# Identification of Factors Affecting Production Costs and their Prioritization based on MCDM (case study: manufacturing Company)

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**Abstract:** In this paper, factors that can reduce the production costs are identified. Then these factors are localized for an industrial factory and their significance and dependencies are identified using the questionnaire and view point collection of managers, experts and practitioners of the Company. To prioritize identified cost factors, a hybrid approach based on fuzzy dematel approach and fuzzy analytic network process was proposed. Fuzzy dematel approach is used to extract the relationships between the main cost-related factors and their sub factors. The outputs of fuzzy Dematel method are used for super matrix formation in fuzzy network analysis. In fuzzy network analysis method, a Super matrix is applied by using paired comparisons and considering the interaction between the main cost-related factors and their relevant sub factors. Then the weights of factors and their cost-related sub factors are determined by the corresponding computational procedures. The output of fuzzy network analysis is the final weights of the main cost-related factors and their cost-related sub factors. In the end, based on the calculated final weights, we prioritize the cost factors.

**Keywords:** cost reduction factors, cost management, dematel fuzzy, fuzzy network analysis, and prioritization.

## 1. Introduction

Generally, activities of each institutes consists of a series of works such as design, production, marketing, delivery and after-sales service that each of them have different costs. Various combinations of these costs reflect the internal cost structure of the organization (Ansari, 1997) (Maher, 1994) (Moradi, 2013). Any company can choose a way to cut costs according to its situation and control and reduce their costs by implementation of these ways. Today, cost management is highly regarded by managers of organizations. In this way, even competitor analyzes their opponent costs. In today's global economy, manufacturing and services enterprises and institutions need to be armed with the strategies and mechanisms of production costs of services and goods with competitive prices to have the ability to respond quickly to opportunities and survive. There are several methods to reduce costs. But before any action, cost factors identification is necessary. These costs and activities begin from the research and development phase and continue until delivery and after sales service. In other words, the activities and costs include activities and costs of before production, activity and costs of production time and activities and cost after production that the agencies and production companies are facing with (Goudarzi, 2003) (Ravi, 2005).

In recent years, there have been changes in the business environment that cause dramatic changes in cost management and its importance. These changes include environmental changes, increased global competition, advances in information technology and manufacturing, new economic system, focusing on customers, management restructuring, and corporate governance and changes in social, political and cultural environment. One of the main goals in this area can be identifications of factors affecting

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production costs and prioritization of these noted factors affecting production costs. According to another study by Mirghorbani (2012), two factors have been proposed for the reduction of the cost-of the company. A) When we want to reduce our costs through saving resources. In this category, we're looking to produce the same value or greater value with fewer resources. In fact, we are looking to increase productivity and B) when we're looking to cut costs through cheaper sources, i.e. the amount of resources we use with cheaper price. For example, we'll use the same amount of drug or the dressing materials in the hospital but looking into how to get cheaper supplies.

Another important headlines that must be considered in the process of implementing cost reduction strategies in the organization can be optimal use of all the capacities, production and service and applying the proper management of maintenance of all equipment in the companies (Mirbagheri, 2012) and (Berk, 2010). Rezaeian et al. (2004) examined the methods and factors that can reduce the cost of manufacturing companies in the automotive industry. Management of energy costs and waste of other resources, waste reduction management organizational, raw materials and components resources, quality improvement, process improvement and services promotion to increase the speed, accuracy and meet the needs of clients and customers, process theory to organizational structure through re-engineering approach , more concentration on information systems and information flow within the organization in order to the speed enhancement, and being careful in the making decisions of organization were among the factors that the researchers found in their study (Ostadi, 2013) (Shank, 1993).

In some studies, the identification of cost factors in organizations and companies were discussed. For example, a study conducted by Ostadi et al. (2013) on forging industry, the cost factors has been identified. Direct labor costs, raw material costs, costs of production line, energy expenditure, cutting operational costs were factors with the most significance. In another study conducted by Mirghorbani (2012), cost factors in an organization or a company were classified generally into several categories. These costs were related to the costs involved in the process of producing a product or providing a service since its formation until its delivery to customers. These costs include: The cost of the initial activities, production operations, distribution and international transportation, sales and marketing service. In another category, the charge on industrial and manufacturing companies are listed as follows (Berk, 2010) Costs of labor, materials, process improvement, and design were among of these factors. This thesis seeks to identify factors that can reduce the cost of organizations, especially manufacturing organizations. To identify factors that significantly reduce the cost, the literature and experts' opinions were used. After the identification of the factors that can reduce the cost, we prioritize these factors by using the techniques of MCDM in the form of a case study of manufacturing company . In this thesis, due to uncertainties in the data, the fuzzy concepts can be exploited to model data uncertainty. MCDM method is used to prioritize cost reduction factors in the case study on the manufacturing company.

## 2. Research methodology

This study is a descriptive-case and objective study. In this study, more intended measures choose for qualitative requirements prioritization. Since many of the qualitative measures of performance are qualitative, for data collection the experts' opinions were used. In order to gather their opinions, the questionnaire was used as a research tool. Two questionnaires related to ANP and DEMATEL requirements were used in the study. This questionnaire is designed based on paired comparisons. ANP questionnaire is used to measure the importance of the cost criteria (the main cost-related factors) and cost sub-criteria (cost-related sub factors) in the prioritization process and the relationships between the factors and sub factors were determined by DEMATEL questionnaire (Wei &Yu, 2007) (Uzunovic et al, 2000)
Factors influencing production costs are provided for use of MCDM methods by some adjustments. Studied manufacturing company includes 400 employees & for doing this research we use 10 experts

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opinion. CFCS method is used for calculation of non-fuzzy decision results. For preferences pricing and ranking, paired comparisons matrix was used.

