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ANALYZING THE JUDGEMENT OF TEXTILE FIRMS OF PUNJAB (INDIA) TOWARDS THE GLITCHES RELATED TO ELECTRIC POWER AND LEVEL OF OCCURRENCE OF POWER OUTAGES

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Abstract: A demographic research was conducted to record the judgment of the textile firms from Punjab (India) towards the different origin and causes of power outages in order to know the position of the connected power systems of the public utility company- Punjab State Power Corporation Limited over a seven-point ordinal Likert scales. From April 2015 to April 2017, a successful response from 148 textile firms was obtained falling in the areas of Central, North and South Punjab. The answers were recorded on a questionnaire schedule by conducting both personal interviews and dropping the schedules at the targeted firms for a stipulated period of time. The respondents were advised to answer the questions keeping in mind the years from 2010 to 2014. The Kruskal Wallis and Friedman's tests with post hoc were applied for the independent and related samples, respectively. The effect sizes were also calculated from the Kruskal Wallis and Mann Whitney test statistics. The power system reliability issues were found highly dominant over the power quality issues. The higher rankings towards the occurrence of power outages because of the failures occurring in infrastructure and equipment showed that the performance of the power systems was not up to the mark. The textile firms from North and South Punjab ranked higher on majority of the dependent variables as compared to the Central Punjab which indicated that the impact of power outages was considerably higher in these regions.
Keywords: power outages, causes, questionnaire schedule, utility, textile industries, Punjab (India)

1. INTRODUCTION

An electric power outage is one of the major cause of downtime in the industrial sector. The occurrence of the electric power outages in the manufacturing and commercial businesses not only results in the economic losses but also impacts the image of the firms in this highly competitive world. The availability of uninterrupted electric power supply at the firms is required in order hold a good image among the consumers and to make the deliveries to the clients in a stipulated period of time. In order to accomplish this goal, the reliability of the power systems connected to the firms is required as high as possible, which can only be achieved if these systems have the ability to withstand sudden disturbances and have the capacity to meet the required demand of the customers. Around 94% of the total energy not served resulting from outages was due to unplanned outages and only 6% can be attributable to planned outages [6]. Power is Africa's major infrastructure weak point and companies in Senegal, Tanzania, and Burundi experienced power outages for an average of 45, 63, and 144 [2]. Increasing numbers of blackouts are predicted due to growing uncertainties in supply and growing certainties in demand. Definite electrical power is also under risk because of supply constraint: fossil fuel diminution and the transient nature of renewable energy sources [5]. During the year 2009 in Cameroon, most of the firms registered nearly 275 to 353 short length outages that caused in an upsurge of 13 to 20% of the expenditures associated to the repair of the equipment damage [1]. The purpose of the presented research was to differentiate and compare among the ratings of the textile firms of Punjab towards the variables depicting the origin of electric power outages, level of satisfaction towards the restoration time taken by the utility in an event of different types of outages and level of occurrence of different types of power outages based on their type and length, on an ordinal seven point Likert scales and Likert scale items.

2. METHODOLOGY

With a simple random sampling approach, 400 textile firms were randomly selected from a specially prepared list of total 1163 registered textile firms from a database of ministry of corporate affairs and ministry of micro, small and medium enterprises, out of which 148 were responded to a questionnaire schedule through conducting the interviews and dropping the schedules with the firms for a specified period of time. The districts where the textile firms have very low concentration were not considered in the list and only the Ludhiana from Central Punjab, Amritsar and Jalandhar from North Punjab, and Patiala and Mohali from South Punjab were targeted because of the high concentration of textile firms in these districts. The judgment of the respondents from Central, North and South Punjab where the textile firms were highly concentrated was recorded for a time frame from 2010 to 2014 over a period of two years from April 2015 to April 2017. During this duration, 84 firms responded from the Central Punjab, 40 firms replied from the North Punjab and 24 industries answered from the South Punjab. A partially filled questionnaires were discarded and only the completely filled questionnaires were considered for the data analysis. As the number of large and medium scale firms was marginally very small as compared to micro and small scale firms, the response of only micro and small scale firms was taken. Moreover, the response of large and medium scale firms was found very poor because of their tight schedules and decision of dropping these firms from the study was taken at the early stages of the research. The distinctiveness of the presented research is the application of ordinal approach applied to the study which revealed the substantial amount of information without the use of time consuming hypothetical calculations which is evident from the literature review. This approach can be very beneficial to assess the condition of the power systems, especially, when the data related to types and frequency of outages are not properly maintained at the local regional offices of the utilities.

3. DATA ANALYSIS AND DISCUSSIONS

Two software, SPSS 24 and Microsoft excel were used for the analysis and visualization of the data. Tableau 2018.1 software was specifically used for making the 100 percent centred diverged stacked charts in order to show the distribution of the textile firms among the seven categories of the survey scale. For the estimation of Krippendorff's Alpha- an ordinal reliability measure, SPSS syntax (macro) was used which was not available in SPSS 24 [3]. The internal consistency and interrater reliability measures were calculated using Cronbach's Alpha and Krippendorff's Alpha, respectively, for the different sections of the survey as shown in the Table 3.1. The Cronbach's Alpha for independent samples was found between 0.69 to 0.92. The Krippendorff's Alpha (K-Alpha) for the levels of independent variable samples was calculated as 0.80 and 0.78, respectively. All the reliability measures were found in the acceptance zone. The values of Kendall's W between 0.65 and 0.78 for the different sections of the study are indicating that the respondents have been unanimous, and each respondent has assigned almost the same order to the variables under consideration.

Table 3.1 Reliability Measurement of the Survey

Reliability Measurement of the Survey (2010-2014)							April 2015 - April 2017			
Independent Variable Location	Districts Punjab	Responders Textile Industries	Reliability Krippendorff's Alpha				Reliability Cronbach's Alpha			
			B	D	Ei	Fii	B	D	Ei	Fii
1. Central Punjab	Ludhiana	84	0.73	0.65	0.53	0.71	0.86	0.85	0.69	0.92
2. North Punjab	Amritsar | Jalandhar	40	0.69	0.64	0.82	0.67				
3. South Punjab	Patiala | Mohali	24	0.64	0.61	0.85	0.60	Confidence Level= 0.95 Significance Level= 0.05			
Total	Major Districts	148	0.63	0.50	0.51	0.44				
Kendall's Coefficient of Concordance- | Part B= 0.78 | Part D= 0.72 | Part Ei= 0.68 | Part Fii= 0.65 |										

Survey Scale	1	2	3	4	5	6	7
Part B	Not at all concerned	Slightly concerned	Somewhat concerned	Moderately concerned	Considerably concerned	Highly concerned	Extremely concerned
Part Ei	Completely dissatisfied	Mostly dissatisfied	Somewhat dissatisfied	Neutral	Somewhat satisfied	Mostly satisfied	Completely satisfied
Part D and Fii	Never	Rarely	Occasionally	Sometimes	Frequently	Usually	Every time

