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# Identifying and Assessing the Risks in the Supply Chain

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**Abstract**

Ranking supply chain risks is as an important part of supply chain risk management especially when the numbers of risk factors are increased. In this study, the comprehensive structure of the main risks are prepared in three levels of the supply chain (3 total sets, 7 sub-categories and 34 categories and 300 subcategories) initially and then these risks are evaluated and ranked in the steel supply chain in Esfahan Steel Complex as a case study. For this purpose, group decision-making methods and means of collection and aggregation experts and linear assignment method is used as a method of Multiple Decision Making to determine the ranking of risks. Ranking indexes were divided in two primary and secondary categories. The primary index is based on likelihood and impact of risks on the main objectives (schedule, cost, quality and scope) of supply chain activities with different weights. The second category of indicators includesocio-economic effects, environmental impacts, near the time of risk, exposure to risk, the confidence level of the estimates and the management of risk, risk reduction and risk discovering. Risks are ranked better using linear assignment method and according to various indices and are ranked more realistic. Based on the results, risks related to procurement and supplier are identified and introduced as the most critical risks.

**Keywords:** supply chain, esfahan steel company, risk assessment, risk breakdown structure, ranking, linear assignment

## 1. Introduction

Supply chain management isplanning process, implementing and controlling the efficient flow of raw materials, inventories, finished goods and also the flow of data associated with the first point to the point of consumption and is done with the aim of meeting the needs of customers and therefore affectsall activities of the Company. Therefore, focusing on opportunities and threats in the field of industry and commerce and evaluation of companies and industries in the face of uncertainties and essential risks is important and supply chain risk management is very important. Incidence and risk factors that lead to uncertainty in the supply chain decreasestolerability and increases its vulnerability. Risk management is a process to identify risk factors and assess and plan to reduce adverse effect of risks, so supply chain risk management is necessary identify and deal with the uncertainties and risks. Supply chain risk management is synchronization of supply chain components in the application of risk management tools to deal with the risks and uncertainties affecting the activities of the supply chain which guarantees the profitability and continuity of the supply chain. In fact, supply chain risk management is interface of risk management and supply chain management (Figure 1). Iran's iron and steel industries, with an emphasis on preserving the environment, improving quality and productivity, and according to the requirements is active and effective in the field of international commerce to promote national interests. Currently, Iran has numerous advantages in terms of steel production including adequate and affordable energy; mines iron ore and refractory materials, the relative experience in the production of steel, young labor force to access new production technologies and effective role in the steel global market competition. In recent years, the self-sufficiency in steel industry to has been focused by officials in the Ministry of Industry, Mine and Trade and actors of the industry. Self-sufficiency in steel industry has been focused by officials due to supply the steel of different industries and self-sufficiency in making steel factories in the country. Iran as the biggest importer of steel in the Middle East plans tosupply steel for the country to achieve self-sufficiency to 2017.

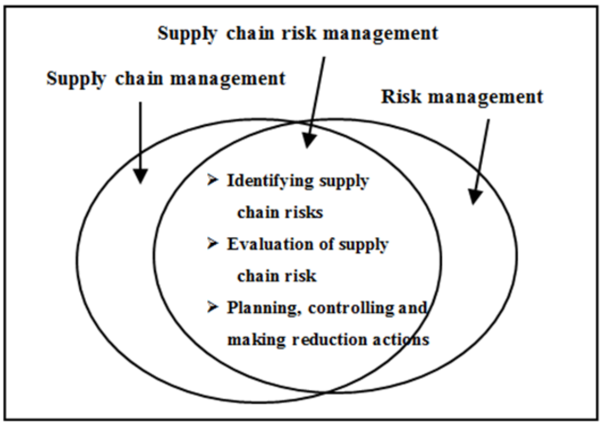


Figure 1. Supply chain risk management

Considering the above factors to identify and assess hazards and risks threatening the supply chain industry and failure conditions, away from significant and provide optimal performance management and evaluation to provide appropriate and timely response to risk. Risk management involves the identification, evaluation and ranking of the different risks. One of the pillars of risk management is risk assessment aims to measure risks based on various factors such as the effect and likely and whatever results of this stage is more accurate to say that the risk management process is performed with a higher degree of confidence. Ranking risks are a key part of this process, because ranking specifies superiority against other risks and consequently decision maker canplan about the allocation of resources to deal with any risk of the program. On the other hand, appropriate methods should be created to identify and ranking specific risks of project or organization to evaluat the risk and successful and efficient implementation of the risk management process, designing risk breakdown structure (RBS) for the risks of supply chain risk and ultimately define criteria and indices measured using a multi-criteria decision-making methods is done. In many clinical studies discussed in general and in the supply chain management and risk assessment has been specifically: Some of the researchers studied literature reviews and concepts of risk management and supply chain. In another study, supply chain risk is considered as the product of the probability of an event and two index "efficacy" and "likely" in Probability-impact risk rating matrix have been used as well as research from other methods of risk assessment, such as FMEA is used that the magnitude of the risk based on three criteria: the product of the intensity, and the probability of the risk of detection is calculated. However, some researchers have pointed weaknesses in risk measurement as unreliable methods such as probability matrix, FMEA and the like. problems of using this method is that the risk of low probability and important work to be ignored, also risks with probably insignificant effect with low probability and impact of risks that are important to assume that these is not necessarily the decision makers. In another study the response to a number of risks and response strategies to control risk in the supply chain is considered. Some others investigators to discuss the modeling and simulation of risk in the supply chain have used techniques such as graph theory, multi-criteria optimization, fuzzy logic, linear programming and nonlinear, stochastic programming, interpretive structural modeling, decision support system multifactorial, etc. contingency theory has been used. Although this research is quantitative or semi-quantitative risk assessment is likely to be done but very limited risk identification and on the other hand a large extent risks can not be explained on the basis of various parameters and therefore, the criticality of risks to be determined and also focused more on case studies.

Therefore result of the review of past studies and surveys have shown that most of the articles and studies (more than 70 percent of them) to the latest concepts of supply chain risk management, field studies and case presentation and literature review focused on issues such as the use of modeling and simulation approaches is very limited and especially those that have been identified and categorized in a comprehensive and hierarchical supply chain risk assessment and measurement of risk and to determine the magnitude and their ranking, especially in the steel supply chain. In cases where a significant set of variables and the need to prioritize the work of making decisions based on their relative importance may be, using different people with expertise, experience and views of different groups using Multi Attribute Decision Making techniques (such as Linear Assignment method) ranking and scientific tools for decision-making is accurate. A group of several expert opinions in the decision-making techniques have been used instead of an expert and detailed analysis in decision-making is involved. To integrate experts from various methods such as averaging is used.

