A strategic model for selecting the location of furniture factories: a case of the study of furniture

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Abstract: Selecting the best place for a factory among some proposed locations based on various indices is a decision-making multi-criteria issue. This issue is one of the most critical steps in establishing the factory since the results of this decision will have economically, socially, environmentally and technologically significant effects in the long-run. Selecting the most appropriate provinces for establishing new manufacturing units of wooden furniture in Iran is the purpose of this study. Effective indicators in the location of the furniture industry were identified and a hierarchy was constructed based on five major groups of criteria. The weight of the indicators was then established by analytical hierarchy process. The amounts of the indicators with regard to alternatives were obtained from factories in public and private sectors. These weights were employed in TOPSIS to rank the alternatives. Finally, the potential provinces were identified according to the priorities obtained by this technique. The results indicated that Qom, Tehran and Razavi Khorasan provinces were the best priorities for establishing furniture industry plants.

Keywords: analytic hierarchy process; AHP; technique for order-preference by similarity to ideal solution; TOPSIS; multicriteria decision making; priority; alternative; criteria; fuzzy; benefit; cost; deterministic; linguistic; province; furniture.
1 Introduction

Location is one of the industrial engineering sciences that its consideration prior to the establishment of production unit will cause efficient use of materials, cost reduction, fair services to customers, taking the largest market and finally, achieving strategic and competitive advantages compared to other competitors (Forghani and Pourebrahim 2008). In any country, some provinces and regions in terms of having facilities, basic infrastructures and market opportunities to create a specific industry are superior to other regions and based on this premise we should try to identify, prioritise and select advantageous provinces based on scientific and accurate methods to construct a desired manufacturing unit. In this study, the research question is as follows: where are the higher priority locations to establish furniture units regarding capacities of the provinces in Iran? Accordingly, the purpose is to find the location and recognise talented provinces of the country for the establishment of wooden furniture manufacturing units using a fuzzy decision-making and based on this, the issue of the location of new manufacturing furniture units based on provincial divisions is studied.

Furniture industry has 2% of world trade share and this amount is increasing in the future (Furniture Exporters Organization, 2009). Iran has only 0.02% of world trade share otherwise from each 10,000 furniture which is exported only two furniture belongs to Iran. The market demand necessitates more factories to be established.

Burdurlu and Edjer (2003) used analytic hierarchy process (AHP) approach for making decisions about selecting the best location for establishing furniture manufacturing factory in Turkey and based on indices such as urban population (market size), population growth rate, ease of product transportation to other areas introduced the
city of Istanbul as the most suitable location for the construction of new units for manufacturing furniture.

Studies on site selection for wood production by Michael et al. (1998) identified a number of factors affecting the selection decision. They clustered the criteria into cost, market distribution, lower production cost and non-tangible factors. McCauley and Caulfield (1990) specified the effective criteria for selecting an oriented strand board (OSB) factory and developed a mixed integer programming model to determine the optimal location of the OSB sites. The factors affecting this model include access to raw material, transportation costs, access to suitable manpower, factory capacity, cost of production, profitability, market observations and investment-requirements. Lin et al. (1996) presented a computerised model for determining the optimal location and size of OSB plants. They considered the continuous supply of the raw material and economic productivity beside other factors. Azizi (2008) used AHP and ANP to determine effective criteria for location selection of wood industry units, and its development in Iran. He introduced Kurdistan Province as the highest priority to set the factory. Mohebbi et al. (2010) used AHP method to locate kiln wood drying and evaluation of effective criteria in Iran. Azizi et al. (2011a) presented a model to determine investments priorities in wood and paper industries of Qom Province. They applied AHP and technique for order-preference by similarity to ideal solution (TOPSIS) to evaluate weighing values of the criteria and ranking the industries.

The results showed that the other types of wood furniture industries have the highest priority. Eichenberg et al. (2011) presented an application of analytic hierarchic process technique in helping a decision making process of a young and small company that developed and currently make use of new mobile technology for the heat treatment of wooden packaging and pallets. The decision process comprised choosing the best combination of location to place the company’s three operation bases. The AHP was able to provide relevant inputs, by incorporating other factors beyond the purely financial view in its analysis. The factors involved, their hierarchical structure and relative weights, were generated in consensus by the company’s managers and executives’ opinion. Salgado et al. (2011) applied AHP to prioritise activities of new products development (NPD) in manufacturing companies of electronic products. An industrial cluster located in Brazilian Southeast was studied. This way, ten out of 42 activities from an NPD model were suggested to be excluded for the electronic companies. These activities have less than 0.5% overall priorities. The results from AHP application were welcomed by companies NPD experts. Azizi (2005) presented a strategic model for location selection of wood industry by AHP and TOPSIS methods. Effective indicators in the location of the industry were identified and a hierarchy was constructed based on five major groups of criteria. The weights of the indicators were then established by analytical hierarchy process. These weights were employed in TOPSIS to rank the alternatives. Finally, the potential provinces were identified according to the priorities obtained by this technique. The results showed that Kurdistan Province, has the best priorities for the establishment of wood industry plants.

