Identification and Clustering Outsourcing Risks of Aviation Part-Manufacturing Projects in Aviation Industries Organization Using K-means Method

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Abstract
The purpose of this paper is to identify and clustering strategic risks in the outsourcing field of part-manufacturing projects of aviation products, that whit survey carried out through the study of literature and experts opinion, meanwhile, identification risk groups in this area through interview, identified cases and factors of risks through FMEA technique, finally, 50 strategic risks identified in 7 titles. In the following to resolve problems of traditional FMEA method, with definition three indicators risk include, risk intensity, occurrence probability, and confrontation frequency by a questionnaire and considering from three factors outsourcing assess contain cost, time and quality, risks of this area were clustered to K-means clustering and using SPSS software in 4 cluster include of significant risks, high level of risks, medium level of risks and low level of risks. Thus, the clustering of risks for decision-making and planning of suggested actions at the time of their occurrence, basis for future improvements will be provided to carry out the continuous improvement process at appropriate intervals with assessment of actions taken, the rate of improvement identified and therefore appropriate decisions are achieved.

Keywords
Data mining, Clustering, K- means Method, Risk, Aviation Industries, Manufacturing Project

1. Introduction

Grover defined as the act of transferring some domestic activities and the right to decide Its activities, with contract to external suppliers say outsourcing. Because of that, the activities are repeated and subject of the contract raised, outsourcing beyond the use of consultants and in practice, not just activities, factors of production and related assets (Including people, facilities, equipment, technology, and other assets) and also the right to decide to be delegated. At the end of the 1980s this term about contracting (outsourcing) subsidiary, management information system has been developed and employed [1].

Outsourcing is a non-stop growing common procedure in companies that if it is targeted on the organization aims, it will result in unimaginable developments. Companies organize outsourcing as a method to gain flexibility parallel with existing structures of their organizations [2]. In fact, outsourcing is one of the modern methods of management for dealing with shortcomings and limitations that organizations are involved with. A special place has been allocated for it. One of the reasons why outsourcing is currently achieving more importance can be more widely improvement of industries, trade, and specialization of activities. Therefore, in order to survive in such a

competitive market, turning to the field of outsourcing is inevitable. On the other hand, although, outsourcing brings interests and benefits to organizations, it involves them with some risks and hazards as well. So, implementing risk management of outsourcing is an important issue that should not be neglected [3]. Examples of these risks can be the loss of technical capabilities over time, missing qualified and expert personnel, lack of supervision on outsourcing activities and etc. which ultimately leads to failure to achieve anticipated benefits and the result is failing the projects [4]. Therefore, recognition and management of this space and its risks are essential. Meanwhile, cost, time (delivery time) and quality are the three main factors to manage to outsource [5]. Identifying these risks based on defined parameters, can lead to lower the costs and achieve strategic advantages [6]. This identification can be more beneficial along with risk management, provided that together clustering and ranking are based on important risks factors. In that case, the senior management and management levels of organizations would be able to make proper decisions and take perfect actions.

The aim of the current study on this issue is to provide and offer a method for identifying and categorizing the risks of outsourcing in the field of part – manufacturing projects in the aviation industries organization. The mentioned three main factors (cost, quality and delivery time) of evaluating outsourcing field, are considered by researchers to identify the risks for companies and organizations are able to improve their actions and gain more interests and benefits to organizations while concentrating on their weak points.

Actually creativity and novelty this paper the reason is those researchers to identify and clustering of risks in this combination of assessment indicators of outsourcing and indicators of risk assessment have used.

2. Research Literature

Identify risks in different areas is a concern for project managers, been evaluated methodology do it in different articles, according conducted research, in projects with many of risk factors can be used clustering methods, including K-means method [7].There are various methods for clustering, to identify and analyze the risks according clustering methodology is recommended FCM our K-MEANS methods [8]. latest research has been done on the clustering of risk can be referred to Moazem jazz's research identified risks areas of electrical airlines based on indicators time, cost and quality, and then clustering them to K-Means method [9]. This paper is accepted by the Sharif journal in-field industrial engineering and management that according to declaration the journal will be available online from 19 March 2017. This refers to the fact that subject of current article is a new article. Also Fgwueleka and Moses in an article, by study risks and dangers of taking drug directly or prescribe the wrong medicine, investigated risks and were clustered them with K-Means method [10]. Hanafizadeh in an article entitled, a data mining model for risk assessment and customer segmentation in the insurance industry, to investigate risks in case study (vehicle insurance), finally18 risk factors identified, were grouped in four clusters by using K-means method [11]. In other research has been done on the clustering of risks, in most of them form fuzzy method of k-means is used that is called FCM. Some of them done recently cited as follows:

Mozaffari et al., in an article titled ”risk assessment and management in factories producing steel details using FMEA and data mining techniques” Identified major risks in this area. This study was

conducted with the aim of remove, reduce and control environmental risks in the company rolled Arian steel has been done [12].

Mirfakhredini and Pourhamid during the researching a bout potential failure scenarios (risk of existing processes) in the steel unit of Iran Alloy Steel Company clustered by FCM method that is fuzzy method k-means. In this study, with describing the concept of cluster analysis and specifications of different models of clustering, classified the potentially harmful situations and evaluated the potential for accidents in the steel unit of Iran Alloy Steel Company by using a combination of methods FMEA and clustering [13].

Also Rahmani Baroji, Arish and Shakeri Roshan, Farid and Porhamidiare are other examples of the use of clustering for classification of risk in the areas of studied [14-16].

In these methods, the aim of clustering is identity and risk categories in the fields studied. From the method k-means or FCM for clustering of risk in different topics including medical, environmental and project risk is used. In this paper, we used this technique for clustering of outsourcing risks part-manufacturing projects.

3. Principles of K- Means Method of Clustering

Clustering is one of the most common data mining techniques that have been used in many areas.

Data mining means the extraction of data, knowledge and detecting surreptitious patterns from a very large and complex database. The two main objectives of data mining are foreseeing and description. In predictive algorithms, by using past values and variables, other unknown future valuable data are identified [17]. Finding descriptive patterns of data, which can be determined by humans, is on descriptive algorithms [18].

Clustering is one of the branches of unsupervised learning that is an automated process in which the samples are divided into categories whose members resemble each other. The categories are called clusters [19]. Therefore the cluster is a collection of similar objects that differ from objects existing in other clusters. Different criteria may be considered for similarity, for example, distance criteria may be used for clustering and the objects closer to each other can be considered as a cluster. This type of clustering is also called distance-based clustering [20].

According to Equation (1), the cluster analysis method is said to be using sample data can be classified into several clusters or classes; so that the data located in each cluster are homogeneous and uniform and the biggest difference and heterogeneity between clusters exist. Of course, this clustering occurs when the distribution of the population being sampled is taken from is high, however, this is the basic condition for the formation of clusters that, the clusters are partition of the community or sample [21].

K-means method is the most practical method of data clustering. This method first time by (McQueen, 1967) was presented. In this way, the number of clusters is constant and predetermined. This method is designed for clustering data that are numerically (quantitative) and clusters have been central to name average. In this way, beginning objects randomly divided into K clusters. In the next step interval of each of the objects of their cluster centers is calculated. If the distance between the intended object of average its cluster is high and to other cluster is closer, this object allocated to the corner that is closer. This process is repeated until the error function is minimized or cluster members do not change.

If D is the data set with n objects and C_1, C_2, C_3, …, C_k represents K clusters separate D. In this case, the error function (ERF) total distances every object is defined from the center of the cluster itself.

$$EF=\sum_{i=1}^{k}\sum_{x\varepsilon c_i} d(x,\mu(c_i)) \quad (1)$$

Where μ represents the center (mean) cluster and, $d(x,\mu(c_i))$, is the distance of each object from the center of its cluster. The distance of each object from its cluster can be calculated based on Euclidean distance or another method. Because in clustering oriented center, whose purpose is to minimize the error function can to clustering issues centripetal looked to see optimization problems. In this type of clustering is the objective function that is error function and aim is minimizing it. There are several limitations to the objective function which include:

• The number of clusters is pre-determined and cannot be low or high.
• The number of members of any of the clusters cannot be zero

In clustering K on average, during the steps are as follows:

Step 1. Separation of preliminary data into K clusters if desired

Step 2. (Repetitious step):

• Calculate the distance of each object from its cluster center
• Calculate the error function

Step 3. (Recovery step): movement member that has Maximum distance from the center of the cluster itself to the cluster that has closest to it.