In this study, based on the risk of failure of the structureto provide a comprehensive structure and hierarchy of supply chain risks, and propose a set of indicators to assess and measure risks, a comprehensive questionnaire was prepared and these risks discussed in the steel supply chain in Esfahan Steel Company using linear assignment method has been evaluated and ranked. To define the parameters ofthe ranking, the first area of impact risk to the objectives of time, cost, quality and performance of the project is in different weights. Then in order to evaluate and rank the risks more accurately, complementary indicators of socio-economic and environmental impacts, near the time of risk, exposure to risk, uncertainty estimation and management of risk is also considered. Also should be noted that so far Studies particularly serious risks of supply chain risk assessment using linear assignment has been done. However, this method is introduced as one of the most important and most powerful multiple attributes decision making methods in engineering.

## 2. The Linear Assignment Method

This method is one of the most multiple attribute decision-making techniques. In the linear assignment method of a problem given options based on their scores for each indicator and then ranking the final ranking Options linear compensation will be determined through a process. In the linear assignment method based on simplex properties of the solution space, keeping in mind all the arrangements implicitly extracted the optimal solution under a convex simplex. In addition to the compensatory nature of the exchange between the ranking criteria and options are obtained, although the weight vector of indices based on expert opinion is obtained. In comparison with other methods of multiple attribute decision making, including the strengths and linear assignment method, it is important that this method Such as hybrid technology (hard and soft) is considered. The techniques are known techniques of hard decisions that define the model based on mathematical equations. Soft decision techniques are techniques where the model is expressed on a contingency table. Therefore decision making techniques are combination of hard skills and soft skills.This means that these techniques seems to follow the logic of the application techniques is defined on the basis of contingency table, but in practice and in the process of solving the mathematical system of equations are therefore soft and hard skills are strengths. The steps application of this technique is as follows:

First step: to determine the level of risk for each of the indicators in the form of a matrix (m × m), which represents rank and row of columns that represent the index.

Step two: allocation matrix or gamma matrix (γ), which is a square matrix (m × m) of the row isrisk i and the column of rank is k. Component matrix γ ( $\gamma_{ik}$ ) is the total weight of the risk indices i in which grade is k. Gamma matrix is a matrix that can be allocated to each of the allocation methods (transport, by Hungarian network and linear programming approach zero and one) to achieve the optimal solution. The most common solution is to allocate linear linear programming methods.

Step Three: calculate the optimum (final ranking) using linear programming through the following models:

$$Max\ Z = \sum_{i=1}^{m}\sum_{k=1}^{m}\gamma_{ik}h_{ik} \tag{1}$$

$$\sum_{k=1}^{m}h_{ik}=1 \qquad ,i=1,2,......,17 \tag{2}$$

$$\sum_{i=1}^{m}h_{ik}=1 \qquad ,k=1,2,......,17 \quad h_{ik}=0 \text{ or } 1 \tag{3}$$

Such as main feature of this technique can be follows:

**1)** Above method using a simple ranking of options will be exchanged between the variables and calculations are complex.

**2)** This method does not require same values measure and the parameters can be of any scale.

## 3. The Method of Entropy Shannon

In some Multiple Attribute Decision Making methods such as linear assignment method to determine the relative importance of the factors is an effective step in the process of problem solving. Such as coefficients of the variables can be extracted, using the Shannon Entropy experts and so on. Using stages Shannon Entropy method is as follows:

After formation of the matrix, making amount of entry $r_{ij}$ (Decision matrix elements) can be $p_{ij}$ Converted (connection 4):

$$p_{ij} = \frac{r_{ij}}{\sum_{i=1}^{m} r_{ij}} \quad \forall i, j \tag{4}$$

The amount of characteristic j Entropy in connection (5) is calculated:

$$E_j = -k \sum_{i=1}^{m} p_{ij} \ln p_{ij} \qquad , k = \frac{1}{\ln m} \tag{5}$$

Using $E_j$ amount $d_j$ is calculated for each characteristic:

$$d_j = 1 - E_j \quad ; \forall j \tag{6}$$

Weight of $w_j^{'}$ ofcharacteristic j is obtained as follows:

$$w_j^{'} = \frac{d_j}{\sum_{i=1}^{m} d_j} \tag{7}$$

If decision maker in his mind for the index as a factor the importance $\lambda_j$, the Weight can be calculated using connection (8):

$$w_j = \frac{\lambda_j w_j^{'}}{\sum_{j=1}^{m} \lambda_j w_j^{'}} \tag{8}$$

**4. Risk Breakdown Structure**

Risk Breakdown Structure (RBS) is a hierarchical structure of project risks and is used for structuring and risk management. Due to the high number and variety of risks that affect supply chain risk management practice effectively, without identification and preparation of the risk of failure is not possible. In other words, without a systematic process for identifying and managing them correctly, any attempt to understand and deal with the risks is difficult. RBS technique can help to bring this matter as an effective tool to identify targeted and provides risk classification. Several studies on the identification and classification of risk factors in the supply chain are done. These include the following items to be mentioned:

Risks arecategorized in nine parts including failures, delays, systems, forecasting, intellectual assets, providing, receiving, inventory and capacity or in the 6 categories of supply, production, demand, logistics, risk to non-natural causes Social risk control and non-control. Some researchers categorized risks in the five including supply, demand, process and controls and environmental. In research, risks are categorized in four parts including risk, supply, demand, operational and safety or supply, demand, failures and natural disasters. Also Some others researchers risks in three categories, deviations, failures and incidents or supply, demand, and catastrophic risk or the supply, demand, and other risks which increase the cost. Or in 2 sets of supply and demand have presented. Other studies can also be noted that some of the projects have other risk factors. In sum total, this research mainly in the form of case studies conducted as part of a comprehensive structure not present risk of failure.