The independent sample Kruskal Wallis test and the related sample Friedman test were applied to know the statistically significant differences between the distributions of independent variables on the ordinal dependent variables and between the distributions of related dependent variables, respectively. A Dunn's Bonferroni post hoc test was used to identify the statistically significant differences for both independent and related sample pairs. A Kruskal Wallis H and Mann Whitney U statistic were used to calculate the effect sizes for the groups and significant pairs. The zone with values of effect sizes from 0.060-0.110 is known as the zone of intermediate effect and values more than 0.140 shows the large effect. The values which were falling in the "no" and "small" effect zone area were not considered [5]. A detailed statistical analysis of the dependent variables (B1-B9) associated with the "level of concern towards the power system reliability and quality issues" is presented in the Table 3.2. A Kruskal-Wallis test was applied on the dependent variables from B1 to B9 to examine if there were differences in level of concern scores between groups that differed in their geographical region: the "Central Punjab" (n = 84), "North Punjab" (n = 40) and "South Punjab" (n = 24) geographical region level groups. A level of concern scores was statistically significantly different between the different levels of geographical region group based on the test statistics "H (Degree of Freedom) or $\chi 2$ (Degree of Freedom)" with p-value of 0.000 for the variables B1, B3-B6, B8 and B9 and 0.002 and 0.037 for the variables B2 and B7, respectively. The H or $\chi 2$ test statistics values for the variables B1, B2, B3, B4, B5, B6, B7, B8 and B9 are 62.276, 12.372, 44.452, 63.379, 55.224, 52.976, 6.606, 21.091 and 72.900, respectively. Next, by using these H-statistics values, effect sizes (η_H^2) were calculated for all the variables using the online effect size calculator and were found in the zone of large effect except for the variables B2 with an effect size of 0.072 and B7 with 0.032 which were found in the zone of intermediate and small effect. The effect sizes calculated for other variables B1, B3, B4, B5, B6, B8 and B9 were seen in the zone of large effect with values 0.416, 0.293, 0.423, 0.367, 0.352, 0.132 and 0.489, respectively. Afterwards, pairwise comparisons were made using Dunn's (1964) procedure. A Bonferroni correction for multiple comparisons was done with statistical significance accepted at the $p < .0167$ level. This post hoc analysis exposed statistically significant differences in the level of concern scores between Central Punjab and North Punjab for the variables B1, B3-B6, B8 and B9 with p- values equal to 0.000 and for the variables B2 and B7 with p-values of 0.005 and 0.031, respectively. Also, pairwise comparisons of Central Punjab and South Punjab for the variables B1, B3-B6 and B9 have shown statistically significant differences with p values of 0.000 and for the variables B2 and B8 with p values of 0.049 and 0.017, respectively, however, no statistical significant difference was found for the variable B7. None of the pairwise comparison have shown statistically significant differences between the North Punjab and South Punjab geographical region groups for any of the dependent variables. For the variable B2, statistically significant difference were seen only between Central and North Punjab groups among the three group pairwise comparisons and for the variable B7, two group pairwise comparisons, Central and North Punjab, and Central and South Punjab have shown statistically significant difference. For all the variables, mean rank was found lower for the Central Punjab than North and South Punjab which is evident from the Table 3.2. After carefully observing the median values and crosstab calculations showing the percentage distribution of the sample, both the groups North and South Punjab were responded similarly with higher ranks on seven-point scale as compared to Central Punjab which showed that the textile firms from North and South Punjab were highly concerned towards the power system reliability and quality issues. However, a closer look on the results of the variables portrayed that the power reliability issues were ranked noticeably higher than the power quality issues which revealed that the reliability problems such as unplanned outages, planned outages and insufficient generation (leads to load shedding) in the power system were the main reason of their apprehension during the period from 2010-2014.

Table 3.2. Level of Concern towards the Power System Reliability and Quality Issues

Dependent Variables	Location	Median	K-W Mean Rank	Visual Mean Rank	Bonferroni Dunn's Post Hoc					
					Group Pairs	Test Statistics	Standard Error	Test Std. Statistcs	p-value	Adjusted p-value
B1 System voltage fluctuations	1 Central Punjab	2	51.15		1-2	-57.333	7.965	-7.198	0.000	0.000
	2 North Punjab	5	108.49		2-3	8.925	10.706	0.834	0.404	*1.000*
	3 South Punjab	3.5	99.56		3-1	-48.408	9.597	-5.044	0.000	0.000
	| p = 0.000 | H = 62.276, df = 2 | η2(H) = 0.42 |				U(1-2)= 389 (0.000), η2= 0.38 || U(3-1)= 338 (0.000), η2= 0.23 |					
B2 System frequency fluctuations	1 Central Punjab	2	64.45		1-2	-23.891	7.661	-3.118	0.002	0.005
	2 North Punjab	3	88.34		2-3	1.713	10.297	0.166	0.868	*1.000*
	3 South Punjab	2.5	86.63		3-1	-22.179	9.231	-2.403	0.016	*0.049*
	| p = 0.002 | H = 12.372, df = 2 | η2(H) = 0.07 |				U(1-2)=1129 (0.001), η2= *0.07* || U(3-1)=714 (0.019), η2= *0.04* |					
B3 System transient faults	1 Central Punjab	2	55.34		1-2	-41.761	7.732	-5.401	0.000	0.000
	2 North Punjab	3	97.1		2-3	-6.796	10.392	-0.654	0.513	*1.000*
	3 South Punjab	3	103.9		3-1	-48.557	9.316	-5.212	0.000	0.000
	| p = 0.000 | H = 44.452, df = 2 | η2(H) = 0.30 |				U(1-2)=700.5 (0.000), η2= 0.22 || U(3-1)=378 (0.000), η2= 0.20 |					
B4 System switching/ operating errors	1 Central Punjab	4	50.98		1-2	-56.511	7.929	-7.127	0.000	0.000
	2 North Punjab	5	107.49		2-3	5.633	10.657	0.529	0.597	*1.000*
	3 South Punjab	5	101.85		3-1	-50.878	9.553	-5.326	0.000	0.000
	| p = 0.000 | H = 63.379, df = 2 | η2(H) = 0.42 |				U(1-2)= 399 (0.000), η2= 0.38 || U(3-1)= 313 (0.000), η2= 0.24 |					
B5 System protection/ relaying problems	1 Central Punjab	5	53.33		1-2	-55.835	7.846	-7.116	0.000	0.000
	2 North Punjab	6	109.16		2-3	18.329	10.545	1.738	0.082	*0.247*
	3 South Punjab	5	90.83		3-1	-37.506	9.453	-3.968	0.000	0.000
	| p= 0.000 | H= 55.224, df= 2 | η2(H) = 0.37 |				U(1-2)=453.5 (0.000), η2= 0.35 || U(3-1)= 456 (0.000), η2= 0.15 |					
B6 System transmission overloading	1 Central Punjab	4	53.09		1-2	-52.898	7.930	-6.671	0.000	0.000
	2 North Punjab	5	105.99		2-3	9.029	10.658	0.847	0.397	*1.000*
	3 South Punjab	5	96.96		3-1	-43.869	9.554	-4.592	0.000	0.000
	| p= 0.000 | H= 52.976, df= 2 | η2(H) = 0.35 |				U(1-2)= 479 (0.000), η2= 0.33 || U(3-1)= 410.5 (0.000), η2=0.18 |					
B7 System supply deficit (insufficient generation)	1 Central Punjab	6	68.4		1-2	-19.395	7.553	-2.568	0.010	0.031
	2 North Punjab	6	87.8		2-3	14.133	10.152	1.392	0.164	*0.492*
	3 South Punjab	6	73.67		3-1	-5.262	9.100	-0.578	0.563	*1.000*
	| p = 0.037 | H = 6.606, df = 2 | η2(H) = 0.03 |				U(1-2)=1244 (0.011), η2= *0.04* || U(3-1)=932 (0.534), η2=*0.003* |					
B8 Unplanned power outages	1 Central Punjab	6	61.68		1-2	-32.321	7.564	-4.273	0.000	0.000
	2 North Punjab	7	94		2-3	7.125	10.166	0.701	0.483	*1.000*
	3 South Punjab	7	86.88		3-1	-25.196	9.113	-2.765	0.006	0.017
	| p = 0.000 | H = 21.091, df = 2 | η2(H) = 0.13 |				U(1-2)= 947 (0.000), η2= *0.12* || U(3-1)= 664 (0.006), η2= *0.06* |					
B9 Planned power outages	1 Central Punjab	3	48.94		1-2	-59.510	8.016	-7.424	0.000	0.000
	2 North Punjab	5	108.45		2-3	1.075	10.773	0.100	0.921	*1.000*
	3 South Punjab	5	107.38		3-1	-58.435	9.658	-6.051	0.000	0.000
	| p= 0.000 | H= 72.900, df= 2 | η2(H) = 0.49 |				U(1-2)= 345 (0.000), η2= 0.41 || U(3-1)= 196 (0.000), η2= 0.33 |					