Selecting a particular plant location is an important issue when the attributes of the location are conflicting in nature and consist of units that cannot be compared. A proposed holistic approach of the multiple criteria decision making methodology makes it possible to select the optimal plant location that fits best for the investor. The methodology presented in this research provides a strong decision support system to plant site selection problem (Bhattacharya et al., 2004).
Horri and Aliahmadi (1998) investigated the location selection of Iran leather industry and reminded that due to the existence of quantity criteria in leather industry location it prefers to use TOPSIS as decision making method. In this paper, effective criteria of location selection have been divided in benefits and costs. Closeness to raw material regions criteria had the highest priority and the desirable alternative has been obtained.

2 Modelling the selection problem

The modelling consists of two main stages. In the first stage an AHP (Saaty, 2000) model is constructed to evaluate the importance of the criteria and the second stage then employs the TOPSIS method to rank the alternatives.

2.1 First stage

In order to analyse the candidate locations and identify the most preferred ones, the initial step is to identify the criteria. A comprehensive list of factors was prepared and a questionnaire was designed to evaluate their contribution in decision process in the case of Iran. This questionnaire was distributed among experts in some Iranian furniture factories. The final set of the attributes was concluded via a Delphi method. A hierarchy of these factors was constructed to establish their weights, using AHP. The pair-wise comparison matrices were completed by 20 experts from industry and academia. The individual judgements were directed towards consistency and the aggregated opinion was derived using TEAM-EC 2000. Figure 1 shows the hierarchy structure of the attributes influencing decision on the selection of sites for furniture factories.

Figure 1 The hierarchy of criteria and sub-criteria
Below, the attributes used in the model are detailed under the criteria of: economics; material and product; infrastructure (environmental); human; and rules and regulations.

1 Economical criteria

This group of criteria consists of the following sub-criteria:

1.1 Costs:

1.1.1 Cost of transportation of the raw material: Cost of transportation of raw material from supplying resources and offering them to the manufacturing plant.

1.1.2 Cost of procuring raw material: Cost of procuring each cubic meter of wood, fittings from their supplying sources to the end product.

1.1.3 Cost of transportation of products: Cost of each round of transportation of final products to the sales market.

1.1.4 Manpower costs: Average monthly wages of manpower employed in the manufacturing plants.

1.1.5 Price of land: Average price of each square meter of land in the region, for constructing a factory.

1.2 Income:

This criterion covers the facilities and aids, granted by the government to the manufacturing plants located in a specific region in the form of loan and tax exemptions for establishing a factory.

2 Material and product criteria

Material and product criterion contains required raw material on one hand and factory end product on the other hand. Meanwhile their properties can be effective in the location selection of a factory.

2.1 Raw material

The required raw material for furniture factories includes round-cut forest wood, fittings and composite products. In this respect, reliability sub-criteria covers supply, distance from raw material, quality of raw material and quantity of raw material.

2.1.1 Confidence in supply: Rate of confidence for accessibility to raw material in the region or continuation of the material in future.

2.1.2 Distance from raw material: The distance between the region and the place where raw material is supplied including the distance between the region and forests (existing supply distance). In cases part of the raw material is supplied from foreign resources we must know the distance from country’s importing point to the factory (supply distance in future).

2.1.3 Quality of raw material: Quality of the raw material in furniture industry is of great importance and we must ensure that high class materials be used.
2.1.4 **Quantity of raw material:** One part of the material can be supplied from inside the region and the other part is supplied from outside the region. This division leads to emphasise those regions which have potential to supply raw material.

2.2 **Final product:**

Final products of the manufacturing plants include plate furniture and wooden furniture. Regarding final product, the amount of sales and distance from sales market are of great importance.

2.2.1 **Amount of sale:** Amount of product that can be sold in target markets and in the region where the factory is located.

2.2.2 **Distance from market:** Distance of the region from the place or places where the products are consumed or sold. This criterion is divided into two sub-criteria:

- 2.2.2.1 local market distance
- 2.2.2.2 border market distance.

3 **Infrastructure (environmental) criteria**

In each region, factors like transportation network, how the competitive industries face the construction of new manufacturing plants, industrial background and the possibility to absorb investment in the region to establish manufacturing plants are considered as infrastructure criteria.

3.1 **Transportation network**

The number, distance and type of roads, highways and railroads which existing in the region.

3.2 **Competitors**

The amount of resistance by competitive industries in the region in the construction of furniture plants

3.3 **Background of Industry**

Background of the region in terms of existence of similar manufacturing plants. This criterion is divided into four criteria which are as follows: energy, services, lateral industries and trade conditions.

- 3.3.1 **Energy:** In any region, existence of water, electricity and fuel are important criteria for constructing a factory.

- 3.3.2 **Services:** Access to services.

- 3.3.3 **Lateral industries:** Existence of similar industries.

- 3.3.4 **Trade condition:** Good business climate.

3.4 **Capital absorption**

Region’s potential in terms of absorption of capital or local facilities which make the investor interested in building furniture factories.
4 Human criteria

Means supplying required manpower and access to specialised and experienced manpower in the region. Training the manpower, employee welfare facilities and technical knowledge of the manpower are sub-criteria for manpower. This section is divided in three sub-criteria:

4.1 Training: Technical and vocational training centre or schools, research centres and similar institutes are needed to train manpower.

4.2 Skilled man force: Information and technical experience in furniture industry will improve the quality and quantity of products.

4.3 Facilities: Health and welfare facilities such as housing, recreational places, telecommunications and education centres, and hospitals will help to attract experienced manpower to the region.