**5. Identification and Classification of Supply Chain Risks**

Supply chain risk has been set according to RBS (Table 1). In this structure, Work Breakdown Structure (WBS) is following and one comprehensive hierarchical structure of supply chain risks (SCRBS) is presented below. The structure consists of 4 levels, which is designed in the first level of supply chain risks in 3 sets of external risks whichhave been divided into internal and external. In the second level of risks were shown in the form of seven subdiaries, the third level in 34 main categories and 320 over the quarter in the following categories (risk factors) according to RBS. The first three levels of the hierarchy have been shown in the table (2). It should be noted that the risk of failure in the design of the structure of the supply chain, several key points have been raised in the debate are identified and risk management. Including the fact that it has been tried, according to the definition in accordance with the literature identifying risk and risk management, and outcome of events may only be recognized as a risk. Because the consequences of their occurrence or imminent hundred percent is not defined as a risk, but they should be called a real phenomenon and how to deal with them is different from risk. Also we have tried to analyze and classify risks in such a way that on the one hand have the necessary integrity and on the other to minimize the interface between them and also risks classified as understandable and appropriate supply chain management literature, in summary logical and scientific association between risk management and supply chain management as supply chain risk management is maintained.

## 6. The Criteria for Risk Assessment

As noted, the purpose of the risk assessment phase measurement of risks is based on different criteria. Therefore in most common methods Research evaluation based only limited measures, such as probability and risk impact has been used and this while many researchers unreliable and lack sufficient credibility of these results have been acknowledged. However, in the other studies, such as the organization's ability to respond to risk factors, the degree of uncertainty estimation and quickly deal with the risk, the probability and the effect of the time, cost and quality of the project in the ranking risks has been proposed. As well as supplemental indicators of the prpximity and manageability of risk and socio-economic effects and environmental effects is used. In a comprehensive set of evaluation criteria risk aggregation so far simultaneously introduced and used. Defined criteria for risk assessment in this study as either primary or secondary (complementary) with the corresponding symbol in Table 1 are shown. In the criteria of the positive effects of these measures (criteria) to have a higher risk of being critical, the risks are higher. In the measures that have negative side effects increase the risk indicator for the degree of criticality of the risk decreases.It should be noted that these criteria are independent of each other and logical connection between any of the indexes does not exist.

## 7. The Process of Risk Assessment

The process of risk assessment and ranking of the supply chain can be done in 6 steps as follows.

### *7.1 The First Stage*

In this stage, a comprehensive questionnaire on supply chain risk breakdown structure (SCRBS) and 34 main risk of (R1 to R34) in Table 1 is shown as the third level risks and also 14 evaluation criteria (Table 1) were designed on the basis of the experts' group decision-making techniques in the form of several experts during several meetings.

### *7.2 The Second Stage*

After collecting the questionnaires to assess the agreement between the experts and, if necessary, delete or re-survey, internal correlation coefficient (ICC) calculated and according to Cronbach's alpha values obtained for comments. If alpha is greater than 0.7 shows good correlation and agreement among experts, if the value of alpha is between 0.7 and 0.5, indicating moderate agreement and if it is less than 0.5 weak correlation and coherence comments show that in this case, if necessary, re-survey will be carried out [48]. The following comments assembly is done by using the mean.

### *7.3 The Third Stage*

In this stage, primary criterion in accordance with the standards of risk management, the initial assessment is done.According to the criteria of likelihood of risk and the impact of risk on the main objectives of the project (chain), including timing, cost, quality, performance and range of activities and different parts of the chain can be identified an primary index risk (PIR), for each risk (Connection 9).

$$PIR= \sum[W_i \, ( P \times I_i)] \tag{9}$$

Pis the probability and $I_1$ to $I_4$ are impact of the risk on time, cost, quality and range of the chain and also, $W_1$ to $W_4$is weighs the importance of effective risk criteria in order of the time, cost, quality and within the chain, which is determined according to experts and the sum of the weights is equal to one. PIR index for each of the 34 risks is obtained. In this stage use of this index may provide a preliminary ranking of risks. Can be seen that a simple definition and primary of the risk (probability × impact risk) lies in PIR index, but in addition to this advantage, the impact risk areas has been extended to four standard "time, cost, quality and range" with different weights.

### *7.4 The Fourth Stage*

As mentioned earlier, the use of conventional indicators of likelihood and effect, result alone does not provide a comprehensive, reliable and credible result, so in this study, nine other complementary measures have been proposed to compensate for the shortage. At this stage experts on the 9 secondary indicators (additional) for each of the 34 risks considered and in order to the use of linear assignment method for evaluating and ranking the risks final, decision matrix with 34 rows of 340 elements (major risks) and 10 columns (primary and secondary indexes) is formed.

*7.5 The Fifth Stage*

At this stage weight of each of these parameters ($W_1$ to $W_{10}$) is calculated. As mentioned, in some Multiple Attribute Decision Making methods such as linear assignment criteria used to determine the relative importance of an effective and necessary step in the process of problem solving that in this study, the combination of experts and Shannon entropy method used for extraction and determination of the coefficients of the variables.

*7.6 The Sixth Stage*

At this stage risk rating of 34 (R1 to R34) on the basis of 10 indicators (including indicators and indices PIR SIR1 to SIR9), using linear assignment is done.

Table 1. Hierarchical structure of supply chain risks in 3 levels (including the main risk 34)

| Level 0 | Level 1 | Level 2 | Level 3 |
|---|---|---|---|
| Supply chain risk | External risk | External risk | The political risk (R1) |
| | | | The social risk (R2) |
| | | | Economic risk (R3) |
| | | | Industrial risk (R4) |
| | | | The environmental risk (R5) |
| | | | Natural risk (R6) |
| | Internal-external risk | Risk related to supplier and supply process | Provide the performance risk (R7) |
| | | | Financial risk (R8) |
| | | | Risk ordering materials (R9) |
| | | | The risk inventories (R10) |
| | | Risk related to supply products | The risk of changes in demand (R18) |
| | | | The risk predicted demand (R19) |
| | | | Risks of competition (R20) |
| | | | Market risk (R21) |
| | | | The risk of customer expectations (R22) |
| | Internal risk | Risk related to production | The risk of disruption to the production process (R11) |
| | | | Technical risk (R12) |
| | | | Safety risk (R13) |
| | | | The risk of human resources (R14) |
| | | | The risk of production quality (R15) |
| | | | The risk of equipment, devices (R16) |
| | | | Risk laws, regulations and warranties (R17) |
| | | Risk related to information system | Security Risk Information System (R23) |
| | | | Failure Risk Information System (R24) |
| | | | Risk accuracy of the information (R25) |
| | | | Risk bullwhip effect (R26) |
| | | | The risk of lack of access to information (R27) |
| | | | The risk of lack of coordination of information (R28) |
| | | Risk related to support | Supplies risk (R29) |
| | | | Risk logistic (R30) |
| | | | Preparation and distribution of risk costs (R31) |
| | | Organizational risk | Risk conventional (R32) |
| | | | Risk Management (R33) |
| | | | The risk of supply chain relationships (R34) |