Stop order: Not Getting change cluster members or not reducing the amount of error function [22].

4. Research Method

Current investigation method according to the nature of the object and purposes is a case study. Data collection has been performed by using library studies, survey methods, and interview with experts and obtaining their ideas. In the first step, in order to identify the risks of this area, the risk groups (risk issues) of the projects were identified through interview with 5 industry experts. During this stage, the risks (processes) were identified in 7 groups. In the second step, in order to complete and final determination of each of the designated groups of risk (risk states), standard FMEA worksheets were prepared and presented to 5 executives and experts of deputies of outsourcing and sale, and also sale managers of industries affiliated by aviation Industries organization, and through interview with designated persons, primary data related to potential risks were obtained. In the third step, in order to gather experts' opinions, considering the risks identified for obtaining defined criteria (risk severity, probability of occurrence, and confrontation frequency), questionnaires were prepared and presented to statistical society of this research in compliance with recommendation some experts and the assistant professor of this project offered. In the fourth step, obtained data were averaged out for each criterion of the risk and finalized. Finally, the outsourcing risks of part manufacturing projects were clustered based on these data using SPSS software by K-means method. The procedure of this project is shown in Figure 1.

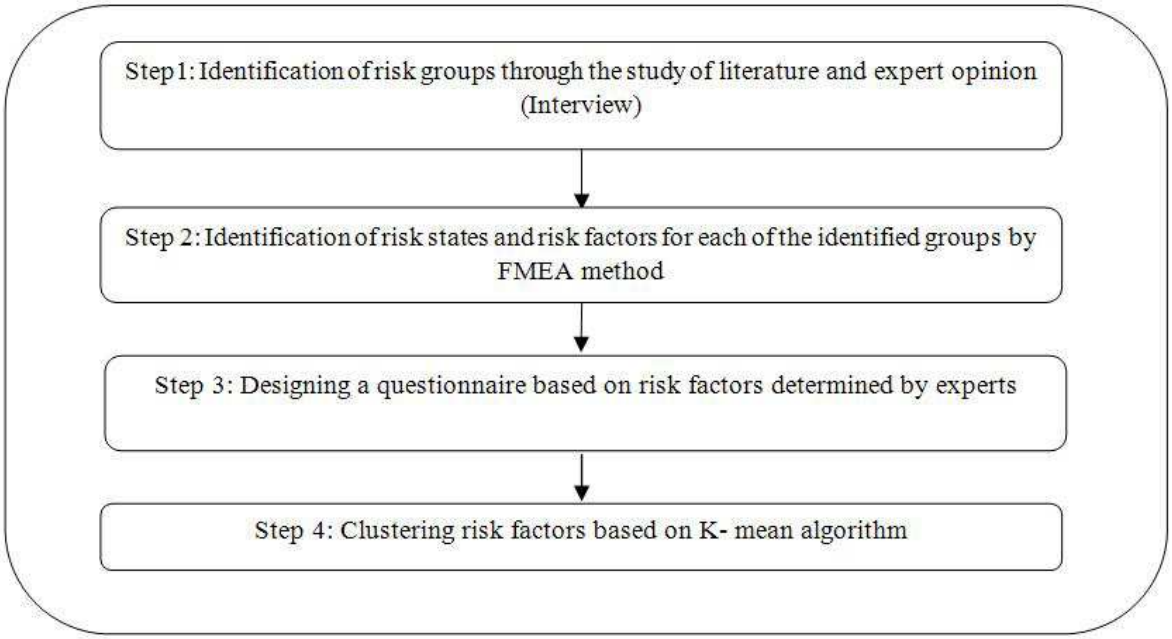

Figure1. Projects outsourcing in aviation industries organization

In this project, reviewing the projects, outsourcing and contractors' activities resulted in identifying and categorizing the features of risk in outsourcing desired processes, in the mold of general forms and then, three factors (Risk Severity (S), Occurrence Probability (OP), and Confrontation Frequency (CF) are defined in Qualitative and Quantitative methods that finally, the Qualitative method is converted to Quantitative method for each factor in a specified tables. The results of this review are based on risk number or RPN that is obtained from the multiplication of above mentioned three factors. For Quantitative method, numerical options 1 through 10, and for Qualitative method, phrasal options- Very efficient, Efficient, Very high, High, Medium, Low, Very low, Poor, Very Poor, and Negligible, have been offered in the questionnaires and distributed among statistical society. In this research, considering the importance of risk severity in current risk Processes, this factor is defined according to the influence on outsourcing objectives of part-manufacturing projects. These objectives include quality, performance, time (delivery time), and cost that are actually outsourcing evaluation indexes. Therefore, this index is defined as follows.