Similarly, a statistical analysis of the dependent variables (D1-D5) related with the "occurrence of the outages based on the fault occurred in the electric components" is shown in the Table 3.3. A Kruskal-Wallis test was conducted on the dependent variables from D1 to D5 to determine if there were differences in level of frequency of occurrence scores between groups that varied in their geographical region: the "Central Punjab" (n = 84), "North Punjab" (n = 40) and "South Punjab" (n = 24) geographical region level groups. A level of concern scores was statistically significantly different between the different levels of geographical region group based on the test statistics "H (Degree of Freedom) or χ2 (Degree of Freedom)" with p-value of 0.000 for all the variables. The H or χ2 test statistics values for the variables D1, D2, D3, D4 and D5 are 96.937, 26.804, 103.927, 108.059 and 51.586, respectively. By using the H-statistics, effect sizes (η_H^2) were calculated for all the variables using the online effect size calculator. The effect sizes calculated for the variables D1, D2, D3, D4 and

D5 were found in the zone of large effect with values 0.655, 0.171, 0.703, 0.731 and 0.342, respectively. Then, pairwise comparisons were made using Dunn's (1964) procedure. A Bonferroni correction for multiple comparisons was applied with statistical significance accepted at the $p < 0.0167$ level. This post hoc analysis exposed statistically significant differences in the level of frequency of occurrence scores between Central Punjab and North Punjab for all the variables with p- values equal to 0.000. Also, pairwise comparisons of Central Punjab and South Punjab for all the variables have shown statistically significant differences with p values of 0.000 except for the variable D2 with p-value equal to 0.004. No statistically significant differences were found considering the pairwise comparison between the North Punjab and South Punjab for any of the dependent variables. For all the variables, mean rank was found lower for the Central Punjab than North Punjab and South Punjab which is evident from the Table 3.3. Crosstabulation calculations showing the percentage distribution of the sample revealed that both the groups North and South Punjab were responded almost in a similar manner with elevated ranks on seven-point scale in contrast with the Central Punjab which presented that the textile firms from North and South Punjab were found exposed to occurrence of more number of outages based on the fault happening in the electric components such as overhead lines, underground cables, transformers, switchgear and fuses. Further, the results of the variables described that the occurrence of electric power outages due to the fault occurring in the overhead lines, transformers and fuses were ranked similarly and markedly higher than the outages originating from switchgear followed by the underground cables which was questioning the condition and protection of electric infrastructure of the public utility- Punjab State Power Corporation Limited considering the period from 2010-2014.

Table 3.3. Occurrence of the Power Outages Based on the Fault Occurred in the Electric Components

Dependent Variables	Location	Median	K-W Mean Rank	Visual Mean Rank	Bonferroni Dunn's Post Hoc					
					Group Pairs	Test Statistics	Standard Error	Test Std. Statistcs	p-value	Adjusted p-value
D1 Overhead lines	1 Central Punjab	4	45.73214		1-2	-67.030	7.824	-8.567	0.000	0.000
	2 North Punjab	6	112.7625		2-3	1.346	10.516	0.128	0.898	*1.000*
	3 South Punjab	6	111.4167		3-1	-65.685	9.426	-6.968	0.000	0.000
	| p= 0.000 | H= 96.937, df= 2 | η2(H) = 0.66 |				U(1-2)= 153.5 (0.000), η2= 0.54 || U(3-1)= 118 (0.000), η2= 0.40					
D2 Underground cables	1 Central Punjab	3	62.20833		1-2	-30.642	6.413	-4.778	0.000	0.000
	2 North Punjab	3	92.85		2-3	5.912	8.620	0.686	0.493	*1.000*
	3 South Punjab	3	86.9375		3-1	-24.729	7.727	-3.200	0.001	0.004
	| p= 0.000 | H= 26.804 , df= 2 | η2(H) = 0.17 |				U(1-2)= 990 (0.000), η2= *0.11* || U(3-1)= 665.5 (0.001), η2= *0.06*					
D3 Transformers/ Equipment	1 Central Punjab	5	45.15476		1-2	-69.033	7.711	-8.953	0.000	0.000
	2 North Punjab	6	114.1875		2-3	3.125	10.363	0.302	0.763	*1.000*
	3 South Punjab	6	111.0625		3-1	-65.908	9.290	-7.095	0.000	0.000
	| p= 0.000 | H= 103.927, df= 2 | η2(H) = 0.70 |				U(1-2)= 119 (0.000), η2= 0.56 || U(3-1)= 104 (0.000), η2=0.41|					
D4 Switchgears	1 Central Punjab	4	43.92857		1-2	-73.271	7.890	-9.287	0.000	0.000
	2 North Punjab	5	117.2		2-3	6.867	10.604	0.648	0.517	*1.000*
	3 South Punjab	5	110.3333		3-1	-66.405	9.506	-6.986	0.000	0.000
	| p= 0.000 | H= 108.059, df= 2 | η2(H) = 0.73 |				U(1-2)= 39 (0.000), η2=0.62 || U(3-1)= 81 (0.000), η2= 0.44 |					
D5 Fuses	1 Central Punjab	5	54.81548		1-2	-47.860	7.366	-6.497	0.000	0.000
	2 North Punjab	6	102.675		2-3	6.238	9.901	0.630	0.529	*1.000*
	3 South Punjab	6	96.4375		3-1	-41.622	8.875	-4.690	0.000	0.000
	| p= 0.000 | H= 51.586, df= 2 | η2(H) = 0.34 |				U(1-2)= 604 (0.000), η2= 0.27 || U(3-1)= 430.5 (0.000), η2= 0.17					

Likewise again, a statistical analysis of the dependent variables (E1i-E5i) linked with the "level of satisfaction towards the restoration time taken by the utility during the different outage types" is shown in the Table 3.4. A Kruskal-Wallis test was conducted on the dependent variables from E1i to E5i to determine if there were differences in level of satisfaction scores between groups that varied in their geographical region: the "Central Punjab" ($n = 84$), "North Punjab" ($n = 40$) and "South Punjab" ($n = 24$) geographical region level groups. A level of satisfaction scores was statistically significantly different between the different levels of geographical region group based on the test statistics "H (Degree of Freedom) or χ2 (Degree of Freedom)" with p-value of 0.000 for all the variables except E4i in which the null hypothesis is accepted. The H or χ2 test statistics values for the variables E1i, E2i, E3i and E5i are 72.424, 117.580, 15.960 and 72.911, respectively. H-statistics values were used to calculate the effect sizes (η_H^2) for all the significant variables using the online effect size calculator. The effect sizes calculated for the variables E1i, E2i, E3i and E5i were found in the zone of large effect with values 0.486, 0.797, 0.096 and 0.489, respectively. Then, pairwise comparisons were made using Dunn's (1964) procedure. A Bonferroni correction for multiple comparisons was applied with statistical significance accepted at the $p < 0.0167$ level. This post hoc analysis exposed statistically significant differences in the level of satisfaction scores between Central Punjab and North Punjab for all the significant variables with p- values equal to 0.000 except for the variable E3i with p-value equal to 0.001. Also, pairwise comparisons of Central Punjab and South Punjab for all the significant variables have shown statistically significant differences with p values of 0.000 except for the variable E3i with p-value equal to 0.014. No statistically significant differences were found considering the pairwise comparison between the North Punjab and South Punjab for any of the dependent variables. For all the variables, mean rank was found higher for the Central Punjab than North Punjab and South Punjab which is evident from the Table 3.4. Crosstabulation results showing the percentage distribution of the sample indicated that both the groups North and South Punjab were responded nearly alike with lower ranks on seven-point scale than the Central Punjab. This showed that the textile firms from Central Punjab were slightly more satisfied than the North and South Punjab with restoration time taken by the utility during an outage of the categories mentioned in the Table 3.4 such as load shedding considering both weekly off days and peak load categories and long notice period or safe advance warning planned power outages. Further, it has been observed from the analysis that Central Punjab was quite satisfied with the restoration time taken by the utility in an event of an outage of the type "dangerous advance warning or short notice period planned power outages than the other two groups. For the variable, considering the "unplanned outages, North and South Punjab have ranked lower than the Central Punjab, depicting that northern and southern regions were dissatisfied towards the restoration time in an event of unplanned outages. This section is fairly linked with the performance of the utility staff based on their quickness to respond and restore the power considering the different type of outages.