Table 2. Risk evaluation criteria (criteria primary including 5 and 9 additional criteria, a total of 14 criteria)

| **Kind of criteria** | Initial | | | | | Secondary | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Criterion** | The probability of risk | The effect of risk on the time | The effect of risk on cost | The effect of risk on the quality | The effect of risk on the range | Exposure to risk | The management of risk | The identification of risk | The reliability of estimates | Discover the risks | Economic and social effects risk | Environmental risks | Close of risk | Risk reduction |
| **Symbol** | P | $I_1$ | $I_2$ | $I_3$ | $I_4$ | $SIR_1$ | $SIR_2$ | $SIR_3$ | $SIR_4$ | $SIR_5$ | $SIR_6$ | $SIR_7$ | $SIR_8$ | $SIR_9$ |
| **Affecting aspect** | Positive | Positive | Positive | Positive | Positive | Positive | Negative | Negative | Negative | Negative | Positive | Positive | Positive | Negative |

## 8. Case Study

Statistical population of this study was to evaluate the risk of the steel supply chain, different parts of a supply chain, including supply, production and distribution are the parts for a case study in this research include: Esfahan Steel Company, affiliated companies, including companies, suppliers of raw materials (such as iron ore mines Mishdavan, Chadormalu, Sangan, Bafg and Tabas Coal Company, Inc. mines manganese, etc.), as well as major buyers of products (cooperatives ironmongery) companies. Esfahan Steel Company located in 45 km south-west of Isfahan and its administrative work began in 1967 and is the first and largest manufacturer of structural steel and rail in the process of steel production in the integrated blast furnace with a capacity of 8.2 million tons by the end product produces a variety of steel construction and industrial. According to the program, the usage of the balance, the company produced 6.3 million tons per year will be increased. In addition to the domestic market, this company exports manufactures products to more than 23 countries in Europe, Asia and Africa. With regard to the form of (1) evaluation and ranking of risk factors in Isfahan Steel Company as a case study in the steel supply chain, in the form of the following 5 steps:

### *8.1 The First Stage*

Questionnaire includes 34 rows and 14 columns that line this table contain 34 main risks and the columns containing various indicators to assess the risk. (Table 2) Opinions of the experts were collected by taking advantage of group decision-making techniques such as Delphi and brainstorming techniques in 6 groups of experts, senior experts and heads of units and various parts Steel Complex, a total of 30 individuals. The first group includes5 experts from the purchase and supply of raw materials, the second group includes four members of the commission transactions, the third group consists of 6 units Order materials, the fourth group includes consultants and laboratory, the fifth group consists of 6 members of the technical operation of the company and finally the sixth group consists of 5 members of the department of Industrial Engineering. Poll scoring in relation to each of the Heptathlon indicators for each of the risks is made based on the spectrum of the table (3).

Table 3: Spectrum rated and linguistic variables for the value of criteria for each risk

| **Expression variable** | Very low | Low | Average low | Average | Medium high | High | Very high |
|---|---|---|---|---|---|---|---|
| **Numerical value** | 0 | 1 | 3 | 5 | 7 | 9 | 10 |

### *8.2 The Second Stage*

After collecting the questionnaires at this stage to assess the degree of agreement Comments 6 Group of Experts in relation to any risk, using software from SPSS, ICC coefficients were calculated for each of the risks and results of Cronbach's alpha of 0.706 and 0.950 respectively and therefore shows good correlation and agreement among Opinions of the experts, it was the accumulation of comments using the average.

### *8.3 The Third Stage*

At this stage, in order to calculate the PIR (Equation 6), the amount of $W_1$ to $W_4$, was determined based on the opinion of expertsrespectively, 0.35, 0.4, 0.1, and 0.15. The results is shown in the table (4), based on these indicators can be set to a preliminary ranking of the risks.

*8.4 The Fourth Stage*

At this stage, taking into account the Opinions of the experts on the amount of supplemental index 9 (SIR1 to SIR9) for each of the 34 risks, with the index PIR (calculated in the previous step), decision matrix consisting of 34 rows of 340 elements (the main risks) and 10 columns (primary and secondary indexes) is formed. (Table 5)

*8.5 The Fifth Stage*

At this stage weight of each indicator ($W_1$ to $W_{10}$) is obtained based on a combination of expert opinion and the method of Shannon entropy (relations 1 to 5). (Table 6) Scoring spectrum of criteria to determine weights for the survey of experts on a range of variables that Heptathlon words include: Very high, high, medium high, medium, medium low, low and very low and commensurate with variable expression values, including: 1, 0.9, 0.7, 0.5, 0.3, 0.1 and zero.

*8.6 The Sixth Stage*

At this stage, risk rating of 34 based on 10 indices (indices and indicators PIR SIR1 to SIR9) is done using linear assignment. Stages of application of this technique are as follows:

8.6.1 The First Step

Determine the level of risk for each of the indicators in the form of a matrix (10 × 34) with its row indicates ranking and column shows the index. (Table 7)

8.6.2 The Second Step

Allocation matrix or gamma matrix ($\gamma$), is a 34 × 34 square matrix that the row is risk i and column is k ranking. Component matrix $\gamma$ ($\gamma_{ik}$) is the total weight of indices with risk i in grade k. Part of this process for ranks 1 to 17 in the table (8) is provided.

Gamma matrix is anallocation matrix, and as mentioned above, optimum result can be achieved using allocation matrix. The most common solution is linear programming method.

8.6.3 The Third Step

Calculate the optimal solution (final ranking) using linear programming through the following model:

$$\text{Max } Z = \sum_{i=1}^{34}\sum_{k=1}^{34} \lambda_{ik} h_{ik} \tag{10}$$

$$\sum_{k=1}^{34} h_{ik} = 1 \qquad , i = 1, 2, ......, 34 \tag{11}$$

$$\sum_{i=1}^{34} h_{ik} = 1 \qquad , k = 1, 2, ......, 34 \tag{12}$$

$$h_{ik} = 0 \;\; or \;\; 1$$

Given that the decision variables values are zero or one, the output of this program for the numerical values indicating the level of risk is required.For example, h (1, 7) indicates the place to solve the problem due to the large volume (1156 decision variable) software for risk 7 (1) and h (2, 28) indicate the level of risk (2) is 28.Accordingly ranking risks according to this table (9) is provided.