5 Rules and regulations criteria

By this criterion we mean those current state regulations governing tax on industries and distance of factory from cities.

5.1 Tax rate

Tax on manufacturing plants is imposed based on the percentage of factory profit. In some parts of country, some factories are exempted from government tax in order to offer incentives for investment and help the industry (Davani, 1999).

5.2 Limit of permissible distance

To avoid concentration of industries and air pollution problems, government has set a limit for cities where factories cannot be established. Outside that limit, manufacturing plants can be built. Table 1 shows the weighing value of the 25 attributes influencing decision on the selection of sites for furniture industry.

Table 1 Weighing values of the criteria

<table>
<thead>
<tr>
<th>Row</th>
<th>Name of criteria</th>
<th>Form of data</th>
<th>Kind of criteria</th>
<th>Weight of criteria</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Procuring raw material</td>
<td>Fuzzy</td>
<td>Cost</td>
<td>0.123</td>
<td>Purchase of raw material (Rials/M3)</td>
</tr>
<tr>
<td>2</td>
<td>Transportation cost of raw material</td>
<td>Fuzzy</td>
<td>Cost</td>
<td>0.027</td>
<td>Transportation cost of raw material (Rials)</td>
</tr>
<tr>
<td>3</td>
<td>Manpower cost</td>
<td>Fuzzy</td>
<td>Cost</td>
<td>0.064</td>
<td>Manpower cost (Rials/Person)</td>
</tr>
<tr>
<td>4</td>
<td>Transportation cost of product</td>
<td>Fuzzy</td>
<td>Cost</td>
<td>0.041</td>
<td>Transportation cost of product (Rials)</td>
</tr>
<tr>
<td>5</td>
<td>Price of land</td>
<td>Fuzzy</td>
<td>Cost</td>
<td>0.061</td>
<td>Price of land (Rials/M2)</td>
</tr>
<tr>
<td>6</td>
<td>Granted facilities</td>
<td>Fuzzy</td>
<td>Benefit</td>
<td>0.088</td>
<td>Granted facilities by government</td>
</tr>
<tr>
<td>Row</td>
<td>Name of criteria</td>
<td>Form of data</td>
<td>Kind of criteria</td>
<td>Weight of criteria</td>
<td>Description</td>
</tr>
<tr>
<td>-----</td>
<td>------------------</td>
<td>--------------</td>
<td>-----------------</td>
<td>-------------------</td>
<td>-------------</td>
</tr>
<tr>
<td>7</td>
<td>Confidence in supply</td>
<td>Fuzzy</td>
<td>Benefit</td>
<td>0.013</td>
<td>Confidence in supply</td>
</tr>
<tr>
<td>8</td>
<td>Quality of raw material</td>
<td>Fuzzy</td>
<td>Benefit</td>
<td>0.023</td>
<td>Quality of raw material</td>
</tr>
<tr>
<td>9</td>
<td>Quantity of raw material</td>
<td>Fuzzy</td>
<td>Benefit</td>
<td>0.006</td>
<td>Quantity of raw material (inside the region, M3)</td>
</tr>
<tr>
<td>10</td>
<td>Distance from raw material</td>
<td>Fuzzy</td>
<td>Cost</td>
<td>0.004</td>
<td>Supply distance (present, kilometre)</td>
</tr>
<tr>
<td>11</td>
<td>amount of sale</td>
<td>Fuzzy</td>
<td>Benefit</td>
<td>0.186</td>
<td>Sale amount of product (M3)</td>
</tr>
<tr>
<td>12</td>
<td>Local market distance</td>
<td>Fuzzy</td>
<td>Cost</td>
<td>0.038</td>
<td>Distance from local markets (kilometre)</td>
</tr>
<tr>
<td>13</td>
<td>Border market distance</td>
<td>Fuzzy</td>
<td>Cost</td>
<td>0.006</td>
<td>Distance from border markets (kilometre)</td>
</tr>
<tr>
<td>14</td>
<td>Capital absorption</td>
<td>Fuzzy</td>
<td>Benefit</td>
<td>0.017</td>
<td>Capital absorption</td>
</tr>
<tr>
<td>15</td>
<td>Transportation network</td>
<td>Fuzzy</td>
<td>Benefit</td>
<td>0.039</td>
<td>Transportation network (highway, road, rail)</td>
</tr>
<tr>
<td>16</td>
<td>Lateral industries</td>
<td>Fuzzy</td>
<td>Benefit</td>
<td>0.024</td>
<td>Presence of lateral industries</td>
</tr>
<tr>
<td>17</td>
<td>Competitors</td>
<td>Fuzzy</td>
<td>Cost</td>
<td>0.045</td>
<td>Presence of competitors</td>
</tr>
<tr>
<td>18</td>
<td>Energy</td>
<td>Fuzzy</td>
<td>Benefit</td>
<td>0.035</td>
<td>Energy (water, electricity)</td>
</tr>
<tr>
<td>19</td>
<td>Facilities</td>
<td>Fuzzy</td>
<td>Benefit</td>
<td>0.018</td>
<td>Welfare facilities</td>
</tr>
<tr>
<td>20</td>
<td>Trade condition</td>
<td>Fuzzy</td>
<td>Benefit</td>
<td>0.016</td>
<td>Good business climate</td>
</tr>
<tr>
<td>21</td>
<td>Skilled man force</td>
<td>Fuzzy</td>
<td>Benefit</td>
<td>0.065</td>
<td>Access to skilled man force</td>
</tr>
<tr>
<td>22</td>
<td>service s</td>
<td>Deterministic</td>
<td>Benefit</td>
<td>0.008</td>
<td>Presence of service centres</td>
</tr>
<tr>
<td>23</td>
<td>Tax rate</td>
<td>Fuzzy</td>
<td>Cost</td>
<td>0.028</td>
<td>Tax rate</td>
</tr>
<tr>
<td>24</td>
<td>Limit distance</td>
<td>Deterministic</td>
<td>Cost</td>
<td>0.015</td>
<td>Limit of permissible distance (kilometre)</td>
</tr>
<tr>
<td>25</td>
<td>Training</td>
<td>Deterministic</td>
<td>Benefit</td>
<td>0.013</td>
<td>Training centres in the region</td>
</tr>
</tbody>
</table>
2.2 Second stage

