

# Critical Factors of Supplier Selection in the Food and Beverage Industry of Saudi Arabia: A Fuzzy-TOPSIS Approach

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## Abstract

To ensure business sustainability, businesses seek reliable suppliers that can meet their customer's expectations. Selecting reliable suppliers can be a winning strategy providing a competitive advantage in the market over competitors. Therefore, unlike many other operational functions, supplier selection is regarded as a strategic function within companies. However, when evaluating and selecting suppliers, procurement departments must build their selection process based on certain factors that they deem most important to their business activities. The food and beverage industry are not an exception to this scenario. The purpose of this study is to reveal the set of the most critical factors of supplier selection in the food and beverage industry of Saudi Arabia. A designed survey was conducted to collect information about factors that play a major role in supplier selection from the perspective of decision-makers, supply chain professionals, and procurement officers in the food and beverage manufacturing companies of Saudi Arabia. Subsequently, The Fuzzy Technique of Order Preference by Similarity to the Ideal Solution (Fuzzy-TOPSIS) approach was used to rank the factors based on their importance. The findings of the study revealed a ranked set of 35 critical factors influencing supplier selection. The top five critical factors are speed, demand capability, customer service, communication system, and responsiveness. Implications of this study include assisting the food and beverage industry of Saudi Arabia for a better supplier selection using the revealed set of ranked critical factors as selection criteria.

## Keywords

Critical factors, supplier selection, Fuzzy-TOPSIS, food and beverage industry, Saudi Arabia

## 1. Introduction

For businesses to increase competitive advantage and meet their customers' demands, an efficacious sourcing strategy must be devised. Hence, seeking reliable suppliers can stimulate a company's success and ensure the maximization of future profits. Unlike other operational functions within companies, supplier selection is regarded as a strategic function (Jain, et al. 2009). Therefore, supplier selection involves many factors that must be met to demonstrate the multi-criteria nature of such decisions. Besides, food supply chains integrate suppliers, producers, distributors, and customers to meet their needs (Cox, 1999). However, supplier selection risk exposure makes a significant impact on the performance of companies in middle-term and long-term disruptions (Simchi-Levi, et al. 2015; Ivanov, et al. 2017; Yoon, et al. 2018).

For a broad-based understanding of the factors that feature in the decision-making process, a literature review of this topic has been conducted. Additionally, a questionnaire was designed and handed out to purchasing managers, production managers, supply chain and logistics professionals...etc. associated with the food and beverage industry in Saudi Arabia to rank the most important factors that are considered when selecting suppliers. However, different suppliers exist for different items with different critical factors which in turn may result in constructing different models (Kilic, 2013).

In this work, an extensive literature review has been conducted to list all the critical factors considered in supplier selection, especially in the food and beverage industry in Saudi Arabia. Table 1 illustrates the main factors or dimensions along with myriad sub-factors that are collected and investigated from the literature. A questionnaire was designed and handed out to seven participants (consisting of purchase managers, production managers, supply chain, and logistics professionals) in three different companies belonging to the food and beverage industry in Saudi Arabia. Then, to fulfill the requirement of paired comparisons, the capacity limitations, and overcoming the inconsistency and vagueness of judgment, a Fuzzy-TOPSIS approach was utilized to rank the most important factors. As the TOPSIS technique doesn't get affected in the presence of large numbers of factors and/or alternatives (Shih Shih, et al. 2007).

## **2. Literature Review**

### **2.2. Fuzzy TOPSIS**

Significant applications have been made over the years in the use of fuzzy set theory in MCDM. The fuzzy set theory introduced by (Zadeh, 1965) proposed a theory which deals with incomplete or vague human judgment or inconsistency in human cognitive processes. Consequently, the fuzzy set theory found its way in pattern discrimination problems and its applications to optimization problems due to its capability of capturing human judgment. On the other hand, Technique of Order Preference by Similarity to the Ideal Solution (TOPSIS) developed by (Hwang et al. 1981) is constructed on the concept of finding the points of a positive ideal solution and negative ideal solution, and select the alternative that is closest to the positive ideal and farthest from the negative ideal.