Table 4. Calculation Primary indicators of risk

| | *P* | *I₁* | *I₂* | *I₃* | *I₄* | *PIR* | | *P* | *I₁* | *I₂* | *I₃* | *I₄* | *PIR* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***R1*** | 0.883 | 7.667 | 9.000 | 3.000 | 1.000 | 6.090 | ***R18*** | 0.050 | 2.333 | 3.500 | 0.500 | 0.000 | 0.115 |
| ***R2*** | 0.133 | 8.667 | 7.833 | 1.833 | 0.833 | 0.882 | ***R19*** | 0.400 | 2.333 | 5.000 | 0.833 | 0.167 | 1.186 |
| ***R3*** | 0.967 | 8.167 | 10.000 | 7.667 | 4.333 | 8.182 | ***R20*** | 0.500 | 1.167 | 7.000 | 1.167 | 0.167 | 1.688 |
| ***R4*** | 0.700 | 3.000 | 9.000 | 8.500 | 2.333 | 4.278 | ***R21*** | 0.367 | 0.833 | 8.500 | 1.833 | 1.500 | 1.491 |
| ***R5*** | 0.233 | 1.667 | 4.667 | 0.333 | 0.667 | 0.598 | ***R22*** | 0.083 | 1.500 | 7.000 | 1.000 | 1.500 | 0.300 |
| ***R6*** | 0.017 | 8.500 | 6.667 | 9.333 | 0.500 | 0.120 | ***R23*** | 0.017 | 2.000 | 7.667 | 0.500 | 5.667 | 0.073 |
| ***R7*** | 0.933 | 8.500 | 9.333 | 7.667 | 4.667 | 7.796 | ***R24*** | 0.017 | 2.000 | 9.000 | 0.500 | 5.667 | 0.081 |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***R8*** | 0.933 | 6.667 | 9.167 | 4.667 | 8.000 | 6.982 | ***R25*** | 0.400 | 5.000 | 4.333 | 4.667 | 1.333 | 1.740 |
| ***R9*** | 0.900 | 7.667 | 8.167 | 9.000 | 1.333 | 6.730 | ***R26*** | 0.400 | 5.333 | 9.000 | 0.667 | 0.833 | 2.272 |
| ***R10*** | 0.633 | 7.000 | 7.833 | 7.333 | 1.500 | 4.352 | ***R27*** | 0.233 | 0.500 | 1.333 | 0.333 | 0.333 | 0.184 |
| ***R11*** | 0.667 | 6.333 | 8.000 | 7.000 | 1.333 | 4.419 | ***R28*** | 0.567 | 7.667 | 7.000 | 3.667 | 2.000 | 3.568 |
| ***R12*** | 0.767 | 9.000 | 8.333 | 6.333 | 1.167 | 5.846 | ***R29*** | 0.700 | 9.667 | 5.667 | 6.667 | 1.000 | 4.797 |
| ***R13*** | 0.850 | 6.000 | 8.000 | 4.333 | 1.833 | 5.237 | ***R30*** | 0.367 | 6.667 | 7.333 | 1.833 | 5.333 | 2.236 |
| ***R14*** | 0.733 | 5.667 | 5.000 | 2.667 | 1.000 | 3.325 | ***R31*** | 0.700 | 5.000 | 10.00 | 1.333 | 0.500 | 4.214 |
| ***R15*** | 0.233 | 2.333 | 6.333 | 9.667 | 0.500 | 1.124 | ***R32*** | 0.400 | 4.667 | 7.667 | 5.667 | 4.667 | 2.399 |
| ***R16*** | 0.400 | 7.667 | 7.667 | 5.667 | 3.000 | 2.778 | ***R33*** | 0.883 | 2.333 | 7.667 | 1.000 | 5.667 | 4.016 |
| ***R17*** | 0.150 | 3.000 | 6.333 | 5.000 | 1.167 | 0.666 | ***R34*** | 0.700 | 2.333 | 7.000 | 3.667 | 4.333 | 3.187 |

