



TOPSIS technique supplier selection in a case study in the Maquiladora Industry in Ciudad Juárez

La técnica TOPSIS de selección de proveedores en un caso de estudio en la Industria Maquiladora de Ciudad Juárez.

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ABSTRACT

Keywords:
Suppliers, TOPSIS,
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With the use of this method, it was demonstrated how important it is for the company to know how to select a reliable supplier when we require raw material for our work process. The Topsis methodology was applied because it is a practical method and the most appropriate to solve this problem. At the moment of applying this methodology, we generated which are the levels of importance that the company requests to select one of them, more than anything are factors or points that each company chooses for a better management of its resources, thus taking care of the part of time and money. In the industry where this observation will be made, the main levels of importance requested are the following: Quality, Time, Price and Reliability of the supplier.

RESUMEN

Palabras Claves:
Proveedores, TOPSIS, Materia
Prima y Planificación.

Con el uso de este método se demostró la importancia que tiene para la empresa la selección de un proveedor a la hora de solicitar o pedir materia prima. Se aplicó la metodología Topsis ya que es un método práctico y es el que mejor se adapta para resolver este problema. Al momento, de aplicar esta metodología, generamos cuales son los niveles de importancia que la empresa solicita para seleccionar uno de ellos, más que nada son factores o puntos que cada empresa elige para un mejor manejo de sus recursos, cuidando así la parte de tiempo y dinero. En la industria donde se hará esta observación, los principales niveles de importancia solicitados son los siguientes: Calidad, Tiempo, Precio y Fiabilidad del proveedor.

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Introduction

At present, the relationship between client and provider usually ends because the client has an observation or complaint about the service or product that he receives from the provider. It is convenient that both the company and the assigned provider aspire to strengthen this relationship and communication, thus making the stability of both parties stronger and conformable.

When we talk about supply chain management, we refer to all that management or network that makes up a large part of the supply chain in a company. This has the objective or benefit of managing the flows of the chain within the processes, the raw material, as well as the finished products, we refer to this as the first inputs and outputs.

The Supply chain methodology or supply chain is a series of processes that go from a customer placing an order for a service or product, until that service or product is delivered to him. Although we know it is understood that there are different levels of depth within this method, since when we talk about this process it is necessary to start from the collection of the raw material to be able to elaborate the determined product in the company or rather since the raw material is in processing until it is delivered to the customer.

Nowadays, all companies have the same objective, which is to obtain a more stable or reliable supply chain, thus making their product more competitive in the market, but as we well know, every system must be linked to the care of the monetary or economic of the company, that is, to have a competitive supply chain and in such a way that it does not exceed the established costs.

This is due to the fact that the industrial sector is more demanding, as well as the needs or demands of the client are more and more. The term Lean Manufacturing is widely used in the industrial field, this is because it has tools capable of strengthening the industry, making it more efficient and effective in its processes and in its personnel, making it increase its competitiveness before others and the market.

Currently the focus is on the supply chain and value generation, therefore, buyers must focus on the total cost and delivery and not only on the price as was done previously. Buyers should rely more on the performance of suppliers rather than making decisions based on price [1].

In this document it is contemplated to evaluate through the TOPSIS method the ways by which we are guided to be able to evaluate the different suppliers of the maquiladora industry, of which we will focus on quality, price-quantity and efficiency. What is sought to do with this method is to know what factors we have to consider selecting a better supplier, currently in the industry there are problems due to lack of coordination to choose the type of supplier that is more feasible, cheaper but that in turn this give us good quality in terms of raw material and services.

The development of this method begins with the choice of a part number with which the company works, this part or piece number has different suppliers, both national and international, to which when implementing the TOPSIS method we will deduce what are the factors that we require and which of all is more capable.

It is important to determine that the supplier selection problem can be determined in four main sections: a) define the problem, b) establish the attributes that will be evaluated c) evaluate the different suppliers through the use of techniques and finally d) Choice end of a supplier [2].

It is mentioned that at this stage you can make use of an investigation to obtain a list of the main suppliers that have influence in the market for both the component and service that you want to obtain.

Materials and Methods

Suppliers are those who provide all small, medium, and large companies with material, financial resources, as well as human resources, to generate or carry out their daily operations.

