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Orthogonal array approach to test case optimization in the field of cellular services

Sunita Khurana[1] and Shakti Banerjee[2]
Devi Ahilya University, Devi Ahilya University, Indore--452001, MP, India
khurana.sunita001@gmail.com

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Abstract

Orthogonal Array testing is a black box testing technique that is a statistical way of software testing. This paper presents, orthogonal array uses in the field of cellular services. Orthogonal Array provides a best set of well-balanced experiments whereas Taguchi method is based on orthogonal array and perform evaluation to test the sensitivity of response variables to control parameters. Our aim is to attain the optimum setting of the control parameters. The objective of this study was to assess the association of demographic variables of using cell phone with socio-demographic variables. Further, we identified to reduce the number of experimental runs by using Orthogonal Arrays to improve the efficiency of software testing and survival analysis method to analyze customer relationship management.

Keywords: Orthogonal array, Taguchi design, signal-to-noise ratio (SN Ratio), survival analysis, factorial design.

Introduction

This paper takes a cautionary stance to the impact of marketing mix on customer satisfaction, via case study of Orthogonal Array Approach to test case optimizationin the field of Cellular Services of India, benchmarking the selected data from students, businessman, employees and housewives in Indore. The study provides guidance on how to improve outline of customer satisfaction level for potential marketing activities that can be used to take advantage of capabilities and convert weaknesses.

The Cellular Operators Association of India (COAI), the joint body of GSM operators in country, has released GSM subscriber figures i.e., total number of mobile subscribers as of December 2017 are 981.65 million, which increased by 0.14 million in December 2017. Airtel recorded the highest mobile subscribers with 290.11 million. Idea recorded the highest subscribers' addition over previous month i.e. 1.25%, highest subscriber for the circle is UP (E) i.e. 85.23 million, highest subscriber additions for the circle is M.P i.e. 0.69 million. The above data includes Reliance Jio Infocomm Ltd and Mahanagar Telephone Nigam Ltd (MTNL).

The purpose of the case study is to explain the analysis and implementation of a tool aimed at reducing the time and effort required to create test cases. The tool used for test case generation is Orthogonal Array**.** It is a multi-dimensional array tool which takes factors and levels as input to generate test cases with maximum coverage as possible for all levels in each factor. This is done to optimize test scenarios that have several factors but have multiple combinations.

When a customer leaves, you lose not only a recurring source of revenue, but also the marketing rupees you paid off to bring them in. If we are ready to get a handle on customer churn in our business, we can choose a method survival analysis. This statistical methods, which have been applied for when we are interested in understanding how long customers survives and what actions can help it to survive longer.

Factorial design: A factorial design is often used by scientists wishing to understand the effect of two or more independent variables upon a single dependent variable. A common experimental design is one with all input factors set at two levels each. These levels are called 'high' and 'low' or '+1' and '-1' respectively. A design with all possible high/low combinations of all the input factors is called a full factorial design in two levels[1].

A factorial design does not have just two independent variables; it can have as many as we want. Typically, there are many factors such as gender, genotype, diet, housing conditions, experimental protocols, social interactions and age which can influence the outcome of an experiment. Factorial designs are efficient and provide extra information like (the interactions between the factors) which cannot be obtained when using single factor designs[2]. Fractional factorial designs are often used to reduce the number of runs in design of experiments (DOE). A fractional factorial design uses a subset of a full factorial design, so some of the main effects and 2-way interactions are confounded and cannot be separated from the effects of other higher-order interactions.

Orthogonal Array: Orthogonal Arrays are often employed in industrial experiments to study the effect of several control factors. Other Taguchi contributions include: Model of the Engineering Design Process, Robust Design Principle and efforts to push quality upstream into the engineering design process[3].

Orthogonal array is a special experimental matrix designed by Li, where i is the number of trials of experimental matrix or total degree of freedom and consists of a set of experiments where we change the settings of process parameters.

An orthogonal Array of strength t with N rows, k columns $(k \geq t)$ and based on s symbols is an $N \times k$ array with entries $0,1, \ldots, s-1$, say, so that every $N \times t$ subarray contains each of the s^t possible t-tuples equally often as a row (say λ times) N must be a multiple of s^t, and $\lambda = \frac{N}{s^t}$ is the index of the array Notation: OA (N; k; s; t) or sometimes OA (N; s^k; t)[4,5].

Taguchi design: The Taguchi method is used whenever the settings of interest parameters are necessary, not only for manufacturing processes. Therefore, the Taguchi approach is used in many domains such as: environmental sciences, agricultural sciences, physics, chemistry, statistics, management and business, medicine.

Taguchi Robust Design Experiment Strategy uses the integration of two primary concepts: Signal-to-Noise Ratio (SNR) and Design of Experiments using Orthogonal Array (OA). Orthogonal Array provides a set of well-balanced minimum number of experiments and Signal-to-Noise ratios (S/N) serve as objective functions for optimization, help in data analysis and prediction of optimum results.

