

Development of Risk Assessment Framework Based on Perspectives of Technical Staff in Power Distribution Companies: A Case Study

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Abstract

The fundamental goal of this article, which investigates the working circumstances of technical personnel at a power distribution company, is to determine the level of danger they face when working in various conditions. The multi-grade fuzzy technique was used in this investigation. The assessment will assist the distribution company in determining the level of risk that their technical personnel face, identifying strong and weak traits, and making appropriate improvement recommendations. The final risk index is calculated as 7.01, which indicates that the risk level of the case electric power distribution company is “High Risk”. The study was further extended to identify the weaker attributes using Importance Performance Analysis (IPA). Medical support provided by the organization and financial aid to the employees in case of an accident are considered weaker attributes of the case power distribution company. The results of the study would help the managers of the company to analyze the current risk level of the company and to focus on their weaker attributes to make necessary improvements in the working pattern and implement new innovative methods that help to reduce the risk level of workers and provide them with a safer environment.

Keywords

Risk assessment, Power distribution company, Risk perception, Multi-grade fuzzy, Importance Performance Analysis

1. Introduction

Power distribution can be defined as the final stage of delivery of power from the transmission system to individual customers. Due to various aspects relating to the operations of a power distribution company, the risks that may cause injuries to the technical staff are also high. The study tries to identify various attributes that might cause risk to the technical staff while they are engaged in certain activities to ensure proper power supply to the consumers. The level of risk is higher in the distribution of electrical energy when compared with the distribution of other types of power.

Even though there are many studies that have been done on the topic of workplace safety in power distribution, the number of studies on electrical workplace risk is comparatively lower. This was the primary motivation for conducting the study and determining the areas where workers' electrical safety is jeopardized. The uniqueness of this study is the use of a multi-grade fuzzy approach in the calculation of the risk index of the distribution company and to provide them with recommendations for improving the workplace safety of technical staff. The framework also addresses the following questions:

RQ1: How can the risk level of a DISCOM's technical team be assessed?

RQ2: What are the enablers, criteria and attributes that influence the risk level of technical staff?

RQ3: How are the weaker attributes addressed to reduce the risk level of technical staff of case DISCOM unit?

The purpose of the study was to provide answers to the above-mentioned questions as well as to assist the case firm in identifying areas where they have limits and improving worker safety procedures in order to reduce the incidence

of workplace accidents. The study also suggests that the measures supplied to the example company be applied as a continuous process in order to maintain and increase the desired quality.

2. Literature Review

Working conditions can be defined as the environment in which an employee works and the features of the agreements and terms that apply to the employee with their employer. Working conditions include training programs, work culture, working activities, health and safety, and work culture. Work shift can be defined as the time allotted to an employee and the rotation of employees within and outside the organization. Positive attitude (Jarvenpaa and Ives, 1991), enthusiastic approvals (Leonard-Barton and Deschamps, 1988), involvement of authority and desires and opinions raised' (Sultan and Chan, 2000) and commitments contribute significantly to organizational support.

Management support is defined behaviorally as straightforward management behaviors such as offering assistance in solving technical or other issues (Compeau and Higgins, 1995), engaging in activities and being in the personal intervention (Jarvenpaa and Ives, 1991), acting as project sponsors (Wixom and Watson, 2001), and facilitating the working environment. Perceived organization support can be defined as how an employee perceives being valued and taken care of by the organization. Risk perception is a complex, multidetermined phenomenon; it is how an individual considers the risks in front of them and it can be considered an important aspect of self-protecting behavior.

Komunjer (2007) has studied the risks and the various ways to measure these risks effectively. It also puts light on the financial aspect of the risk faced by the companies. Brown (2017) has studied the reliability of power distribution. This study also explains the existing correlation between the cost of electricity and customer satisfaction. The study helps to address the issues faced due to aging infrastructure, avoid the common pitfalls, and conduct effective risk management. Fischhoff (1995) studied the importance of risk perception and its impact on the overall health of the person engaged in that particular activity. Precautionary measures are important while performing a particular activity that includes risk (Esmaeili et al., 2015). It includes using PPE kits, helmets, understanding rules, etc. Dong et al.(2009) has studied how the role of top management and their support helps in improving the working of an enterprise. The study also suggests that the management should adjust various actions so as to achieve the expected outcome.