### 3. Data Analysis

Based on the measures of Table 1, the following numerical values replace the linguistic variables of the effects of factors on each other and the following table is achieved.

**Table 1: the numerical value of an expert's opinion based on fuzzy measures**

| | Net costs | Storage costs | Production costs | Quality control cost | Engineering cost | Cost Guaranteed | Subscribe cost |
|---|---|---|---|---|---|---|---|
| **Net costs** | (0,0,0.25) | (0.25,0.5,0.75) | (0.75,1,1) | (0.25,0.5,0.75) | (0,0,0.25) | (0,0,0.25) | (0,0.25,0.5) |
| **Storage costs** | (0.25,0.5,0.75) | (0,0,0.25) | (0,0,0.25) | (0.25,0.5,0.75) | (0,0,0.25) | (0,0.25,0.5) | (0,0,0.25) |
| **Production costs** | (0.75,1,1) | (0,0.25,0.5) | (0,0,0.25) | (0.75,1,1) | (0.5,0.75,1) | (0.5,0.75,1) | (0.5,0.75,1) |
| **Quality control cost** | (0.25,0.5,0.75) | (0,0,0.25) | (0.25,0.5,0.75) | (0,0,0.25) | (0,0,0.25) | (0,0,0.25) | (0.25,0.5,0.75) |
| **Engineering cost** | (0,0.25,0.5) | (0,0,0.25) | (0.5,0.75,1) | (0.5,0.75,1) | (0,0,0.25) | (0,0.25,0.5) | (0.5,0.75,1) |
| **Cost Guaranteed** | (0.25,0.5,0.75) | (0,0.25,0.5) | (0.25,0.5,0.75) | (0.25,0.5,0.75) | (0.5,0.75,1) | (0,0,0.25) | (0.5,0.75,1) |
| **Subscribe cost** | (0.5,0.75,1) | (0.5,0.75,1) | (0.5,0.75,1) | (0.5,0.75,1) | (0.5,0.75,1) | (0.5,0.75,1) | (0,0,0.25) |

Similarly, the initial fuzzy relation matrix is obtained for nine other experts. The initial fuzzy relation matrix that is the aggregation of opinions of ten of experts is calculated based on the arithmetic mean (Yang et al, 2008). After this stage a 21 × 7 matrix is obtained and becomes non phase by using fuzzy dematel method. The step by step results of these relations (absolute values) are shown in Table 2.

**Table 2: The final absolute value**

| | Net costs | Storage costs | Production costs | Quality control cost | Engineering cost | Cost Guaranteed | Subscribe cost |
|---|---|---|---|---|---|---|---|
| **Net costs** | 0.0343 | 0.7879 | 0.6689 | 0.6283 | 0.5582 | 0.5153 | 0.6045 |
| **Storage costs** | 0.4675 | 0.0343 | 0.4196 | 0.4145 | 0.3100 | 0.4145 | 0.3749 |
| **Production costs** | 0.7657 | 0.6293 | 0.0343 | 0.7672 | 0.5897 | 0.5631 | 0.6012 |
| **Quality control cost** | 0.3556 | 0.3556 | 0.4905 | 0.0343 | 0.4675 | 0.3556 | 0.4905 |
| **Engineering cost** | 0.3509 | 0.2587 | 0.4145 | 0.4430 | 0.0343 | 0.3670 | 0.4430 |
| **Cost Guaranteed** | 0.4905 | 0.5095 | 0.5325 | 0.5095 | 0.5380 | 0.0343 | 0.5380 |
| **Subscribe cost** | 0.3268 | 0.4011 | 0.3707 | 0.3707 | 0.4190 | 0.3491 | 0.0343 |

#### 3.1. Determination of the main cost-related factors

Determination of the internal weighting of main cost factor was done by using fuzzy Dematel method. Using the data in Table 2 and the following equations, the normalized direct relation matrix were obtained based on the data in Table 3. Matrix x (i.e. the normalized matrix) is direct relation matrix and $\mathbf{I}$ is the identity matrix.

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$$s = \min\{1/max_{1\le i\le n}\sum_{j=1}^{n} z_{ij}, 1/max_{1\le j\le n}\sum_{i=1}^{n} z_{ij}\}\ ,\ \ i,j = 1,2,\dots,n$$

$$\boldsymbol{T} = \boldsymbol{X}(\boldsymbol{I}-\boldsymbol{X})^{-1}$$

**Table 3: The normalized direct relation matrix**

| | Net costs | Storage costs | Production costs | Quality control cost | Engineering cost | Cost Guaranteed | Subscribe cost |
|---|---|---|---|---|---|---|---|
| **Net costs** | 0.0087 | 0.1994 | 0.1693 | 0.1591 | 0.1413 | 0.1304 | 0.1530 |
| **Storage costs** | 0.1183 | 0.0087 | 0.1062 | 0.1049 | 0.0785 | 0.1049 | 0.0949 |
| **Production costs** | 0.1938 | 0.1593 | 0.0087 | 0.1942 | 0.1493 | 0.1425 | 0.1522 |
| **Quality control cost** | 0.0900 | 0.0900 | 0.1242 | 0.0087 | 0.1183 | 0.0900 | 0.1242 |
| **Engineering cost** | 0.0888 | 0.0655 | 0.1049 | 0.1121 | 0.0087 | 0.0929 | 0.1121 |
| **Cost Guaranteed** | 0.1242 | 0.1290 | 0.1348 | 0.1290 | 0.1362 | 0.0087 | 0.1362 |
| **Subscribe cost** | 0.0827 | 0.1015 | 0.0938 | 0.0938 | 0.1061 | 0.0884 | 0.0087 |

