$ 20,000	2 Quotations
Higher than \$ 20,001	3 Quotations

According to the purchase record of 11 months period, the total amount of purchases was obtained for each of the established ranks as shown in Table 2. These amounts allowed to conduct a study to determine the lost opportunity costs

Table 2. Purchase by amounts in different ranks.

Purchase amount ranks (MXN)	$x < \\$ 5,000$	$\\$ 5,001 < x < \\$ 20,000$	$x > \\$ 20,001$
Purchase number	1482	446	207
Purchases amounts (MXN)	\$ 2,620,067.22	\$ 4,257,424.75	\$ 22,744,917.91

III. METHODOLOGY

The proposed development methodology for the project is presented in Figure. 1

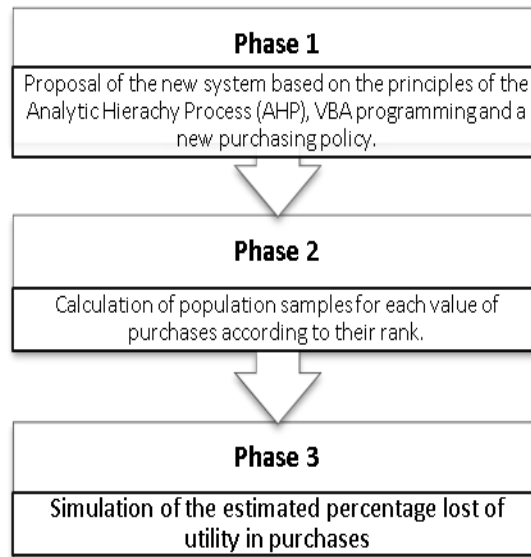


Figure 1. Methodological structure (own elaboration)

Phase 1: Proposal of the new system based on the principles of the Analytic Hierarchy Process (AHP), VBA programming and a new purchasing policy : Once the selection and evaluation of suppliers system was known, a study of critical factors for the construction of a new system was carried out [13], the choice of critical factors was made through a panel of experts composed by the personnel of the purchasing area, a brainstorm was made by them (according to business needs). The results of the surveys for the criteria are presented in Figure 2. The generated information analysis resulted in the following critical (quantitative and qualitative) evaluation criteria; total cost (unit cost, shipping cost, extra cost, commercial discount or promotions), delivery time, payment terms, required quality, remarks about the supplier and additional information about the product or service.

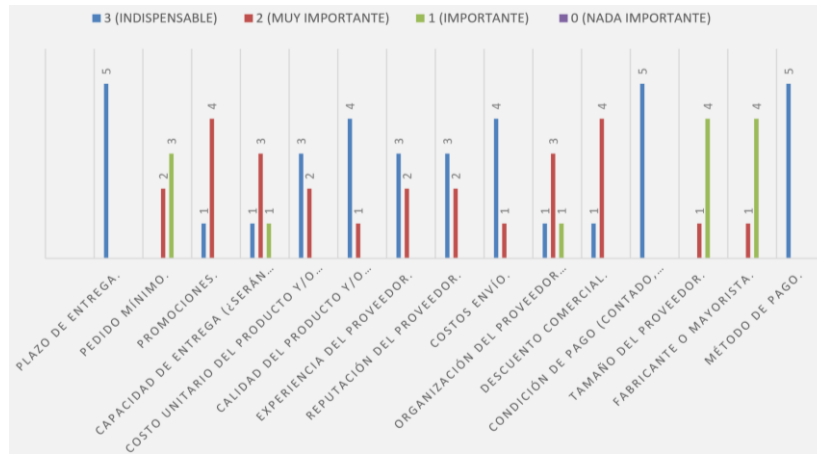


Figure 2 Evaluation criteria results

The criteria were integrated and worked with the principles of the AHP through the weighting criteria charts design of suppliers. Due to the need to streamline the process, reduce the times and errors during the allocation of weights in the charts, a proposal is made for the values of the AHP method, as shown in Table (3) where number 1 is the most low and 4 the highest rating.