The data obtained from the experiments were analyzed with Taguchi method. Taguchi recommends analyzing the mean response for each run and also suggests analyzing variation using signal-to-noise ratio (S/N) to assess the robustness of a process and showed the magnitude of the interactions between control factors and noise factors. For the larger the better responses, the following relation is used for the S/N calculation[6].

$$S/N = -10\log\left(\frac{1}{n}\sum_{k=1}^{n}\frac{1}{y_i^2}\right)$$

Where y_i represents response variables and “n” denotes number of experiments.

To reduce the variability in the response due to noise calculates a separate standard deviation for each combination of control factor levels in the design. The product of array is used to systematically test for various combinations of the control factor settings over all combinations of noise factors after which the mean response and standard deviation may be approximated for each run.

Survival Analysis: Survival analysis is a statistical technique for analyzing data on the occurrence of events especially in cohort study. The time starting from a specified point to the occurrence of a given event, for example injury is called the survival time and hence, the analysis of group data is referred to the survival analysis[7,8]. In survival analysis some subjects have censored survival times, i.e., the survival times of some subjects are not observed, for example, because the event of interest does not take place for these subjects before the termination of the study[9].

Kaplan–Meier: A Kaplan-Meier analysis allows estimation of survival over time and also estimates a population survival curve from a sample. Kaplan-Meier used when the subjects are continuously observed at the time of dropout. Dropouts are considered in the analysis till the time they dropped out and after that they are ignored since they are no longer considered as risk for the end-point[10].

Application for Customer Satisfaction in the Field of Cellular Services

The main aim of the study is to know the brand preferences and identify the factors that influence the subscriber to choose the particular brand. Therefore, this descriptive research is used to find out the brand preferences among customers. For that, the study was conducted among students pursuing higher education i.e., graduation, post graduation, businessman, salaried, housewives who are using cellular services in Indore city. For that primary data has been collected from the respondents who are using the services of the companies under study. A structured questionnaire was developed, tested and administered for collection of data.

For the study we take following attributes i.e., network coverage, customer care support, tariffs, promotional schemes, value added services (VAS), billing etc. and also take variables i.e., age, gender, profession etc.

Used Taguchi design based on orthogonal array approach in the field of cellular services: Genichi Taguchi is famous for his pioneering methods of robust quality engineering. One of the major contributions that he made to quality improvement methods is Taguchi designs[10]. Taguchi suggests a three-stage process: system design, parameter design, and tolerance design. In parameter design, there are two types of factors that affect a product’s functional characteristic: control factors and noise factors. Control factors are those factors which can easily be controlled such as material choice, cycle time, or temperature process. Noise factors are factors that are difficult or impossible or too expensive to control[1].

Case study-1: Taguchi Design: -$L_{18}(6^1\ 3^3)$: In our research methodology we are using a Dynamic Taguchi design as following:

Notation is L (number ^ exponent number ^ exponent) and we have a mixed-level design is $L_{18}(6^1 3^3)$ i.e., the design have 18 runs, 1 factor with 6 levels, and 3 factors with 3 levels.

Table-1: The factors and levels of Taguchi $L_{18}(6^1\ 3^3)$ design.

Used services	Age	Profession	Satisfaction level
Airtel	less than 25	Student	Satisfied
Idea	25-45	Salaried	Not satisfied
Vodafone	Above 45	Housewife	Neutral
Reliance smart	_	_	_
Tata DoCoMo	_	_	_
BSNL	_	_	_

Table-2: The Taguchi L_{18} $(6^1\ 3^3)$ Orthogonal Array design of experiment.

Used services	Age	Profession	Satisfaction level
1	1	1	1
1	2	2	2
1	3	3	3
2	1	1	2
2	2	2	3
2	3	3	1
3	1	2	1
3	2	3	2
3	3	1	3
4	1	3	3
4	2	1	1
4	3	2	2
5	1	2	3
5	2	3	1
5	3	1	2
6	1	3	2
6	2	1	3
6	3	2	1

By the method of Taguchi's design, each row of the orthogonal array represents a run, where a specific set of factor levels would be tested. Each run of experiment having mixed levels of factors indicate its contribution on S/N ratios of responses. The combination of the orthogonal array levels in Table-2 established the dynamic experimental design.

We can see effective combinations of customers (in the above orthogonal array Table) who are taking services from cellular companies with their preferences or best opinion and assuming responses according to these factors age, profession and satisfaction level also calculating signal to noise ratios with their responses.

Table-3: Response table for signal to noise ratios.

Level	Used services	Age	profession	Satisfaction level
1	30.29	31.94	31.99	32.06
2	31.89	33.39	33.33	33.26
3	32.95	34.37	34.37	34.37
4	33.89	_	_	_
5	34.81	_	_	_
6	35.56	_	_	_
Delta	5.27	2.43	2.37	2.30
Rank	1	2	3	4

The above data of response Table-3 shows means S/N ratios for each level of each factor. The Table-3 indicates the ranks based on Delta statistics, which compare the relative magnitude of effects. Minitab assigns ranks based on Delta values; rank 1 to the highest Delta value, rank 2 to the second highest, and so on. The ranks indicate the relative importance of each factor to the response.