In the second stage, TOPSIS method has been applied. TOPSIS method works based on the concept that the best alternative should have the shortest distance from the ideal solution and the farthest from the negative ideal solution. The final advantage of each alternative is because of its relative proximity to positive ideal response (Hwang and Yoon, 1981). Algorithm of TOPSIS is as follows:

The TOPSIS method evaluates the following decision matrix which contains m alternatives associated with n attributes (or criteria) (Hwang and Yoon, 1981):

\[
D = \begin{bmatrix}
X_1 & X_2 & \ldots & X_j & \ldots & X_n \\
A_1 & X_{11} & X_{12} & \ldots & X_{1j} & \ldots & X_{1n} \\
A_2 & X_{21} & X_{22} & \ldots & X_{2j} & \ldots & X_{2n} \\
\vdots & \vdots & \vdots & \ddots & \vdots & \ddots & \vdots \\
A_m & X_{m1} & X_{m2} & \ldots & X_{mj} & \ldots & X_{mn}
\end{bmatrix}
\]

where

- \( A_j \) the \( j^{th} \) alternative considered
- \( x_{ij} \) the numerical outcome of the \( j^{th} \) alternative with respect to the \( j^{th} \) criterion.

TOPSIS assumes that each attribute in the decision matrix takes either monotonically increasing or monotonically decreasing utility. For the sake of simplicity the proposed method will be presented as a series of successive steps.

Step 1  **Constructing the normalised decision matrix:** An element \( r_{ij} \) of the normalised decision matrix \( R \) can be calculated as:

\[
r_{ij} = \frac{X_{ij}}{\sqrt{\sum_{j=1}^{n} X_{ij}^2}}
\]

Step 2  **Constructing the weighted normalised decision matrix:** A set of weights is applied to the decision matrix in this step as:

\[
w = \left( w_1, w_2, \ldots, w_j, \ldots, w_n \right), \sum_{j=1}^{n} w_j = 1.
\]

This matrix can be calculated by multiplying each column of the matrix \( R \) with its associated weight \( w_j \). Therefore, the weighted normalised decision matrix \( V \) equals to:
Step 3 *Determining ideal and negative ideal solutions:* Let the two artificial alternatives $A^*$ and $\overline{A}$ be defined as:

$$A^* = \left\{ \left( \max V_j | j \in J \right), \left( \min V_j | j \in J \right) \right\} = \left\{ V^*_1, V^*_2, ..., V^*_j, ..., V^*_n \right\}$$

$$A = \left\{ \left( \max V_j | j \in J \right), \left( \min V_j | j \in J \right) \right\} = \left\{ V^-_1, V^-_2, ..., V^-_j, ..., V^-_n \right\}$$

where $J = \{ j = 1, 2, ..., n \}$ is associated with benefit criteria and $J' = \{ j = 1, 2, ..., n \}$ is associated with cost criteria. Then it is certain that the two created alternatives, $A^*$ and $\overline{A}$, indicate the most preferable alternative (ideal solution) and the least preferable alternative (negative ideal solution), respectively.

Step 4 *Calculating the separation measure:* The separation between each alternative and the ideal alternative can be measured by $n$-dimensional Euclidean distance. The separation of each alternative from the ideal one is then given by:

$$S_i^* = \sqrt{\sum_{j=1}^{n} \left( v_{ij} - v^*_{ij} \right)^2}, i = 1, 2, ..., m$$

Similarly, the separation from the negative ideal one is given by:

$$\overline{S}_i = \sqrt{\sum_{j=1}^{n} \left( v_{ij} - \overline{v}_{ij} \right)^2}, i = 1, 2, ..., m$$

Step 5 *Calculating the relative closeness to the ideal solution:* The relative closeness of $A_i$ with respect to $A^*$ is defined as:

$$C_i = \frac{S_i}{S_i^* + \overline{S}_i}; 0 < C_i < 1; i = 1, 2, ..., m$$

It is clear that $c_i = 1$ if $A_i = A^*$ and $c_i = 0$ if $A_i = \overline{A}$. As $c_i$ approaches 1, the alternative $A_i$ gets closer to $A^*$. 

$$\begin{bmatrix} V_{11} & V_{12} & ... & V_{1j} & ... & V_{1n} \\ ... & ... & ... & ... & ... & ... \\ V_{i1} & V_{i2} & ... & V_{ij} & ... & V_{in} \\ ... & ... & ... & ... & ... & ... \\ V_{m1} & V_{m2} & ... & V_{mj} & ... & V_{mn} \end{bmatrix}$$

Equation (3)
Step 6  Ranking the preference order: A set of alternative can now be preference ranked according to the decreasing order of $c_i$. However, we do not use ranked alternatives in our approach and the value of relative closeness is enough to continue the procedure.