Normalized value of direct relation matrix can be used as an estimate of the direct relationship between the weights of the main cost-related factors in ANP super-matrix. The normalized value of T that is obtained by dividing each value by the sum of the column is gathered in the table below.

| | Net costs | Storage costs | Production costs | Quality control cost | Engineering cost | Cost Guaranteed | Subscribe cost |
|---|---|---|---|---|---|---|---|
| **Net costs** | 0.1412 | 0.1983 | 0.1901 | 0.1840 | 0.1821 | 0.1842 | 0.1832 |
| **Storage costs** | 0.1340 | 0.0974 | 0.1287 | 0.1260 | 0.1205 | 0.1322 | 0.1238 |
| **Production costs** | 0.2052 | 0.1930 | 0.1468 | 0.1990 | 0.1905 | 0.1935 | 0.1890 |
| **Quality control cost** | 0.1275 | 0.1253 | 0.1357 | 0.0990 | 0.1346 | 0.1293 | 0.1342 |
| **Engineering cost** | 0.1188 | 0.1102 | 0.1223 | 0.1221 | 0.0915 | 0.1222 | 0.1230 |
| **Cost Guaranteed** | 0.1584 | 0.1573 | 0.1595 | 0.1551 | 0.1602 | 0.1200 | 0.1580 |
| **Subscribe cost** | 0.1149 | 0.1185 | 0.1168 | 0.1148 | 0.1207 | 0.1186 | 0.0888 |

### 3.2. Determination of internal weights of the cost-related sub factors

Similarly, the computation process could be done for the sub factors of each main cost-related factors and their internal weighting computation. In the following tables this calculation is done for all cost-related sub factors. In each of these tables, the internal weight of the sub factors and the values of D, R, D + R, D-R is provided. It should be noted that the normalized matrix of T obtained by division of each column value with the sum of each column value, show the internal weight of the cost-related sub factors. These values are used in the preparation of super matrix in fuzzy network analysis.

**Table 5: The internal weight of the sub factors of net costs and the D, R, D+R, D-R values**

| | | | | | D | R | D+R | D-R |
|---|---|---|---|---|---|---|---|---|
| **C11** | 0.2464 | 0.2818 | 0.2902 | 0.2886 | 6.1277 | 5.1603 | 11.2879 | 0.9674 |
| **C12** | 0.2021 | 0.1724 | 0.2029 | 0.1991 | 4.2796 | 5.8334 | 10.1130 | -1.5538 |
| **C13** | 0.2958 | 0.2928 | 0.2516 | 0.2948 | 6.2723 | 5.4416 | 11.7139 | 0.8308 |
| **C14** | 0.2557 | 0.2530 | 0.2553 | 0.2175 | 5.4151 | 5.6594 | 11.0745 | -0.2444 |

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**Table 6: The internal weight of the sub factors of storage costs and the D, R, D+R, D-R values**

| | | | | | D | R | D+R | D-R |
|---|---|---|---|---|---|---|---|---|
| **C21** | 0.2508 | 0.2689 | 0.2677 | 0.2673 | 14.3870 | 13.6907 | 28.0778 | 0.6963 |
| **C22** | 0.2362 | 0.2233 | 0.2408 | 0.2374 | 12.7792 | 14.3765 | 27.1557 | -1.5973 |
| **C23** | 0.2582 | 0.2642 | 0.2453 | 0.2621 | 14.0482 | 13.6138 | 27.6621 | 0.4344 |
| **C24** | 0.2549 | 0.2436 | 0.2463 | 0.2332 | 13.3490 | 12.8825 | 26.2315 | 0.4665 |

**Table 7: The internal weight of the sub factors of production costs and the D, R, D+R, D-R values**

| | | | | | | | D | R | D+R | D-R |
|---|---|---|---|---|---|---|---|---|---|---|
| **C31** | 0.1193 | 0.1329 | 0.1368 | 0.1526 | 0.1437 | 0.1557 | 2.9541 | 2.8420 | 5.7961 | 0.1121 |
| **C32** | 0.1883 | 0.1626 | 0.2093 | 0.2020 | 0.2101 | 0.2027 | 4.1107 | 3.2515 | 7.3622 | 0.8591 |
| **C33** | 0.1775 | 0.1973 | 0.1489 | 0.1869 | 0.1875 | 0.1814 | 3.7734 | 3.1987 | 6.9721 | 0.5747 |
| **C34** | 0.1714 | 0.1477 | 0.1449 | 0.1196 | 0.1421 | 0.1570 | 3.0350 | 4.2230 | 7.2580 | -1.1879 |
| **C35** | 0.1326 | 0.1364 | 0.1349 | 0.1283 | 0.1054 | 0.1326 | 2.6639 | 3.9597 | 6.6236 | -1.2958 |
| **C36** | 0.2108 | 0.2231 | 0.2252 | 0.2106 | 0.2111 | 0.1706 | 4.3520 | 3.4143 | 7.7663 | 0.9377 |