Finally, fuzzy-TOPSIS which is developed by Chen (1997) proposes an extension of TOPSIS with triangular fuzzy numbers that calculates the distance between two fuzzy numbers through a vertex method, where this extension to fuzzy environment assists in solving multi-criteria decision-making problems under uncertainty i.e., the inconsistency of judgment. Additionally, the analytic hierarchy process (AHP) is great at capturing all the comparison between factors to deliver ratio scale priorities, however, it would be difficult and infeasible due to the large number of factors incorporated. Hence, the fuzzy-TOPSIS approach is utilized to alleviate the paired requirements and capacity therefore it's considered suitable for cases with a large number of factors and alternatives (Shih Shih, et al. 2007).

Agarwal and Vijayvargy (2011) illustrated an application of selecting suppliers in a multinational food coffee industry incorporating both tangible and intangible criteria in aid to address decision-making problems as a strategic-level management issue.

### **2.3. Supplier Selection**

In literature there are numerous factors for the evaluation and selection of suppliers, however, the argument is whether the chosen factors are valid. Dickson (1966) defined a set of 23 factors that are incorporated in the supplier evaluation and selection process. Weber et al (1991) reviewed and classified 74 articles related to supplier selection based on a set of factors and analytical methods utilized. Cebi and Bayraktar (2003) proposed an integrated model for supplier selection using goal programming and the analytic hierarchy process (AHP) in a food production company based in Istanbul, Turkey.

Agarwal and Vijayvargy (2011) proposed an analytic hierarchy process (AHP) model for better supplier selection among Indian coffee companies. Shen et al (2011) utilized an analytic network process (ANP) and a decision-making trial and evaluation laboratory (DEMATEL) approach to identify key performance improvement factors within the food industry context. Liao et al (2012) applied a fuzzy-MSGP approach to evaluate and select the best foodstuff supplier. Magdalena (2012) identified the best suppliers' factors in the food packaging industry by integrating the Taguchi loss function with fuzzy-AHP.

Prusak et al (2013) demonstrated the application of the Analytic Hierarchy Process (AHP) in the assessment and selection of best suppliers in an enterprise, namely food wholesalers and the analysis stopped at ranking the importance of the studied factors. Finally, in an interesting work, Ren and Hautuco (2016) managed to study the supplier selection process in a company in the Chinese Dairy Industry. The literature review includes the food supply chain, the frameworks and models of supplier selection, the selection methods and sourcing strategies, a case study methodology including seven interviews with managers and employees was carried out. Their paper discusses the similarities and differences between the research findings and literature review. Lastly, our aim in this paper, a fuzzy-TOPSIS approach is applied to prioritize factors influencing supplier selection among food and beverage companies in Saudi Arabia.

Table 1. Supplier selection factors collect from the literature review.