The material resources that we can obtain from the supplier are raw materials, machinery and equipment, tools, maintenance services, among many others, but the most common are usually those mentioned. Among human resources we refer to all labor, speaking from operators and administrators who do the business process itself, finally, the financial resource is that amount that the company requires to be able to continue producing its product or service.

It is basically important to define or establish that there are two clearly different types of providers. We can find those of goods, which are those that contribute, those that offer and supply a place with components or tangible items [3].

But on the other hand, there are service providers such that, as their name suggests, they do not offer any material or machinery but rather a simulation that allows customers to carry out their activity with total satisfaction.

Logistics in the supply chain

It's critical to realize that developing supply chains and logistics is talking about two different tools, but even so, both fulfill the same objective. When speaking of Supply chain, we generalize it in a broader way or at a global level to which logistics is only an indispensable part of it.

As we well know, logistics is the fundamental part of any process within the supply chain since this is what plans, controls the flow of material, is what carries out the process and therefore stores goods and services, adding that. This information is relevant to that topic from the source of origin of the material to its consumption point, this with the objective of satisfying the market.

The utilization of this trip through the production of value, in other words, value produced for clients, partners, and firm shareholders. Every aspect of logistics' value is fundamentally based on the terms of the time and space it creates. We know that all raw material or finished material does not generate value by being in one place, but in order to generate value, it must be in the possession or consumption of the client when he requires it [4].

Difference between Logistics and Supply chain

More than anything, logistics is the one that refers to obtaining and delivering raw materials, and at the same time this generates the shipment and transport of your product or customer service, while on the other hand when we refer to Supply chain we refer to a broader concept since we cover the organizations, methods, tools implemented in the distribution of this product or service. On the other hand, logistics is usually either implemented internally or externally.

One of the systems used in the company where the problem arises is the SAP system, which is a viable tool

for obtaining data in a more real and correct way. In this we can obtain the raw material, the state in which our inventory is, as well as a series of lists with the names of our current suppliers, but more than that, SAP is an infinity of tools to use only depending on the needs that the company has to implement this system.

SAP is a software or system considered in the management of processes, developed faster solutions under a system or a database acting in a fluid way your information before the different departments or organizations. This system is one of the most current and used within the industry, but not everyone is able to stick to the difficult use that this can generate.

One of the advantages that we can obtain from this software is the statistical capacity it provides, just as it can be compatible with any other tool, including Excel graphs, but like any system, it has disadvantages from the point of view of each organization. One of them is, as mentioned before, not everyone adapts to the way this software works, it turns out to be more confusing when implementing it, as well as generating high costs since, as it is a new system, therefore its prices are high [5].

Lastly, this software is constantly being updated, which is why for some users it generates annoyance or frustration.

Importance of new suppliers

It is important that as a company one always has alternative routes, this so that at the time of not having the supplier or he cannot supply us with material or therefore he cannot offer us a service adequate to our needs, on this occasion the second supplier or in this case a new supplier can make the solution of this problem feasible [6].

In recent times we have observed that when implementing or collaborating with a new supplier association, these tend to be superior in terms of communication or tend to have greater attention in a certain way than those that we had already established over time.

That is to say, these new suppliers are more prepared, they obtain more resistant or higher quality materials, the service is more complete, that is, lower costs in exporting and importing the material, delivery time and load, which are measured by tons or size of the material, as well as their prices are usually reasonable in relation to other suppliers, since some can raise or vary their prices, but others lower them due to competition, as shown in table I.

Table I: Advantages and disadvantages of a single or multiple provider

Single source supplier	Several suppliers
Ensures the continuity of supply in case of problems. Lower supplier changeover costs. Ability to contact suppliers whose capacity cannot absorb the entire demand.	Easier to coordinate relationships, improve material flow, etc. Closer relationship with the supplier-customer, since there is a certain trust or inion in relation to previous orders. More uniform quality, delivery times and services.
Avoids the risk of overdependence	Improved supplier accountability.

Methodology for the selection of suppliers

According to the ISO 9001 standard, it establishes that suppliers must be assessed and chosen by the organization based on their capacity to deliver goods in line with business requirements [7].