Table 5. Decision Matrix

| | ***PIR*** | $SIR_1$ | $SIR_2$ | $SIR_3$ | $SIR_4$ | $SIR_5$ | $SIR_6$ | $SIR_7$ | $SIR_8$ | $SIR_9$ | | **PIR** | $SIR_1$ | $SIR_2$ | $SIR_3$ | $SIR_4$ | $SIR_5$ | $SIR_6$ | $SIR_7$ | $SIR_8$ | $SIR_9$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***R1*** | 6.09 | 8.50 | 6.67 | 1.50 | 8.67 | 5.00 | 0.67 | 8.33 | 7.67 | 0.83 | ***R18*** | 0.12 | 8.33 | 2.67 | 1.00 | 1.33 | 1.33 | 5.67 | 5.67 | 7.67 | 5.67 |
| ***R2*** | 0.88 | 9.50 | 9.50 | 1.00 | 0.00 | 0.50 | 7.33 | 9.33 | 9.67 | 5.33 | ***R19*** | 1.19 | 4.33 | 7.33 | 1.33 | 3.67 | 0.67 | 1.67 | 6.67 | 3.00 | 4.00 |
| ***R3*** | 8.18 | 9.33 | 9.50 | 0.67 | 9.83 | 9.33 | 0.00 | 8.00 | 8.83 | 0.83 | ***R20*** | 1.69 | 7.67 | 5.33 | 1.33 | 2.67 | 5.33 | 3.67 | 7.00 | 8.33 | 4.33 |
| ***R4*** | 4.28 | 4.67 | 5.00 | 6.67 | 5.00 | 9.00 | 8.17 | 9.33 | 8.33 | 3.00 | ***R21*** | 1.49 | 9.00 | 1.00 | 0.67 | 3.67 | 5.67 | 4.67 | 6.00 | 7.33 | 2.67 |
| ***R5*** | 0.60 | 3.33 | 1.00 | 1.00 | 2.33 | 2.33 | 9.17 | 9.50 | 9.33 | 8.50 | ***R22*** | 0.30 | 8.33 | 1.33 | 0.00 | 5.33 | 5.33 | 3.33 | 8.00 | 3.67 | 8.33 |
| ***R6*** | 0.12 | 10.00 | 0.83 | 1.00 | 2.33 | 0.50 | 8.50 | 9.67 | 9.00 | 5.00 | ***R23*** | 0.07 | 4.67 | 0.33 | 0.67 | 0.50 | 1.50 | 9.50 | 8.00 | 9.67 | 8.67 |
| ***R7*** | 7.80 | 8.83 | 6.00 | 1.17 | 8.83 | 9.50 | 4.00 | 3.33 | 0.67 | 5.33 | ***R24*** | 0.08 | 9.33 | 0.33 | 0.17 | 0.50 | 0.50 | 9.50 | 8.00 | 9.67 | 6.33 |
| ***R8*** | 6.98 | 5.00 | 9.50 | 1.00 | 8.83 | 9.00 | 7.00 | 4.00 | 1.83 | 4.00 | ***R25*** | 1.74 | 7.00 | 0.17 | 4.00 | 7.67 | 7.33 | 7.67 | 9.00 | 5.67 | 8.33 |
| ***R9*** | 6.73 | 6.67 | 6.00 | 4.33 | 9.17 | 8.83 | 5.33 | 5.67 | 3.33 | 6.33 | ***R26*** | 2.27 | 3.67 | 0.50 | 0.67 | 6.33 | 7.00 | 7.00 | 3.67 | 8.33 | 7.00 |
| ***R10*** | 4.35 | 4.33 | 1.00 | 0.33 | 5.33 | 4.67 | 7.33 | 4.33 | 1.17 | 5.67 | ***R27*** | 0.18 | 8.00 | 0.17 | 0.33 | 6.00 | 1.00 | 6.00 | 9.00 | 8.00 | 9.50 |
| ***R11*** | 4.42 | 9.00 | 3.00 | 7.67 | 6.00 | 5.33 | 8.33 | 8.33 | 9.17 | 8.33 | ***R28*** | 3.57 | 8.17 | 0.33 | 2.00 | 1.00 | 2.67 | 8.00 | 7.00 | 8.00 | 7.33 |
| ***R12*** | 5.85 | 8.00 | 5.33 | 6.33 | 7.67 | 7.67 | 5.67 | 7.67 | 9.17 | 7.67 | ***R29*** | 4.80 | 6.00 | 1.67 | 3.67 | 7.33 | 9.17 | 5.33 | 7.67 | 8.33 | 6.00 |
| ***R13*** | 5.24 | 7.33 | 6.67 | 4.00 | 7.33 | 7.67 | 5.33 | 8.33 | 7.67 | 7.00 | ***R30*** | 2.24 | 8.83 | 4.67 | 5.33 | 6.67 | 9.00 | 4.67 | 7.33 | 3.67 | 6.67 |
| ***R14*** | 3.33 | 5.33 | 7.33 | 2.00 | 5.00 | 6.33 | 4.33 | 7.33 | 8.67 | 4.00 | ***R31*** | 4.21 | 4.00 | 4.33 | 5.00 | 7.33 | 9.00 | 5.67 | 4.00 | 5.00 | 2.67 |
| ***R15*** | 1.12 | 6.67 | 1.67 | 6.33 | 8.17 | 2.33 | 7.67 | 6.67 | 8.17 | 5.00 | ***R32*** | 2.40 | 6.67 | 7.00 | 6.33 | 5.00 | 6.33 | 7.00 | 6.67 | 8.50 | 7.00 |
| ***R16*** | 2.78 | 5.67 | 3.33 | 1.50 | 6.33 | 6.33 | 1.50 | 8.50 | 8.00 | 8.50 | ***R33*** | 4.02 | 6.67 | 6.67 | 6.00 | 8.50 | 8.83 | 6.00 | 4.67 | 9.67 | 6.00 |
| ***R17*** | 0.67 | 1.50 | 4.33 | 1.50 | 2.33 | 1.50 | 4.33 | 7.00 | 8.83 | 8.50 | ***R34*** | 3.19 | 4.00 | 6.67 | 1.50 | 7.67 | 7.00 | 4.67 | 3.33 | 9.50 | 6.67 |

Table 6. Calculate the total weight of each indicator by combining Opinions of the experts and Shannon Entropy

| | *PIR* | $SIR_1$ | $SIR_2$ | $SIR_3$ | $SIR_4$ | $SIR_5$ | $SIR_6$ | $SIR_7$ | $SIR_8$ | $SIR_9$ |
|---|---|---|---|---|---|---|---|---|---|---|
| $E_j$ | 0.9357 | 0.9841 | 0.9103 | 0.8917 | 0.9512 | 0.9418 | 0.9681 | 0.989 | 0.9752 | 0.9766 |
| $d_j$ | 0.0643 | 0.0159 | 0.0897 | 0.1083 | 0.0488 | 0.0582 | 0.0319 | 0.011 | 0.0248 | 0.0234 |
| $W'_j$ | 0.1187 | 0.0822 | 0.0548 | 0.0731 | 0.0457 | 0.0799 | 0.0868 | 0.0639 | 0.0708 | 0.0753 |
| $W_j$ | 0.1622 | 0.0278 | 0.1045 | 0.1682 | 0.0473 | 0.0988 | 0.0589 | 0.015 | 0.0373 | 0.0375 |