The data for the attributes were collected from the alternative locations where have desirable capability in establishing furniture factory. For this, the questionnaires were presented to the managers of the neighbouring factories. Then the fuzzy decision making (FDM) (Memariani, 2000) software was used to rank the location because the data for certain attributes were either qualitative or imprecise. This software is based on the fuzzy version of TOPSIS. It incorporates besides quantitative information, the imprecise (fuzzy numbers) and qualitative (linguistic) data. Figure 2 shows the description of the problem in FDM.

Figure 2  Description of the problem in FDM

The software is also capable of generating detailed description and analysis of the decision problem in an intelligent report form. The weights are calculated as follows:

The questionnaires of the data for the attributes were distributed to the selected locations and then collected as the source of information. Some of the data were linguistic type while others were deterministic. Some kinds of attributes were divided into cost or benefits, depending on being considered as desirable or undesirable by the decision makers (Table 1). For applying FDM software, the linguistic data were converted to fuzzy data (Table 2). A sample of the attributes is shown in Figure 3.

The trapezoid fuzzy data is in the form of $m_1$, $m_2$, $\alpha$, $\beta$, where $m_1$ means a lesser approximate value, $m_2$ a more approximate one, $\alpha$ the left tolerance of $m_1$, and $\beta$ represents the right tolerance of $m_2$. A sample of the data entry and its matrix in FDM software is shown in Figure 4. This results in a matrix of $25 \times 15$ in the present research.
Table 2  The conversion of linguistic data to fuzzy data

<table>
<thead>
<tr>
<th>Deterministic</th>
<th>Fuzzy data ((m_1, m_2, \alpha, \beta))</th>
<th>Linguistic data</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.75</td>
<td>0, 0.1, 0, 0.1</td>
<td>Very low</td>
</tr>
<tr>
<td>0.2</td>
<td>0.2, 0.2, 0.1, 0.1</td>
<td>Low</td>
</tr>
<tr>
<td>0.35</td>
<td>0.3, 0.4, 0.1, 0.1</td>
<td>Fairly low</td>
</tr>
<tr>
<td>0.5</td>
<td>0.5, 0.5, 0.1, 0.1</td>
<td>Average</td>
</tr>
<tr>
<td>0.65</td>
<td>0.6, 0.7, 0.1, 0.1</td>
<td>Fairly high</td>
</tr>
<tr>
<td>0.8</td>
<td>0.8, 0.8, 0.1, 0.1</td>
<td>High</td>
</tr>
<tr>
<td>0.925</td>
<td>0.9, 1, 0.1, 0</td>
<td>Vary high</td>
</tr>
</tbody>
</table>

Figure 3  Description of the criteria in FDM (a sample)

In the next step, the fuzzy numbers are converted into real numbers using defuzzification methods. Then, the matrices are normalised to do away with dimensions of indicators and their coefficients are multiplied by the related vector. We can obtain the radius value of any alternatives in an \(n\) dimensional space (where \(n\) means the number of indicators) by finding ideally positive and negative solutions.
3 Results

Fifteen location candidates were ranked using FDM software and the ranking result is presented in Table 3. Also, results of weighing values of criteria and sub-criteria have been shown in Figures 5 and 6, respectively.

Table 3 Ranking of alternative locations

<table>
<thead>
<tr>
<th>Score</th>
<th>Province</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Qom</td>
<td>67/73</td>
</tr>
<tr>
<td>2</td>
<td>Tehran</td>
<td>75/69</td>
</tr>
<tr>
<td>3</td>
<td>Razavi Khorasan</td>
<td>63/66</td>
</tr>
<tr>
<td>4</td>
<td>Mazandaran</td>
<td>59/63</td>
</tr>
<tr>
<td>5</td>
<td>Isfahan</td>
<td>45/61</td>
</tr>
<tr>
<td>6</td>
<td>Eastern Azerbaijan</td>
<td>32/60</td>
</tr>
<tr>
<td>7</td>
<td>Golestan</td>
<td>20/57</td>
</tr>
<tr>
<td>8</td>
<td>Gilan</td>
<td>89/56</td>
</tr>
<tr>
<td>9</td>
<td>Zanjan</td>
<td>78/55</td>
</tr>
<tr>
<td>10</td>
<td>Semnan</td>
<td>50/54</td>
</tr>
<tr>
<td>11</td>
<td>Western Azerbaijan</td>
<td>54/52</td>
</tr>
<tr>
<td>12</td>
<td>Hamedan</td>
<td>09/51</td>
</tr>
<tr>
<td>13</td>
<td>Fars</td>
<td>30/46</td>
</tr>
<tr>
<td>14</td>
<td>Ardabil</td>
<td>65/45</td>
</tr>
<tr>
<td>15</td>
<td>Khuzestan</td>
<td>88/25</td>
</tr>
</tbody>
</table>
4 Discussion

In the present study, in order to recognise the higher priority locations to establish furniture units regarding capacities of the provinces, we studied some criteria and their sub-criteria and obtained their weighing values by AHP after that the ranking of the provinces were done by TOPSIS.