Table 3 Comparison criteria regard to selection objective (adapted from Saaty)

Weights	Description
1	Equally important
2	Weak
3	strong
4	Extremely strong

As it is marked by the AHP methodology [14], the programming of the charts in the Excel macros (VBA) was carried out considering a matrix for each criterion and suppliers. Once the programmed macros were held, they were validated with some pilot tests, in which weights were assigned to each criterion according to the ratings of the new comparative chart, weights were obtained for each criterion and were used for the final interaction with the weights obtained for each provider. Part of the structure of the macro is shown in Figure. 3. The evaluation system designed with the principles of the AHP and programmed in a VBA platform makes the work of the buyer easier, since it evaluates suppliers efficiently and effectively.

Descripción del producto o servicio	Proveedor 1						Proveedor 2						Proveedor 3									
	Unid.	Precio Unitario	Precio total	Costo de envío	Costo extra	Desc. Comercial	PRECIO TOTAL	Unid.	Precio Unitario	Precio total	Costo de envío	Costo extra	Desc. Comercial	PRECIO TOTAL	Unid.	Precio Unitario	Precio total	Costo de envío	Costo extra	Desc. Comercial	PRECIO TOTAL	
Descripción de prod. o servic. Ocupa una celda para cada producto y/o servicio							\$ -							\$ -							\$ -	
							\$ -							\$ -							\$ -	
							\$ -							\$ -							\$ -	
							\$ -							\$ -							\$ -	
							\$ -							\$ -							\$ -	
							\$ -							\$ -							\$ -	
							\$ -							\$ -							\$ -	
							\$ -							\$ -							\$ -	
Comentarios del comprador	T. Entrega (días):		Exc.	Subtotal	\$ -	T. Entrega (días):		Exc.	Subtotal	\$ -	T. Entrega (días):		Exc.	Subtotal	\$ -	Condición de pago ()		Condición de pago ()		Condición de pago ()		Condición de pago ()
	Calidad requerida			Total	\$ -	Calidad requerida			Total	\$ -	Calidad requerida			Total	\$ -							
	Comentarios acerca del proveedor											Comentarios acerca del proveedor										
					Exc.					Exc.					Exc.							Exc.

Figure 3. Matrix programming in VBA.

In this way, the use of the principles of the AHP method, together with the elaboration of a new comparative suppliers' chart, the VBA programming for the automation of the AHP method, the proposal of a new purchasing policy that indicates new criteria and increases at least one more quotation according to each range of the purchase amount, it creates an efficient integral purchases management system for the organization.

Phase2: Calculation of population samples for each value of purchases according to their rank. By means of a random sampling [15] for a finite population with a significance level of 95%, an error of 10% and a probability against and in favor of 0.5, the sample size was determined by each purchase amount . The objective was to simulate purchases that allowed estimating the loss of profits due to the lack of quotations and thus validating the performance of the designed system. The sample sizes for each amount are presented in Table 4.

Table 4. Population samples results.

Purchase amount (MXN)	$x < \$ 5,000$	$\$ 5,001 < x < \$ 20,000$	$x > \$ 20,001$
Population sample	45.195 \approx 45	25.5868 \approx 26	14.8534 \approx 15

Phase3: Simulation of the estimated percentage loss of utility in purchases. The search for new quotes for products and services was carried out randomly according to the sample obtained for each purchase amount, with this, the amounts of purchases made with the traditional system were compared against the amounts of purchases using the new system. For purposes of simulation, the loss of opportunity is understood as the loss of profits for not having adequately compared or for not making more comparisons and / or contributions, the percentages obtained are the result of comparing the amount of the purchase made with the amount of a new quote for the same product or, if appropriate, a better one or with the same characteristics but with a different supplier and the average of contributions is the number of quotes or searches made to achieve such percentage. Table 5 is presented, which shows the result of subtracting the average percentage of opportunity loss, which corresponds to obtaining said percentage of the total amount of purchases, leaving in evidence the negative economic impact for not addressing this problem.