Table 7. Determining the ranking of risk for each of the indicators

| Rank | *PIR* | $SIR_1$ | $SIR_2$ | $SIR_3$ | $SIR_4$ | $SIR_5$ | $SIR_6$ | $SIR_7$ | $SIR_8$ | $SIR_9$ | Rank | PIR | $SIR_1$ | $SIR_2$ | $SIR_3$ | $SIR_4$ | $SIR_5$ | $SIR_6$ | $SIR_7$ | $SIR_8$ | $SIR_9$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | *R3* | *R17* | *R2* | *R11* | *R3* | *R7* | *R3* | *R7* | *R7* | *R1* | 18 | *R32* | *R25* | *R31* | *R34* | *R27* | *R21* | *R31* | *R30* | *R4* | *R9* |
| 2 | *R7* | *R5* | *R3* | *R4* | *R9* | *R3* | *R1* | *R34* | *R10* | *R3* | 19 | *R26* | *R13* | *R16* | *R19* | *R10* | *R11* | *R27* | *R12* | *R20* | *R24* |
| 3 | *R8* | *R26* | *R8* | *R12* | *R7* | *R29* | *R16* | *R26* | *R8* | *R21* | 20 | *R30* | *R20* | *R11* | *R20* | *R22* | *R20* | *R33* | *R29* | *R26* | *R30* |
| 4 | *R9* | *R31* | *R14* | *R15* | *R8* | *R4* | *R19* | *R8* | *R19* | *R31* | 21 | *R25* | *R12* | *R18* | *R7* | *R4* | *R22* | *R8* | *R3* | *R29* | *R34* |
| 5 | *R1* | *R34* | *R19* | *R32* | *R1* | *R8* | *R22* | *R31* | *R9* | *R4* | 22 | *R20* | *R27* | *R15* | *R2* | *R14* | *R1* | *R26* | *R22* | *R32* | *R13* |
| 6 | *R12* | *R10* | *R32* | *R33* | *R33* | *R30* | *R20* | *R10* | *R22* | *R8* | 23 | *R21* | *R28* | *R29* | *R5* | *R32* | *R10* | *R32* | *R23* | *R14* | *R26* |
| 7 | *R13* | *R19* | *R1* | *R30* | *R15* | *R31* | *R7* | *R33* | *R30* | *R14* | 24 | *R19* | *R18* | *R22* | *R6* | *R19* | *R28* | *R2* | *R24* | *R3* | *R32* |
| 8 | *R29* | *R4* | *R13* | *R31* | *R12* | *R9* | *R14* | *R9* | *R31* | *R19* | 25 | *R15* | *R22* | *R5* | *R8* | *R21* | *R5* | *R10* | *R1* | *R17* | *R28* |
| 9 | *R11* | *R23* | *R33* | *R9* | *R25* | *R33* | *R17* | *R18* | *R25* | *R20* | 26 | *R2* | *R1* | *R10* | *R18* | *R20* | *R15* | *R15* | *R11* | *R6* | *R12* |
| 10 | *R10* | *R8* | *R34* | *R13* | *R34* | *R12* | *R21* | *R21* | *R21* | *R6* | 27 | *R17* | *R7* | *R21* | *R3* | *R5* | *R17* | *R25* | *R13* | *R11* | *R11* |
| 11 | *R4* | *R14* | *R7* | *R25* | *R13* | *R13* | *R30* | *R15* | *R1* | *R15* | 28 | *R5* | *R30* | *R6* | *R21* | *R6* | *R23* | *R28* | *R16* | *R12* | *R22* |
| 12 | *R31* | *R16* | *R9* | *R29* | *R29* | *R25* | *R34* | *R19* | *R13* | *R2* | 29 | *R22* | *R11* | *R26* | *R23* | *R17* | *R18* | *R4* | *R25* | *R5* | *R25* |
| 13 | *R33* | *R29* | *R12* | *R14* | *R31* | *R26* | *R9* | *R32* | *R18* | *R7* | 30 | *R27* | *R21* | *R23* | *R26* | *R18* | *R27* | *R11* | *R27* | *R34* | *R5* |
| 14 | *R28* | *R9* | *R20* | *R28* | *R30* | *R34* | *R13* | *R17* | *R16* | *R10* | 31 | *R6* | *R3* | *R24* | *R10* | *R28* | *R19* | *R6* | *R2* | *R2* | *R16* |

| | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 15 | *R14* | *R15* | *R4* | *R1* | *R16* | *R14* | *R29* | *R20* | *R27* | *R18* | 32 | *R18* | *R24* | *R28* | *R27* | *R23* | *R2* | *R5* | *R4* | *R23* | *R17* |
| 16 | *R34* | *R32* | *R30* | *R16* | *R26* | *R16* | *R12* | *R28* | *R28* | *R29* | 33 | *R24* | *R2* | *R25* | *R24* | *R24* | *R6* | *R23* | *R5* | *R24* | *R23* |
| 17 | *R16* | *R33* | *R17* | *R17* | *R11* | *R32* | *R18* | *R14* | *R15* | *R33* | 34 | *R23* | *R6* | *R27* | *R22* | *R2* | *R24* | *R24* | *R6* | *R33* | *R27* |