The effect of this factor is then calculated by determining the range:

$\triangle$ = Max-Min = 34.37-31.94= 2.43

Case study-2: Taguchi Design: -L_{16} $(4^3\ 2^1)$: Notation is L (number ^ exponent number ^ exponent) and we have a mixed-level design is L16 $(4^3\ 2^1)$ i.e., the design have 16 runs, 3 factor with 4 levels, and 1 factors with 2 levels.

Table-4: The factors and levels of Taguchi L_{16} (4^3 2^1) design.

Rating scales for service	Age	Profession	Gender
1. Excellent	1.16-25	1.Student	1 Male
2.Good	2.26-35	2.Businessmen	2 Female
3.Average	3.36-45	3.Salaried	_
4. Poor	4.Above 45	4.Housewife	_

Table-5: The Taguchi L_{18} (6^1 3^3) Orthogonal Array design of experiment.

Rating scales for service	Age	Profession	Gender
1	1	1	1
1	2	2	1
1	3	3	2
1	4	4	2
2	1	2	2
2	2	1	2
2	3	4	1
2	4	3	1
3	1	3	1
3	2	4	1
3	3	1	2
3	4	2	2
4	1	4	2
4	2	3	2
4	3	2	1
4	4	1	1

Table-6: Response Table for Signal to Noise Ratios.

Level	Rating scale	Profession	age	Gender
1	30.86	30.94	30.99	32.19
2	32.43	32.30	32.30	33.39
3	33.47	33.52	33.47	_
4	34.39	34.39	34.39	_
Delta	3.53	3.46	3.41	1.20
Rank	1	2	3	4

The Delta statistic is calculated the effects by the highest minus the lowest average for each factor. The ranks indicate the relative importance of each factor to the response.

According to S/N ratio – larger the better, the rating of services according to profession has the largest effect and gender has the smallest effect. It means for improvement of cellular companies or to do target new customers use this information for satisfaction improve service and offer more facilities in the product.

Survival Analysis

Business Applications of Survival Analysis Customer Management: To do survival analysis using Kaplan-Meier estimators, all we need is a table of customers with a binary value indicating whether they've diedand a "follow-up time." The follow-up time can take on one of two values. If the customer died, it's the number of months(less than 24 months) and the month they survive (above 24 months).

Kaplan- Meier Survival Analysis is a descriptive procedure for examining the distribution of time to event variables. Additionally, you can compare the distribution by level of a factor variable or produce separate analysis by level of a stratification variable.

This technique help to analyze the customer satisfaction with policies of telecom services, first to calculate the percentage of censored cases (e.g., customers) per intervention group, which suggests that customers should be monitored more closely during time and their satisfaction with the company's service and second to produce a scatterplot illustrating the "pattern" of censoringor censorship per group by Kaplan-Meier.

Which types of customers' lapse early in Telecom Company?: With the help of survival analysis, we experienced an increase in monthly reducing rate of customers in Telecom Company and wanted to understand which types of customers were reducing early and identify optimal intervention point for reducing customers' rates.

Due to this technique we examine the act on predicted customer survival rates over time and identified the customers whose predicted survival rates are low or rapidly falling. We also predicted each customer's time in company and identify "active" vs. "inactive" customers.

Case 1: Descriptive Survival Analysis – by Services used by respondents according to gender: In this section we find that the Idea is most popular telecom service for the customers and 17.90% of total respondents of Idea were censored within 22 months.

Similarly Airtel is second most popular telecom service and 22.70% of total respondents of Airtel were censored within 23 months.

