Evaluation and Selection of the Suppliers by TOPSIS Model
(Case Study: East Azerbaijan National Gas Company)\(^1\)

Soleyman Iranzadeh\(^1\), Asghar Azarkash\(^2\)

\(^1\)Department of Industrial Management, Tabriz Branch, Islamic Azad University, Tabriz, Iran
\(^2\)M.A. of Industrial management, Tabriz Branch, Islamic Azad University, Tabriz, Iran

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ABSTRACT

Supply chain has been gained attention of the researchers and craftsmen in recent years. In today competitive world, the suppliers not only seek to improve domestic conditions but also they try to select the best markets and suppliers (according to the globalization phenomenon). Evaluation, selection and planning of the upper level and lower level members of the supply chain is important. Organizations should consider total supply chain, from providers of the primary materials to end users in order to satisfy their customers and reduce costs. Selection of the best alternatives in each of the above decision making processes requires to analysis of many factors that encounters the organization with multi dimensional decision making. The statistical population consists of the items and equipments supplier sector experts in East Azerbaijan Gas Company. In this article at first ,the important criteria in evaluation of the suppliers were determined by a questionnaire distributed among experts of the purchase sector. Then a questionnaire was designed for following four categories of the suppliers:1-common items, 2-levage items, 3-bottleneck items, 4-strategic items; The suppliers were categorized in four groups based on the criteria and TOPSIS model. Since, investigation of all the mentioned groups is impossible in this article, only the suppliers of the strategic items were graded.

KEY WORDS: supply chain, entropy, strategic items, TOPSIS

INTRODUCTION

In recent competitive world, the customers demand diverse products. The customers demanding high quality products and services leads to pressures on the suppliers and as a result the firms could not meet all needs of their customers. In this competitive market, economic and productive businesses manage and supervise the resources out of the organization. The main reason is achieving competitive advantages by the aim of more gaining shares in the market (Razmi and et al., 2006). Accordingly, activities such as demand and supply planning, preparing materials, production and planning, maintenance, inventory, distribution, delivery and customer services done in the firms previously now these affairs have been entered in demand chain scope. Selection of the supplier is a multi dimensional issue involving qualitative and quantitative criteria .For selection of the best supplier, it is necessary to trade off between contrary qualitative and quantitative criteria. When the capacity is limited, this challenge will be problematic; so that in this condition, the mangers should decide on the selection of the supplier and amount of the purchase done from one supplier. Supply chain management is a phenomenon that leads to offering reliable and rapid services in the form of qualitative products by minimum cost (Charsougi and Sahraian, 2007).

In recent competitive world, employing proper process for selection of the reliable suppliers plays an important role in success of the organizations .Selection of the best suppliers is one of the important issues in supply chain. So, application of the best model aids in reduction of the costs and enhancement of the competitive activities. One of the main duties of the purchase department is selection of the efficient suppliers. For assurance of the correct decision making in this regard, it is necessary to use proper tools. The purchase experts believe that there is no best method in this regard so, they use different and diverse evaluation and selection methods (Asgarpour, 2003).

Suppliers relationship management has been gained attention of the productive and commercial units. The organizations need to correct decision making on the suppliers for achieving the best results (Will and Wan, 2008). One of these conditions is research on the market and selection of the best suppliers. Inattention to the items and primary materials supply leads to increase the cost of purchase, quality control and quality assurance and finally customer dissatisfaction (Simichi and Kaminshk, 2009). Concerning to the issue of ranking and selection of the suppliers, necessity of the attention to several criteria, interactional relationship and concurrent effect lead to difficulty in decision making. Criteria such as received item quality cost and prize, delivery cost and other criteria are considered in selection of the effective suppliers. It is natural that solving such problems is difficult. For doing so, methods called multi criteria decision making models have been expanded. These methods aid us in selection of the beat suppliers based on the criteria (Yang and Chen, 2006).

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1- Article is taken from the M.A. thesis.