**Table 8: The internal weight of the sub factors of quality control cost costs and the D, R, D+R, D-R values**

| | | | | | | | D | R | D+R | D-R |
|---|---|---|---|---|---|---|---|---|---|---|
| **C41** | 0.1305 | 0.1638 | 0.1619 | 0.1796 | 0.1608 | 0.1618 | 3.1945 | 3.1966 | 6.3912 | -0.0021 |
| **C42** | 0.1637 | 0.1302 | 0.1769 | 0.1583 | 0.1669 | 0.1705 | 3.2171 | 3.7618 | 6.9789 | -0.5446 |
| **C43** | 0.1116 | 0.1151 | 0.0910 | 0.1107 | 0.1180 | 0.1155 | 2.2003 | 3.8777 | 6.0780 | -1.6775 |
| **C44** | 0.2022 | 0.2010 | 0.1952 | 0.1581 | 0.2056 | 0.2020 | 3.9067 | 2.8172 | 6.7239 | 1.0894 |
| **C45** | 0.1735 | 0.1750 | 0.1705 | 0.1627 | 0.1329 | 0.1765 | 3.2854 | 3.9498 | 7.2352 | -0.6644 |
| **C46** | 0.2185 | 0.2149 | 0.2044 | 0.2307 | 0.2158 | 0.1737 | 4.2231 | 2.4239 | 6.6470 | 1.7991 |

**Table 9: The internal weight of the sub factors of engineering costs and the D, R, D+R, D-R values**

| | | | | | D | R | D+R | D-R |
|---|---|---|---|---|---|---|---|---|
| **C51** | 0.1329 | 0.1848 | 0.1850 | 0.1988 | 1.6146 | 3.1491 | 4.7636 | -1.5345 |
| **C52** | 0.2770 | 0.1989 | 0.2753 | 0.2943 | 2.4589 | 2.5034 | 4.9623 | -0.0444 |
| **C53** | 0.2955 | 0.3004 | 0.2089 | 0.2747 | 2.5990 | 2.0777 | 4.6767 | 0.5213 |
| **C54** | 0.2945 | 0.3160 | 0.3307 | 0.2322 | 2.8132 | 1.7555 | 4.5687 | 1.0577 |

**Table 10: The internal weight of the sub factors of Cost Guaranteed and the D, R, D+R, D-R values**

| | | | | D | R | D+R | D-R |
|---|---|---|---|---|---|---|---|
| **C61** | 0.2831 | 0.3415 | 0.3437 | 4.2790 | 4.4476 | 8.7266 | -0.1685 |
| **C62** | 0.3110 | 0.2574 | 0.3180 | 3.8837 | 5.0166 | 8.9002 | -1.1329 |
| **C63** | 0.4059 | 0.4012 | 0.3384 | 5.1047 | 3.8032 | 8.9079 | 1.3014 |

| | | | | | | | D | R | D+R | D-R |
|---|---|---|---|---|---|---|---|---|---|---|
| **C71** | 0.1761 | 0.2955 | 0.2912 | 0.3109 | 0.2940 | 0.3005 | 2.1197 | 1.2713 | 3.3910 | 0.8484 |
| **C72** | 0.2160 | 0.1160 | 0.1837 | 0.1717 | 0.2072 | 0.1616 | 1.3371 | 1.2851 | 2.6221 | 0.0520 |
| **C73** | 0.1187 | 0.1186 | 0.0743 | 0.1142 | 0.1146 | 0.1192 | 0.8384 | 1.2505 | 2.0889 | -0.4122 |
| **C77** | 0.1917 | 0.1625 | 0.1604 | 0.1044 | 0.1458 | 0.1748 | 1.1884 | 1.3732 | 2.5615 | -0.1848 |
| **C75** | 0.1327 | 0.1528 | 0.1439 | 0.1383 | 0.0888 | 0.1471 | 1.0247 | 1.1845 | 2.2093 | -0.1598 |
| **C76** | 0.1648 | 0.1545 | 0.1465 | 0.1606 | 0.1497 | 0.0968 | 1.1104 | 1.2541 | 2.3645 | -0.1437 |

### 3.3. Fuzzy Network analysis results

For the calculation of fuzzy network analysis, at first the super matrix must be formed. Three categories of information used to create super matrix that include:

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Internal weighting of main cost-related factors that normalized T-matrix is the result of the direct fuzzy relationship of the main cost-related factors. Internal weighting of cost-related sub factors that normalized T-matrix is the result of the direct fuzzy relationship of the cost-related sub factors. Local weights derived from paired comparisons between the main cost-related factors and their sub factors. The output of the fuzzy Dematel has been reported in the previous sections. In the following, we explain the local weights calculation from the paired fuzzy comparisons matrix.

### 3.4. Calculation of the local weights the main cost-related factors and their sub factors

Fuzzy paired comparison matrix is obtained for each individual expert opinion after collecting expert opinions in linguistic variables form. The experts' opinions were integrated according the following equation and an integrated paired fuzzy comparison matrix for the fuzzy aggregation of costs is achieved. The following table shows the paired comparisons fuzzy matrix in which the aggregation of ten expert opinions about the main cost-related factors:

$$\tilde{Z}_{ij} = \left(\sqrt[k]{l_1 \times l_2 \times \ldots \times l_k}, \sqrt[k]{m_1 \times m_2 \times \ldots \times m_k}, \sqrt[k]{r_1 \times r_2 \times \ldots \times r_k}\right)$$