Streff et al.(1993) in his study discusses a meeting carried out in a company where the employees have discussed the importance of using PPE while working. The paper discusses several pieces of safety equipment and their applications, which help to avoid various accidents that might occur in the workplace. Davidson et al.(2009) have conducted a study that explains the impact of natural disasters on the working environments of people. They have discussed various factors like personal factors, personal safety, perceived importance, etc. in this study.

3. Research Methodology

3.1 Multi-grade fuzzy

The multi-grade fuzzy approach was used in the industrial and service industries to examine lean, agile, performance, safety practice level, and supply chain management effectiveness (Vinodh and Aravindraj, 2015; Sridharan and Suresh, 2016; Ganesh and Suresh, 2016; Vinodh and Chintha, 2011; Vinodh, 2011; Vimal et al., 2015; Almutairi et al., 2019).

This study was conducted at a case distribution firm that utilized multi-grade fuzzy to develop a workplace risk assessment framework for technical staff working there. The current study begins with a literature review on risk in power distribution companies and a multi-grade fuzzy assessment. Table 1, given below, shows a new conceptual model for assessing the risk index, which includes five enablers, twelve criteria, and thirty-two attributes.

Table 1. Conceptual model of risk assessment for technical staff in a power distribution company

Enabler	Criteria	Attributes
External Support to the employees(A1)	Support from the organization (A11)	Medical support provided by the organization (A111)
		Financial aid to the employees in case of an accident (insurance, compensation) (A112)
		Reporting of incidents by the authorities (A113)

	Support from top management (A12)	Inspection of the workplace by the top management before normal workers start their work (A121)
		Support from trade unions in the topics related to safety. (A122)
		Providing proper safety equipment to employees on time(A123)
		Quality of equipment provided to employees (A124)
Hazard avoidance factors (A2)	Risk perception (A21)	Ability to assess risk in a given situation (A211)
		Role of work experience in analyzing a situation (A212)
		Thought process of workers and their attitude towards risk (A213)
	Precautionary measures (A22)	First aid facilities provided to the workers(A221)
		Training provided to staff on how to avoid an accident (A222)
		Checking of electrical safety guidelines (A223)
Job-related factors (A3)	Working conditions (A31)	Long working hours be a reason for accidents (A311)
		Exposure to the electric and magnetic field (A312)
	Behavioral factors (A32)	Effect of carelessness and negligence in workplace safety. (A321)
		Behavior from top management officials while doing high-risk duties. (A322)
		The behavior of customers on facing a glitch (A323)
	Work shift (A33)	Level of safety in work during the day shift (A331)
Level of safety in work during the night shift (A332)		
Uncontrollable factors (A4)	Natural factors (A41)	Influence of seasons on the working conditions and risk level. (A411)
		Natural disasters lead to various workplace hazards (A412)
	Demographic factors (A42)	Role of age and gender in the risk level (A421)
		Role of the level of education in assessing the risk level (A422)
		Role of employment type in the assessing risk level (Permanent or contract workers) (A423)
Controllable factors (A5)	The mental attitude of workers (A51)	Risk tolerance level seen in employees (A511)
		Influence of Personal Problems of the workers (A512)
		Job stress-releasing activities (A513)
	Physical health of workers (A52)	Fatigue or drowsiness felt during working (A521)
		Health issues faced during work (A522)
	Employee efficiency (A53)	Knowledge gained by workers on several aspects of safety in working (A531)
Job satisfaction of workers (A532)		

4. Case Study

4.1 Case of a power distribution company

The case power distribution company is based in India (hereafter referred to as the ABC distribution company). The firm is mainly focused on electrical power production and distribution. The study being conducted now is to measure the risk level of the technical staff working in the organization.