Corresponding Author: Soleyman Iranzadeh, Department of Industrial Management, Tabriz Branch, Islamic Azad University, Tabriz, Iran (Dr.Iranzadeh@yahoo.com)
Reduction of the production cost is one of the important factors in survival in the competitive markets. Selection of the best suppliers could reduce the costs significantly and increase competitiveness, since in most of the industries, the cost of the primary materials and constituents cover significant part of the product cost. In recent decade, manner of selection of the best supplier has been emphasized as a strategic factor in supply chain. Offering a decision making method for selection of the suppliers is important in supply chain.

**Strategic ranking of suppliers**

Kraljic viewpoints on the purchase management: Kraljic proposed the first decision making process for different purchase strategies in 1983. This viewpoint is based on the minimizing the supply chain and maximizing purchase power. In other words, he investigates purchase in two dimensions, there is a risk in one hand and there is purchase power in other hand. Profit and supply risk are dimensions of this matrix. The model has been designed so that in the coordinate system center, the value of both factors is minimum and the value is maximized leaving the center (Razmi and et al., 2006).

It is strategic viewpoint for purchase in different positions. This model has two dimensional perspectives that try to control the purchase condition for reaching optimal status. According to the supply risk and strategic importance and profitability of the purchased item, the final product can be observed in four conditions based on the figure (1). The strategic importance relies on the mentioned item value added related to the product, cost of the item relative to the total accost and its effect on the buyer profitability. The market complexity is related to reliability of the suppliers, level of replacing the purchased item and required technology for materials, barriers and logistic cost. Exclusive suppliers increase supply risk.

**Noncritical items:** The items that the suppliers supply them in standard way and the level of inventory and order is optimal.

**Leverage items:** The items that the buyer maneuvers in purchasing and he could purchase by bidding or replacing the purchaser item.

**Bottleneck items:** The items that experience many problems and risks. In this condition, assurance of amount, control of the supplier and inventory planning are proposed.

**Strategic items:** The items that shape strategic relationship between buyer and seller. Based on these conditions, the buyer has different alternatives in the market. In spite of passing of several years from offering this model; the famous firms like Philips, Akzo Nobel, Shell Océ and Siemens, Alcatel use this model. Boodie(1997) investigated the Polish firms and concluded that 50 percent of the purchase managers use this strategy and in firms with stuff higher than 5000 personnel use this analysis more than 85 percent (Will and Wan, 2008).

![Figure (1): Classification of items purchased by kraljic (Razmi and et al., 2006)](image-url)

**Data analysis**

In this article, the data were analyzed by TOPSIS model where matrix n*m that has m alternatives and n criteria. In this algorithm, it is assumed that any index in decision making matrix has monotonous increasing and decreasing optimality and in other words, the more value achieved by criteria in this matrix the more profit is gained and high value means high fitness and cost shows low optimality. Of advantages of this method it can be referd to concurrent using of objective and subjective indices (Wanga and et al., 2004). It is necessary to use quantitative values for the criteria for mathematical calculations. It is recommended to employ TOPSIS model where the indices and information is limited (Sonmez, 2009). For employing this model, following steps are conducted (Aktar Demirtas, and Üstün, 2005).

Step 1: formation of data matrix based on n alternatives and k indices.

\[
A_i = \begin{bmatrix}
a_{i1} & a_{i2} & \ldots & a_{in} \\
a_{i1} & a_{i2} & \ldots & a_{in} \\
\vdots & \vdots & \ddots & \vdots \\
a_{im} & a_{im} & \ldots & a_{mn}
\end{bmatrix}
\]

Step 2: standardization of the data and formation of the standard matrix by following relation:

\[
r_{ij} = \frac{a_{ij}}{\sqrt{\sum_{j=1}^{m} a_{kj}^2}}
\]

\[
A_{ij} = \begin{bmatrix}
r_{11} & r_{12} & \ldots & r_{1n} \\
r_{21} & r_{22} & \ldots & r_{2n} \\
\vdots & \vdots & \ddots & \vdots \\
r_{m1} & r_{m2} & \ldots & r_{mn}
\end{bmatrix}
\]

Step 3: determination of the indices weight \((w_i)\) based on \(\sum_{i=1}^{n} w_i = 1\). In this regard, the more important indices have high weight (Momeni, 2006).