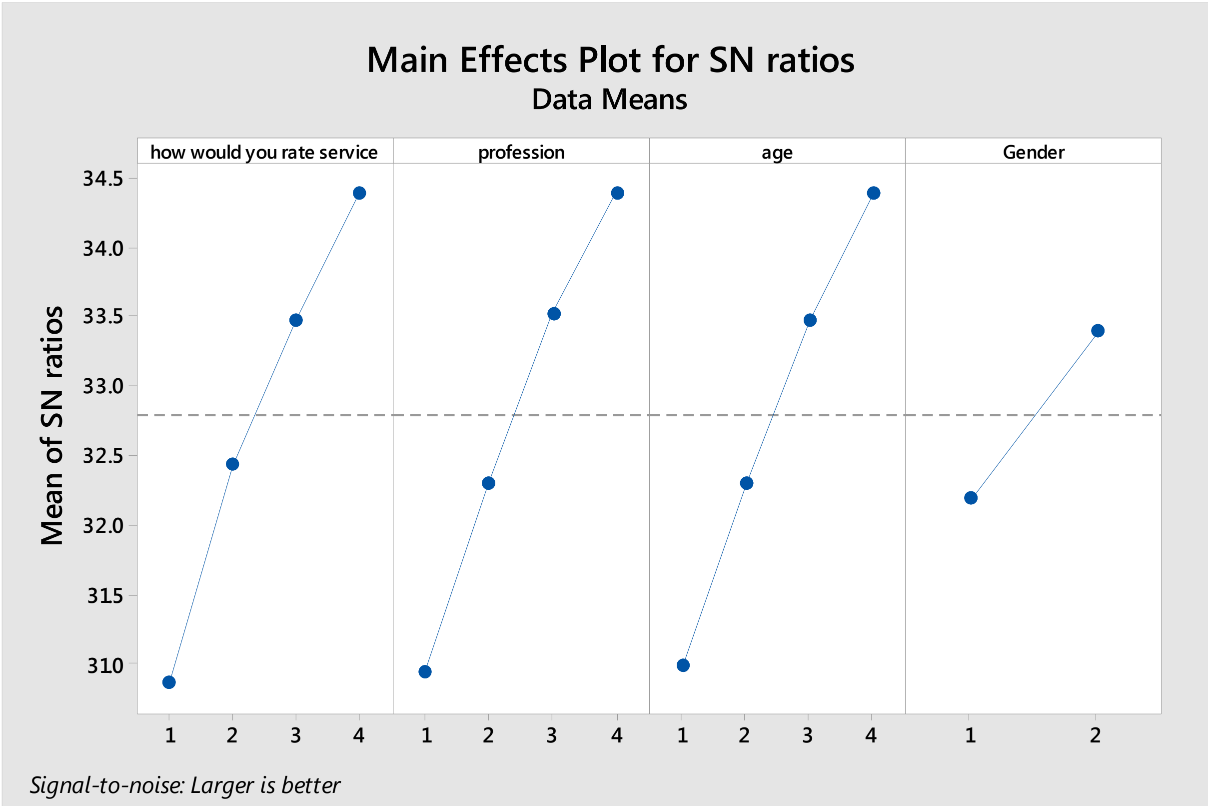

Figure-1: Main effects of factors on S/N ratios.

Figure-2: Main effects of factors for mean.

Table-7: Case Processing Summary.

Gender	Total N	N of Events	Censored	
			N	Percent
Male	60	50	10	16.7%
Female	40	34	6	15.0%
Overall	100	84	16	16.0%

Table-8: Survival Table.

Gender		Time	Status	Cumulative Proportion Surviving at the Time		N of Cumulative Events	N of Remaining Cases
				Estimate	Std. Error		
Male	1	13.000	censored	.	.	0	59
	2	14.000	censored	.	.	0	58
	3	15.000	censored	.	.	0	57
	4	15.000	censored	.	.	0	56
	5	16.000	censored	.	.	0	55
	6	17.000	censored	.	.	0	54
	7	18.000	censored	.	.	0	53
	8	22.000	censored	.	.	0	52
	9	23.000	censored	.	.	0	51
	10	24.000	censored	.	.	0	50
	11	25.000	survive	.980	.020	1	49
	12	26.000	survive	.960	.028	2	48
	13	27.000	survive	.940	.034	3	47
	14	28.000	survive	.	.	4	46
	15	28.000	survive	.	.	5	45
	16	28.000	survive	.880	.046	6	44
	17	29.000	survive	.	.	7	43
	18	29.000	survive	.840	.052	8	42
	19	33.000	survive	.	.	9	41
	20	33.000	survive	.800	.057	10	40

	21	34.000	survive	.780	.059	11	39
	22	35.000	survive	.760	.060	12	38
	23	36.000	survive	.	.	13	37
	24	36.000	survive	.720	.063	14	36
	25	37.000	survive	.700	.065	15	35
	26	38.000	survive	.680	.066	16	34
	27	39.000	survive	.660	.067	17	33
	28	44.000	survive	.	.	18	32
	29	44.000	survive	.620	.069	19	31
	30	45.000	survive	.	.	20	30
	31	45.000	survive	.	.	21	29
	32	45.000	survive	.560	.070	22	28
	33	46.000	survive	.540	.070	23	27
	34	48.000	survive	.520	.071	24	26
	35	50.000	survive	.500	.071	25	25
	36	51.000	survive	.480	.071	26	24
	37	52.000	survive	.460	.070	27	23
	38	53.000	survive	.440	.070	28	22
	39	55.000	survive	.	.	29	21
	40	55.000	survive	.	.	30	20
	41	55.000	survive	.380	.069	31	19
	42	64.000	survive	.	.	32	18
	43	64.000	survive	.	.	33	17
	44	64.000	survive	.	.	34	16
	45	64.000	survive	.	.	35	15
	46	64.000	survive	.	.	36	14
	47	64.000	survive	.	.	37	13
	48	64.000	survive	.240	.060	38	12
	49	65.000	survive	.220	.059	39	11