| <b>Factors</b>                     | <b>Definitions</b>  |
|------------------------------------|---|
| Net price                          | The net price (including discounts and freight charges) that is offered by each supplier.   |
| Cost reduction plan                | Cost reduction plan is a process used by the supplier to reduce their cost and increase profits by each supplier in the proposal.   |
| Warranty cost                      | The warranty cost offered by each vendor for repair or replacement.   |
| Operating cost                     | The operating cost is rent, payroll, overhead to raw material, and maintenance expenses by each supplier.   |
| Freight                            | Process of transportation by each supplier.   |
| Durability                         | Ability of the product to remain functional by each supplier.   |
| Conformity                         | Conformity is the process of a product being produced when it was designed.   |
| Certificate                        | Industry-recognized professional certificates held by the supplier.   |
| Design / Image                     | Design/Image is the process of creating a new product by each supplier.   |
| Consistency                        | Consistency is product variation accrued by each supplier.  |
| Statistical Process Control (SPC)  | Current methods of quality control employed by each supplier to monitor the process.  |
| ISO                                | The ISO certificate is a standard of quality management held by each supplier.  |
| Technical Support                  | Technical support is tech service suppliers provide to their customers.   |
| Responsiveness                     | Responsiveness is willingness or quickness with which a supplier reacts to something.   |
| Delivery                           | The ability of the supplier to meet specified delivery schedules which include lead-time, on-time performance, fill rate, returns management, location, transportation, and incoterms.  |
| Attitude                           | Attitude (politeness and confidence) of the supplier while you are in contact with them.  |
| Packaging ability                  | The ability of each supplier to meet your packaging requirements for his product.   |
| Flexibility                        | Ability to adapt and respond quickly to different circumstances of order demand.  |
| Warranties and claims policy       | The superiority of the specified written guarantee that vouchsafes repair or replacement of the product if necessary, within a specified period, and also the claim policy as a formal request for coverage or compensation for a covered loss or policy event. |
| Order process                      | The order process is the workflow from order request to delivery by each supplier.  |
| Customer service                   | Customer service is the level of assistance and courtesy extended by each supplier.   |
| Geographical location              | The geographical location of each supplier.   |
| Repair service                     | The ability of the supplier to restore something damaged, faulty, or worn to a good condition.  |
| Technical capability               | The technical capability (including research and development facilities) of each vendor.  |
| Demand capability                  | Purchasing options are available to exceed expected order quantity supplies and the potential to increase volume activity that meet customer needs.   |
| Future potential                   | The ability of a supplier to meet the aspirations of business planning to grow. (this seems to be clear and direct to the point).   |
| Financial position                 | The financial position and credit rating of each vendor.  |
| Impression                         | The impression being made by each supplier in personal contacts with you.   |
| Production facility and capability | The volume of products or services that can be produced by a supplier using current resources.  |
| Speed                              | The speed is the capability of suppliers to meet customer requirements at right time.   |
| Delivery lead-time                 | The delivery lead-time is the amount of time consumed in the production and delivery of a product to the customer by each supplier.   |
| Reputation and position            | Ranking and reputation of a brand, product, or company, in terms of its sales volume relative to the sales volume of its competitors in the same industry.  |
| Communication System               | The communication system of the supplier including information on progress data of orders.  |
| Business Desire                    | The desire for your business that is shown by each supplier.  |

### 3. Methodology

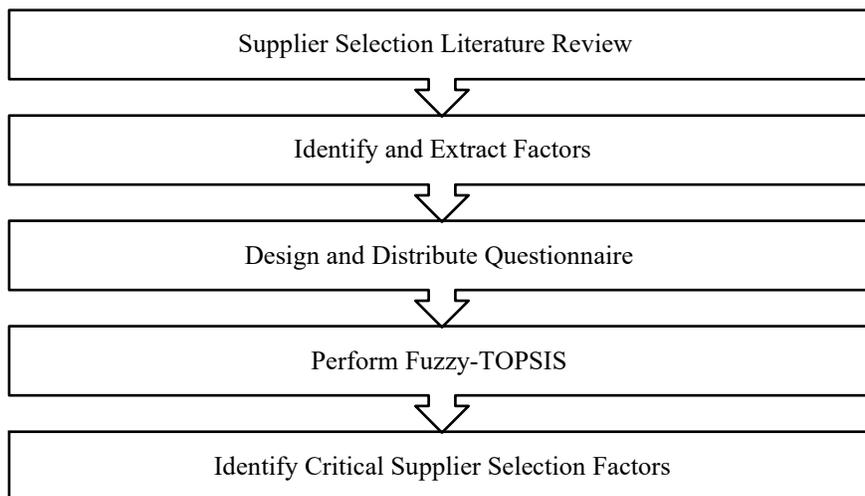


Figure 1: General Research Procedure

As shown in Figure 1, the general procedure for this paper was to review literature related to the topic, identify and extract factors from it, then a questionnaire was designed based upon a 5-point Likert scale as listed in Table 3, and distributed to 7 professionals or experts from three different food and beverage companies operating in Jeddah, Riyadh, and Hail which makes the results of this study more representative of the current situation in Saudi. Finally, the responses listed in Table 2 were used in our Fuzzy-TOPSIS approach to rank the critical supplier selection factors in Saudi Arabia.

As mentioned previously, the Fuzzy-TOPSIS approach is suitable for alleviating the requirements of paired comparisons, capacity limitations, and overcoming the inconsistency and vagueness of judgment or uncertain information. The following seven steps based on the technique introduced by Chen (1997), are used for this research purpose in ranking the critical supplier selection factors.