$$S=\sum (W_1 I_1+ W_2 I_2+ W_3 I_3) \quad (2)$$

I_1 through I_3 are effectiveness rate of risk severity on time, cost, quality, and performance of part-manufacturing projects outsourcing, and W_1 through W_2 are index importance weight of risk severity on time, cost, and quality. They are verified for each feature of the risk so that the sum of the weights for each risk is one. This index with two other indexes is designed and used in questionnaires for evaluating the risk and obtaining data of each identified risk according to experts' opinions.

Index importance weight of the risk severity affected on delivery time, cost, quality and performance of part-manufacturing outsourcing projects in aviation industries organization is determined by 7 outstanding experts for each feature of identified risks.

Comprehensively, for identifying and clustering general risks in this project, the following steps are performed:

- Dividing investigating units into independent units.
- Selecting experts and motivated and experienced persons to interview in order to identify and determine risk groups.
- Evaluation of the activities of each unit and risk features based on determined groups.
- Preparation of investigation form of risk features in accordance with the optimized FMEA method.
- Interview and data collection and identification of risk features.
- Recognition and distinguishing of causes of the risk (risk factors).
- A designing questionnaire based on specified criteria by experts
- Distributing questionnaires to complete the required information.
- Perform calculations to determine the final index
- Performing clustering in SPSS software to K-means method

Determine the criteria for clustering (Traits used in clustering)

according to the main indicators of the risk assessment, including Risk Severity (S), occurrence Probability (OP), and Confrontation Frequency (CF) and also assessment indicators outsourcing which are quality, time and cost [23], according the importance of risk severity index, this index defined according to affect tot he objectives of outsourcing part manufacturing projects actually are same indicators quality and performance, time (delivery time) and cost. So 5 index number of confrontation are Frequency (CF), occurrence Probability (OP), amount of influence Risk Severity (S) to quality, amount of influence Risk Severity to the delivery time and amount of influence Risk Severity to cost as the main indicators to be considered in the cluster analysis. That statistical data indicators achieved (data) from statistical society research with questionnaire was designed.