	50	66.000	survive	.	.	40	10
	51	66.000	survive	.180	.054	41	9
	52	67.000	survive	.	.	42	8
	53	67.000	survive	.140	.049	43	7
	54	68.000	survive	.120	.046	44	6
	55	69.000	survive	.100	.042	45	5
	56	70.000	survive	.080	.038	46	4
	57	71.000	survive	.060	.034	47	3
	58	72.000	survive	.040	.028	48	2
	59	76.000	survive	.020	.020	49	1
	60	84.000	survive	.000	.000	50	0
Female	1	17.000	censored	.	.	0	39
	2	18.000	censored	.	.	0	38
	3	18.000	censored	.	.	0	37
	4	20.000	censored	.	.	0	36
	5	21.000	censored	.	.	0	35
	6	22.000	censored	.	.	0	34
	7	25.000	survive	.	.	1	33
	8	25.000	survive	.	.	2	32
	9	25.000	survive	.912	.049	3	31
	10	26.000	survive	.	.	4	30
	11	26.000	survive	.853	.061	5	29
	12	28.000	survive	.824	.065	6	28
	13	31.000	survive	.794	.069	7	27
	14	33.000	survive	.765	.073	8	26
	15	35.000	survive	.	.	9	25
	16	35.000	survive	.	.	10	24
	17	35.000	survive	.676	.080	11	23
	18	36.000	survive	.647	.082	12	22

	19	37.000	survive	.618	.083	13	21
	20	45.000	survive	.	.	14	20
	21	45.000	survive	.559	.085	15	19
	22	53.000	survive	.529	.086	16	18
	23	55.000	survive	.500	.086	17	17
	24	63.000	survive	.471	.086	18	16
	25	65.000	survive	.	.	19	15
	26	65.000	survive	.	.	20	14
	27	65.000	survive	.382	.083	21	13
	28	66.000	survive	.	.	22	12
	29	66.000	survive	.324	.080	23	11
	30	68.000	survive	.294	.078	24	10
	31	69.000	survive	.265	.076	25	9
	32	71.000	survive	.235	.073	26	8
	33	72.000	survive	.	.	27	7
	34	72.000	survive	.176	.065	28	6
	35	75.000	survive	.147	.061	29	5
	36	76.000	survive	.118	.055	30	4
	37	78.000	survive	.088	.049	31	3
	38	79.000	survive	.059	.040	32	2
	39	81.000	survive	.	.	33	1
	40	81.000	survive	.000	.000	34	0

In the above Table-8, satisfaction level of customers according to time, status of customers, estimate cumulative proportion survival time and standard error are given.

In the above table the time indicate the time at which the event or censored occurred, status indicate whether the case experienced the terminal event or was censored. Cumulative proportion surviving at the time indicates the proportion of cases surviving from the start of the table until this time. When multiple cases experienced the terminal event at the same time, these estimates are printed once for the time period and apply for all cases of respondents whose response at the effect of time in cellular services. N of the cumulative event indicate the number of cases that have experienced the terminal events from the starting time. N of the remaining cases indicate the number of cases that, at this time, have yet to experience the terminal event or be censored.

The median survival time is calculated as the smallest survival time for which the survivor function is less than or equal to 0.5. Mean survival time is estimated as the area under the survival curve. The estimator is based upon the entire range of data. Samples of survival times are frequently highly skewed, therefore, in survival analysis; the median is generally a better measure of central location than the mean.

Table-9 shows the means and median for survival time, here the mean survival time of male customers is 50.360 and female customers is 53.147 and median for male customers is 50.00 and for female customers is 55.00. Also we can see the difference between the groups of gender and significant difference between survival distributions.

In Table-10 we can see the overall comparison i.e. as we get the value of log Rank 0.141>0.05, hence there is no statistically significant difference between the satisfaction level of cellular services according to gender.

The Figure-3 shows the survival function of gender. The vertical line shows the male and female censored i.e. the customers who are male or female using cellular services and left the service after using it for some time.

Case-2: Descriptive Survival Analysis – by Services used by respondents according to age groups.

Table-9: Means and Medians for Survival Time.

Gender	Mean				Median			
	Estimate	Std. Error	95% Confidence Interval		Estimate	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound			Lower Bound	Upper Bound
Male	50.360	2.279	45.893	54.827	50.000	4.714	40.760	59.240
Female	53.147	3.436	46.413	59.882	55.000	9.718	35.952	74.048
Overall	51.488	1.936	47.694	55.283	52.000	4.166	43.835	60.165

Table-10: Overall Comparisons.