Table 8. Part of the allocation matrix

| | Rank 1 | Rank 2 | Rank 3 | Rank 4 | Rank 5 | Rank 6 | Rank 7 | Rank 8 | Rank 9 | Rank 10 | Rank 11 | Rank 12 | Rank 13 | Rank 14 | Rank 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R1 | 0.10 | 0.12 | 0.00 | 0.00 | 0.22 | 0.00 | 0.07 | 0.00 | 0.00 | 0.00 | 0.09 | 0.00 | 0.00 | 0.00 | 0.10 |
| R2 | 0.07 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.10 | 0.00 | 0.00 | 0.00 |
| R3 | 0.33 | 0.28 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| R4 | 0.00 | 0.10 | 0.00 | 0.11 | 0.10 | 0.00 | 0.00 | 0.11 | 0.00 | 0.00 | 0.16 | 0.00 | 0.00 | 0.00 | 0.07 |
| R5 | 0.00 | 0.11 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| R6 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.10 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| R7 | 0.29 | 0.16 | 0.06 | 0.00 | 0.00 | 0.00 | 0.12 | 0.00 | 0.00 | 0.00 | 0.07 | 0.00 | 0.10 | 0.00 | 0.00 |
| R8 | 0.00 | 0.00 | 0.33 | 0.15 | 0.11 | 0.10 | 0.00 | 0.00 | 0.00 | 0.11 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| R9 | 0.00 | 0.06 | 0.00 | 0.16 | 0.09 | 0.00 | 0.00 | 0.19 | 0.10 | 0.00 | 0.00 | 0.07 | 0.12 | 0.11 | 0.00 |
| R10 | 0.00 | 0.09 | 0.00 | 0.00 | 0.00 | 0.19 | 0.00 | 0.00 | 0.00 | 0.16 | 0.00 | 0.00 | 0.00 | 0.10 | 0.00 |
| R11 | 0.10 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.16 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| R12 | 0.00 | 0.00 | 0.10 | 0.00 | 0.00 | 0.16 | 0.00 | 0.06 | 0.00 | 0.11 | 0.00 | 0.00 | 0.07 | 0.00 | 0.00 |
| R13 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.16 | 0.07 | 0.00 | 0.10 | 0.17 | 0.09 | 0.00 | 0.12 | 0.00 |
| R14 | 0.00 | 0.00 | 0.00 | 0.07 | 0.00 | 0.00 | 0.10 | 0.12 | 0.00 | 0.00 | 0.11 | 0.00 | 0.10 | 0.00 | 0.26 |
| R15 | 0.00 | 0.00 | 0.00 | 0.10 | 0.00 | 0.00 | 0.06 | 0.00 | 0.00 | 0.00 | 0.19 | 0.00 | 0.00 | 0.00 | 0.11 |
| R16 | 0.00 | 0.00 | 0.12 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.11 | 0.00 | 0.09 | 0.06 |
| R17 | 0.11 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.12 | 0.00 | 0.00 | 0.00 | 0.00 | 0.09 | 0.00 |
| R18 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.09 | 0.00 | 0.00 | 0.00 | 0.09 | 0.00 | 0.10 |
| R19 | 0.00 | 0.00 | 0.00 | 0.21 | 0.07 | 0.00 | 0.11 | 0.10 | 0.00 | 0.00 | 0.00 | 0.09 | 0.00 | 0.00 | 0.00 |
| R20 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.12 | 0.00 | 0.00 | 0.10 | 0.00 | 0.00 | 0.00 | 0.00 | 0.07 | 0.09 |
| R21 | 0.00 | 0.00 | 0.10 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.29 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| R22 | 0.00 | 0.00 | 0.00 | 0.00 | 0.12 | 0.09 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| R23 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.11 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| R24 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| R25 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.16 | 0.00 | 0.10 | 0.11 | 0.00 | 0.00 | 0.00 |
| R26 | 0.00 | 0.00 | 0.19 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.11 | 0.00 | 0.00 |
| R27 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.09 |
| R28 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.26 | 0.00 |
| R29 | 0.00 | 0.00 | 0.11 | 0.00 | 0.00 | 0.00 | 0.00 | 0.16 | 0.00 | 0.00 | 0.00 | 0.16 | 0.11 | 0.00 | 0.12 |
| R30 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.11 | 0.19 | 0.00 | 0.00 | 0.00 | 0.12 | 0.00 | 0.00 | 0.06 | 0.00 |
| R31 | 0.00 | 0.00 | 0.00 | 0.21 | 0.09 | 0.00 | 0.11 | 0.19 | 0.00 | 0.00 | 0.00 | 0.16 | 0.06 | 0.00 | 0.00 |
| R32 | 0.00 | 0.00 | 0.00 | 0.00 | 0.10 | 0.07 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.09 | 0.00 | 0.00 |
| R33 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.16 | 0.09 | 0.00 | 0.18 | 0.00 | 0.00 | 0.00 | 0.16 | 0.00 | 0.00 |
| R34 | 0.00 | 0.09 | 0.00 | 0.00 | 0.11 | 0.00 | 0.00 | 0.00 | 0.00 | 0.13 | 0.00 | 0.12 | 0.00 | 0.11 | 0.00 |

Table 9. Ranking of different risks

| Risk | Rank | Risk | Rank | Risk | Rank | Risk | Rank |
|---|---|---|---|---|---|---|---|
| R1 | 7 | R10 | 17 | R19 | 19 | R28 | 25 |
| R2 | 28 | R11 | 12 | R20 | 23 | R29 | 11 |
| R3 | 2 | R12 | 6 | R21 | 24 | R30 | 13 |
| R4 | 8 | R13 | 10 | R22 | 27 | R31 | 5 |
| R5 | 30 | R14 | 14 | R23 | 32 | R32 | 16 |
| R6 | 33 | R15 | 20 | R24 | 34 | R33 | 9 |
| R7 | 3 | R16 | 18 | R25 | 21 | R34 | 15 |
| R8 | 4 | R17 | 26 | R26 | 22 | | |
| R9 | 1 | R18 | 29 | R27 | 31 | | |

Finally, in order to rank the risks of first level (seven risk categories), it can mean less risk ranking category, ranking each study. (Table 10)As observed in the process of securing and providing the lowest risk ranking and win in the study were identified as the most critical risks.Therefore, the company should control the response and reaction of these risks and their management

Table 10. Ranking of seven main risk categories according to the following ranking categories

| Risk category | External risks | Risks related to procurement and supplier | Risks related to the supply of products | Risks related to production process | Risks related to information systems | Risks related to the support | Organizational risks |
|---|---|---|---|---|---|---|---|
| Subsidiaries | $R_1$ to $R_6$ | $R_7$ to $R_{10}$ | $R_{11}$ to $R_{17}$ | $R_{18}$ to $R_{22}$ | $R_{23}$ to $R_{28}$ | $R_{29}$ to $R_{31}$ | $R_{30}$ to $R_{34}$ |
| Ranking average | 18 | 6.3 | 15.1 | 24.4 | 27.5 | 9.7 | 13.3 |

## 9. Conclusion

Ranking risks in cases such as supply chains are faced uncertainty and the risks of exposure, including the necessary measures to manage and respond to risks.This requires the identification of risk-inducing factors and in this research in has been consideredterms of designing a model of comprehensive supply chain risk failure in three levels (3 sets total, 7 and 34 sub-categories and 300 subcategories).this model have been used to examine the steel supply chain in Esfahan Steel Complex and using new techniques based on group decision to gather Opinions of the experts and their input has been used to mean the assembly.In order to define the parameters of risk assessment first, the scope of the risk on the investment objectives of time, cost, quality and range of activities in different parts chain with different weights (Primary risk index calculation) have been developed.In order to more accurately assess and rank risks, secondary indicators (complementary) effects of socio-economic and environmental impacts, proximity of risk, exposure to risk, the confidence estimation, risk reduction, risk detection and management the amount of the risk is considered. Finally ranking was done by linear assignment. Methods and approaches presented in this paper give the credible results than traditional methods. Some of the reasons for this goal include:

1.in the Classical methods, a limited number of indicators (2 or 3 indicators) was used, and other important criteria have been overlooked. The results obtained from classical realistic and are not valid.

2. In classical methods, there is the possibility of systematic error.

3. According to the properties of linear assignment method of multiple criteria (such as the possibility of taking along a number of criteria, considering the different weights to the indicators, the exchange between indices, flexibility and optimization of results), risks assessment is done better and are ranke in realistic mode.

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