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Suppliers Selection in Restaurants: Application of Delphi and Fuzzy AHP Methods

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Abstract

In the restaurant industry, it is essential to identify the best suppliers to ensure that processes within the company are executed efficiently, meeting customer standards and needs. The objective of this research is to know the criteria used by managers when selecting suppliers and to analyze them based on the literature, using the Delphi method to find and choose the most important criteria. Based on the results found in the multicriteria decision analysis was observed that the product variety criterion was classified as the most important, followed by the criteria payment period, delivery time, delivery time, supplier service, price, product yield, and product quality. Based on the results found from the multicriteria decision analysis, it is observed that the option criterion of product variety was classified as the most important. Other criterions found were payment period, delivery time, delivery time, supplier service, price, product yield, and product quality. The objectives of the study were achieved, but some results contradict what was reported in the literature. For example, according to some authors, the most critical criteria in the selection of suppliers are Product Quality and Price. However, the results indicate that these were not the main criteria pointed out by the specialists.

Keywords: Suppliers Selection, Delphi Methods, Fuzzy AHP Methods.

1. Introduction

Globalization is a remarkable process that has been promoting an increase in global competition, increasing consumer demands, and providing more significant interaction between all stages within an organization. Because of this, many companies are looking for ways to acquire competitive advantages concerning cost, service, quality, delivery time and other essential criteria to attract a more significant number of customers (Liker & Choi, 2004).

Considering that the goods and services purchased in any retail and wholesale companies represent 50 to 70% of a company's revenues. And that the proportion of the income spent on the purchase of inventory items is

even higher sometimes exceeding 90% (Haq & Kannan, 2006; Sala, 2015), studies indicate that companies with high levels in purchasing process also achieve high levels of business performance.

To ensure that processes within the company occur efficiently, guaranteeing standards and meeting customer needs, the tasks of identifying the best suppliers are essential. However, many companies face complex issues when they need to select suppliers, as this task usually involves multiple criteria (Bozarth & Handfield, 2008; Guarnieri, 2015).

The problem that guides this study is to list which criteria are used by specialists in the purchasing area when selecting suppliers within the institutions of which they are part. Thus, the general objective is to know these criteria and analyze them based on the literature.

The specific goals that make up this analysis are to use the Delphi Method to obtain the essential criteria to be considered when selecting suppliers, based on the expert's opinion. And, apply a questionnaire to a larger group of specialists in the purchasing area, in which they will order the criteria obtained with consensus, in the first phase, through a comparison matrix, using a scale of 1 to 9, comparatively, based on the Saaty scale, for application of the Fuzzy AHP multicriteria analysis method.

2. Literature Review

The purchasing sector within a company should receive considerable attention since a selection of suitable suppliers can bring significant savings to the organization. Also, factors such as globalization, increased product offerings, and accelerated technological change can affect this sector, as it is possible to have access to numerous information, which makes the selection of a supplier increasingly critical (Haq & Kannan, 2006).

The purchasing sector's role goes far beyond the purchase of raw materials, inputs, and components for the organization. This sector is responsible for other important factors that include the quality of goods and services and their delivery time, which can have a significant impact on the company's performance (Haq & Kannan, 2006; Sala, 2015).

Studies show that companies with high levels of purchasing performance also achieve high levels of business performance. In light of this, the importance of the purchasing sector's role can be easily understood if one considers that the goods and services purchased represent 50 to 70% of a company's revenues. The proportion of income spent on the purchase of inventory items is even higher for retail and wholesale companies, sometimes exceeding 90% (Haq & Kannan, 2006; Sala, 2015).

Supplier selection has become one of the main functions within a company so that an appropriate variety maximizes organizational competitiveness. Therefore, the selection process of these suppliers has become strategic since these selected partners have a direct influence on the maximization of companies' financial results (Willis, Huston & Pohlkamp, 1993). The supplier selection process is an essential and vital activity for the competitive differentiation of an organization, as well as for the improvement of the level of service provided (Junior & Borges, 2018).