\[
A_{ij} = \begin{bmatrix}
w_1 r_{11} & w_2 r_{12} & \ldots & w_n r_{1n} \\
w_1 r_{21} & w_2 r_{22} & \ldots & w_n r_{2n} \\
\vdots & \vdots & \ddots & \vdots \\
w_1 r_{m1} & w_2 r_{m2} & \ldots & w_n r_{mn}
\end{bmatrix}
\]

Step 4: determination of ith distance of alternative from ideal alternative (highest index performance) that is shown by \(A^{+}\).

\[
A^{+} = \left\{ \max_{j \in J} v_{ij} \right\} \left\{ \min_{j \in J} v_{ij} \right\}
A^{+} = \left\{ v_1^{+}, v_2^{+}, \ldots, v_n^{+} \right\}
\]

Step 5: determination of ith distance of minimum alternative (lowest index performance) that is shown by \(A^{-}\).

\[
A^{-} = \left\{ \min_{j \in J} v_{ij} \right\} \left\{ \max_{j \in J} v_{ij} \right\}
A^{-} = \left\{ v_1^{-}, v_2^{-}, \ldots, v_n^{-} \right\}
\]

Step 6: determination of the interval criterion for ideal alternative \(S^{+}_i\) and minimum alternative \(S^{-}_i\).
Step 7: determination of the coefficient equals to distance of minimum alternative $(S_i^-)$ divided on the sum of the minimum alternatives $(S_i^-)$ and ideal alternative $(S_i^*)$ that it is shown by $(C_i^*)$ and it is calculated by following relation [5,2]:

$$C_i^* = \frac{S_i^-}{S_i^- + S_i^*}$$

Step 8: The alternatives are graded based on $C_i^*$ and this value is changed between $0 \leq C_i^* \leq 1$. In this regard, $C_i^* = 1$ indicates the highest grade and $C_i^* = 0$ depicts the lowest grade (Azar and Rajab Zadeh, 2001).

**Ranking of East Azerbaijan gas company suppliers**

- **a-** specification of the alternatives (investigation on the items, machineries and suppliers groups in order to identification of the alternatives in the selection of the best suppliers)

  Any issue is considered regarding selection of the best alternatives and ranking of the options. In the issue of selection of the best suppliers, the important element is firms supplying items and equipments. This research investigates the performance of the suppliers in the strategic items. It is avoided to mention the name of the suppliers due to confidentiality of the information so, the experts were asked to codify the suppliers.

- **b- Evaluation criteria of Gas company suppliers**

  The following criteria were proposed based on the theoretical foundation and meeting with experts of the Gas Company products supply sector:

  **Table (1): Criteria for the evaluation and ranking of East Azerbaijan gas suppliers**

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Row</th>
<th>Criteria</th>
<th>Row</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td>6</td>
<td>Quality</td>
<td>1</td>
</tr>
<tr>
<td>Technical capability</td>
<td>7</td>
<td>Flexibility in pricing</td>
<td>2</td>
</tr>
<tr>
<td>Services</td>
<td>8</td>
<td>Reliability of delivery</td>
<td>3</td>
</tr>
<tr>
<td>Promotional activities and incentive</td>
<td>9</td>
<td>Guarantee and warranty</td>
<td>4</td>
</tr>
<tr>
<td>Cooperation in transport</td>
<td>10</td>
<td>Easy Returns</td>
<td>5</td>
</tr>
</tbody>
</table>

- **c- Decision making matrix by the aid of the experts**

  After determination of the alternatives and criteria, it is necessary to prepare decision making matrix by the collaboration of the supply experts. Decision making matrix involves alternatives and criteria used for alternatives ranking. For doing so, a questionnaire consists of the name of the suppliers of each item group and evaluation of their performance. The respondents were asked to score the suppliers according to criteria. The score of each supplier equals to geometrical mean achieved by observing the criteria. The final score in each cell of the matrix is obtained by mean of the scores determined by the experts. Following tables depict decision making final matrix for strategic items suppliers.