The 25 criteria and 15 provinces as location candidates for establishing wooden furniture units were ranked using Expert Choice and FDM softwares respectively and the ranking results are presented in Figures 5 to 6 and Table 3. In this part, we analyse results of criteria, sub-criteria and alternatives.
4.1 Weight value of the main indices

Weight value indices which influence the selection of the location of constructing wooden furniture manufacturing units in Iran (Figure 5) show that three indices including ‘economic’, ‘materials and products’ and ‘infrastructure’ indices are respectively considered as the most effective parameters in selecting the factory location. These results are discussed and conclusions are as follows:

4.1.1 ‘Economic index’

The results of previous research indicates that according to decentralised structure and the competitive furniture industry (US Department of Commerce, 1985), economic factors (financial – cost) are always considered as the most significant basis of the decisions of investors and managers of furniture manufacturing units and manufacturing strategy developments and marketing. Here, it should be noted that the major presence of small and medium enterprises (SMEs) in the furniture industry, especially in Iran (Ratnasingam, 1999) and very low power liquidity of these units has put the possibility of easier access to cheaper and achievable financial resources and also particular attention to the costs of raw materials, labour and unemployed forces as three components of finalised cost of the material as the focus of investors and managers in the industry (Ratnasingam, 1999). Therefore, placing economic indicators in the position of the most influential factor on selecting the location of the establishment of a furniture manufacturing unit is quite logical and assessable according to natural structure of this industry.

4.1.2 ‘Materials and products index’

Generally, based on the type of furniture, 48 to 55% of the finalised cost of a unit consists of the cost of raw materials (Ratnasingam, 1999). On the other hand, many researchers have accentuated the critical importance of area, capacity and structure of the ‘market’ of the product on a growth and survival of a manufacturing unit. Accordingly, determining materials and product factor (which contains the material properties and volume indices and the distance from the product market to place of the unit), as the second index influencing the choice of the location of the establishment of a furniture manufacturing unit is consistent with key factors affecting the furniture production and supply chain.

4.1.3 ‘Infrastructure index’

Today, the ‘value network’ and ‘supply network’ are key concepts in the field of strategic marketing. These concepts after early theorisation by Michael Porter in 1985 and during the process of the development have become the dominant discourse in the field of strategic management industry. Based on the concepts of ‘value network’ and ‘supply network’, birth, growth and survival of a company are tied to something more than the company’s internal strengths and weaknesses. Quality and quantity of communications of companies or suppliers of goods and services needed by companies, consumers that receive goods and services produced by companies and finally, union and non-union competitors form the company network or system of communication with its surroundings will affect all steps of the quality of the establishment, growth and maturity (or decline) of the company. Therefore, the network of roads and transportation systems,
energy suppliers, ancillary industries that supply materials and equipment and services required, and the monetary system of competing firms that basically form the infrastructure for an industrial unit in a region, in fact they are considered value networks that the industrial unit in action and reaction, and interact with it determines its success or failure. It is by adopting such an approach that choosing ‘infrastructures’ as the third index influencing the location of the establishment of a wooden furniture manufacturing units is considered as a correct approach and consistent with the principles of industrial economy.

4.2 Weight-value effective ‘sub-criteria’

‘Market size’ (0.186): In general, regardless of industry and product type, the presence and possibility of access (close) to the market (demand) are considered as necessary conditions for establishing a production unit (Kotler and Keller, 2009). Accordingly, non-existence, small size, weakness in tension and finally, being away from the market will cancel the philosophical and the economic justification for any unit or service. In interpreting the importance of special reasons for market size and proximity to it for creating a manufacturing furniture unit, the following ones can be mentioned (Alishahi, 2008; Ziaie, 2009).

4.2.1 Lack of development of furniture supply and distribution network in the country

Lack of up to date supply and sales networks on the national scale and as a result, the formation of the huge costs of ownership or lease for furniture fairs around the country have caused that a major proportion of the profits from the furniture manufacturing value chain be concentrated and swallowed in the supply and sale centres. However, due to high transport costs, access to low-volume consuming markets and scattered around the country is considered costly and without appropriate economic justification. Accordingly, based on the producers’ bottlenecks in face with the supply and sales department, establishing furniture manufacturing units in the closest possible point to the large consumer markets can be considered as the best solution in achieving greater part of the excess value of production (profit). Focusing much of furniture manufacturing units near the biggest industrial cities in the country is evidence to prove this trend.

4.2.2 Complete dependence on the domestic market and lack of access to foreign markets

Lack of a suitable position in export markets and as a result, the furniture industry’s full dependence on the domestic market is another factor that causes investors in the furniture industry to focus on factor being closed to major consumption markets.

4.2.3 Small-scale production and lack of financial capacity for the accumulation of the product

Expensiveness and limited financial resources in the country prevent the formation and accumulation of production potentiality and accumulation based on anticipating the market future needs in manufacturing units. So, it is obvious that manufacturing units try
to spend their limited cash ability to up to date manufacturing by being more close to large markets based on the urgent need of target markets. Burdurlu and Ejder (2003) introduced market size (the amount of population) as an effective factor in selecting the location of Turkey furniture factory.