*Step one*

Consider a fuzzy decision matrix of participants' ideas as follows, where  $i$  stand for the number of factors (supplier selection factors) and  $j$  stands for the number of respondents. Additionally,  $X_{ij}$  stands for the assigned score by respondent number  $i$  for factor  $j$ . Finally, since all respondents are considered to have the same weight,  $W_{ij}$  will be defined as  $W_j = (1, 1, 1)$ :

$$D = \begin{matrix} & x_{11} & x_{12} & \dots & x_{1n} \\ x_{21} & x_{22} & \dots & x_{2n} \\ \dots & \dots & \dots & \dots \\ x_{m1} & x_{m2} & \dots & x_{mn} \end{matrix}$$

$$X = (a_{ij}, b_{ij}, c_{ij})$$

$$W = (w_1, w_2, w_3)$$

*Step two*

Calculate the aggregate fuzzy decision matrix and compute the normalized decision matrix using the following relations:

For benefit criterion

$$r_{ij} = \left( \frac{a_{ij}}{c_j^*}, \frac{b_{ij}}{c_j^*}, \frac{c_{ij}}{c_j^*} \right)$$

Where

$$c_j^* = \max c$$

For cost criterion

$$r_{ij} = \left( \frac{a_{ij}^-}{a_{ij}^-}, \frac{a_j^-}{b_{ij}^-}, \frac{a_j^-}{c_{ij}^-} \right)$$

Where

$$a_j^- = \min a_{ij}$$

*Step three*

Determine the positive ideal (FPIS,  $A^+$ ) and negative ideal (FNIS,  $A^-$ ):

$$A^+ = (v_1^*, v_2^*, v_3^*, )$$

$$A^- = (v_1^-, v_2^-, v_3^-, )$$

The positive and negative ideas introduced by Chen (1997) are used. Thus:

$$v_j^+ = (1, 1, 1)$$

$$v_j^- = (0, 0, 0)$$

*Step four*

Calculate the sum of distances from the positive and negative for each criterion using:

$$A = (a_1, a_2, a_3), B = (b_1, b_2, b_3)$$

$$D(A, B) = \frac{1}{3} [(a_2 - a_1)^2 + (b_2 - b_1)^2 + (c_2 - c_1)^2]$$

Thus, the difference of each factor from positive and negative ideals is:

$$d_i^* = \frac{\sum_{j=1}^n d(v_{ij} - v_j^*)}{n}$$

$$d_i^- = \frac{\sum_{j=1}^n d(v_{ij} - v_j^-)}{n}$$

*Step five*

Calculate the adjacency of each factor to positive ideal or the closeness coefficient  $CC_i$

$$CC_i = \frac{d_i^-}{d_i^* + d_i^-}$$

*Step six*

Finally, the factors are ranked in descending order from  $CC_i$  i.e., factors with higher values are prioritized.