**Table 12: Ten paired comparisons fuzzy matrix of the integration of expert opinions about the main cost-related factor**

| | C1 | | | C2 | | | C3 | | |
|---|---|---|---|---|---|---|---|---|---|
| **C1** | 1 | 1 | 1 | 4.90 | 6.01 | 6.93 | 0.66 | 0.78 | 0.92 |
| **C2** | 0.14 | 0.17 | 0.20 | 1 | 1 | 1 | 0.69 | 0.83 | 1.01 |
| **C3** | 1.08 | 1.29 | 1.52 | 0.99 | 1.20 | 1.45 | 1 | 1 | 1 |
| **C4** | 0.21 | 0.24 | 0.29 | 0.32 | 0.37 | 0.44 | 0.13 | 0.15 | 0.18 |
| **C5** | 0.20 | 0.22 | 0.25 | 0.25 | 0.31 | 0.39 | 0.12 | 0.13 | 0.15 |
| **C6** | 0.34 | 0.39 | 0.47 | 0.41 | 0.47 | 0.56 | 0.14 | 0.16 | 0.19 |
| **C7** | 0.28 | 0.33 | 0.40 | 0.33 | 0.38 | 0.46 | 0.14 | 0.15 | 0.19 |
| | **C4** | | | **C5** | | | **C6** | | |
| **C1** | 3.42 | 4.14 | 4.76 | 3.93 | 4.55 | 5.10 | 2.11 | 2.54 | 2.95 |
| **C2** | 2.30 | 2.74 | 3.14 | 2.59 | 3.27 | 3.93 | 1.79 | 2.14 | 2.45 |
| **C3** | 5.63 | 6.71 | 7.51 | 6.65 | 7.67 | 8.24 | 5.31 | 6.38 | 7.34 |
| **C4** | 1 | 1 | 1 | 3.07 | 3.91 | 4.70 | 1.58 | 1.87 | 2.17 |
| **C5** | 0.21 | 0.26 | 0.33 | 1 | 1 | 1 | 0.86 | 1.14 | 1.47 |
| **C6** | 0.46 | 0.53 | 0.63 | 0.68 | 0.87 | 1.16 | 1 | 1 | 1 |
| | **C7** | | | | | | | | |
| **C1** | 2.52 | 3.03 | 3.57 | | | | | | |
| **C2** | 2.17 | 2.62 | 3.07 | | | | | | |
| **C3** | 5.40 | 6.53 | 7.30 | | | | | | |
| **C4** | 1.74 | 2.18 | 2.59 | | | | | | |
| **C5** | 1.15 | 1.36 | 1.58 | | | | | | |
| **C6** | 2.78 | 3.44 | 4.10 | | | | | | |

After the aggregation of experts' opinions and the aggregated fuzzy paired comparisons matrix formation, paired comparisons fuzzy matrix phase is defuzzied. This process is done by using Opricovic

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and Tzeng (2003) method. Defuzzied paired comparisons matrix is presented in the following table. Local weights of the matrix can be derived using the following equation.

$$W_i = \frac{\left(\prod_{j=1}^{n} a_{ij}\right)^{1/n}}{\sum_{i=1}^{n}\left(\prod_{j=1}^{n} a_{ij}\right)^{1/n}} \quad, i, j = 1, 2, \dots, n$$

Local weights obtained for the main cost-related factors of cost have been reported in the last column of the table below. It should be noted that we have to evaluate the compatibility of the aggregated response before weights calculations and after the aggregation of expert opinion using the geometric mean. Calculation of the matrix compatibility is reported in the table below which indicates that the matrix is consistent. As previously mentioned, the validity of questionnaires is checked by adapting indicators. If the consistency index $CR \leq 0.1$ of questionnaire credit is acceptable. Given the obtained consistency index for the main cost-related factors and the sub factors of cost that are reported in the tables, we can conclude the designed questionnaire have acceptable reliability.

**Table 13: paired comparisons defuzzied matrix of main cost-related factors, the local weights and the compatibility rates**

| | C1 | C2 | C3 | C4 | C5 | C6 | C7 | Local weight |
|---|---|---|---|---|---|---|---|---|
| C1 | 1 | 5.932 | 0.780 | 4.120 | 4.530 | 2.540 | 3.042 | 0.272 |
| C2 | 0.166 | 1 | 0.837 | 2.736 | 3.276 | 2.139 | 2.629 | 0.142 |
| C3 | 1.295 | 1.211 | 1 | 6.611 | 7.574 | 6.310 | 6.425 | 0.339 |
| C4 | 0.242 | 0.366 | 0.149 | 1 | 3.901 | 1.877 | 2.184 | 0.086 |
| C5 | 0.220 | 0.307 | 0.130 | 0.257 | 1 | 1.158 | 1.362 | 0.048 |
| C6 | 0.396 | 0.469 | 0.157 | 0.537 | 0.889 | 1 | 3.446 | 0.070 |
| C7 | 0.331 | 0.382 | 0.153 | 0.462 | 0.742 | 0.292 | 1 | 0.044 |
| | | | CR=0.095 $\leq$ 0.1 | | | **Compatible Matrix** | | |

Similarly, the above computational procedure can be done for each set of cost-related sub factors and local weight of cost-related sub factors. The following table show the defuzzied paired comparisons matrix, the local weights and compatibility rates for each category of cost-related sub factors.