To consider supply management as a source of advantage within the supply and supply chain, it requires more efficient logistics processes. Its strategy must be aligned to the strategy and objectives that the company has as such. A series of relevant criteria are set for price, quality, forms of payment that stand out from the competition itself [8].

On the other hand, when selecting a supplier, it can be the result of good or bad practices, since in it we can find diversity of materials or services offered, that is, materials with quantitative and qualitative differences in terms of demand and services that they generate or offer.

Mutually beneficial supplier relationships

The company must take measures to strengthen the company-supplier relationship, thus strengthening the supply chain between them, thus not generating long-term friction or differences. Certain actions can be applied to suppliers, which are the following [9]:

1. Establish fluid and coordinated communication, as well as create a relationship of mutual trust and collaboration between both parties.
2. Engage the supplier to indicate what can be improved in terms of their needs to help them more effectively meet the requirements of the product or service that we are requiring. A good practice is the improvement of communication as this is usually taken by both parties in a non-urgent or non-important way, but we know that this action generates the reduction of doubts or possession of bad information collected by the supplier or client.
3. Establish a reliable system for measuring the competence of suppliers, which allows the particular monitoring of the most important suppliers. The information obtained should be used not only to select providers, but to help them improve what is not right.

Request for information to meet suppliers

Taking into account a compilation of data of the possible suppliers in which direct or telephone contact with the supplier is initiated, to request appointments with managers requesting the necessary information on the aspects of the suppliers, this to make our selection more agile or go discarding in a more partial way the information or conditions in which its material or service is found [10]

It is necessary to verify that the product or service offered by the supplier establishes levels of trust in the market, that is, that it is verified that the product or service to be offered is of quality and durability, taking into account the price of the product that is going to dispose.

Currently there is a way or faster way to obtain this information with the help of a request for information (RFI) which is a document to collect information about what we are requesting. These types of tools are usually beneficial for any company that does not have knowledge about its possible suppliers and therefore requires a more viable and timely solution, just as it does not generate monetary value at the time of implementation. Another of the alternatives that we can obtain is to generate a general supplier profile, requesting general characteristics, for example, its prestige before other clients and the market, experience, or references of another client. Investigate their levels of reputation and compliance, as well as their trajectory in the industrial sector. Another even more important thing is its technical capacity, to which we refer with this, it is the number of

personnel that this demand and their possible training or training.

As opposed to that, technology takes a very important role in the customer-supplier relationship since it is responsible more than anything for the improvements in communication and understanding that it establishes, as well as through systems capable of attending in a general way what the client requires, that is, the specifications, costs and percentages that the material or service will generate are obtained more clearly.

Customer-supplier relationship

Customer-supplier relationships have evolved over time via means of development in the chain of supplies. Management of the supply chain is based on trust and commitment, for which it requires that certain factors be met. Among the use of these factors is a limited number of suppliers that allows working closely and creating an environment of cooperation and trust [11]

The reduction of suppliers may result in a decrease in the variation in the provisions offered by the supplier, which results in a reduction of waste, rework and the need for control or inspection. Similarly, a reduction in administration costs is achieved and a long-term relationship is fostered when the results are satisfactory, explains [12]

To improve or obtain a closer relationship with the supplier, it is necessary that we maintain or implement methods to be more in contact, that is, to engage in the use of tools such as emails, prolonged visits to the company, social networks, among others. The most common mistakes that are made when trying to relate to the customer and supplier is that the supplier neglects or does not fully meet the needs that he seeks for his company, maintain long response and delivery times, and lastly, close communication between both parties [13]. It is important to take care of every relationship, for which we must generate reliability and always be on the lookout for what the client requires, since this will be the one that will generate monetary goods and provide material goods, although we make it clear that we have to look for alternatives that favor us both economic and relational parts.

Research Methodology

Technique for Order of Preference by Similarity to Ideal Solution: TOPSIS Methodology

It is a multi-criteria decision method (MCDA) for selecting alternatives that was proposed by [14] and it is based on the idea that a decision-making problem with multiple criteria can be solved by prioritizing the problem posed. This method deals with the problem of establishing an order in the alternatives using the idea of distance to the ideal alternative and the anti-ideal one.