The proper choice of a supplier can produce positive results. In contrast, a wrong choice will undoubtedly bring problems, not only for a specific area of the company but for other areas involved in this decision, directly

impacting the economy of the same. For the supplier selection step to be carried out in a standardized and always successful manner, some criteria are used to ensure that choices are made fairly and within the organization's standards (Vanalle & Guerhardt, 2013).

According to Sala (2015), standardization in purchases, such as standardization of materials and purchasing procedures, has a significant positive effect on the sector's performance and, consequently, on the company's business performance. Standardization in purchases is justified because this standardization helps the company to meet the expenditure targets for materials, increases its quality standards, in addition to favoring the delivery of suppliers on time.

When it comes to the selection of suppliers, the main characteristic of this process is the existence of criteria that seek to identify aspects that assist in the preparation of the supplier's profile, and from there, proceed to the choice of suppliers that will meet the company's demands. According to the literature, the criteria for selecting suppliers are of two types: quantitative and qualitative. Quantitative criteria, such as price, service capacity, quality, are easier to assess, allowing a precise and accurate measurement to compare the alternatives. Qualitative criteria, such as trust and supplier service, are more subjective; that is, it depends a lot on the personal judgment of the person responsible for the supplier selection process. In this context, multicriteria methods to support decision-making can be used in the development of models to select alternatives for such problem (Chai, Liu & Ngai, 2013)

In a study by Boran, Genc, Kurt, and Akay (2009), in an automotive company, whose objective was to select the most suitable supplier for one of the main elements of its manufacturing process. For this, a committee was formed composed of decision-makers, and four criteria for selecting suppliers were considered: product quality, proximity to the relationship, delivery performance, and price. Also, Boran et al. (2009) affirm that to have a good selection of suppliers, it is necessary a process that finds the right suppliers, who can supply the buyer with quality products, at the right price, at the right time and in the right quantities.

These studies show that in the purchasing sector scenario, the traditional price/cost analysis is no longer a criterion for the selection of suppliers. Thus, there is a need to value other factors to assist a decision with several criteria, such as quality, delivery, service, technological capacity, ease of communication, management, flexibility, trust, among others (Ho, Xu & Dey, 2010; Guarnieri, 2015). Besides, the quality of the products is also directly related to their performance. When the quality of the raw material is weak, it becomes necessary to increase the quantity used, as in this case, the merchandise does not offer the income required to obtain the required standard (Cintra, 2016).

Among the criteria considered when selecting suppliers, Junior and Borges (2018) realized in the results of their research that the main factor to be considered is the cost/price factor, resulting in less importance to the various criteria that may be of summary importance for successful decision making. For Chang and Hung (2010), the main criteria used to assess suppliers are cost/price, quality, delivery performance, customer service, and flexibility. According to the literature, the product/service price criterion appears, in most cases, as the most outstanding selection criterion, as can also be seen in the study by Schneiders and Sellitto (2017). Payment condition and delivery time occupied the second and third positions, respectively, regarding the degree of importance (Schneiders & Sellitto, 2017).

Studies show that among aspects used to select suppliers is the variety of products and services available by the supplier. Different purchasing specialists evaluate this criterion as one of the most important and sufficient to measure the performance of suppliers. Authors bring this variety of products and services as a characteristic of the supplier's flexibility (Viana & Alencar, 2012).

In this context, the criteria for selecting suppliers combined with multicriteria methods, which support decision making, can be used in the development of models for the selection of suitable alternatives at a given decision point in the choice of suppliers (Chai et al., 2013).

3. Methodology

For the development of research, an exploratory approach was used, in its first phase, through the application of the Delphi method, to obtain the criteria for selecting suppliers based on the opinion of experts and specialists (Gil, 2008; Kerlinger, 1988; Selltiz, Wrightsman & Cook, 2007).

The Delphi method was initially developed by the company Rand Corporation, during the 1950s in the United States, its name originates from the name of a Greek city where Apollo's temple is located, this method which aims to obtain the consensus of experts concerning a specific theme (Chang-hee & Karen, 2018; Philsoophian, Ghorbani, Akhavan & Afshar-jalili, 2016; Strasser, 2017). The Delphi method was precisely chosen because it is a technique that obtains a strong consensus, based on the opinion of experts, through the application of a series of questions, through controlled feedback about ideas (Gajda, 2015).