Table 3.4. Level of satisfaction towards the restoration time taken by the utility during the different outage types

Dependent Variables	Location	Median	K-W Mean Rank	Visual Mean Rank	Bonferroni Dunn's Post Hoc					
					Group Pairs	Test Statistics	Standard Error	Test Std. Statistics	p-value	Adjusted p-value
E1i Unplanned power outages	1 Central Punjab	3	99.15		1-2	54.511	7.777	7.010	0.000	0.000
	2 North Punjab	2	44.64		2-3	6.638	10.452	0.635	0.525	*1.000*
	3 South Punjab	2	38.00		3-1	61.149	9.369	6.526	0.000	0.000
	| p= 0.000 | H= 72.424, df= 2 | η2(H) = 0.49 |				U(1-2)= 438 (0.000), η2= 0.35 || U(3-1)= 179 (0.000), η2= 0.35 |					
E2i Dangerous advance warning planned power outages	1 Central Punjab	5	106.49		1-2	74.532	7.901	9.434	0.000	0.000
	2 North Punjab	2	31.96		2-3	-1.454	10.619	-0.137	0.891	*1.000*
	3 South Punjab	2.5	33.42		3-1	73.077	9.519	7.677	0.000	0.000
	| p= 0.000 | H= 117.580 , df= 2 | η2(H) = 0.80 |				U(1-2)=0.000 (0.000), η2=0.65 || U(3-1)=0.500 (0.000), η2=0.51 |					
E3i Safe advance warning planned power outages	1 Central Punjab	6	85.20		1-2	24.977	7.174	3.482	0.000	0.001
	2 North Punjab	5	60.23		2-3	-0.608	9.642	-0.063	0.950	*1.000*
	3 South Punjab	5	60.83		3-1	24.369	8.643	2.819	0.005	0.014
	| p= 0.000 | H= 15.960, df= 2 | η2(H) = 0.10 |				U(1-2)=1113 (0.000), η2=*0.07* || U(3-1)=676 (0.004), η2=*0.06* |					
E4i Long length load shedding	1 Central Punjab	6	77.20		Multiple comparisons are not performed because the overall test does not show significant differences across samples.					
	2 North Punjab	6	68.95							
	3 South Punjab	6	74.31							
	| p= 0.377 | H= 1.953, df= 2 | η2(H) = 0.00 |									
E5i Short length load shedding	1 Central Punjab	6	98.43		1-2	53.816	7.511	7.165	0.000	0.000
	2 North Punjab	5	44.61		2-3	4.050	10.096	0.401	0.688	*1.000*
	3 South Punjab	5	40.56		3-1	57.866	9.050	6.394	0.000	0.000
	| p= 0.000 | H= 72.911, df= 2 | η2(H) = 0.49 |				U(1-2)= 459 (0.000), η2= 0.34 || U(3-1)= 219 (0.000), η2= 0.32 |					

Table 3.5. Level of Frequency of Occurrence of the Different Category of Outages Based on their Length

Dependent Variables	Location	Median	K-W Mean Rank	Visual Mean Rank	Bonferroni Dunn's Post Hoc					
					Group Pairs	Test Statistics	Standard Error	Test Std. Statistcs	p-value	Adjusted p-value
F1ii Dangerous Advance Warning, Short length Outage (DAW, SLO)	1 Central Punjab	3	42.58		1-2	-73.442	7.864	-9.338	0.000	0.000
	2 North Punjab	5	116.03		2-3	-0.975	10.570	-0.092	0.927	*1.000*
	3 South Punjab	5	117.00		3-1	-74.417	9.475	-7.854	0.000	0.000
	| p= 0.000 | H= 118.079 , df= 2 | η2(H) = 0.80 |				U(1-2)= 4 (0.000), η2= 0.65 || U(3-1)= 3 (0.000), η2= 0.51 |					
F2ii Dangerous Advance Warning, Medium length Outage (DAW, MLO)	1 Central Punjab	4	44.22		1-2	-70.030	7.856	-8.914	0.000	0.000
	2 North Punjab	6	114.25		2-3	0.021	10.559	0.002	0.998	*1.000*
	3 South Punjab	6	114.23		3-1	-70.009	9.466	-7.396	0.000	0.000
	| p= 0.000 | H= 106.488, df= 2 | η2(H) = 0.72 |				U(1-2)= 100.5 (0.000), η2= 0.58 || U(3-1)= 44 (0.000), η2= 0.47 |					
F3ii Dangerous Advance Warning, Long length Outage (DAW, LLO)	1 Central Punjab	3	51.39		1-2	-53.101	7.565	-7.020	0.000	0.000
	2 North Punjab	4	104.49		2-3	-0.929	10.167	-0.091	0.927	*1.000*
	3 South Punjab	4	105.42		3-1	-54.030	9.114	-5.928	0.000	0.000
	| p= 0.000 | H= 66.932, df= 2 | η2(H) = 0.45 |				U(1-2)= 471 (0.000), η2= 0.34 || U(3-1)= 275.5 (0.000), η2=0.27 |					
F4ii Safe Advance Warning, Short length Outage (SAW, SLO)	1 Central Punjab	3	48.49		1-2	-59.724	7.775	-7.682	0.000	0.000
	2 North Punjab	4	108.21		2-3	-1.142	10.449	-0.109	0.913	*1.000*
	3 South Punjab	4	109.35		3-1	-60.866	9.367	-6.498	0.000	0.000
	| p= 0.000 | H= 80.258 , df= 2 | η2(H) = 0.54 |				U(1-2)= 307 (0.000), η2= 0.43 || U(3-1)= 196 (0.000), η2= 0.33 |					
F5ii Safe Advance Warning, Medium length Outage (SAW, MLO)	1 Central Punjab	3	44.88		1-2	-71.107	8.003	-8.885	0.000	0.000
	2 North Punjab	6	115.99		2-3	6.967	10.756	0.648	0.517	*1.000*
	3 South Punjab	5	109.02		3-1	-64.140	9.642	-6.652	0.000	0.000
	| p= 0.000 | H= 98.617, df= 2 | η2(H) = 0.67 |				U(1-2)= 110 (0.000), η2= 0.57 || U(3-1)= 90 (0.000), η2= 0.43 |					
F6ii Safe Advance Warning, Long length Outage (SAW, LLO)	1 Central Punjab	2	49.55		1-2	-60.421	7.618	-7.932	0.000	0.000
	2 North Punjab	3	109.98		2-3	7.287	10.239	0.712	0.477	*1.000*
	3 South Punjab	3	102.69		3-1	-53.134	9.178	-5.789	0.000	0.000
	| p= 0.000 | H= 77.383, df= 2 | η2(H) = 0.52 |				U(1-2)= 303 (0.000), η2= 0.44 || U(3-1)= 289.5 (0.000), η2= 0.26						
F7ii Long Advance Warning, Long Load Shedding-Week off days (LAW,LLS)	1 Central Punjab	4	54.85		1-2	-51.355	7.477	-6.868	0.000	0.000
	2 North Punjab	5	106.20		2-3	15.742	10.049	1.566	0.117	*0.352*
	3 South Punjab	5	90.46		3-1	-35.613	9.008	-3.953	0.000	0.000
	| p= 0.000 | H= 51.951, df= 2 | η2(H) = 0.34 |				U(1-2)= 511 (0.000), η2= 0.32 || U(3-1)= 526 (0.000), η2= *0.12* |					
F8ii Long Advance Warning, Short Load Shedding-Peak Load (LAW, SLS)	1 Central Punjab	5	61.58		1-2	-30.248	7.126	-4.245	0.000	0.000
	2 North Punjab	5	91.83		2-3	0.971	9.577	0.101	0.919	*1.000*
	3 South Punjab	5	90.85		3-1	-29.277	8.585	-3.410	0.001	0.002
	| p= 0.000 | H= 23.588 , df= 2 | η2(H) = 0.15 |				U(1-2)=1003.5 (0.000), η2=*0.11* || U(3-1)=599 (0.000), η2=0.09 |					
F9ii No Advance Warning, Short Length Outage (NAW, SLO)	1 Central Punjab	3	51.30		1-2	-55.971	7.454	-7.509	0.000	0.000
	2 North Punjab	4	107.28		2-3	6.213	10.018	0.620	0.535	*1.000*
	3 South Punjab	4	101.06		3-1	-49.759	8.980	-5.541	0.000	0.000
	| p= 0.000 | H= 69.813, df= 2 | η2 (H) = 0.47 |				U(1-2)=418.5 (0.000), η2= 0.37 || U(3-1)= 321 (0.000), η2= 0.24 |					
F10ii No Advance Warning, Medium Length Outage (NAW, MLO)	1 Central Punjab	5	56.38		1-2	-48.619	7.232	-6.723	0.000	0.000
	2 North Punjab	6	105.00		2-3	17.917	9.720	1.843	0.065	*0.196*
	3 South Punjab	5	87.08		3-1	-30.702	8.713	-3.524	0.000	0.001
	| p= 0.000 | H= 48.401, df= 2 | η2(H) = 0.32 |				U(1-2)= 594 (0.000), η2= 0.27 || U(3-1)= 572 (0.000), η2= *0.10* |					
F11ii No Advance Warning, Long Length Outage (NAW, LLO)	1 Central Punjab	3	61.15		1-2	-32.858	7.014	-4.684	0.000	0.000
	2 North Punjab	4	94.01		2-3	5.325	9.427	0.565	0.572	*1.000*
	3 South Punjab	4	88.69		3-1	-27.533	8.451	-3.258	0.001	0.003
	| p= 0.000 | H= 26.269 , df= 2 | η2(H) = 0.17 |				U(1-2)=931.5 (0.000), η2=0.13 || U(3-1)=635.5 (0.002), η2=*0.07* |					