Table 2: Questionnaire's responses

| Dimension                         | Factors                                 | DM 1                     | DM 2                     | DM 3                   | DM 4                    | DM 5                    | DM 6                    | DM 7                   |
|-----------------------------------|---|--------------------------|--------------------------|------------------------|-------------------------|-------------------------|-------------------------|------------------------|
| Cost                              | Net price                               | (5, 7, 9)                | (5, 7, 9)                | (5, 7, 9)              | (5, 7, 9)               | (5, 7, 9)               | (5, 7, 9)               | (7, 9, 11)             |
|                                   | Cost reduction plan                     | (5, 7, 9)                | (5, 7, 9)                | (3, 5, 7)              | (7, 9, 11)              | (3, 5, 7)               | (5, 7, 9)               | (5, 7, 9)              |
|                                   | Warranty cost                           | (7, 9, 11)               | (7, 9, 11)               | (5, 7, 9)              | (1, 3, 5)               | (7, 9, 11)              | (5, 7, 9)               | (5, 7, 9)              |
|                                   | Operating cost                          | (7, 9, 11)               | (7, 9, 11)               | (5, 7, 9)              | (3, 5, 7)               | (3, 5, 7)               | (1, 1, 3)               | (5, 7, 9)              |
|                                   | Freight                                 | (7, 9, 11)               | (7, 9, 11)               | (3, 5, 7)              | (3, 5, 7)               | (3, 5, 7)               | (5, 7, 9)               | (5, 7, 9)              |
| Quality                           | Durability                              | (7, 9, 11)               | (7, 9, 11)               | (7, 9, 11)             | (1, 3, 5)               | (5, 7, 9)               | (7, 9, 11)              | (7, 9, 11)             |
|                                   | Conformity                              | (7, 9, 11)               | (7, 9, 11)               | (7, 9, 11)             | (5, 7, 9)               | (7, 9, 11)              | (7, 9, 11)              | (5, 7, 9)              |
|                                   | Certificate                             | (7, 9, 11)               | (7, 9, 11)               | (3, 5, 7)              | (1, 1, 3)               | (7, 9, 11)              | (7, 9, 11)              | (5, 7, 9)              |
|                                   | Design / Image                          | (7, 9, 11)               | (7, 9, 11)               | (3, 5, 7)              | (1, 1, 3)               | (3, 5, 7)               | (5, 7, 9)               | (7, 9, 11)             |
|                                   | Consistency                             | (7, 9, 11)               | (7, 9, 11)               | (1, 1, 3)              | (7, 9, 11)              | (5, 7, 9)               | (5, 7, 9)               | (5, 7, 9)              |
|                                   | SPC                                     | (7, 9, 11)               | (7, 9, 11)               | (5, 7, 9)              | (1, 3, 5)               | (7, 9, 11)              | (3, 5, 7)               | (5, 7, 9)              |
|                                   | ISO                                     | (7, 9, 11)               | (7, 9, 11)               | (3, 5, 7)              | (1, 3, 5)               | (3, 5, 7)               | (7, 9, 11)              | (3, 5, 7)              |
|                                   | Technical support<br>Responsiveness     | (7, 9, 11)<br>(7, 9, 11) | (7, 9, 11)<br>(7, 9, 11) | (3, 5, 7)<br>(5, 7, 9) | (5, 7, 9)<br>(7, 9, 11) | (7, 9, 11)<br>(5, 7, 9) | (7, 9, 11)<br>(5, 7, 9) | (5, 7, 9)<br>(5, 7, 9) |
| Service                           | Delivery                                | (7, 9, 11)               | (7, 9, 11)               | (7, 9, 11)             | (7, 9, 11)              | (7, 9, 11)              | (5, 7, 9)               | (7, 9, 11)             |
|                                   | Attitude                                | (7, 9, 11)               | (5, 7, 9)                | (5, 7, 9)              | (1, 3, 5)               | (5, 7, 9)               | (5, 7, 9)               | (5, 7, 9)              |
|                                   | Packaging ability                       | (7, 9, 11)               | (7, 9, 11)               | (5, 7, 9)              | (3, 5, 7)               | (7, 9, 11)              | (5, 7, 9)               | (5, 7, 9)              |