The risk index is represented as A . It is the product of the overall assessment level of ratings based on each driver (R) and the overall weights (W) given by the experts. The equation for the risk index is

$$A = W \times R \text{ (Anil and Suresh, 2020; Suresh et al., 2020; Menon and Suresh, 2020)}$$

The assessment has been divided into ten grades since the entire risk index involves fuzzy determination. $A = \{10, 9, 8, 7, 6, 5, 4, 3, 2, 1\}$. 9-10 represents 'Extremely High Risk', 8-9 represents 'Very High Risk', 7-8 represents 'High

Risk', 6–7 represents 'Risk', 5–6 represents 'Moderate Risk', 4–5 represents 'Low Risk', 3–4 represents 'Very low Risk', 2–3 represents 'Very very low Risk', 1–2 represents 'No Risk', and less than 1 represents 'Risk-free operations. For the attribute's ratings, we used a questionnaire with a 10-point Likert scale that represents extremely high risk (10 points) to risk-free operations (1 point). The weightage has been collected from five experts from various divisions of the power distribution company using a 10-point Likert scale that represents extremely high importance (10 points) to extremely low importance (1 point). The risk ratings are collected from the case division of power distribution company experts and are captured in Table 2.

Table 2. Weights and performance rating from experts

Ai	Aij	Aijk	R1	R2	R3	R4	R5	Wijk	Wij	W
A1	A11	A111	7	8	6	6	5	0.350	0.506	0.21
		A112	8	7	8	6	6	0.307		
		A113	9	9	8	9	8	0.341		
	A12	A121	6	7	9	5	6	0.254	0.493	
		A122	7	7	6	8	9	0.176		
		A123	8	9	9	8	8	0.281		
A2	A21	A211	7	8	6	7	8	0.368	0.493	0.194
		A212	8	9	6	8	7	0.319		
		A213	7	8	7	7	6	0.311		
	A22	A221	7	8	9	6	6	0.333	0.506	
		A222	8	9	9	8	7	0.35		
		A223	8	6	7	6	6	0.316		
A3	A31	A311	7	6	7	8	7	0.555	0.336	0.2
		A312	2	1	1	2	2	0.444		
	A32	A321	9	8	9	8	8	0.412	0.318	
		A322	8	8	9	8	8	0.309		
		A323	7	6	5	6	5	0.278		
	A33	A331	8	7	6	7	8	0.522	0.345	
A332		5	6	5	4	4	0.477			
A4	A41	A411	9	9	8	8	9	0.552	0.507	0.189
		A412	8	8	6	8	9	0.447		
	A42	A421	5	6	6	5	6	0.326	0.492	
		A422	7	7	8	7	8	0.346		
A5	A51	A511	2	2	1	6	4	0.416	0.33	0.205
		A512	2	2	1	2	2	0.166		
		A513	4	4	8	7	5	0.416		
	A52	A521	8	9	8	9	8	0.449	0.346	
		A522	7	8	7	8	9	0.550		
	A53	A531	8	8	7	7	8	0.528	0.322	
A532		7	7	9	8	9	0.471			

Primary assessment calculation

The primary calculation done for the "Support from the organization (A11)" is given below.

Weights concerning to "Support from organization" criterion is $W_{11} = [0.350, 0.307, 0.341]$

Assessment for the practice of the "Support from organization" criterion is given below as

$$R_{11} = \begin{bmatrix} 7 & 8 & 6 & 6 & 5 \\ 8 & 7 & 8 & 6 & 6 \\ 9 & 9 & 8 & 9 & 8 \end{bmatrix}$$

Index concerning of "Support from organization" criterion is given by

$$A_{11} = W_{11} \times R_{11}$$

$$A_{11} = [7.991, 8.034, 7.299, 7.025, 6.333]$$

Using the above principle, the indexes for the following risk assessment criteria were calculated and are listed below.

$$A_{12} = [7.601, 8.137, 8.470, 7.235, 7.954]$$

Secondary assessment calculation

The calculation concerning to enabler of “External Support to the employees(AI)” is given below as

Weights concerning to “External Support to the employees” enabler given as $W_1 = [0.506, 0.493]$

Assessment of “External Support to the employees” enabler is given as below

$$A_1 = \begin{bmatrix} 7.991 & 8.034 & 7.299 & 7.025 & 6.333 \\ 7.601 & 8.137 & 8.470 & 7.235 & 7.954 \end{bmatrix}$$

Index concerning “External Support to the employees” enabler is given by

$$A_1 = W_1 \times R_1$$

$$A_1 = [7.798, 8.085, 7.877, 7.129, 7.134]$$

Using the above principle, the indexes for the following risk enablers were calculated and are listed below.