	Chi-Square	df	Sig.
Log Rank (Mantel-Cox)	2.166	1	.141

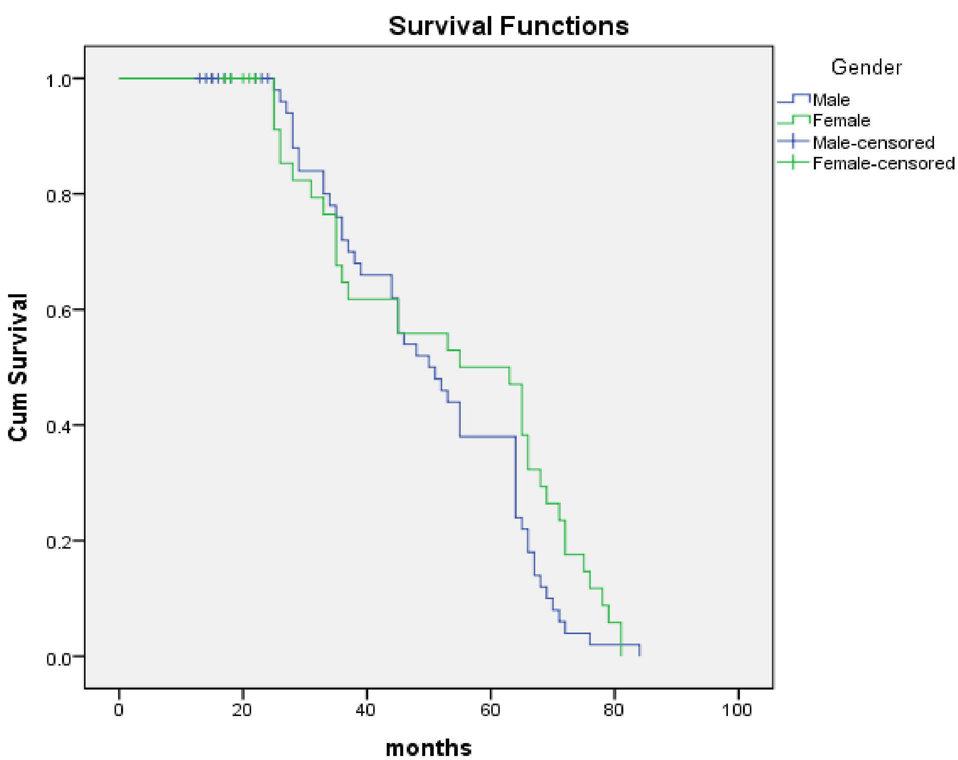

Figure-3: Cumulative survival curve according to gender.

Table-12 shows the means and median for survival time and the CI of different group. Also we can see the mean difference between the age groups and significant difference between survival distributions.

In Table-13 we can see the overall comparison i.e., as we get the value of log rank test 0.068>0.05, hence there is no statistically significant difference between the satisfaction level of cellular services according to age group.

The Figure-4 shows the survival function of age group. The vertical line shows the age censored i.e. the customers who are using cellular services and left the service after using it for sometimes.

Case study-3: Descriptive survival analysis–by Services used by respondents according to profession.

Table-11: Case Processing Summary.

Age Group	Total N	N of Events	Censored	
			N	Percent
16-25	20	19	1	5.0%
26-35	32	25	7	21.9%
36-45	33	27	6	18.2%
Above 45	15	13	2	13.3%
Overall	100	84	16	16.0%

Table-12: Means and Medians for Survival Time.

Age Group	Mean				Median			
	Estimate	Std. Error	95% Confidence Interval		Estimate	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound			Lower Bound	Upper Bound
16-25	46.947	4.088	38.935	54.960	37.000	6.529	24.203	49.797
26-35	47.520	3.203	41.243	53.797	48.000	4.996	38.208	57.792
36-45	56.370	3.424	49.659	63.081	64.000	7.659	48.988	79.012
Above 45	55.615	5.299	45.229	66.002	64.000	8.987	46.385	81.615
Overall	51.488	1.936	47.694	55.283	52.000	4.166	43.835	60.165

Table-13: Overall Comparisons.

	Chi-Square	df	Sig.
Log Rank (Mantel-Cox)	7.118	3	.068

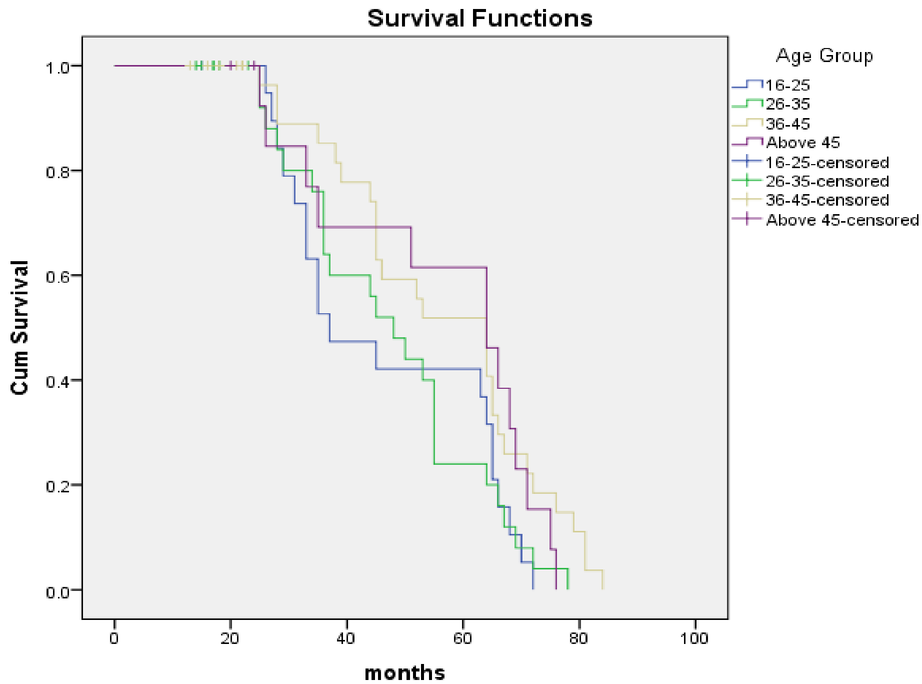

Figure-4: Cumulative survival curve according age groups.