‘Procuring raw material’ (0.123): Generally, according to the studies conducted by Ratnasingam (1999), among the four cost factors in furniture industry, including materials, labour, equipment and overhead costs, purchasing raw material and labour have the highest share of finalised cost of production per unit of furniture, respectively. Therefore, it seems perfectly logical and axiomatic that the quality of access to raw material with an affordable cost was considered as an important factor in profit margins on products and financial and operational performance of a furniture unit and has a decisive influence on the choice of location for the factory to be established. Michael et al. (1998) introduced the cost of buying raw materials as an important factor in finding the location of factories for secondary wood products. In their studies, Azizi et al. (2002, 2011b) identified the index of the cost of buying raw materials as indicators of high priority in positioning the plywood and MDF industry.

‘Granted facilities’ (0.088): to interpret the importance of this index, two of the following can be considered:

1 Note that in general, investment in the furniture industry has been done by the private sector, usually the amount of this investment for the private sector is not considered as a heavy domestic power, however, due to the unstable economic policies, investment risk in the country’s manufacturing sector is higher than international standards, most of the investors prefer to enjoy banking facilities while strengthening the economic power of manufacturing unit; they try to share the risk of their investment with the government and have a high bargaining power against the government agencies in times of crisis.

2 As principally the furniture production and sales cycle is considered as a long-term process and as the cycle of financial operations of this industry is generally credential and time consuming, money resources, cheap liquidity or low-interest banking facilities are considered as decisive factors that if a furniture manufacturing unit accesses it that unit will have production and good competition power. However, it should be noted that considering this indicator for investors before choosing the location of industrial factory is useful and causes development in furniture industry in the underdeveloped regions of the country. Therefore, the importance of this index in selecting the location of establishing furniture manufacturing unit after the market indices of volume and cost of raw material seems perfectly reasonable and acceptable. Hosun et al. (2003) argues that granted facilities have an important role in selecting the location of industrial units.

‘Skilled and specialised workforce’ (0.065): Furniture manufacturing units are essentially around in two main branches of manufacturing units with a focus on technology (large or industrial manufacturers that around the machinery and equipment modern manufacturing follow the strategy of mass-produced product) and manufacturing units with a focus on skilled workforce (small and medium scale producers who generally follow the strategy of a project in a limited number of copies as workshop and based on skilled workforce). Meanwhile, according to the existing statistics and documents, the vast majority of furniture manufacturing units in Iran are considered as the second type.
Primarily, lack of development in three sectors: distribution and supply, presence in global markets and monetary resources will lead the approach of establishing new furniture manufacturing units to create medium and small units with a focus on a skilled workforce and less investment. Boone and Van (1996) argue that taking advantage of a skilled workforce, while reducing the costs of education, plays a significant role in reducing waste production, improving quality of products and ultimately increasing competitive advantage of the manufacturing unit in long-term. In the present study, although the area of furniture manufacturing unit has not been defined as a variable, the ranking of the importance of skilled labour and also, labour costs compared to other indices show the place of medium and small units in the centre of decision-making to establish a manufacturing unit. Accordingly, in this study, we cannot consider the size of manufacturing unit as an influential variable.

4.4 Prioritisation of provinces based on influencing indices

As it was presented in Table 3, the provinces of Qom, Tehran, Razavi Khorasan and Mazandaran are among the main priorities for future investment and establishment of wooden furniture manufacturing units. Based on the indicators defined in the first stage of this research as the main variables in the process of selecting the site of establishing factory, analysis is presented below.

4.4.1 Qom Province

There is no doubt that at the first glance, variables such as population, marriage rate, growth rate of construction industry and most importantly, market size as variables affecting the furniture industry and the three indicators of economic conditions, materials and infrastructure in Qom, put the selection of this province as the most attractive place to establish the wooden furniture manufacturing units out of the expected limitations. However, with a realistic look at this phenomenon, it can be found that not only Qom Province is as the closest province to the country’s largest furniture market, but also due to enjoying infrastructures such as having good communication between Qom and Tehran, large number of industrial estates equipped with a small distance to Tehran, and finally extensive facilities to attract investment, in practice, it has become the largest industrial town closed to Tehran Province. At the same time, law enforcement complies with 120 km distance to the capital of the country for the establishment of industrial units also should be considered as a very important factor in the incidence of this condition. With this considerations, selecting Qom Province as an exciting option for establishing a furniture manufacturing unit seems reasonable and justifiable select the desired qualities of Qom.

4.4.2 Tehran Province

The majority of desirable criteria and indicators, especially the huge consumer market of furniture in the vast capital of Iran does not leave any doubt that different parts of the province have very high potential for establishing a furniture manufacturing unit. However, the high price of land and legal restrictions as negative factors reduced the magnitude of the utility. On the contrary, it is not deniable that even with the obstacles
described the attractions of this province, particularly in terms of market size and infrastructure, is not negligible for any investment.

4.4.3 Razavi Khorasan Province

Razavi Khorasan Province is considered as the second overpopulated provinces of the country that until recently, in the position of the widest province of the country played the central role of both North and South Khorasan provinces. As one of the large industrial poles besides having a large consumer market, this province is considered as the main export terminal to Central Asia and Afghanistan. In addition, high economic indicators and industrial infrastructure in this province have confirmed a high potential for this region to establish furniture manufacturing units.