**Table 14: paired comparisons defuzzied matrix of cost-related sub factors of net costs, the local weights and the compatibility rates**

| | C11 | C12 | C13 | C14 | Local weight |
|---|---|---|---|---|---|
| C11 | 1 | 6.381 | 0.688 | 2.275 | 0.384 |
| C12 | 0.154 | 1 | 0.712 | 1.205 | 0.130 |
| C13 | 1.473 | 1.421 | 1 | 3.855 | 0.364 |
| C14 | 0.446 | 0.842 | 0.260 | 1 | 0.121 |
| | CR=0.092 $\leq$ 0.1 | | compatible matrix | | |

**Table 15: paired comparisons defuzzied matrix of cost-related sub factors of storage costs, the local weights and the compatibility rates**

| | C21 | C22 | C23 | C24 | Local weight |
|---|---|---|---|---|---|
| C21 | 1 | 2.681 | 3.569 | 5.135 | 0.511 |

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| | | | | | |
|---|---|---|---|---|---|
| C22 | 0.377 | 1 | 2.385 | 5.358 | 0.286 |
| C23 | 0.283 | 0.425 | 1 | 1.765 | 0.131 |
| C24 | 0.192 | 0.184 | 0.573 | 1 | 0.073 |
| CR=0.037 ≤ 0.1 | | | compatible matrix | | |

**Table 16: paired comparisons defuzzied matrix of cost-related sub factors of production costs, the local weights and the compatibility rates**

| | C31 | C32 | C33 | C34 | C35 | C36 | Local weight |
|---|---|---|---|---|---|---|---|
| C31 | 1 | 0.651 | 0.790 | 0.672 | 0.672 | 0.427 | 0.110 |
| C32 | 1.578 | 1 | 1.433 | 2.184 | 0.878 | 0.510 | 0.184 |
| C33 | 1.304 | 0.706 | 1 | 1.339 | 1.312 | 1.012 | 0.175 |
| C34 | 1.519 | 0.457 | 0.769 | 1 | 0.566 | 0.851 | 0.128 |
| C35 | 1.523 | 1.160 | 0.776 | 1.768 | 1 | 0.676 | 0.175 |
| C36 | 2.327 | 1.962 | 1.002 | 1.183 | 1.486 | 1 | 0.228 |
| | | | CR=0.033 ≤ 0.1 | | | compatible matrix | |

**Table 17: paired comparisons defuzzied matrix of cost-related sub factors of quality control costs, the local weights and the compatibility rates**

| | C41 | C42 | C43 | C44 | C45 | C46 | Local weight |
|---|---|---|---|---|---|---|---|
| C41 | 1 | 1.695 | 3.932 | 1.692 | 1.983 | 2.537 | 0.296 |
| C42 | 0.602 | 1 | 2.724 | 1.383 | 1.977 | 2.375 | 0.224 |
| C43 | 0.251 | 0.371 | 1 | 1.488 | 0.623 | 1.565 | 0.108 |
| C44 | 0.602 | 0.728 | 0.696 | 1 | 1.159 | 2.034 | 0.143 |
| C45 | 0.512 | 0.507 | 1.637 | 0.872 | 1 | 2.412 | 0.148 |
| C46 | 0.400 | 0.428 | 0.660 | 0.504 | 0.422 | 1 | 0.081 |
| | | | CR=0.038 ≤ 0.1 | | | compatible matrix | |

**Table 18: paired comparisons defuzzied matrix of cost-related sub factors of engineering costs, the local weights and the compatibility rates**

| | C51 | C52 | C53 | C54 | Local weight |
|---|---|---|---|---|---|
| C51 | 1 | 0.893 | 0.631 | 0.618 | 0.186 |
| C52 | 1.150 | 1 | 0.700 | 0.700 | 0.210 |
| C53 | 1.610 | 1.456 | 1 | 0.743 | 0.278 |
| C54 | 1.637 | 1.454 | 1.378 | 1 | 0.326 |
| | CR=0.014 ≤ 0.1 | | compatible matrix | | |

**Table 19: paired comparisons defuzzied matrix of cost-related sub factors of guaranteed cost, the local weights and the compatibility rates**

| | C61 | C62 | C63 | Local weight |
|---|---|---|---|---|
| C61 | 1 | 0.982 | 0.963 | 0.320 |
| C62 | 1.051 | 1 | 1.848 | 0.407 |
| C63 | 1.069 | 0.549 | 1 | 0.273 |
| | CR=0.060 ≤ 0.1 | | | compatible matrix |

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**Table 20: paired comparisons defuzzied matrix of cost-related sub factorsof subscribe costs, the local weights and the compatibility rates**

| | C71 | C72 | C73 | C74 | C75 | C76 | Local weight |
|---|---|---|---|---|---|---|---|
| C71 | 1 | 6.234 | 6.603 | 5.830 | 4.512 | 4.161 | 0.508 |
| C72 | 0.158 | 1 | 3.500 | 1.816 | 0.587 | 0.742 | 0.109 |
| C73 | 0.149 | 0.285 | 1 | 0.651 | 0.616 | 0.605 | 0.058 |
| C74 | 0.169 | 0.556 | 1.560 | 1 | 0.908 | 0.969 | 0.089 |
| C75 | 0.221 | 1.738 | 1.661 | 1.119 | 1 | 2.543 | 0.138 |
| C76 | 0.240 | 1.362 | 1.661 | 1.037 | 0.396 | 1 | 0.097 |
| | | | CR=0.047 $\leq$ 0.1 | | | compatible matrix | |

### 3.5. Super matrix formation and final weights calculation

In this step, super matrix is formed and the final weight of the main cost-related factors and their sub factors are calculated. For Super matrix formation, the normal T matrix is used to determine the relationship between the inter-relationships between the main cost-related factors of cost and inter-relationships between sub factors. Also, the local weight-obtained is formed from the paired comparisons between the cost main factor and the cost-related sub factors of uneven super-matrix. This matrix is then normalized by the given sum of the values of the columns of the matrix T. In the final step, to obtain the final weights, each factor or sub-factor of uneven super-matrix get the exponent of 2k + 1 to be converged where k is an arbitrary number.