  **Table (2): Matrix of Strategic Decision for Suppliers Group items**

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Options</th>
<th>Location</th>
<th>Promotional activities and incentive</th>
<th>Technical capability</th>
<th>Services</th>
<th>Cooperation in transport</th>
<th>Quality</th>
<th>Flexibility in pricing</th>
<th>Reliability of delivery</th>
<th>Guarantee and warranty</th>
<th>Easy Returns</th>
</tr>
</thead>
<tbody>
<tr>
<td>Code-4410</td>
<td>7</td>
<td>1</td>
<td>7</td>
<td>7</td>
<td>5</td>
<td>3</td>
<td>9</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>Code-4411</td>
<td>5</td>
<td>3</td>
<td>7</td>
<td>7</td>
<td>3</td>
<td>7</td>
<td>5</td>
<td>7</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Code-4412</td>
<td>3</td>
<td>1</td>
<td>7</td>
<td>7</td>
<td>5</td>
<td>9</td>
<td>5</td>
<td>9</td>
<td>7</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>Code-4413</td>
<td>7</td>
<td>3</td>
<td>9</td>
<td>5</td>
<td>5</td>
<td>7</td>
<td>5</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>5</td>
</tr>
<tr>
<td>Code-4414</td>
<td>9</td>
<td>5</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>5</td>
<td>9</td>
<td>9</td>
<td>7</td>
<td>7</td>
<td>7</td>
</tr>
</tbody>
</table>
d- Implementation of the model and specification of the best alternatives
In this part, East Azerbaijan Gas company suppliers are graded based on TOPSIS model (in strategic items).

**Strategic items Group supplier ranking models using TOPSIS**

Step one: conversion of scaled up matrix is done on the matrix of table 2 by using formula \( r_{ij} = \frac{a_{ij}}{\sqrt{\sum_{k=1}^{m} a_{kj}^2}} \). Table 3 depicts scaled up matrix:

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Location</th>
<th>Promotional activities and incentive</th>
<th>Technical capability</th>
<th>Services</th>
<th>Cooperation in transport</th>
<th>Quality</th>
<th>Flexibility in pricing</th>
<th>Reliability of delivery</th>
<th>Guarantee and warranty</th>
<th>Easy Returns</th>
</tr>
</thead>
<tbody>
<tr>
<td>Code-4410</td>
<td>0.0254</td>
<td>0.0469</td>
<td>0.0382</td>
<td>0.04612</td>
<td>0.04931</td>
<td>0.0312</td>
<td>0.03376</td>
<td>0.0384</td>
<td>0.1364</td>
<td>0.04532</td>
</tr>
<tr>
<td>Code-4411</td>
<td>0.04193</td>
<td>0.03184</td>
<td>0.0386</td>
<td>0.03296</td>
<td>0.03835</td>
<td>0.03056</td>
<td>0.04725</td>
<td>0.0389</td>
<td>0.4081</td>
<td>0.3642</td>
</tr>
<tr>
<td>Code-4412</td>
<td>0.02562</td>
<td>0.04562</td>
<td>0.04931</td>
<td>0.03294</td>
<td>0.04931</td>
<td>0.05096</td>
<td>0.04726</td>
<td>0.0389</td>
<td>0.1362</td>
<td>0.1948</td>
</tr>
<tr>
<td>Code-4413</td>
<td>0.04197</td>
<td>0.04461</td>
<td>0.03834</td>
<td>0.03297</td>
<td>0.03839</td>
<td>0.05097</td>
<td>0.03376</td>
<td>0.04992</td>
<td>0.4087</td>
<td>0.4534</td>
</tr>
<tr>
<td>Code-4414</td>
<td>0.05871</td>
<td>0.04463</td>
<td>0.04937</td>
<td>0.05941</td>
<td>0.02745</td>
<td>0.07134</td>
<td>0.04721</td>
<td>0.03881</td>
<td>0.6804</td>
<td>0.5837</td>
</tr>
<tr>
<td>Code-4415</td>
<td>0.04193</td>
<td>0.03189</td>
<td>0.01642</td>
<td>0.03298</td>
<td>0.03836</td>
<td>0.03059</td>
<td>0.03378</td>
<td>0.0386</td>
<td>0.4086</td>
<td>0.3241</td>
</tr>
</tbody>
</table>