Table-14: Case Processing Summary.

Profession	Total N	N of Events	Censored	
			N	Percent
Student	22	20	2	9.1%
Businessman	20	17	3	15.0%
Salaried	38	32	6	15.8%
Housewife	20	15	5	25.0%
Overall	100	84	16	16.0%

Table-15: Means and Medians for Survival Time.

Profession	Mean				Median			
	Estimate	Std. Error	95% Confidence Interval		Estimate	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound			Lower Bound	Upper Bound
Student	45.850	4.030	37.951	53.749	35.000	2.981	29.156	40.844
Businessman	50.059	3.872	42.469	57.649	45.000	4.802	35.588	54.412
Salaried	55.875	3.138	49.725	62.025	64.000	4.304	55.565	72.435
Housewife	51.267	4.794	41.870	60.664	53.000	9.661	34.065	71.935
Overall	51.488	1.936	47.694	55.283	52.000	4.166	43.835	60.165

Table-15 shows the means and median for survival time and the CI of different group. Also we can see the very small mean difference between the profession and significant difference between survival distributions.

Table-16: Overall Comparisons.

	Chi-Square	df	Sig.
Log Rank (Mantel-Cox)	4.163	3	.244

In Table-16 we can see the overall comparison i.e., as we get 0.244>0.05, hence there is no statistically significant difference between the satisfaction level of cellular services according to profession.

The Figure-5 shows the survival function of profession. The vertical line shows the age censored i.e. the customers who are using cellular services and left the service after using it for sometimes.

In this section we can see that the most of the respondents are salaried persons in which 15.8% respondents of total salaried persons were censored within 23 months.

Case study-4: Descriptive Survival Analysis–by opinion of respondents about Network coverage.

Table-17 shows the no. of events for different opinion about network coverage out of total no. of events. Here the other column shows the percent of censored for each group.

Table-18 shows the mean and median for survival time and the CI of different groups. Also we can see the very small mean difference and significant difference between survival distributions.

In Table-19 we can see the overall comparison i.e., as we get 0.261>0.05, hence there is no statistically significant difference between the satisfaction level of cellular services according to network coverage.

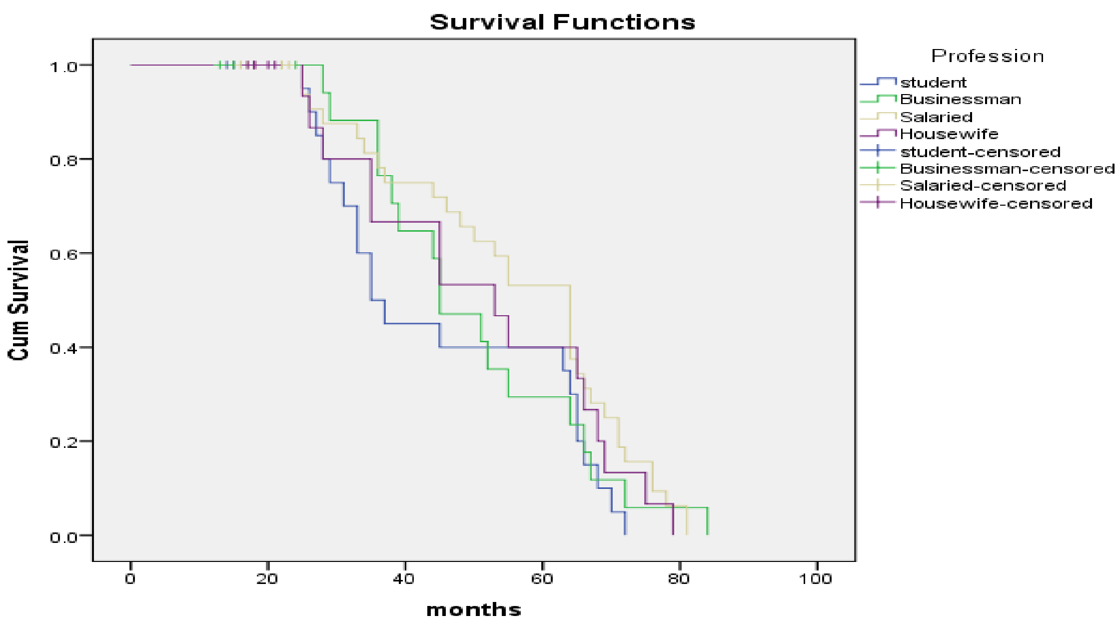

Figure-5: Cumulative survival curve according to profession.