Further, statistical analysis of the dependent variables (F1ii-F11ii) linked with the "level of frequency of occurrence of the different category of outages based on their length" is shown in the Table 3.5. A Kruskal-Wallis test was applied on the dependent variables from F1ii to F11ii to examine if there were differences in level of frequency of occurrence scores between groups that differed in their geographical region: the "Central Punjab" (n = 84), "North Punjab" (n = 40) and "South Punjab" (n = 24) geographical region level groups. A score was statistically significantly different between the different levels of geographical region group based on the test statistics "H (Degree of Freedom) or χ2 (Degree of Freedom)" with p-value of 0.000 for all the variables. The H or χ2 test statistics values for the variables F1ii, F2ii, F3ii, F4ii, F5ii, F6ii, F7ii, F8ii, F9ii, F10ii and F11ii are 118.079, 106.488, 66.932, 80.258, 98.617, 77.383, 51.951, 23.588, 69.813, 48.401 and 26.269, respectively. Next, H-statistics values were used to calculate the effect sizes (η_H^2) for all the significant variables using the online effect size calculator. The effect sizes for the variables F1ii, F2ii, F3ii, F4ii, F5ii, F6ii, F7ii, F8ii, F9ii, F10ii and F11ii were calculated and found in the zone of large effect with values 0.801, 0.721, 0.448, 0.540, 0.666, 0.520, 0.344, 0.149, 0.468, 0.320 and 0.167, respectively. Then, pairwise comparisons were made using Dunn's (1964) procedure. A Bonferroni correction for multiple comparisons was applied with the statistical significance accepted at the $p < 0.0167$ level. This post hoc analysis uncovered statistically significant differences in the level of satisfaction scores between Central Punjab and North Punjab for all the significant variables with p-values equal to 0.000. Likewise, pairwise comparisons of Central Punjab and South Punjab for all the significant variables have shown statistically significant differences with p-values of 0.000 except for the variables F8ii, F10ii and F11ii with p-values of 0.002, 0.001 and 0.003, respectively. Statistically, no significant differences were seen between the North Punjab and South Punjab for any of the dependent variables. For all the variables, mean rank was found lower for the Central Punjab than North Punjab and South Punjab which is evident from the Table 3.5.

After cautiously spotting the median and crosstab calculations results showing the percentage distribution of the sample specified that both the groups North and South Punjab were replied nearly identical with higher ranks on seven-point scale than the Central Punjab. This showed that the textile firms from Central Punjab were considerably less affected by the power outages described by their types i.e. dangerous advance warning (short advance notification), safe advance warning (long advance notification), no advance warning (no advance notification) and long advance notification load shedding, and lengths with up to half an hour (short length outages), greater than half an hour to four hours (medium length outages) and greater than four hours outage (long length outages), than the North and South Punjab as mentioned in the Table 3.5. It has also been investigated that the vastly affected North and South Punjab region marked very high rank towards "No Advance Warning, Medium Length Outage (NAW, MLO)", Dangerous Advance Warning, Medium-length Outage (DAW, MLO) and Safe Advance Warning, Medium-length Outage (SAW, MLO), which indicated that the outages of the length greater than half an hour to four hours, were occurred maximum during the concerned period from 2010 to 2014. However, the occurrence of the outages of the type "Safe Advance Warning, Long length Outage (SAW, LLO)" were found minimum among all the categories.

Table 3.6. Contingency Table for the Dependent Variables under Part B.

Dependent Variables	Independent Variable	Not at all concerned (1)	Slightly concerned (2)	Somewhat concerned (3)	Moderately concerned (4)	Considerably concerned (5)	Highly concerned (6)	Extremely concerned (7)	Sample Percentage Distribution-Data Visulization	Dependent Variables	Independent Variable	Not at all concerned (1)	Slightly concerned (2)	Somewhat concerned (3)	Moderately concerned (4)	Considerably concerned (5)	Highly concerned (6)	Extremely concerned (7)	Sample Percentage Distribution-Data Visulization
B1	CP	12%	44%	36%	8%	0%	0%	0%		B6	CP	0%	7%	35%	33%	20%	5%	0%	
	NP	0%	8%	23%	18%	40%	10%	3%			NP	0%	0%	0%	10%	65%	18%	8%	
	SP	0%	8%	42%	8%	29%	8%	4%			SP	0%	0%	4%	25%	42%	25%	4%	
	Total	7%	28%	33%	11%	16%	4%	1%			Total	0%	4%	20%	26%	36%	11%	3%	
B2	CP	24%	50%	25%	1%	0%	0%	0%		B7	CP	0%	0%	0%	1%	23%	54%	23%	
	NP	8%	40%	48%	5%	0%	0%	0%			NP	0%	0%	0%	0%	15%	38%	48%	
	SP	13%	38%	38%	13%	0%	0%	0%			SP	0%	0%	0%	0%	17%	58%	25%	
	Total	18%	45%	33%	4%	0%	0%	0%			Total	0%	0%	0%	1%	20%	50%	30%	
B3	CP	25%	32%	39%	4%	0%	0%	0%		B8	CP	0%	0%	0%	4%	18%	51%	27%	
	NP	0%	10%	63%	25%	3%	0%	0%			NP	0%	0%	0%	0%	5%	28%	68%	
	SP	8%	0%	46%	46%	0%	0%	0%			SP	0%	0%	0%	0%	8%	33%	58%	
	Total	16%	21%	47%	16%	1%	0%	0%			Total	0%	0%	0%	2%	13%	42%	43%	
B4	CP	0%	5%	35%	43%	18%	0%	0%		B9	CP	0%	17%	39%	35%	7%	2%	0%	
	NP	0%	0%	0%	20%	45%	33%	3%			NP	0%	0%	3%	23%	38%	35%	3%	
	SP	0%	0%	4%	21%	46%	25%	4%			SP	0%	0%	0%	25%	46%	25%	4%	
	Total	0%	3%	20%	33%	30%	13%	1%			Total	0%	9%	23%	30%	22%	15%	1%	
B5	CP	0%	0%	18%	27%	45%	10%	0%		CP- Central Punjab (Ludhiana)									
	NP	0%	0%	0%	3%	30%	45%	23%		NP- North Punjab (Amritsar and Jalandhar)									
	SP	0%	0%	0%	8%	46%	46%	0%		SP- South Punjab (Patiala and Mohali)									
	Total	0%	0%	10%	18%	41%	25%	6%											

Table 3.7. Contingency Table for the Dependent Variables under Part D, Ei and Fii.