The net weight of main cost-related factors and sub factors are extractable from limited super matrix. In limited Super-matrix, elements in each row of the matrix are equal, because the matrix is converge. Therefore the net weight values show the final weight of cost factor or sub factors (Asgharpour, 2004). These weights have been reported in the following table. As can be seen in the table below, the total net weight of the main cost-related factors or their sub factors is not equal to one but the sum of each column of the limited super-matrix that the final weight is extracted from equals to one. According to data obtained from the above tables, among the main cost factors, costs of production and net costs have more significance and therefore have a higher priority. The subscribe cost has the least significant and lowest priority. The following figure shows the importance of the main cost factors.

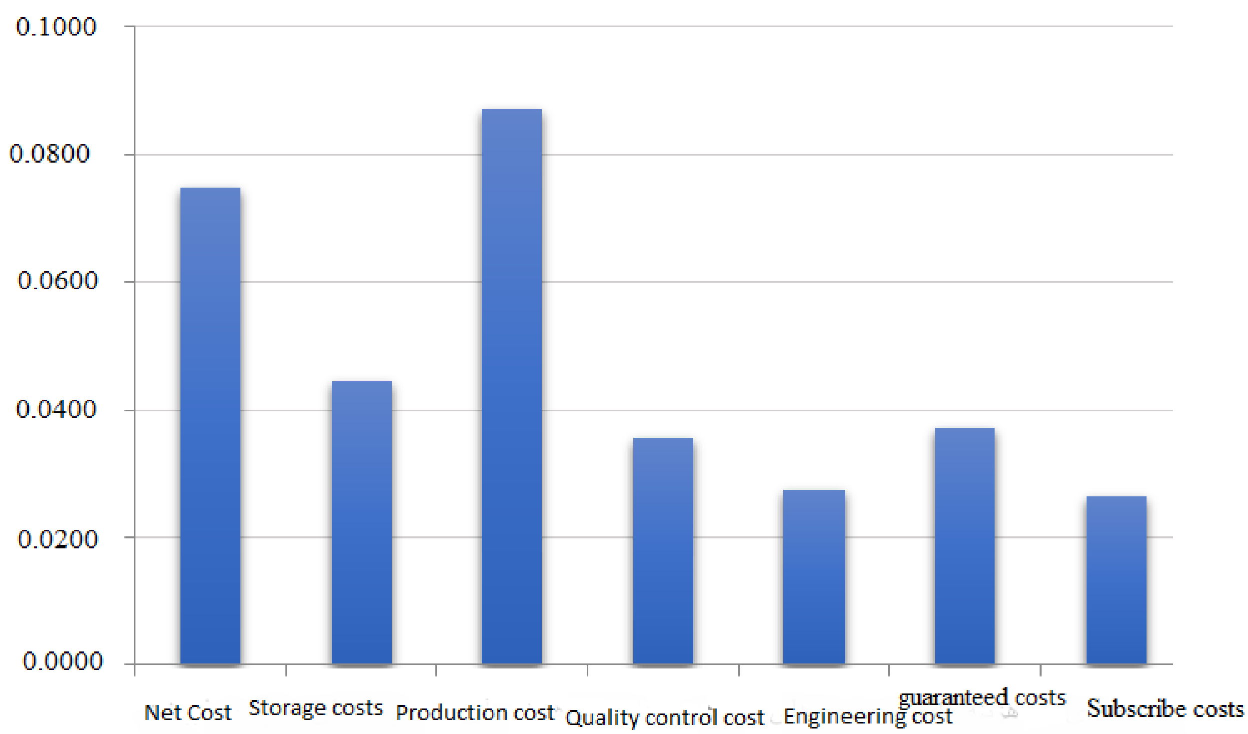


**Figure 1: The final weight of main cost-related factors**

In addition, based on the presented results in the before tables it can be concluded than among the cost-related sub- factors, the cost of spare parts and tools, the cost of lost production, the cost of the new technology have higher importance and therefore have higher priority .
Figure 2 shows the importance of the cost-related sub-factor. Based on this figure, the cost-related sub factorscan be listed as follows in order of preference :

Cost of consumable, spare parts and tools, the cost of repairs missing, cost of new technology, inventory costs, manufacturing scrap and rework costs, cost restart, the cost of equipment depreciation, cost of materials and supplies, process design cost, cost repair contractors, audit fees, ancillary cost, the cost of energy consumed in the production, depreciation expenses of building, salary costs, cost of research for products, purchase cost of test equipment, waste storage costs due to faulty, review and determine the cost of returned products, incoming materials inspection fees, cost analysis of design, determine the cost of bad items, documentation fee, purchase of equipment and software costs, transportation costs, Education costs, Production bonuses, Tax expenses, Internet cost, Power costs