|                                   | Flexibility                             | (5, 7, 9)                | (7, 9, 11)               | (3, 5, 7)              | (1, 3, 5)               | (5, 7, 9)               | (5, 7, 9)               | (5, 7, 9)              |
|                                   | Warranties and claims<br>policy         | (7, 9, 11)               | (7, 9, 11)               | (5, 7, 9)              | (5, 7, 9)               | (7, 9, 11)              | (5, 7, 9)               | (5, 7, 9)              |
|                                   | Order process                           | (7, 9, 11)               | (7, 9, 11)               | (3, 5, 7)              | (5, 7, 9)               | (7, 9, 11)              | (5, 7, 9)               | (7, 9, 11)             |
|                                   | Customer service                        | (5, 7, 9)                | (7, 9, 11)               | (5, 7, 9)              | (5, 7, 9)               | (5, 7, 9)               | (5, 7, 9)               | (5, 7, 9)              |
|                                   | Geographical location<br>Repair service | (7, 9, 11)<br>(3, 5, 7)  | (5, 7, 9)<br>(7, 9, 11)  | (5, 7, 9)<br>(3, 5, 7) | (1, 3, 5)<br>(5, 7, 9)  | (7, 9, 11)<br>(5, 7, 9) | (5, 7, 9)<br>(5, 7, 9)  | (5, 7, 9)<br>(3, 5, 7) |
| Technology                        | Technical capability                    | (5, 7, 9)                | (7, 9, 11)               | (7, 9, 11)             | (3, 5, 7)               | (5, 7, 9)               | (5, 7, 9)               | (5, 7, 9)              |
|                                   | Demand capability                       | (5, 7, 9)                | (7, 9, 11)               | (5, 7, 9)              | (5, 7, 9)               | (7, 9, 11)              | (5, 7, 9)               | (5, 7, 9)              |
|                                   | Future potential                        | (5, 7, 9)                | (7, 9, 11)               | (3, 5, 7)              | (1, 3, 5)               | (7, 9, 11)              | (5, 7, 9)               | (5, 7, 9)              |
| Reliability                       | Financial position                      | (7, 9, 11)               | (7, 9, 11)               | (3, 5, 7)              | (3, 5, 7)               | (5, 7, 9)               | (5, 7, 9)               | (5, 7, 9)              |
|                                   | Impression                              | (7, 9, 11)               | (7, 9, 11)               | (3, 5, 7)              | (1, 3, 5)               | (3, 5, 7)               | (3, 5, 7)               | (5, 7, 9)              |
|                                   | Production facility and<br>capability   | (7, 9, 11)               | (7, 9, 11)               | (1, 3, 5)              | (3, 5, 7)               | (7, 9, 11)              | (7, 9, 11)              | (7, 9, 11)             |
| Time                              | Speed                                   | (7, 9, 11)               | (7, 9, 11)               | (7, 9, 11)             | (7, 9, 11)              | (7, 9, 11)              | (7, 9, 11)              | (7, 9, 11)             |
|                                   | Delivery lead-time                      | (7, 9, 11)               | (7, 9, 11)               | (5, 7, 9)              | (5, 7, 9)               | (3, 5, 7)               | (7, 9, 11)              | (5, 7, 9)              |
| Management<br>and<br>Organization | Reputation and position                 | (5, 7, 9)                | (7, 9, 11)               | (5, 7, 9)              | (1, 3, 5)               | (3, 5, 7)               | (7, 9, 11)              | (3, 5, 7)              |
|                                   | Communication system                    | (5, 7, 9)                | (7, 9, 11)               | (5, 7, 9)              | (5, 7, 9)               | (5, 7, 9)               | (5, 7, 9)               | (5, 7, 9)              |
|                                   | Business desire                         | (5, 7, 9)                | (7, 9, 11)               | (3, 5, 7)              | (1, 3, 5)               | (5, 7, 9)               | (5, 7, 9)               | (3, 5, 7)              |
|                                   | Financial strength                      | (5, 7, 9)                | (7, 9, 11)               | (3, 5, 7)              | (3, 5, 7)               | (5, 7, 9)               | (5, 7, 9)               | (5, 7, 9)              |