Dependent Variables	Independent Variable	Never (1)	Rarely (2)	Ocassionally (3)	Sometimes (4)	Frequently (5)	Usually (6)	Everytime (7)	Sample Percentage Distribution-Data Visulization	Dependent Variables	Independent Variable	Completely dissatisfied (1)	Mostly dissatisfied (2)	Somewhat dissatisfied (3)	Neutral (4)	Somewhat satisfied (5)	Mostly satisfied (6)	Completely satisfied (7)	Sample Percentage Distribution-Data Visulization
D1	CP	0%	0%	2%	65%	31%	1%	0%		E1i	CP	0%	13%	43%	5%	35%	5%	0%	
	NP	0%	0%	0%	0%	25%	68%	8%			NP	8%	68%	25%	0%	0%	0%	0%	
	SP	0%	0%	0%	0%	33%	50%	17%			SP	0%	92%	8%	0%	0%	0%	0%	
	Total	0%	0%	1%	37%	30%	27%	5%			Total	2%	41%	32%	3%	20%	3%	0%	
D2	CP	0%	23%	73%	5%	0%	0%	0%		E1ii	CP	0%	0%	0%	1%	67%	32%	0%	
	NP	0%	0%	70%	30%	0%	0%	0%			NP	0%	53%	48%	0%	0%	0%	0%	
	SP	0%	0%	79%	21%	0%	0%	0%			SP	0%	50%	46%	4%	0%	0%	0%	
	Total	0%	13%	73%	14%	0%	0%	0%			Total	0%	22%	20%	1%	38%	18%	0%	
D3	CP	0%	0%	4%	32%	62%	2%	0%		E1iii	CP	0%	0%	0%	1%	32%	65%	1%	
	NP	0%	0%	0%	0%	8%	88%	5%			NP	0%	0%	0%	0%	68%	33%	0%	
	SP	0%	0%	0%	0%	13%	83%	4%			SP	0%	0%	0%	0%	67%	33%	0%	
	Total	0%	0%	2%	18%	39%	39%	2%			Total	0%	0%	0%	1%	47%	51%	1%	
D4	CP	0%	4%	32%	61%	4%	0%	0%		E1iv	CP	0%	0%	0%	0%	13%	82%	5%	
	NP	0%	0%	0%	0%	65%	35%	0%			NP	0%	0%	0%	0%	25%	70%	5%	
	SP	0%	0%	0%	8%	67%	21%	4%			SP	0%	0%	0%	0%	17%	79%	4%	
	Total	0%	2%	18%	36%	30%	13%	1%			Total	0%	0%	0%	0%	17%	78%	5%	
D5	CP	0%	0%	0%	18%	70%	12%	0%		E1v	CP	0%	0%	0%	0%	12%	67%	21%	
	NP	0%	0%	0%	0%	30%	65%	5%			NP	0%	0%	0%	3%	78%	20%	0%	
	SP	0%	0%	0%	0%	38%	63%	0%			SP	0%	0%	0%	0%	88%	13%	0%	
	Total	0%	0%	0%	10%	54%	34%	1%			Total	0%	0%	0%	1%	42%	45%	12%	

Dependent Variables	Independent Variable	Never (1)	Rarely (2)	Ocassionally (3)	Sometimes (4)	Frequently (5)	Usually (6)	Everytime (7)	Sample Percentage Distribution-Data Visulization	Dependent Variables	Independent Variable	Never (1)	Rarely (2)	Ocassionally (3)	Sometimes (4)	Frequently (5)	Usually (6)	Everytime (7)	Sample Percentage Distribution-Data Visulization
F1ii	CP	32%	65%	2%	0%	0%	0%	0%		F7ii	CP	0%	0%	51%	48%	1%	0%	0%	
	NP	0%	0%	0%	10%	75%	15%	0%			NP	0%	0%	0%	0%	60%	35%	5%	
	SP	0%	0%	0%	13%	67%	21%	0%			SP	0%	0%	0%	17%	54%	25%	4%	
	Total	0%	18%	37%	6%	31%	7%	0%			Total	0%	0%	0%	32%	52%	14%	2%	
F2ii	CP	0%	23%	68%	10%	0%	0%	0%		F8ii	CP	0%	0%	49%	51%	0%	0%	0%	
	NP	0%	0%	0%	3%	40%	58%	0%			NP	0%	0%	0%	18%	65%	18%	0%	
	SP	0%	0%	0%	0%	46%	54%	0%			SP	0%	0%	0%	13%	79%	8%	0%	
	Total	0%	0%	13%	39%	24%	24%	0%			Total	0%	0%	0%	34%	59%	6%	0%	
F3ii	CP	30%	63%	7%	0%	0%	0%	0%		F9ii	CP	0%	63%	37%	0%	0%	0%	0%	
	NP	0%	0%	30%	68%	3%	0%	0%			NP	0%	0%	0%	68%	33%	0%	0%	
	SP	0%	0%	29%	67%	4%	0%	0%			SP	0%	0%	4%	71%	25%	0%	0%	
	Total	0%	17%	49%	33%	1%	0%	0%			Total	0%	0%	36%	51%	13%	0%	0%	
F4ii	CP	33%	62%	5%	0%	0%	0%	0%		F10ii	CP	0%	0%	19%	71%	10%	0%	0%	
	NP	0%	0%	23%	58%	20%	0%	0%			NP	0%	0%	0%	0%	33%	63%	5%	
	SP	0%	0%	25%	46%	29%	0%	0%			SP	0%	0%	0%	0%	58%	42%	0%	
	Total	2%	18%	44%	26%	10%	0%	0%			Total	0%	0%	0%	11%	59%	29%	1%	
F5ii	CP	25%	51%	24%	0%	0%	0%	0%		F11ii	CP	0%	56%	44%	0%	0%	0%	0%	
	NP	0%	0%	0%	28%	20%	53%	0%			NP	0%	0%	13%	85%	3%	0%	0%	
	SP	0%	0%	0%	38%	29%	33%	0%			SP	0%	0%	21%	75%	4%	0%	0%	
	Total	0%	14%	29%	27%	10%	20%	0%			Total	0%	0%	39%	60%	1%	0%	0%	
F6ii	CP	74%	26%	0%	0%	0%	0%	0%											
	NP	0%	3%	60%	38%	0%	0%	0%											
	SP	0%	13%	54%	29%	4%	0%	0%											
	Total	2%	43%	39%	15%	1%	0%	0%											

1 - Never.
2 - Rarely, in less than 10% of the chances when I could have.
3 - Occasionally, in about 30% of the chances when I could have.
4 - Sometimes, in about 50% of the chances when I could have.
5 - Frequently, in about 70% of the chances when I could have.
6 - Usually, in about 90% of the chances I could have.
7 - Every time.

Further, the group wise and overall percentage distribution of the samples are shown in the corresponding contingency tables Table 3.6 and Table 3.7 for all the dependent variables under the parts B, D, Ei and Fii, respectively. The category which got the higher responses are marked black as compared to the other categories which are marked in grey colour. The visualization of the data is clearly depicting the orientation of the textile consumers of Punjab.

Finally, for the parts B, D, Ei and Fii, a related sample Friedman's test was applied to determine whether there are any statistically significant differences between the distributions of the related groups (dependent variables). Also, a Kendal's W, which is considered as the normalization of the statistic of the Friedman test, was applied for assessing the agreement among the raters (textile firms of Punjab). Kendall's W ranges from 0 (no agreement) to 1 (complete agreement). The results of both Friedman's Q and Kendal's W test statistics were statistically significantly different as shown in the Table 3.8. The high values of Kendal's W revealed that degree of unanimity among the various responses were fairly good which means that each respondent has allocated nearly the similar order to the variables.