$$A_2 = [7.495, 8.014, 7.352, 7.005, 6.699]$$

$$A_3 = [6.464, 5.892, 5.875, 6.086, 5.991]$$

$$A_4 = [7.625, 7.625, 7.223, 7.023, 8.184]$$

$$A_5 = [5.948, 6.295, 6.440, 7.241, 7.048]$$

Tertiary assessment calculation

The risk assessment value of the case power distribution firm has been calculated as follows

Complete weight $W = [0.210, 0.194, 0.2, 0.189, 0.205]$

$$\text{Complete assessment vector } R = \begin{bmatrix} 7.798 & 8.085 & 7.877 & 7.129 & 7.134 \\ 7.495 & 8.014 & 7.352 & 7.005 & 6.699 \\ 6.464 & 5.892 & 5.875 & 6.086 & 5.991 \\ 7.625 & 7.625 & 7.223 & 7.023 & 8.184 \\ 5.948 & 6.295 & 6.440 & 7.241 & 7.048 \end{bmatrix}$$

Risk index $A = W \times R$

$$A = [7.06, 7.17, 6.95, 6.89, 7.00]$$

The final risk index is the average of $A = 7.01 \in (7 \text{ to } 8)$. \therefore ‘High Risk’

4.2 Importance Performance Analysis (IPA)

In the industrial and service industries, IPA is commonly used to identify qualities based on their relevance and performance. (Chacko et al., 2021; Vaishnavi and Suresh, 2021; Sreedharshini et al., 2021). In IPA, the x -axis is the performance rating of the attributes, and the y -axis is their importance (Suresh and Gopakumar, 2021). The mean of the x -axis is 6.84 and the mean of the y -axis is 7.00 as a perpendicular line is given below in Table 3 Quadrant I (Keep up the good work): This quadrant consists of attributes that need to be maintained as the same, and these attributes are “Medical support provided by the organization; financial aid to the employees in case of an accident (insurance, compensation); inspection of the workplace by the top management before normal workers start their work; thought process of workers and their attitude towards risk; checking of electrical safety guidelines”.

Table 3. IPA analysis for risk assessment of technical staff in the power distribution company

Importance \uparrow	9	Quadrant -I									A211		A123	A124
	8.5								A111	Quadrant -II		A222		
	8								A121,A213, A223	A221	A212, A522	A321	A113	
	7.5								A112		A531		A411	
	7							A421, A513		A331,A422, A423	A532			
	6.5						A332					A521		
	6								A311		A412	A322		
	5.5							A323		A122				
	5	A312												

	4.5																
	4																
	3.5																
	3	A512															
	2.5	Quadrant -IV							Quadrant -III								
	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	
	Risk Rating →																

Quadrant II (concentrate here): The attributes in this quadrant needed more attention to be given by the case division of power distribution company managers to reduce the risk level of their operations. The attributes are “Reporting of incidents by the authorities; providing proper safety equipment to employees on time; quality of equipment provided to employees; ability to assess risk in a given situation, the role of work experience in analyzing a situation; first aid facilities provided to the workers; training provided to staff on how to avoid an accident; effect of carelessness and negligence in workplace safety; influence of seasons on the working conditions and risk level; health issues faced during work; knowledge gained by workers on several aspects of safety in working”.

Quadrant III (Possible overkill): The attributes in this quadrant are of low importance but they are high-risk rating (Subramanian and Suresh, 2022). The risk level of these attributes should be minimized. The attributes are “Support from trade unions on the topics related to safety; behavior from top management officials while doing high-risk duties; level of safety in work during the day shift; natural disasters leading to various workplace hazards; the role of the level of education in assessing the risk level; the role of employment type in assessing the risk level (permanent or contract workers); fatigue or drowsiness felt during work; job satisfaction of workers”.

Quadrant IV (Low priority): The attributes in this quadrant are of low importance and low risk rating (Thomas and Suresh, 2022). The attributes are “Long working hours are a reason for accidents; exposure to the electric and magnetic fields; behavior of customers when facing a glitch; level of safety in work during the night shift; the role of age and gender in the risk level; risk tolerance level seen in employees; influence of personal problems of the workers; job stress-releasing activities”.

5. Results and discussions

The suggestions for the improvement of weaker attributes are given in Table 4.