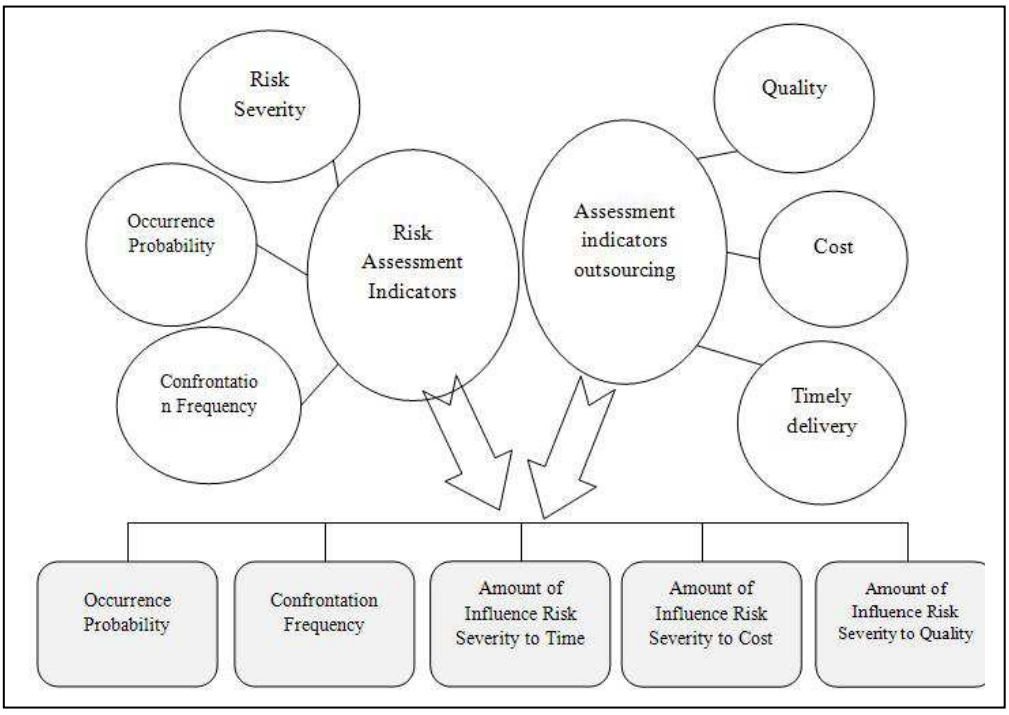

Figure2. Determine the final index to assess and Clustering of Outsourcing Risks of Part-Manufacturing Projects

5. Findings and Results of the Research

Through interviews with experts in the aviation industry and the use of FMEA questionnaire designed based on the obtained index, the risk in this area in the 3 groups (categories) and 7 titles risks that are Contains 50 risk factors that been identified as follows Table1.

Table1. Identified Outsourcing Risks of Part-Manufacturing Projects of Aviation Products

Risk Factors	Risk States	Subjects	Row
Lack of experience, skills, and knowledge in the field of outsourcing	Structural defects	Quality	1
Different working styles			2
Contractors policies with negative effects			3
Contractor's team Compounds			4
Contractor’s Unwarranted and unrealistic expectations			5
The moral hazard of contractor			6
Involvement and access to confidential materials by the contractor			7
The uncertainty of the project	Structural defects	Quality	8
Unknown needs, disproportionate and contradictory			9
Change and slip on the objectives, scope, and needs of the project			10
Reasoning and computational complexity			11
The high level of technical complexity	Structural defects	Quality	12
Important changes and integration requirements			13
Ignore posts in outsourcing			14
Lack of organizational structure in contractors			15
Communication problems			16
Lack of governance, leadership, and management in project			17
Lack of executive support	Functional defects	Quality	18
Contractor's Cultural weakness			19
Lack of experience and expertise in project tasks			20
Lack of skills needed			21
Loss of key employees			22
Contractor's Unrealistic claims			23
Contradictions between the employer and the contractor			24
Lack of participation of contractors			25
Lack of care, control and quality assurance			26
Lack of accountability specified procedures			27
Administrative and technical problems			28
The complexity of tasks			29
The inadequacy of the operations taken place in some cases			30
Lack of experience and expertise in the management of contracts	Management’s	Cost	31

Risk Factors	Risk States	Subjects	Row
Inadequate capital	Unwanted cost		32
Uncertainty in environmental laws			33
The lack of definition of responsibilities between outsourcing and contractor			34
being large Some of the outsourcing projects			35
A large number of suppliers (contractors)	Unforeseen expenses in the choice of suppliers		36
Lack of support from the contractor culture			37
Disputes between Contracting parties			38
The low number of suppliers			39
Fluctuations in currency exchange	Hidden costs		40
Uncertainty about the technological changes That are customers' needs			41
The complexity of contract activity			42
Change in project management	The cost of rework and replacement	Cost	43
Replacement contractor before the completion of the project because of the lack of supply requirements			44
Dependence Activities			45
Error in determining penalties for Inefficiency			46
Inaccurate estimates schedules and resources needed	Error in starting the project and provide customer service	Timely delivery	47
Lack of preparation and tools and equipment			48
Lack of timely supply required resources			49
contractor's Incomplete commitments			50

After identifying risks for their management clustering these risks is done For this purpose, with using a questionnaire and distributed it among the 145 population, data will be charged, those descriptive statistics were obtained from data collected with using from SPSS software that is presented in Table 2. According to this Table, dispersion and the average between the selected samples are smaller and equal to 0.05 in the other words, the mean and standard deviation between each pair of risks, are uniform. Nevertheless, K-Means clustering can be performed on obtained samples.