The sample consisted of five hospitality specialists who were responsible for carrying out the purchasing processes in these organizations. These experts provided information on what essential criteria should be considered when selecting suppliers. (Aldret, 2018; Borges & Richard, 2018; Strasser, 2017; Szpilko, 2014; Yusof, Ishak & Doheim, 2018).

In the second phase, 20 procurement specialists were asked, among them, the five who participated in the first phase, to order the criteria obtained by consensus in the first phase, through a comparison matrix, using a scale from 1 to 9, from comparative form, based on the Saaty scale, for application of the Fuzzy AHP method (Saaty, 2008).

For the analysis of the data of this second phase, the method I chose was the Fuzzy AHP multicriteria decision analysis, for better treating data from expert opinion, for better balancing linguistic inaccuracies arising from view, obtained using a Pair comparison scale. -Wise (Buckley, 1985; Chen, Chen & Padró, 2017; Govindan, Darbari, Agarwal & Jha, 2019).

The Fuzzy method was chosen, as it is an excellent method to deal with the linguistic inaccuracies of human decisions, thus providing a more reliable result. For this reason, it is used in several fields of activity, such as the selection of suppliers, production decisions, tourism, among others (Asemi, Asemi, Baba & Abdullah, 2014; Keršulienė, Zavadskas & Turskis, 2010; Vatansever, 2014).

The choice of the Fuzzy AHP method was because it provides an orderly ranking of the options presented by specialists, thus generating a form of prioritization that can be used by managers to make their decisions regarding the selection of suppliers through analysis of weights (Kirubakaran & Ilangkumaran, 2016; Lu,

Cancan & Yubin, 2017; Nazari-Shirkouhi, Miri-Nargesi & Ansarinejad, 2017; Tan, Low, Sulaiman, Tan & Promentilla, 2016).

4. Analysis of Results and Discussion

To establish the criteria for selecting suppliers, using the Delphi method, five specialists from the hotel purchasing area participated in the process. In the first round, the specialists received, through What's app, the following question: "What criteria do you use to select your suppliers?". The answer from experts listed as criteria: supplier service, product variety option, price, delivery time, payment term, product quality, product yield. Of these, delivery time, price, and product quality were mentioned by four specialists, payment term by two specialists, and, finally, supplier service, product yield, and product variety options were mentioned only once. Some criteria cited by experts in this first round were renamed, as they were cited in different ways. Still, bringing the same information, among them, billing was renamed by payment terms, cost by price, and product standard by product quality.

In the second round, the data answers were sent to the experts, by What's app, informing the tabulated answers and in which answers they gave, asking if they wanted to exchange or keep the answers. Only one expert added two more criteria to their choices, and the other experts wished to maintain the responses from the first round. From there, the criteria for selecting suppliers to be used in the research were determined: supplier service, product variety option, price, delivery time, payment term, product quality, product yield. Where product quality was chosen by all specialists, delivery time, and price by four specialists, payment term and supplier service by two specialists, and, finally, product yield and product variety options were chosen by only one specialist.

In the second phase of the study, based on the criteria for selecting determined suppliers, a questionnaire was prepared on Google Docs, which was answered by 20 experts and specialists, also from the purchasing area. This questionnaire aimed to assess the importance of the criteria, that is, to evaluate the usefulness of these criteria among them to each other.

The data of the experts' judgments were consolidated, in a single spreadsheet of results, which are shown in Table 1.