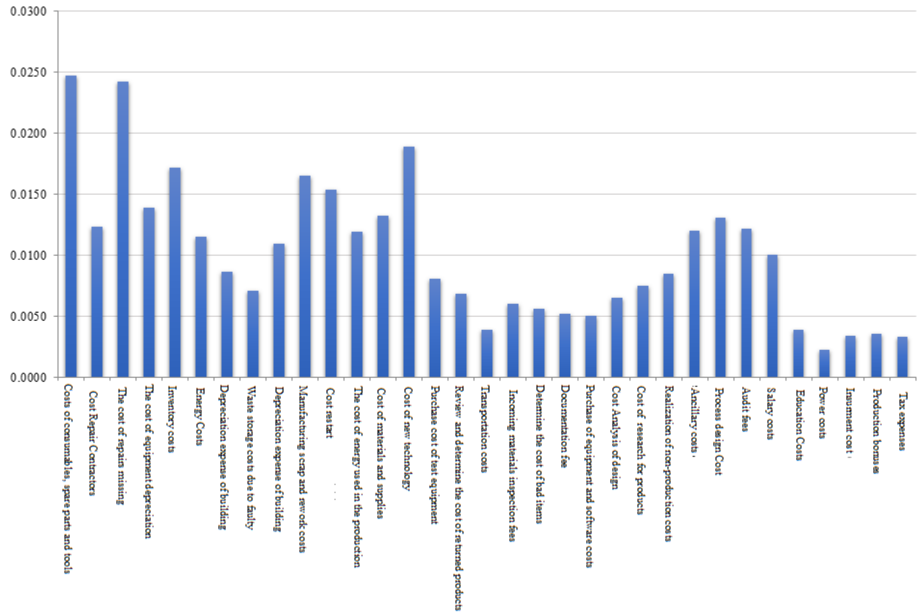


**Figure 2: The final weight of cost-related sub factors**

Figure 3 shows the main cost-related factors in terms of priority. Due to the uncertainty and confusion surrounding the expert opinions about questions of network analysis the fuzzy concepts and relations were utilized to model these uncertainties and ambiguities . In this research to prioritize costs, the combination of fuzzy dematel and fuzzy analytic network suggested. Among the usual methods used to solve multi-criteria decision problems on uncertainty space is the method of fuzzy AHP. However, this method does not consider the cost of communication and interdependence . The proposed fuzzy hybrid approach resolves the disability in measurement uncertainty. In addition to its simplicity and ability to understand the proposed method, the other important benefits include : Support network structure (described complex systems), considering the relationships and dependencies between the main and sub factors of cost, support of the fuzzy concept (expressed confusion and uncertainty), the ranking feature (help to make better decisions), The model helps the decision makers to make more accurate decisions and be able to make proper management actions to prioritize spending money that is the important strategies of organizations

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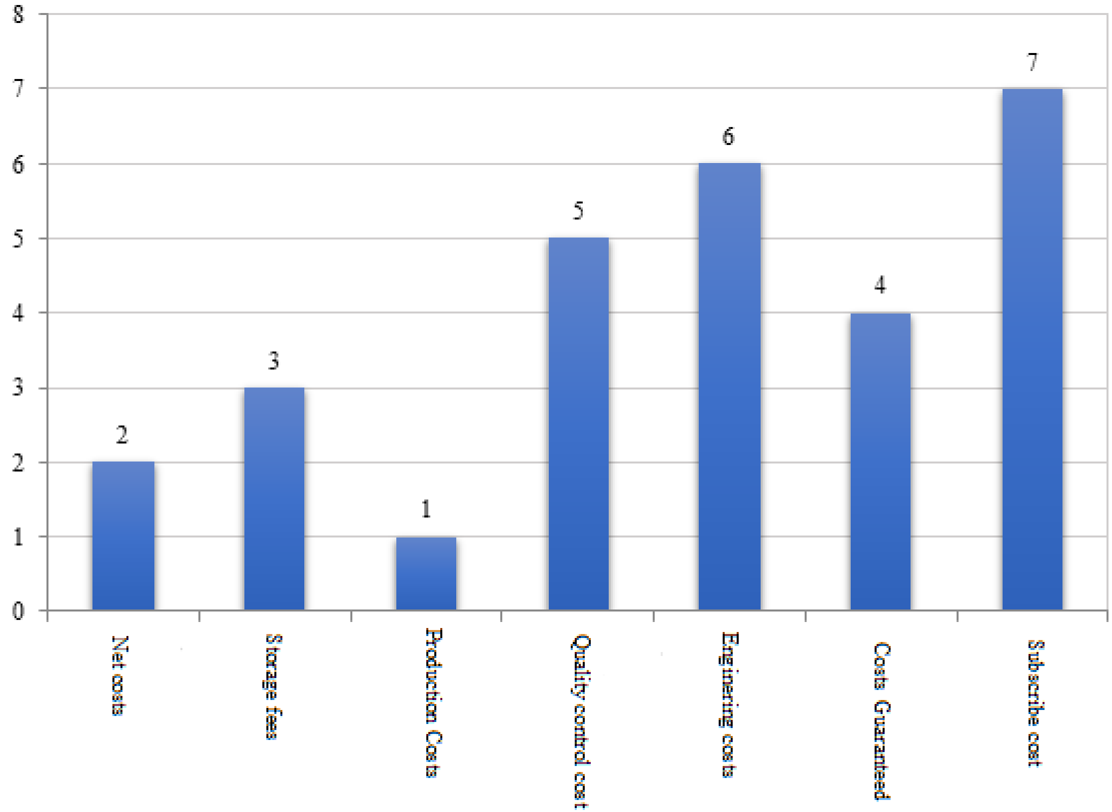


**Figure 3: The main cost-related factors based on their preference**

## 4. Conclusion

The results show that among the cost-related sub factors, cost of consumable, spare parts and tools, the cost of repairs missing, cost of new technology, and inventory costs have higher priority in comparison with the other sub factors. Results of implementing this technique on the main factors that were identified in the company's cost of industrial production shows that among the main cost-related factor, production costs, net costs, storage costs have higher priority than other factors . The figure below shows the priority rank of the main cost factors.

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