Table 3: Linguistic scale

| Linguistic Terms                  | Fuzzy Numbers |
|-----------------------------------|---------------|
| Extremely unimportant             | (1, 1, 3)     |
| Unimportant                       | (1, 3, 5)     |
| Neither unimportant nor important | (3, 5, 7)     |
| Important                         | (5, 7, 9)     |
| Extremely Important               | (7, 9, 11)    |

Table 4: Ranking factors' importance

| Rank | Factor                             | FNIS   | FPIS   | CCi    |
|------|------------------------------------|--------|--------|--------|
| 1    | Speed                              | 0.8421 | 0.5556 | 2.7891 |
| 2    | Demand capability                  | 1.0302 | 0.4576 | 2.6097 |
| 3    | Customer service                   | 0.5249 | 1.1205 | 2.6032 |
| 4    | Communication System               | 0.5255 | 1.1057 | 2.6032 |
| 5    | Responsiveness                     | 0.6359 | 0.8051 | 2.6030 |
| 6    | Warranties and claims policy       | 1.0768 | 0.5306 | 2.6030 |
| 7    | Conformity                         | 1.1252 | 0.3160 | 2.5503 |
| 8    | Delivery                           | 1.0371 | 0.5475 | 2.5061 |
| 9    | Technical capability               | 1.0131 | 0.5645 | 2.1332 |
| 10   | Packaging ability                  | 1.0371 | 0.5475 | 2.1331 |
| 11   | Financial position                 | 1.0371 | 0.5475 | 2.1262 |
| 12   | Technical Support                  | 1.0131 | 0.5645 | 2.1258 |
| 13   | Order process                      | 1.0819 | 0.4271 | 2.1258 |
| 14   | Net price                          | 1.0970 | 0.3244 | 2.1172 |
| 15   | Cost reduction plan                | 1.1400 | 0.3149 | 2.1121 |
| 16   | Financial strength                 | 1.0248 | 0.5555 | 2.1121 |
| 17   | Repair service                     | 1.0682 | 0.4326 | 2.0913 |
| 18   | Production facility and capability | 1.0131 | 0.5645 | 1.7774 |
| 19   | Certificate                        | 1.0970 | 0.3244 | 1.7740 |
| 20   | Consistency                        | 1.0819 | 0.4271 | 1.7740 |
| 21   | SPC                                | 1.0706 | 0.3406 | 1.7740 |
| 22   | Durability                         | 0.5249 | 1.1172 | 1.7728 |
| 23   | Attitude                           | 1.0185 | 0.4685 | 1.7660 |
| 24   | Future potential                   | 1.0551 | 0.4395 | 1.7660 |
| 25   | Design / Image                     | 1.0836 | 0.3316 | 1.7540 |
| 26   | ISO                                | 1.0248 | 0.5555 | 1.7540 |
| 27   | Flexibility                        | 1.0424 | 0.4479 | 1.7540 |
| 28   | Reputation and position            | 1.0019 | 0.5746 | 1.7540 |
| 29   | Impression                         | 1.0631 | 0.5350 | 1.7380 |
| 30   | Business Desire                    | 0.9916 | 0.3639 | 1.7380 |
| 31   | Freight                            | 0.6129 | 0.8281 | 1.4419 |
| 32   | Delivery lead-time                 | 1.0131 | 0.5645 | 1.3899 |
| 33   | Operating cost                     | 1.0706 | 0.3406 | 0.8325 |
| 34   | Geographical location              | 1.0019 | 0.5746 | 0.8175 |
| 35   | Warranty cost                      | 1.0302 | 0.4576 | 0.8133 |

#### 4. Results and Discussion

The findings of this research shown in Table 4 list the ranking of the factors influencing supplier selection among Saudi Arabia's food and beverage companies. The foremost factor, according to the respondents, is "Speed" which is the provision of the required material by the suppliers at the agreed time. Secondly, "Demand capability" is considered the second most important factor. "Customer service" and "Communication system" follow, respectively. Finally, "Responsiveness" and "Warranties and claims policy" are considered equally as the third most important factor when selecting suppliers. These five factors are considered, the most important due to intense competition posed to the companies in satisfying the customer needs in a fast and timely manner.

It is noteworthy that "Geographical location" is usually considered an important factor in other research works. Nevertheless, the "Geographical location" factor is not relevant among Saudi Arabia's food and beverage companies and this is clearly illustrated in the Food and Agriculture Organization's recent annual report, where Saudi Arabia is considered the first largest importer of barley and the 12<sup>th</sup> largest importer of sugar worldwide (Food and Agriculture Organization FAO, 2019, Annual Report).

## 5. Conclusion

To sum up, the obtained results are generally concerned with three main issues i.e., time, service, and capability. Hence, the top five factors ranked in Table 4. This crystallizes the challenges being faced on food and beverage companies in Saudi Arabia while evaluating and selecting between suppliers. In addition, the strictly reflects the nature of the food and beverage industry in Saudi market. (Marshall 1997) classified supply chain strategies into two categories, low-cost strategy, and responsive strategy. Hence, the respondents have shown that the strategy that is suitable to be incorporated in Saudi, as the highlighted criteria are concerned with speed, demand, capability, and responsiveness.