4.4.4 Mazandaran Province

Regarding economic and industrial infrastructure, Mazandaran Province is not like high-ranking provinces of the country; nevertheless, the position of the province as a main domestic source for Iran wood supply is quite evident. In addition, Mazandaran is important timber terminal to Iran which is done mainly from Russia. Therefore, the province has the potentiality of one of the most talented provinces to be considered to establish the wooden furniture manufacturing units.

5 Conclusions

The present study aimed to recognise talented provinces of Iran in the field of selecting appropriate places for wooden furniture industries. Iran wooden furniture needs development and an increase in world trade share; accordingly it necessitates more wooden furniture units to be established. Contributions of the current research were all wooden furniture managers and experts of the neighbouring factories fulfilling questionnaires of the first and second stages. Limitation of the research was inconsistency ratio of the comparison matrices used to obtain weighing values of the criteria in the first stage. An important advantage of AHP over other algorithmic methods is that it takes into account inconsistencies in the preferences. Inconsistencies exist due to the redundant information related to the priorities in each decision matrix. If the inconsistency exceeds 0.10, some revisions of judgements may be required. When the inconsistency ratios are below 10%, the decision matrices prepared for the criteria are consistent. The quality of the output of the AHP is strictly related to the consistency of the pair-wise comparison judgements. In the first stage, an extensive list of criteria and sub-criteria which affects the location selection of Iran wooden furniture factories was prepared and concluded using Delphi method, then five major groups of criteria including economics; material and product; infrastructure (environmental); human; and rules and regulations and their sub-criteria were identified and a hierarchy was constructed applying AHP method and Expert Choice software 2000. After designing the questionnaire and distributing them among the experts, weighing values of criteria and sub-criteria were obtained. In the second stage, to rank the alternatives, the questionnaire was prepared based on the data which were linguistic and deterministic types also they were divided into cost or benefit regarding decision makers opinions, next TOPSIS method and FDM software were
applied. Results revealed that among 15 provinces, Qom Province has the highest priority
to establish wooden furniture industry units due to closeness to the country’s largest
furniture market and enjoying infrastructures such as having good communication with
capital city, large number of industrial estates equipped with a small distance to Tehran,
and finally extensive facilities to attract investment. Tehran, Razavi Khorasan and
Mazandaran as second, third and fourth provinces have higher priorities for the
establishment of wooden furniture industry plants because of the huge consumer market
of furniture, and the main export terminal to the neighbour countries and the main
domestic source for Iran wood supply, respectively. For future investigation, it is
suggested that a study be conducted to determine the type of technology with respect to
the cost of human resources and also employment generation. Further study is
recommended to establish a relation capable of determining the size and capacity of each
unit with respect to the availability of raw material and market demand.

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Appendix 1

Questionnaire I (distributed between 20 experts): Comparison of effective criteria and
sub criteria in location selection of Wood furniture units by AHP: (a sample).

Table A1 Comparison of the criteria in level 1

<table>
<thead>
<tr>
<th>Criteria 2</th>
<th>Raw material and product</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw material and product</td>
<td></td>
</tr>
<tr>
<td>Infrastructure</td>
<td></td>
</tr>
<tr>
<td>Technical</td>
<td></td>
</tr>
<tr>
<td>Economical</td>
<td></td>
</tr>
<tr>
<td>Rules</td>
<td>Criteria 1</td>
</tr>
</tbody>
</table>

Diagram: A strategic model for selecting the location of furniture factories
Table A2  Comparison of the criteria in level 2

<table>
<thead>
<tr>
<th>Criteria 2</th>
<th>Criteria 1</th>
</tr>
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<tbody>
<tr>
<td>Product</td>
<td>Raw material</td>
</tr>
<tr>
<td>Raw material</td>
<td>Product</td>
</tr>
</tbody>
</table>

Table A3  Comparison of the criteria in level 3

<table>
<thead>
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<th>Criteria 2</th>
<th>Criteria 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance from</td>
<td>Quantity raw material</td>
</tr>
<tr>
<td>raw material</td>
<td>Confidence in supply</td>
</tr>
<tr>
<td>Quality of raw material</td>
<td>Quantity raw material</td>
</tr>
<tr>
<td>Confidence in supply</td>
<td>Confidence in supply</td>
</tr>
<tr>
<td>Quantity raw material</td>
<td>Quality of raw material</td>
</tr>
<tr>
<td>Distance from raw material</td>
<td>Distance from raw material</td>
</tr>
</tbody>
</table>

Appendix 2

Questionnaire 2  (distributed between managers of the neighbouring factories and 15 province): Gathering linguistic and deterministic data of the criteria with respect to the provinces by TOPSIS: (a sample)

1  How much is confidence rate in supply in your province? (Linguistic data)

<table>
<thead>
<tr>
<th>Average</th>
<th>Fairly low</th>
<th>Low</th>
<th>Very low</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Very high</td>
<td>High</td>
<td>Fairly high</td>
<td></td>
</tr>
</tbody>
</table>

2  How much is distance of raw material supply from your province (per kilometre)? (Deterministic data)