Table 4. Suggestions for weaker attributes

Weaker attributes	Suggestions for improvement
Reporting of incidents by the authorities	<ul style="list-style-type: none"> • An online portal can be set up for the employees to raise their concerns. • A committee can be formed which investigates the reasons behind the occurrence of a project.
Providing proper safety equipment to employees on time	<ul style="list-style-type: none"> • Regular checks should be made on the availability of equipment. • The entire region under the firm can be divided into several zones, and analysis of safety equipment can be done.
Quality of equipment provided to employees	<ul style="list-style-type: none"> • A quality check needs to be done for all the safety equipment. • A quality officer is to be appointed in each zone who is responsible for making sure that the equipment is of high quality.
Ability to assess risk in a given situation	<ul style="list-style-type: none"> • Effective training has to be given to the workers to foresee a risky situation • Modern equipment is to be provided to the workers.

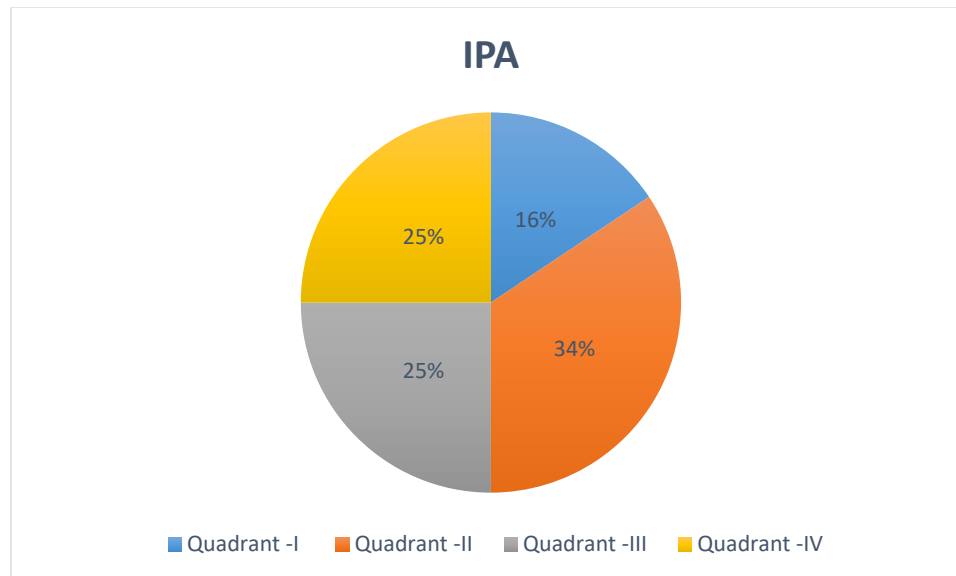


Figure 1. The percentage of number of factors in each quadrant.

If the case company focuses on the above weaker attribute so that they can reduce the risk level of their operations. Figure 1 represents the percentage of number of factors in each quadrant. The attributes in this quadrant II needed more attention to be given by the case division of power distribution company managers to reduce the risk level of their operations.

6. Practical Implication

The study has identified about 32 attributes and they have been classified under 5 different enablers. This type of classification has made it easier to analyze various factors which are contributing to increased risk levels in the working atmosphere of staff in the case distribution company. Workplace safety is an important factor that affects the efficient working of an organization. So, it is the responsibility of the top-level management to ensure that the workers are provided with all the facilities to work safely and that they are in a mental condition to work properly. With the help of IPA, the study has identified several weak attributes. It is identified that “reporting of incidents by the authorities, providing proper safety equipment to employees on time, and quality of equipment provided to employees” are the weaker attributes that contribute to the “high level” of risk existing now in the case distribution company. The management can analyze the various aspects to improve workplace safety and can concentrate more on these weaker attributes so that the risk level of the employees will reach a point where the risk is negligible. A continuous assessment needed to be done to maintain the level of safety and to improve.

7. Conclusion

Power distribution is an integral part of modern society and its use and application will be increasing in the near future. This is also a field that has workplace risks that lead to many accidents that cause casualties and injuries. The proposed study would help the top-level management of the distribution company to analyze their position in providing safety to workers and identify those fields in which they are lacking proper attention and need improvement. The study uses an approach named the multi-grade fuzzy approach and the case study was conducted at ABC Distribution Company. It has been found that the risk level of the firm comes under the category of “High Risk”. The study also included an IPA which helps to identify the weaker attributes of the firm.

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