Table 3.8. Test Statistics for the parts B, D, Ei & Fii

Test Statistics	Part B	Part D	Part Ei	Part Fii
N	148	148	148	148
Friedman's Q or Chi-Square	925.374	424.587	403.095	967.169
Kendall's W	0.782	0.717	0.681	0.653
df	8	4	4	10
Asymp. Sig.	0.000	0.000	0.000	0.000

Table 3.9 mentioned below shows the descriptive statistics for the dependent variables under the parts B, D, Ei and Fii. The variables are arranged in a descending order based on their mean ranks. The abbreviations DAW, SAW, NAW and LAW stands for dangerous advance warning (short notice advance warning), safe advance warning (long notice warning), no advance warning and long advance warning, respectively. The terms SLO, MLO and LLO stands for short length outages (up to half an hour duration), medium length outages (greater than half an hour but less than four hours) and long length outages (greater than four hours), respectively. Further, LLS and SLS stands for long length load shedding and short length

load shedding, respectively. DAW, PPO stands for dangerous advance warning, planned power outages and SAW, PPO-Safe advance warning, planned power outages The sequence of the variables under part B indicated that the unplanned outages, supply deficit (cause of load shedding) and relaying problems were the three major power reliability issues towards which the textile firms of Punjab were highly concerned. Also, it appeared that the textile firms were not much concerned about the power quality issues. The outcomes of the part D revealed that the major causes of the outages were the failure of fuses, electric equipment (transformers) and overhead lines. Moreover, the part Ei uncovered that the textile firms were largely dissatisfied towards the restoration time taken by the utility in an event of unplanned outages and DAW, PPO- dangerous advance warning planned power outages. Finally, the part F exposed that the occurrence of NAW, MLO-no advance warning, medium length outages were found noticeably high followed by LAW, LLS- long advance warning, long length load shedding (weekly off days) and LAW, SLS- long advance warning, short length load shedding (peak load restriction hours per day). It has been observed that the outages of the medium length (greater than half an hour to less than four hours) were occurred higher for every type of the outages under consideration. A test statistics of Dunn's Bonferroni post hoc test for the parts B, D and Ei, and Fii are shown in the Table 3.10 and Table 3.11, respectively. The rows of the table which are showing insignificant pairwise comparisons are marked grey.

Table 3.9. Descriptive Statistics for the Dependent Variables under Parts B, D, Ei and Fii

Dependent Variables	Mean Rank	Visual Mean Rank	Percentiles 25th	Percentiles 50th (Median)	Percentiles 75th	Mean	Std. Dev.	Dependent Variables	Mean Rank	Visual Mean Rank	Percentiles 25th	Percentiles 50th (Median)	Percentiles 75th	Mean	Std. Dev.
F10ii- NAW, MLO	9.81		5.00	5.00	6.00	5.21	0.64	B8- Unplanned outages	8.28		6.00	6.00	7.00	6.26	0.76
F7ii- LAW, LLS	8.91		4.00	5.00	5.00	4.86	0.73	B7- Supply deficit	7.96		6.00	6.00	7.00	6.09	0.72
F8ii- LAW, SLS	8.40		4.00	5.00	5.00	4.72	0.57	B5- Relaying problems	6.46		4.00	5.00	6.00	4.99	1.04
F2ii- DAW, MLO	8.23		4.00	4.00	5.00	4.59	1.00	B6- Transmission overloading	5.27		4.00	4.50	5.00	4.39	1.13
F5ii- SAW, MLO	5.93		3.00	4.00	5.00	3.92	1.32	B4- Switching errors	5.20		4.00	4.00	5.00	4.34	1.07
F9ii- NAW, SLO	5.43		3.00	4.00	4.00	3.76	0.66	B9- Planned outages	4.79		3.00	4.00	5.00	4.14	1.24
F1ii- DAW, SLO	5.29		3.00	3.00	5.00	3.72	1.28	B1- Voltage fluctuations	2.99		2.00	3.00	4.00	3.18	1.36
F11ii- NAW, LLO	4.93		3.00	4.00	4.00	3.63	0.51	B3- Transient faults	2.25		2.00	3.00	3.00	2.66	0.95
F4ii- SAW, SLO	3.59		3.00	3.00	4.00	3.24	0.94	B2- Frequency fluctuations	1.81		2.00	2.00	3.00	2.24	0.79
F3ii- DAW, LLO	3.41		3.00	3.00	4.00	3.19	0.72	* DAW, PPO- Dangerous advance warning, planned power outages							
F6ii- SAW, LLO	2.07		2.00	3.00	3.00	2.69	0.77	** SAW, PPO- Safe advance warning, planned power outages							
Dependent Variables	Mean Rank	Visual Mean Rank	Percentiles 25th	Percentiles 50th (Median)	Percentiles 75th	Mean	Std. Dev.	Dependent Variables	Mean Rank	Visual Mean Rank	Percentiles 25th	Percentiles 50th (Median)	Percentiles 75th	Mean	Std. Dev.
D5- Fuses	3.98		5.00	5.00	6.00	5.27	0.66	E4i- Long length load shedding	4.11		6.00	6.00	6.00	5.88	0.45
D3- Equipment	3.95		5.00	5.00	6.00	5.20	0.83	E5i- Short length load shedding	3.85		5.00	6.00	6.00	5.69	0.69
D1- Overhead lines	3.51		4.00	5.00	6.00	4.97	0.94	E3i- SAW, PPO**	3.51		5.00	6.00	6.00	5.52	0.53
D4- Switchgears	2.47		4.00	4.00	5.00	4.36	1.01	E2i- DAW, PPO*	2.18		3.00	5.00	5.00	4.09	1.49
D2- Underground cables	1.09		3.00	3.00	3.00	3.01	0.52	E1i Unplanned power outages	1.35		2.00	3.00	3.75	3.05	1.24