Decision making is the process by which a choice is made between two or more actions or alternatives in order to provide a solution to a problem. All our actions, conscious or not, are the result of some decision. The information we collect to understand an event helps us in turn to develop good judgments when making decisions about similar events.

Benefits of TOPSIS:

1. TOPSIS can assess a lot of data, options, or standards.
2. Since TOPSIS provides for explicit balance and interactions between attributes, changes to one attribute can

be countered by changes to others.

3. Unlike other MCDA tools, TOPSIS provides a preferred ranking of alternatives along with a numerical value in order to help users better grasp the differences and similarities between the alternatives.

4. Out of all MCDA techniques, TOPSIS has the fewest rank reversals, according to the simulation comparison.

The TOPSIS Method's key component is the assignment to maximum and minimum priorities of the weights of each criterion. So that a weight is added to each attribute which will represent its contribution to said problem, and which allows assigning a weighted value to each alternative in order to obtain a ranking or an order in said solution.

TOPSIS Application

He identified the following application areas of TOPSIS [15]:

1. Logistics and supply chain management.
2. Systems for design, engineering, and production.
3. Marketing and commercial management
4. Environmental and Safety Management.
5. Control of human resources.
6. Management of energy.

MCDA

One definition of multi-criteria decision analysis (MCDA) as a process for assessing options based on individual criteria and combining them into an overall evaluation. The MCDA can be used in multiple contexts and is useful in various fields of work. The standards are used to assess each alternative's choice in relation to the objective. Criteria of one or more preference grading scales to the real problem can also be defined. Scales can be classified as continuous scales, discrete scales, ordinal scales, or cardinal scales [16].

The four steps of the MCDA methodology can be thought of as a nonlinear recursive process:

1. Defining the problem
2. Identifying preference or criteria
3. Aggregating preference
4. Ordering alternatives

The use of methodologies such as MCDA considerably simplify the solution of the problems presented in said company, as well as allowing the people in charge of this implementation to make better decisions or expand their possibilities. One of the objectives of this methodology is to facilitate the comparisons or evaluations that will be applied, these being transparent, weighted and, above all, analytical [17]

This allows a more rigorous assessment between the different selected attributes, so it can be said that decision-making is made more rationally.

This methodology allows both the provider and the client to have a clearer and more objective view of their needs so as not to generate erroneous interpretations that could stain the stability or reliability established by both parties.

Participants

The purchasing and supplier quality area participates in this study, as well as a student and company personnel in the engineering area.

Instruments

According to the information obtained through the personnel in charge of the position, the company has more than 1,600 suppliers, of which they are located within Ciudad Juárez, El Paso Tx, and external. They change providers approximately every two years, this is due to their availability or due to problems that have occurred in terms of deliveries.

This maquiladora industry to choose a supplier is based more than anything on criteria such as cost and how much material will be obtained, as well as the efficiency that it provides and how good its quality and delivery is, what we want to do with this method is to observe the different ways in which a supplier is evaluated and why taking these criteria is so important.

The problem presented in this text is the way or the said factors that are taken into account when selecting suppliers. The factors on which the company as such was based to choose the supplier are: Quality, Price, Time and Reliability. For this we will use the formula established in the TOPSIS method, which is based on establishing the decision matrices, as well as the normalization of the matrix [18]this study aims at selecting suppliers among SMEs (Small and Medium Enterprises).

In the table II there are establish the weights to evaluate the suppliers.

Table II. Weights to evaluate the suppliers.

Weighting %	0.8	0.6	0.8	0.7
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STEP 1: Establish the Decision Matrix.

This step is represented by alternatives and criteria, these types of criteria are constituted by their level or degree of importance, table III.

Table III. Types of criteria constituted by level or degree of importance

		Max	min	min	Max
Suppliers	Ranking	C1	C2	C3	C4
P1	2.0	4.5	27.11	2	50
P2	3.0	50	35.15	2	78
P3	5.0	30	27.8	3	30
P4	4.0	25	13.08	4	30
P5	1.0	30	18.5	2	65
		83,366	5.706.707	608.276	

2 STEP: Normalized Decision Matrix

We apply the following equation (1) to obtain our normalized matrix, in which we can find a set of alternatives and a set of criteria, as show the table IV.

$$V_{ij}=(W_j)*(R_{ij}) \text{ ,for } i=1,2,\dots,m;j=1,2,\dots,n \quad (1)$$

Table IV. Set of alternatives and a set of criteria.