Continue on with calculating the average of data taken from questionnaires to five defined criteria final data has been entered within 19 SPSS software. Clustering with using of K– Means and with level of assurance of 0.95 and Maximum 30 repeat times is done. For this purpose, data clustering for 3 to 5 cluster implement and its output was obtained from software. One of these outputs ANOVA tables for each of the clustering is done. For the best clustering is discovered, is used from ANOVA table that is related to the analysis of variance for comparing the average cluster and extracted from SPSS software [24]. Results clustering for 3 to 5 clusters is presented in Tables 3 to 5.

Table2. Descriptive statistics risks

Variance	Average	Maximum	Minimum	Number of risks	Indicators
0.786	2.37	5	1	50	number of confrontation frequency
0.602	2.76	5	1	50	occurrence probability
0.841	2.55	5	1	50	amount of influence risk severity to quality
0.752	2.81	5	1	50	amount of influence risk severity to delivery time
0.659	2.46	5	1	50	amount of influence risk severity to cost

Table3. Analysis of variance for 3 clusters

The level of assurance	F	Error		Cluster		Clusters
		N-١	Average of squares	N-١	Average of squares	
0.000	2.88	47	0.605	2	2.523	number of confrontation frequency
0.000	3.54	47	0.425	2	3.485	occurrence probability
0.000	2.97	47	0.503	2	2.951	amount of influence risk severity to quality
0.335	0.98	47	1.523	2	0.889	amount of influence risk severity to delivery time
0.042	1.74	47	1.212	2	1.526	amount of influence risk severity to cost

Table4. Analysis of variance for 4 clusters

The level of assurance	F	Error		Cluster		Clusters
		N-1	Average of squares	N-1	Average of squares	
0.000	2.73	46	0.615	3	2.647	number of confrontation frequency
0.000	3.65	46	0.448	3	3.328	occurrence probability
0.000	2.87	46	0.535	3	2.845	amount of influence risk severity to quality
0.000	2.212	46	0.646	3	2.456	amount of influence risk severity to delivery time
0.004	1.74	46	1.315	3	1.452	amount of influence risk severity to cost

Table5. Analysis of variance for 5 clusters

The level of assurance	F	Error		cluster		Clusters
		N-1	Average of squares	N-1	Average of squares	
0.000	2.54	45	0.589	4	2.845	number of Confrontation Frequency
0.000	3.12	45	0.354	4	2.984	occurrence Probability
0.000	1.75	45	0.626	4	2.115	amount of influence risk severity to quality
0.008	1.21	45	1.446	4	1.945	amount of influence risk severity to delivery time

The level of assurance	F	Error		cluster		Clusters
		N-1	Average of squares	N-1	Average of squares	
0.000	0.86	45	1.715	4	1.354	amount of influence risk severity to cost

Considering the ANOVA tables in Table 3 the level of assurance indicator of influence risk severity to delivery time is greater than 0.05 (0.335 is greater than 0.05). So be investigated clustering with more number. According to Tables 4 and 5, all numbers have the values level of assurance less than 0.05.therefore, both clustering is done with 4 or 5 clusters can be selected final Clustering. And these clustering's have accuracy and level of assurance are. with regards to aim of this research that is clustering of outsourcing risks of part-manufacturing projects and achieve to a logical category that while classifying risk in this area also prevent from the data dispersion, so Is selected clustering with 4clusterfor final clustering.

According to Table 4 all amounts in all characteristics level of assurance have been zero and only one case has the value 0.008(less than 0.05)that is not acceptable assumption equality average of groups in the other words, this amount shows that difference of clusters average is high and specifies that the clustering is done properly.

So according to the identified risks as described in Table 2, and obtaining data from the statistical population and the relevant calculation, these risks in SPSS software based on 5 specified index clustering were in four clusters, that with regard to the output of SPSS software 50 risks identified in four clusters as follow Table 7 distributed in clusters 1 to 4.