Table 5. Loss of opportunity simulation

Purchase amount ranks	$x < \$ 5,000$	$\$ 5,001 < x < \$ 20,000$	$x > \$ 20,001$	Total
Purchase number	1482	446	207	2135
Purchase amount	\$2,620,067.22	\$ 4,255,522.97	\$ 22,744,917.91	\$29,620,508.10
Average opportunity loss percentage	17%	12%	8%	9.4%
Average quotes	2.378	3.192	4.467	
Opportunity loss (MXN)	\$ 445,411.43	\$ 510,662.76	\$ 1,819,593.43	\$ 2,775,667.62

Given the above, it is shown that only carrying out 1 to 3 comparisons of suppliers according to each amount or range of purchases and the lack of inclusion of decisive criteria for the selection of the best supplier, gives the guideline to an average loss of utility of almost three million Mexican pesos in a study period of less than one year, thus identifying a significant loss of opportunity that puts the organization at latent risk; with the incorporation of the new designed system, it will be possible to avoid extra and excessive expenses of the purchasing department .

IV. RESULTS AND CONCLUSIONS

The objective of creating an integral and efficient system to the management of suppliers that reduces the operation time, errors at the decision making time, loss of opportunity for making a bad evaluation and not to perform more searches and comparisons of suppliers was covered satisfactorily. Likewise, this study allowed to identify an estimate an average loss of 9.4% of the total of the purchases made in a period of no more than 11

months, which is equivalent to losing \$ 2,775,667.62 MXN, that is, almost three million of pesos just to not giving the due importance to the supplier's management. Given that suppliers are the most important allies of an organization since they are an essential part of the supply chain [16], this document should be considered as a business milestone to grow under the philosophy of continuous improvement and the development on logistics and customer service.

REFERENCES

- [1] Sánchez Gómez, M. (2008). Cuantificación y generación de valor en la cadena de suministro extendida. León: Del Blanco.
- [2] Christopher, M. (1994). Logística y aprovisionamiento. Barcelona: Folio.
- [3] Porter, M. and Bueno Campos, E. (2015). Ventaja competitiva. Madrid: Pirámide.
- [4] S. A. Berumen y F. L. Redondo, «La utilidad de Los métodos de decisión multicriterio (como el AHP) en un entorno de competitividad creciente», *Cuadernos de Administración*, no.34, pp. 65–87, 2007.
- [5] Herrera, M. F. y Osorio, J. C. (2006). “Modelo para la gestión de proveedores utilizando AHP fuzzy”. *Estudios Gerenciales*, vol. 99, No. 1 (junio), pp. 69-88.
- [6] Lee, A.H.I. (2009). “A fuzzy supplier selection model with the consideration of benefits, opportunities, costs and risks”. *Expert Systems with Applications*, vol. 36, No. 2 (March), pp. 2879-2893.
- [7] Herrera, M. F., & Osorio, J. C. (2006). Modelo Para la Gestión de Proveedores Utilizando AHP Difuso . *Estudios Gerenciales*, 69-80.
- [8] Medina, P. d., Cruz, E. A., & Gómez, R. (2012). Selección de proveedor de WMS utilizando método. *Scientia et Technica*, 65-72.
- [9] T. L. Saaty (1990), How to Make a Decision: The Analytic Hierarchy Process», *European Journal of Operational Research*, volumen 48, número 1, páginas 9-26
- [10] T. L. Saaty, The analytic hierarchy process: planning, priority setting, resource allocation. The United States: McGraw-Hill International Book Co., 1980.
- [11] Matos, J. H. (2017). Qué es el lenguaje VBA. Excel Avanzado
- [12] Soret los Santos, I. (2006). Logística y marketing para la distribución comercial. Pozuelo de Alarcón (Madrid): ESIC, pp.119-132.
- [13] Summers, D. (2006). Administración de la calidad. México: Pearson-Prentice-Hall, pp.242-256.
- [14] Gil, J. and Sebastián Pérez, M. (2017). El proceso analítico jerárquico. Madrid: UNED - Universidad Nacional de Educación a Distancia.
- [15] Martínez Almecina, A., Muñoz García, J. and Pascual Acosta, A. (2004). Tamaño de muestra y precisión estadística. Almería: Universidad, Servicio de Publicaciones, pp.168-171.
- [16] R. Ballou, Logística: Administración de la cadena de suministro. México: Prentice Hall, 2004