Table 1. Consolidated Data from Experts' Judgments

	Supplier service	Product Variety Option	Price	Deadline	Payment Term	Product quality	Product Yield
Supplier service	1.000	4.000	1.000	4.000	5.000	4.000	1.000
Product Variety Option	1.000	1.000	1.000	1.000	1.000	1.000	1.000

Price	5.000	5.000	1.000	7.000	6.000	1.000	1.000
Deadline	1.000	4.000	1.000	1.000	4.000	1.000	1.000
Payment Term	1.000	3.000	1.000	1.000	1.000	1.000	1.000
Product quality	1.000	4.000	5.000	7.000	7.000	1.000	5.000
Product Yield	4.000	5.000	4.000	5.000	5.000	1.000	1.000

Source: Research (2019)

The data were then subjected to multicriteria decision analysis, fuzzy analytic hierarchy process (FAHP), to find the weights that were given by the experts, for each criterion in a pairwise comparison (Cho, Wang & Hsu, 2016; Nazari- Shirkouhi et al., 2017; Tan et al., 2016).

The data present in Table 1, were fuzzified to capture the imprecision in the experts' judgment, based on the values presented in Table 2:

Table 2. Pairwise Comparison Scale

Importance Scale	**Value**	**Fuzzy Triangulation (L, M, U)**
Equal	1	(1,1,1)
Moderate	3	(2,3,4)
Strong	5	(4,5,6)
Very strong	7	(6,7,8)
Extremely Strong	9	(9,9,9)
Intermediate Values	2	(1,2,3)
	4	(3,4,5)
	6	(5,6,7)
	8	(7,8,9)

Source: Adapted from Kirubakaran and Ilangkumaran (2016).

The table is used to capture the uncertainty generated by the experts' judgment to be able to make the comparison, in which the triangular method was used to define the members. The triangular function (TFN) was used to make it easier to assess expert opinion. This method was chosen because it is useful in formulating decision problems, based on subjective and inaccurate data, limiting numbers close to the interval of belonging defined by [0.1], that is, it belongs or does not belong (Kirubakaran & Ilangkumaran, 2016). The following formula can represent TFN:

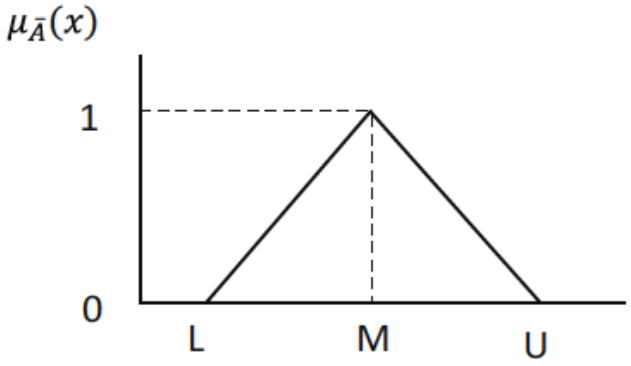
$\frac{x-l}{m-l}$, l < x < m,

$\frac{u-x}{u-m}$, m < x < u,

0, x > u

The triangulation itself is represented by means of figure 1:

Figure 1. Fuzzy Triangulation



Source: Kirubakaran and Ilangkumaran (2016).

The numbers collected through table 1 were then fuzzified, using the criteria presented in Table 3:

Table 3. Fuzzified Numbers

	Supplier service	**Product Variety Option**	**Price**	**Deadline**	**Payment Term**	**Product quality**	**Product Yield**
Supplier service	1,1,1	3,4,5	0.25,0.2, 0.1666	3,4,5	4,5,6	3,4,5	0.33,0.25, 0.2
Product Variety Option	0.33,0.25, 0.2	1,1,1	0.25,0.2, 0.1666	0.33,0.25 ,0.2	0.5,0.33, 0.25	0.33,0.25 ,0.2	0.25,0.2,0. 1666
Price	4,5,6	4,5,6	1,1,1	6,7,8	5,6,7	0.25,0.2, 0.1666	0.33,0.25, 0.2

Deadline	0.33,0.25, 0.2	3,4,5	0.1666,0. 142,0.12 5	1,1,1	3,4,5	0.1666,0. 142,0.12 5	0.25,0.2,0. 1666
Payment Term	0.25,0.2,0. 1666	2,3,4	0.2,0.166 6,0.142	0.33,0.25 ,0.2	1,1,1	0.1666,0. 142,0.12 5	0.25,0.2,0. 1666
Product quality	0.33,0.25, 0.2	3,4,5	4,5,6	6,7,8	6,7,8	1,1,1	4,5,6
Product Yield	3,4,5	4,5,6	3,4,5	4,5,6	4,5,6	0.25,0.2, 0.1666	1,1,1

Source: Research (2019)

Step 1 was the application of the geometric mean, per criterion using the method proposed by Buckley (1985), where the numbers of the respective standards are multiplied, one by the other, respecting the positioning of the fuzzy numbers (L, M, U), through the following formula.