Then according to this output of SPSS software and experts opinion of aviation industry, this four cluster was introduced and named as Table 6, that accordingly, risks are in cluster 1, called important risks, that the occurrence of and disregard for them will be created irrecoverable damage to the organization. Therefore, manage these risks should be a top priority for the aviation Industries organization. The second cluster risks are risks that their occurrence caused severe disruptions in the activities of an organization and sometimes need to spend time and money to compensate them is high. The third cluster risks Lead that organizational processes are slow. Basically, these risks by managing supervisors and managers within an appropriate process to eliminate or reduce the effects are unexpected. The fourth cluster risks include risks that usually occur at predictable times that which according to existing guidelines and developed under the supervision of managers, supervisors, suggested actions and corrective are proposed.

Table6. Description and title each of the clusters have been finalized.

Ranking(Title)	Description	Cluster
Important risks	Risks of this cluster basically, the risks are that with the occurrence and in case of lack of attention of the related managers, be created irreparable damage to their organization	1
High-level risks	These risks need special attention on behalf of senior management, and their occurrence causing severe disruptions in the activities of an organization and sometimes need to spend time and money to compensate them is high.	2
Risks to the medium level	These risks have to be inferior to two previous levels,their occurrence is slowed or stopped the organization's activities for a while.	3
Low-level risk	The risks of this cluster in organizational processes usually occur at predictable	4

Ranking(Title)	Description	Cluster
	times, which according to existing guidelines and developed under the supervision of managers and supervisors, suggested actions and corrective Performed.	

Table7. Final result clustering of Outsourcing Risks of Part-Manufacturing Projects of Aviation Products

Cluster4	Cluster3	Cluster2	Cluster1	Subject
• being large Some of outsourcing projects • Reasoning and computational complexity • Lack of participation of contractors • The large number of suppliers (contractors) • Lack of accountability specified procedures • The low number of suppliers • Lack of support from the contractor culture • The uncertainty of project • Contractors policies with negative effects • The high level of technical complexity • Contractor's team Compounds • Involvement and access to confidential materials by the contractor • Uncertainty in environmental laws • Disputes between Contracting parties • Dependence	• Administrativeand technical problems • contractor's Unrealistic claims • Contradictions between the employer and the contractor • Lack of care, control and quality assurance • Contractor’s Unwarranted and unrealistic expectations • The complexity of tasks • Communication problems • Change in project management • Unknown needs, disproportionate and contradictory • Error in determining penalties for Inefficiency • Moral hazard of contractor • Ignore posts in outsourcing • The inadequacy of the operations taken place in some cases • Lack of organizational structure in contractors	• Inaccurate estimates schedules and resources needed • Inadequate capital • contractor's Incomplete commitments • Change and slip on the objectives, scope and needs of the project • The complexity of contract activity • Loss of key employees • Lack of preparation and tools and equipment • The lack of definition of responsibilities between outsourcing and contractor • contractor's Cultural weakness • Different working styles	• Lack of skills needed • Lack of experience, skills and knowledge in the field of outsourcing • Fluctuations in currency exchange • Lack of governance, leadership and management in project • Lack of timely supply required resources • Lack of executive support • Uncertainty about the technological changes That are customers' needs • Lack of experience and expertise in project tasks • Lack of experience and expertise in the management of contracts	Risk Title

Cluster4	Cluster3	Cluster2	Cluster1	Subject
Activities • Replacement contractor before the completion of the project because of the lack of supply requirements • Important changes and integration requirements				

In fact in this study meanwhile, identify outsourcing risks of aviation part-manufacturing projects, was presented a prioritization of these risks along with preventative measures that should be planned which results of this research can be a basis for other aviation industries in Iran.

6. Limitations of the Research and Suggestions

6.1 Limitations

- According to the issues, data mining require substantial numbers of data so if have a wide range of risks data in this area, perhaps the results to improve.
- Conducted research about clustering did often and especially in recent years in field's quantity discussions, and about risks and different factors of risk do not do much. Therefore, in this study, researchers in literature review have been limited.

6.2 Suggestions

In future researches can with risk analysis and determine preventive measures, did clustering before performing these steps and then after the implementation of preventive measures and optimization and proposed a comparison of the situation before and after the improvements proposed, in fact, as a performance evaluation method for the continuous improvement of quality management, use, and exploitation.

- Expand the scope of research in the fields of contractors can be considered in future research, it can even be a combination of the two areas studied and implemented.
- It is suggested to increase the accuracy of results use from fuzzy clustering for the final categories of risk such as FCM method (fuzzy c-mean).

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