Suppliers	C1	C2	C3	C4
P1	0.540	0.475	0.329	0.414
P2	0.600	0.616	0.329	0.645
P3	0.360	0.487	0.493	0.248
P4	0.300	0.229	0.658	0.248
P5	0.360	0.324	0.329	0.538

STEP 3: Make a weighted normalized decision matrix.

With the following equation (2) we can obtain the data of the Normalized Weighted matrix and the Normalized weights [19] such as degree, betweenness, and closeness centralities, they all have some limitations. Recently, technique for order performance by similarity to ideal solution (TOPSIS, as show in Table V.

$$X_{ij} = \frac{X_{ij}}{\sqrt{\sum_{i=1}^m x_{ij}^2}} \quad (2)$$

Table V. Normalized weights of the matrix resulting from the equation.

Suppliers	C1	C2	C3	C4
P1	0.135	0.119	0.082	0.103
P2	0.150	0.154	0.082	0.161
P3	0.090	0.122	0.123	0.062
P4	0.075	0.057	0.164	0.062
P5	0.090	0.081	0.082	0.134

4 STEP: In this step the positive ideal solution A+ and the negative ideal solution A- of the matrix are identified by means of equation 3, [20]Battery energy saving With systems (BESS).

$$A^+ = \left\{ \left(\max_i v_{ij} \mid j \in J \right), \left(\min_i v_{ij} \mid j \in J' \right), i = 1, 2, \dots, m \right\} = \{v_1^+, v_2^+, \dots, v_n^+\} \quad (3)$$

$$A^- = \left\{ \left(\min_i v_{ij} \mid j \in J \right), \left(\max_i v_{ij} \mid j \in J' \right), i = 1, 2, \dots, m \right\} = \{v_1^-, v_2^-, \dots, v_n^-\}$$

With the equation two types of vectors are obtained, as shown in table VI:

Table VI. Types of vectors obtained of the matrix'.

A+	0.150	0.057	0.082	0.161
A-	0.075	0.154	0.164	0.062

5 STEP: Determined are the matrix's positive ideal solution S+ and negative ideal solution S- as shown in table VII:

Table VII. Determined are the matrix's positive ideal solution and negative ideal.

suppliers	S+	S-	Ci	Ranking
P1	0.086	0.168	0.661	2
P2	0.097	0.181	0.652	3
P3	0.139	0.178	0.561	5
P4	0.149	0.216	0.591	4
P5	0.070	0.185	0.726	1

Conclusion

In short, once the weighting and attributes to be selected have been established, we can see at a glance that the supplier with which it is most convenient for us to have a close company-supplier relationship is with the P5, since it meets the requirements that the company seeks, given that it adheres to the attributes which are quality, reliability, price and waiting time, the previous results shown are based on these attributes, as we well know, every company will always look for a way to take care of its economic assets, but thus obtaining levels of confidence regarding the quality of the raw material obtained. Therefore, we can conclude that the objective we wanted to reach was achieved, since we wanted a solution or a more accurate way of selecting a single supplier

who could give us all the benefits based on our attributes or requirements.

Recommendations

It is recommended that in this type of problem, criteria or attributes are established that help us as a company to have control in the supply chain, the TOPSIS method is a decision-making tool that helps us to have a quick response to what we were looking for, but just as there are various methodologies that we can apply for solutions to this type of case, or just as we can compare the use of TOPSIS with another methodology to verify which is more feasible or if both are similar to the answer. What is expected with this methodology is to have greater knowledge or control over when it is more convenient for us as a company to request raw material from the supplier, this would help us to be more efficient in our processes.

Future works

As technology and demand advance, the authors' job is to update the applied methodology, since as time progresses, new providers may emerge that offer better products, services, or processes, so it will be necessary to apply this technique again to be able to provide a solution to the problems that arise during the course.

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