$\tilde{A}_1 \otimes \tilde{A}_2 = ((l_1, m_1, u_1)^{1/n} \otimes (l_2, m_2, u_2)^{1/n} = ((l_1 * l_2)^{1/n}, (m_1 * m_2)^{1/n}, (u1 * u_2)^{1/n})(1)$

After applying the formula to the data, the results found were: $\sim r_1$ = Supplier service =>(0.73059995564324,0.67295009631618,0.63138503555892); $\sim r_2$ = Product Variety Option =>(2.6272534028386,3.3565382864326,4.0541150777068); $\sim r_3$ = Price =>(0.590383602775,0.56788834641353,0.54821037033993); $\sim r_4$ = Deadline =>(1.7385105064448,1.8001175682962,1.8592479749976); $\sim r_5$ = Payment Term =>(2.5597075924979,2.8147955919589,3.061359715205); $\sim r_6$ = Product quality =>(0.40332387485812,0.3621076513829,0.33086083446812) e $\sim r_7$ = Product Yield = (0.49165731051871,0.42489062049197,0.37841239709016).

Step 2 was the calculation of the fuzzified weights by the criterion as observed by Pitchipoo, Venkumar, and Rajakarunakaran (2013), using the formula available in Chen et al. (2017), shown below:

$$\sim\omega_i = \sim ri \otimes (\sim r_1 \oplus \sim r_2 \oplus \ldots \sim r_n \oplus)^{-1} \quad (2)$$

The values found for the fuzzy weights were as follows: $\sim\omega_1$ = Supplier service =>(0.079921790845152,0.067299800291905,0.058119365134353); $\sim\omega_2$ = Product Variety Option => (0.28740050603208,0.33567772348295,0.37318368543428); $\sim\omega_3$ = Price => (0.064583243476723,0.056792877378197,0.050463088115512); $\sim\omega_4$ = Deadline => (0.19017914250466,0.18002457167547,0.17114487333159); $\sim\omega_5$ = Payment Term => (0.2800115347013,0.28149959742686,0.28179996844255); $\sim\omega_6$ = Product quality => (0.044120405593082,0.036213342944214,0.030455935069933) e $\sim\omega_7$ = Product Yield => (0.053783376847006,0.042492086800412,0.034833084471791).

Step 3 was the defuzzification of the numbers using the COA (Center Area) method, as recommended by Chen et al. (2017) and Tzeng and Teng (1993), applying the following formula:

$$w_i = \left(\frac{l+m+u}{3}\right) \quad (3)$$

The results of the defuzzified weights are shown in Table 4:

Table 4. Weights Defuzzified by the COA method

Criteria	Fuzzy Weights	Defuzzified Weights
Supplier service	(0.079921790845152,0.067299800291905,0.058119365134353)	0.068446985423803
Product Variety Option	(0.28740050603208,0.33567772348295,0.37318368543428)	0.3320873049831
Price	(0.064583243476723,0.056792877378197,0.050463088115512)	0.057279736323477
Deadline	(0.19017914250466,0.18002457167547,0.17114487333159)	0.18044952917057
Payment Term	(0.2800115347013,0.28149959742686,0.28179996844255)	0.28110370019023
Product quality	(0.044120405593082,0.036213342944214,0.030455935069933)	0.036929894535743
Product Yield	(0.053783376847006,0.042492086800412,0.034833084471791)	0.04370284937307

Source: Research (2019)

Based on the values found in table 4, it can be seen that the criterion Product Variety Option = 0.3320 => 33.20% was classified as the most important by decision makers, followed by the criterion in second place Payment Term = 0.2811 => 28.11%, third was the Deadline criterion = 0.180 => 18%, fourth was the Supplier service criterion = 0.0684 => 6.84%, fifth was the Price = 0.057 => 5 criterion, 7%, in sixth place was the criterion Product Yield = 0.0437 => 4.37% and finally in seventh place was the criterion Product quality = 0.0369 => 3.69%. These criteria represent the importance that decision makers take as to what they consider to select a supplier.