Table 3.10. Test Statistics of Dunn's Bonferroni Post Hoc for Parts B, D and Ei

Sample 1-Sample 2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj. Sig.[a]	Sample 1-Sample 2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj. Sig.[a]
B2-B3	-0.439	0.318	-1.380	0.168	*1.000*	B1-B5	-3.476	0.318	-10.920	0.000	0.000
B2-B1	1.179	0.318	3.704	0.000	*0.008*	B1-B7	-4.976	0.318	-15.631	0.000	0.000
B2-B9	-2.980	0.318	-9.360	0.000	0.000	B1-B8	-5.291	0.318	-16.618	0.000	0.000
B2-B4	-3.389	0.318	-10.644	0.000	0.000	B9-B4	0.409	0.318	1.284	0.199	*1.000*
B2-B6	-3.466	0.318	-10.888	0.000	0.000	B9-B6	0.486	0.318	1.528	0.126	*1.000*
B2-B5	-4.655	0.318	-14.623	0.000	0.000	B9-B5	1.676	0.318	5.264	0.000	0.000
B2-B7	-6.155	0.318	-19.335	0.000	0.000	B9-B7	3.176	0.318	9.975	0.000	0.000
B2-B8	-6.470	0.318	-20.322	0.000	0.000	B9-B8	3.490	0.318	10.962	0.000	0.000
B3-B1	0.740	0.318	2.324	0.020	*0.725*	B4-B6	-0.078	0.318	-0.244	0.807	*1.000*
B3-B9	-2.541	0.318	-7.980	0.000	0.000	B4-B5	-1.267	0.318	-3.979	0.000	*0.002*
B3-B4	-2.949	0.318	-9.264	0.000	0.000	B4-B7	-2.767	0.318	-8.691	0.000	0.000
B3-B6	-3.027	0.318	-9.508	0.000	0.000	B4-B8	-3.081	0.318	-9.678	0.000	0.000
B3-B5	-4.216	0.318	-13.244	0.000	0.000	B6-B5	1.189	0.318	3.735	0.000	*0.007*
B3-B7	-5.716	0.318	-17.955	0.000	0.000	B6-B7	-2.689	0.318	-8.447	0.000	0.000
B3-B8	-6.030	0.318	-18.942	0.000	0.000	B6-B8	-3.003	0.318	-9.434	0.000	0.000
B1-B9	-1.801	0.318	-5.656	0.000	0.000	B5-B7	-1.500	0.318	-4.712	0.000	0.000
B1-B4	-2.209	0.318	-6.940	0.000	0.000	B5-B8	-1.814	0.318	-5.699	0.000	0.000
B1-B6	-2.287	0.318	-7.184	0.000	0.000	B7-B8	-0.314	0.318	-0.987	0.324	*1.000*
Sample 1-Sample 2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj. Sig.[a]	Sample 1-Sample 2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj. Sig.[a]
D2-D4	-1.378	0.184	-7.499	0.000	0.000	E1i-E2i	-0.834	0.184	-4.540	0.000	0.000
D2-D1	2.422	0.184	13.179	0.000	0.000	E1i-E3i	-2.162	0.184	-11.763	0.000	0.000
D2-D3	-2.858	0.184	-15.550	0.000	0.000	E1i-E5i	-2.503	0.184	-13.620	0.000	0.000
D2-D5	-2.885	0.184	-15.697	0.000	0.000	E1i-E4i	-2.760	0.184	-15.017	0.000	0.000
D4-D1	1.044	0.184	5.680	0.000	0.000	E2i-E3i	-1.328	0.184	-7.223	0.000	0.000
D4-D3	1.480	0.184	8.051	0.000	0.000	E2i-E5i	-1.669	0.184	-9.080	0.000	0.000
D4-D5	-1.507	0.184	-8.198	0.000	0.000	E2i-E4i	-1.926	0.184	-10.477	0.000	0.000
D1-D3	-0.436	0.184	-2.371	0.018	*0.177*	E3i-E5i	-0.341	0.184	-1.856	0.063	*0.634*
D1-D5	-0.463	0.184	-2.518	0.012	*0.118*	E3i-E4i	-0.598	0.184	-3.253	0.001	*0.011*
D3-D5	-0.027	0.184	-0.147	0.883	*1.000*	E5i-E4i	0.257	0.184	1.397	0.162	*1.000*

Table 3.11. Test Statistics of Dunn's Bonferroni Post Hoc for Part Fii

Sample1 Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj. Sig.[a]	Sample1 Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj. Sig.[a]
F6ii-F3ii	1.334	0.386	3.461	0.001	0.030	F11ii-F9ii	0.500	0.386	1.297	0.195	1.000
F6ii-F4ii	1.517	0.386	3.934	0.000	0.005	F11ii-F5ii	1.003	0.386	2.602	0.009	0.509
F6ii-F11ii	-2.851	0.386	-7.396	0.000	0.000	F11ii-F2ii	3.307	0.386	8.578	0.000	0.000
F6ii-F1ii	3.216	0.386	8.342	0.000	0.000	F11ii-F8ii	3.476	0.386	9.017	0.000	0.000
F6ii-F9ii	-3.351	0.386	-8.692	0.000	0.000	F11ii-F7ii	3.986	0.386	10.340	0.000	0.000
F6ii-F5ii	3.855	0.386	9.998	0.000	0.000	F11ii-F10ii	4.882	0.386	12.662	0.000	0.000
F6ii-F2ii	6.159	0.386	15.974	0.000	0.000	F1ii-F9ii	-0.135	0.386	-0.350	0.726	1.000
F6ii-F8ii	-6.328	0.386	-16.412	0.000	0.000	F1ii-F5ii	-0.639	0.386	-1.656	0.098	1.000
F6ii-F7ii	-6.838	0.386	-17.735	0.000	0.000	F1ii-F2ii	-2.943	0.386	-7.632	0.000	0.000
F6ii-F10ii	-7.733	0.386	-20.057	0.000	0.000	F1ii-F8ii	-3.111	0.386	-8.070	0.000	0.000
F3ii-F4ii	-0.182	0.386	-0.473	0.636	1.000	F1ii-F7ii	-3.622	0.386	-9.393	0.000	0.000
F3ii-F11ii	-1.517	0.386	-3.934	0.000	0.005	F1ii-F10ii	-4.517	0.386	-11.715	0.000	0.000
F3ii-F1ii	1.882	0.386	4.881	0.000	0.000	F9ii-F5ii	0.503	0.386	1.306	0.192	1.000
F3ii-F9ii	-2.017	0.386	-5.231	0.000	0.000	F9ii-F2ii	2.807	0.386	7.282	0.000	0.000
F3ii-F5ii	-2.520	0.386	-6.537	0.000	0.000	F9ii-F8ii	2.976	0.386	7.720	0.000	0.000
F3ii-F2ii	4.824	0.386	12.513	0.000	0.000	F9ii-F7ii	3.486	0.386	9.043	0.000	0.000
F3ii-F8ii	-4.993	0.386	-12.951	0.000	0.000	F9ii-F10ii	-4.382	0.386	-11.365	0.000	0.000
F3ii-F7ii	-5.503	0.386	-14.274	0.000	0.000	F5ii-F2ii	2.304	0.386	5.976	0.000	0.000
F3ii-F10ii	-6.399	0.386	-16.596	0.000	0.000	F5ii-F8ii	-2.473	0.386	-6.414	0.000	0.000
F4ii-F11ii	-1.334	0.386	-3.461	0.001	0.030	F5ii-F7ii	-2.983	0.386	-7.737	0.000	0.000
F4ii-F1ii	1.699	0.386	4.408	0.000	0.001	F5ii-F10ii	-3.878	0.386	-10.059	0.000	0.000
F4ii-F9ii	-1.834	0.386	-4.758	0.000	0.000	F2ii-F8ii	-0.169	0.386	-0.438	0.661	1.000
F4ii-F5ii	-2.338	0.386	-6.064	0.000	0.000	F2ii-F7ii	-0.679	0.386	-1.761	0.078	1.000
F4ii-F2ii	4.642	0.386	12.040	0.000	0.000	F2ii-F10ii	-1.574	0.386	-4.083	0.000	0.002
F4ii-F8ii	-4.811	0.386	-12.478	0.000	0.000	F8ii-F7ii	0.510	0.386	1.323	0.186	1.000
F4ii-F7ii	-5.321	0.386	-13.801	0.000	0.000	F8ii-F10ii	-1.405	0.386	-3.645	0.000	0.015
F4ii-F10ii	-6.216	0.386	-16.123	0.000	0.000	F7ii-F10ii	-0.895	0.386	-2.322	0.020	1.000
F11ii-F1ii	0.365	0.386	0.946	0.344	1.000						

a. Significance values have been adjusted by the Bonferroni correction for multiple tests.

Each row tests the null hypothesis that the Sample 1 and Sample 2 distributions are the same. Asymptotic significances (2-sided tests) are displayed. The significance level is .05.

4. CONCLUSION

The power system reliability issues were found vastly dominant over the power quality issues. The results of the survey revealed that the districts, Amritsar and Jalandhar from Northern region, and districts Patiala and Mohali from the Southern region of Punjab faced the higher level of occurrence of different type and length of electric power outages, and had shown a high level of dissatisfaction towards the restoration time taken by the utility in the event of unplanned outages and dangerous or short period advance warning planned outages, than a district Ludhiana falling in the region of Central Punjab. Further, the higher rankings towards the causes of power outages related to the failure of utility infrastructure and equipment uncovered the deprived condition of the only available Punjab State Power Corporation Limited, a public utility company. Due to the non-availability of the accurate databases of the power outage events at the regional levels, these type of surveys are the need of hour to draw the attention of governments towards the different power system reliability issues so that the robust policies can be drafted in order to improve the reliability of power systems. The limitation of this demographic study was the spread of the sample around the distant areas of the Punjab which not only adds up to the cost but also consumed substantial time, however, if these type of surveys are supported by the funding of government, the results of these surveys will definitely help the regimes to make decisions on investment and improvement of power systems at each level of the utilities. This research can be extended to target the different types of firms and record their judgements towards the power system reliability and quality issues.

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