Additionally, many companies have multiple items sourced from multiple suppliers, thus, constructing multiple models for these multiple items. If this case occurs, other alternative approaches should be considered e.g., Goal Programming. Finally, the Implications of this study aims in revealing the most critical factors and assisting the food and beverage industry of Saudi Arabia for a better supplier selection process using the revealed set of ranked critical factors.

## 6. Acknowledgments

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## References

- Agarwall, G., & Vijayvargy, L. (2011). An application of supplier selection in supply chain for modeling of intangibles: A case study of multinational Food Coffee industry. *African Journal of Business Management*, 11505-11520.
- Cebi, F., & Bayraktar, D. (2003). An integrated approach for supplier selection. *Logistics Information Management*, 395-400.
- Chen, C. T. (1997). Extensions of the TOPSIS for group decision-making. *Fuzzy Sets and Systems*, 1-9.
- Cox, A. (1999). Power, value and supply chain management. *Supply Chain Management: An International Journal*, 167-175.
- Dickson, G. W. (1966). An Analysis of Vendor Selection Systems And Decisions. *Journal of Supply Chain Management*, 5-17.
- FAO. (2019). *Annual Report*. Food and Agriculture Organization FAO.
- Hwang, C. L., & Yoon, K. (1981). Methods for Multiple Attribute Decision Making. *Multiple Attribute Decision Making*, 58-191.
- Ivanov, D., Dolgui, A., Sokolo, B., & Ivanova, M. (2017). Literature review on disruption recovery in the supply chain. *International Journal of Production Research*, 6158-6174.
- Jain, V; Benyoucef, L; and Deshmukh, S.G. (2009). Strategic supplier selection: some emerging issues and challenges. *International Journal of Logistics Systems and Management*, 61-88.
- Kilic, H. S. (2013). An integrated approach for supplier selection in multi-item/multi-supplier environment. *Applied Mathematical Modelling*, 7752-7763.
- Liao, C. N., Kai Fu, Y., Cheng Chen, Y., & Liang Chih, I. (2012). Applying fuzzy-MSGP approach for supplier evaluation and selection in food industry. *African Journal of Agricultural Research*, 726-740.
- Magdalena, R. (2012). Supplier Selection for Food Industry: A Combination of Taguchi Loss Function and Fuzzy Analytical Hierarchy Process. *The Asian Journal of Technology Management*, 13-22.
- Marshall F. (1997), What is the Right Supply Chain for You?. *Harvard Business Review* 75, 105-117, 199
- Prusak, A. M., Stefanów, P., Niewczas, M., & Sikora, T. (2013). APPLICATION OF THE AHP IN EVALUATION AND SELECTION OF SUPPLIERS. *57th EOQ Congress, Quality Renaissance - Co - creating a Viable Future*, (p. 9). Talin, Estonia.
- Ren, X., & Hautuco, L. (2016). Supplier Selection Processes: A Case Study in a Chinese Dairy Company

- Shen, J. L., Tzeng , Y. L., & Liu, Y. M. (2011). The Cluster-Weighted DEMATEL with ANP Method for Supplier Selection in Food Industry. *Journal of Advanced Computational Intelligence and Intelligent Informatics*, 567-575.
- Shih Shih, H., Jyh Shyur, H., & Lee, E. S. (2007). An extension of TOPSIS for group decision making. *Mathematical and Computer Modelling*, 801-813.
- Simchi-Levi , D., Schmidt , W., Wei, Y., Zhang, P. Y., Combs , K., Ge, Y., . . . Zhang , D. (2015). Identifying Risks and Mitigating Disruptions in the Automotive Supply Chain. *Informs Journal on Applied Analytics*, 371- 484.
- Weber, C. A., Current, J. R., & Benton, W. C. (1991). Vendor selection criteria and methods. *European Journal of Operational Research*, 2-18.
- Yoon, J., Talluri, S., Yildiz, H., & Ho, W. (2018). Models for supplier selection and risk mitigation: a holistic approach. *International Journal of Production Research*, 3636-3661.
- Zadeh, L. (1965). Fuzzy Sets. *Information and Control* , 338-353.