Step two: calculation of the harmonic scaled up matrix (V):
For doing so it is necessary to weight the indices. At first, the indices weight is calculated by Shannon entropy. These weights are as follows:

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Location</th>
<th>Promotional activities and incentive</th>
<th>Technical capability</th>
<th>Services</th>
<th>Cooperation in transport</th>
<th>Quality</th>
<th>Flexibility in pricing</th>
<th>Reliability of delivery</th>
<th>Guarantee and warranty</th>
<th>Easy Returns</th>
</tr>
</thead>
<tbody>
<tr>
<td>( E_J )</td>
<td>0.0849</td>
<td>0.0892</td>
<td>0.0956</td>
<td>0.0948</td>
<td>0.0992</td>
<td>0.0965</td>
<td>0.0947</td>
<td>0.0945</td>
<td>0.0956</td>
<td>0.0938</td>
</tr>
<tr>
<td>( D_J )</td>
<td>0.106</td>
<td>0.108</td>
<td>0.044</td>
<td>0.052</td>
<td>0.073</td>
<td>0.035</td>
<td>0.053</td>
<td>0.055</td>
<td>0.044</td>
<td>0.062</td>
</tr>
<tr>
<td>( W_J )</td>
<td>0.168</td>
<td>0.170</td>
<td>0.069</td>
<td>0.082</td>
<td>0.015</td>
<td>0.055</td>
<td>0.084</td>
<td>0.087</td>
<td>0.069</td>
<td>0.098</td>
</tr>
</tbody>
</table>

Now the harmonic scaled up matrix is calculated. For doing so, the scaled up matrix is multiplied in square (\( W_n \times n \)) that its main elements are indices and the other elements are zero.

Table 5 depicts matrix (V):

\( V = N \times W_n \times n \)
Step three: specification of the positive ideal solution and negative ideal solution:
Ideal amount of negative and positive decision for this position are as follows:

\[ A^+ = \left( \max_{j \in J} v_{ij} \right) \left( \min_{j \in J} v_{ij} \right) \]
\[ A^- = \left( \min_{j \in J} v_{ij} \right) \left( \max_{j \in J} v_{ij} \right) \]

Tables 6 and 7 show the positive ideal solution and negative ideal solution for suppliers:

**Table (6): positive ideal solution strategic Suppliers Group items**

<table>
<thead>
<tr>
<th>vi</th>
<th>V1</th>
<th>V2</th>
<th>V3</th>
<th>V4</th>
<th>V5</th>
<th>V6</th>
<th>V7</th>
<th>V8</th>
<th>V9</th>
<th>V10</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00425</td>
<td>0.00312</td>
<td>0.00342</td>
<td>0.00285</td>
<td>0.00321</td>
<td>0.00335</td>
<td>0.00365</td>
<td>0.00365</td>
<td>0.00365</td>
<td>0.00321</td>
<td>0.00296</td>
</tr>
</tbody>
</table>

**Table (7): Negative Ideal Solutions Group suppliers of strategic items**

<table>
<thead>
<tr>
<th>vi</th>
<th>V1</th>
<th>V2</th>
<th>V3</th>
<th>V4</th>
<th>V5</th>
<th>V6</th>
<th>V7</th>
<th>V8</th>
<th>V9</th>
<th>V10</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00237</td>
<td>0.00214</td>
<td>0.00231</td>
<td>0.00218</td>
<td>0.00248</td>
<td>0.00231</td>
<td>0.00184</td>
<td>0.00145</td>
<td>0.00169</td>
<td>0.00147</td>
<td></td>
</tr>
</tbody>
</table>

Step four: calculation of the intervals
To obtain the ideal distance between the positive and negative of each option, the following formula is used:

\[ S_i^+ = \sqrt{\sum_{j=1}^{n} \left( v_{ij}^+ - v_i^+ \right)^2} \]
\[ S_i^- = \sqrt{\sum_{j=1}^{n} \left( v_{ij}^- - v_i^- \right)^2} \]

Table (8) shows the interval of all suppliers from positive to negative ideal:

**Table (8): distance between the positive and negative ideal**

<table>
<thead>
<tr>
<th>Suppliers</th>
<th>Distance from the positive ideal solution (( S_i^+ ))</th>
<th>Distance from the negative ideal solution (( S_i^- ))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Code-4410</td>
<td>0.009756</td>
<td>0.003365</td>
</tr>
<tr>
<td>Code-4411</td>
<td>0.003547</td>
<td>0.002315</td>
</tr>
<tr>
<td>Code-4412</td>
<td>0.002748</td>
<td>0.000142</td>
</tr>
<tr>
<td>Code-4413</td>
<td>0.002143</td>
<td>0.000152</td>
</tr>
<tr>
<td>Code-4414</td>
<td>0.003465</td>
<td>0.001215</td>
</tr>
<tr>
<td>Code-4415</td>
<td>0.001245</td>
<td>0.002847</td>
</tr>
</tbody>
</table>

Step five: Calculation of the relative closeness of each alternative to the ideal solution:
At this point, the relative closeness of each alternative to the ideal solution are calculated. To do this, the following formula is used:

\[ 0 \leq C_i^* \leq 1 \]
\[ C_i^* = \frac{S_i^-}{S_i^- + S_i^+} \]

The CL, is between zero and one. This value is much closer to a solution that is closer to the ideal solution and the solution is better. Table 9 shows the relative closeness to the ideal suppliers:

**Table (9): the relative closeness to the ideal options**

<table>
<thead>
<tr>
<th>Suppliers</th>
<th>( C_i^* )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Code-4410</td>
<td>0.2564</td>
</tr>
<tr>
<td>Code-4411</td>
<td>0.3949</td>
</tr>
</tbody>
</table>
Step Six: ranking of alternatives:
According to the CL values, the alternatives can be graded as follows (Table 10):

<table>
<thead>
<tr>
<th>Suppliers</th>
<th>C^*_i</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Code-4415</td>
<td>0.6957</td>
<td>1</td>
</tr>
<tr>
<td>Code-4413</td>
<td>0.5975</td>
<td>2</td>
</tr>
<tr>
<td>Code-4411</td>
<td>0.3949</td>
<td>3</td>
</tr>
<tr>
<td>Code-4414</td>
<td>0.2591</td>
<td>4</td>
</tr>
<tr>
<td>Code-4410</td>
<td>0.2564</td>
<td>5</td>
</tr>
<tr>
<td>Code-4412</td>
<td>0.0491</td>
<td>6</td>
</tr>
</tbody>
</table>

Conclusions and recommendations
In this paper, the evaluation and selection of East Azerbaijan Gas company suppliers were conducted by using TOPSIS method based on the ranking criteria and theoretical foundation and interview with the experts and the degree of importance of each item was determined. Based on the results, criteria such as price with a weight of 86, the quality by the weight 88, and the guaranty of the product by weight 82 were most important ranking suppliers and criteria such as communications and information, past performance, financial condition and packaging requirements were less important than any other gas suppliers ranking criteria.

According to the results obtained from the model of TOPSIS, in the group of strategic suppliers items, the relative closeness to the ideal (C^*_i) for the firms is shown by code-4415 (0.6957), code-4413 (0.5975), code-4411 (0.3949) that indicate the company's performance is compared to other suppliers. Indicators such as relative closeness to the ideal suppliers, code-4410 (0.2564), code-4412 (0.0491) depict the relative performance of these firms that it is weaker in comparison to other suppliers.

It is recommended to:
- Study of supply chain activities for the coming years in addition to considering the results of this paper, taking necessary and effective steps to improve the qualitative and quantitative criteria to evaluate and rank the suppliers.
- An independent unit of suppliers to be established in Department of Commerce.
- All the information in the form of evaluating suppliers includes information management, personnel, production, etc. Once identified any new supplier is collected and recorded. Obviously the old supplier information collected should be reviewed and should be recorded in a database.
- Use this system, as a decision making tool for improving of the decisions of the selection and systematizing of the process in commercial unit.
- Results of the study showed that the algorithm of TOPSIS, is a powerful model for the alternatives by simulating the ideal answer.

REFERENCES