It can be observed that the Variety Option of Products was the most important criterion, a result similar to that found by Santos and Osiro (2016), where a variety of products and services available by the supplier, were evaluated by different purchasing specialists as one of the criteria. Most essential and enough to measure supplier performance. During a selection, where suppliers are presented who have a wide variety of product/service options, these will be better viewed, since only they can meet a good part of a company's needs, without it needing a large number of suppliers to serve it.

Unlike what is shown in the literature, in this study, Product Quality and Price were among the criteria classified as least critical by decision-makers, along with product yield. In the research by Chang and Hung (2010) and Junior and Borges (2018), which addressed criteria for selecting suppliers, according to the results, among the requirements that received high importance were: quality and price. Studies show that the short-term

delivery criterion (delivery of goods or services in a short time after the customer's request) is commonly classified as high and partially critical. What is in line with the results found in this study shows that delivery time was the third most crucial criterion in the selection of suppliers.

According to the literature, as previously stated, the product/service price criterion often appears as one of the most critical selection criteria, as can be seen in the study by Schneiders and Sellitto (2017) and different from the result found in that study. However, Payment Term / Term and Delivery Term were in agreement with what was found in this study, where these criteria occupied the second and third positions, respectively, regarding the degree of importance, being similar to the results of the current research.

According to the literature, the criterion service to the supplier is among the fundamental and most important criteria, as can be observed in the studies by Boran et al. (2009); Chang and Hung (2010); Guarnieri (2015) and Ho et al. (2010). In this survey, the Supplier Service criterion was classified as the fourth most important criterion when selecting the supplier.

The method used to arrive at these results evaluated the weights given by the specialists, decision-makers during the process of selection of suppliers. This strategy can be used to classify a company's current and future suppliers. This strategy was used in the study by Salomon (2002), where the author deals with the purchasing process and its inherent decision making. He used tools to aid decision making by multi-criteria, using the application of the AHP method, which resulted in a change in the classification of suppliers, where he attributed the weights to the evaluation criteria of existing suppliers and the criteria for selecting new suppliers.

The research carried out by Santos and Osiro (2016) evaluated the supplier base focused on the scenario of SMEs. He surveyed the literature on the criteria and then weighed the criteria, that is, the weighting of each criterion, which should be based on its importance to the company. In this study, AHP was used precisely to determine the weight of each supplier evaluation/selection criterion, where the scale of values of highest relative importance starts from 1 (equality) and goes up to 9 (absolute superiority). He further concluded that AHP provides less dispersion of judgments and decision making.

5. Conclusions

The present work had as objective to know the essential criteria, in the opinion of specialists in the purchasing area, used when selecting suppliers, within the institutions of which they are part. Based on the Delphi Method, seven criteria were cited by experts: supplier service, product variety option, price, delivery time, payment term, product quality, product yield. With these criteria already established, it was possible to order them by consensus, through a comparison matrix. The experts' judgments were consolidated, and the data were then submitted to FAHP multicriteria decision analysis.

Thus, the objectives of the study were achieved. Still, some results were in disagreement with the literature, as were the cases of the selection criteria of Product Quality and Price, which, according to many authors of the literature, are the most important criteria when selecting suppliers, which was not noticed with the results of the present study.

As a limitation of the study, we can point out the small number of specialists who participated in the phases of this research. For future studies, it would be interesting to use methods of aggregation of opinion, also to try to

understand the reason for the responses in the specific context of each specialist participating in the research, or to use other multicriteria techniques and to compare the results obtained.

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