Table-17: Case Processing Summary.

Opinion about Network coverage	Total N	N of Events	Censored	
			N	Percent
Excellent	41	36	5	12.2%
Good	38	30	8	21.1%
Average	13	12	1	7.7%
Poor	8	6	2	25.0%
Overall	100	84	16	16.0%

Table-18: Means and Medians for Survival Time.

Opinion about Network coverage	Mean				Median			
	Estimate	Std. Error	95% Confidence Interval		Estimate	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound			Lower Bound	Upper Bound
Excellent	48.111	2.887	42.452	53.770	45.000	8.986	27.387	62.613
Good	56.133	3.316	49.634	62.633	63.000	6.573	50.118	75.882
Average	52.667	4.842	43.176	62.157	51.000	7.794	35.723	66.277
Poor	46.167	7.574	31.322	61.011	35.000	8.165	18.997	51.003
Overall	51.488	1.936	47.694	55.283	52.000	4.166	43.835	60.165

Table-19: Overall Comparisons.

	Chi-Square	df	Sig.
Log Rank (Mantel-Cox)	4.003	3	.261

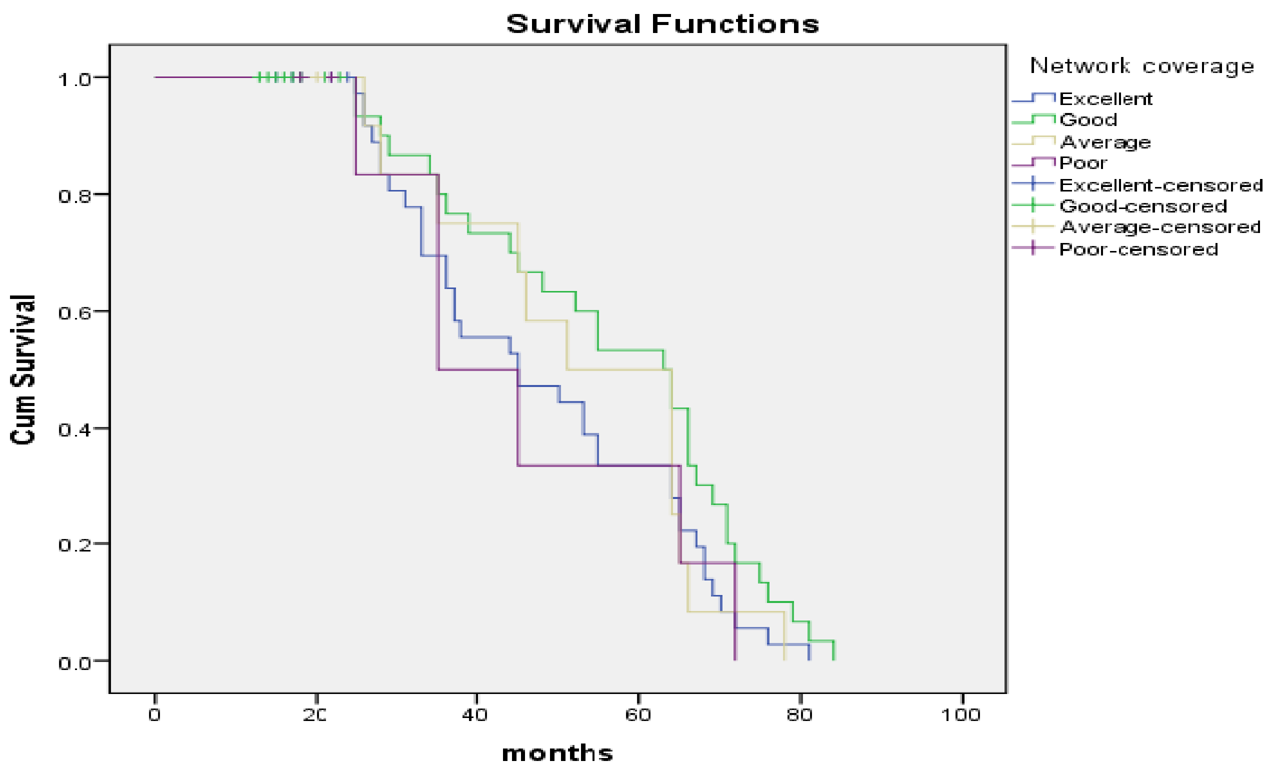

Figure-6: Cumulative survival curve.

The graph shows the survival function of network coverage. The vertical line shows the age censored i.e. the customers who are using cellular services and left the service after using it for sometimes.

Case study-5: Descriptive survival analysis–by Customer survivals with different brands.

Table-20: Group-1 Airtel.

Time	No. of risk	No. of event	Survival	Std. error	Lower 95% CI	Upper 95% CI
24	17	1	0.9412	0.0571	0.83572	1.000
26	16	1	0.8824	0.0781	0.74175	1.000
31	15	1	0.8235	0.0925	0.66087	1.000
33	14	3	0.6471	0.1159	0.45548	0.919
35	11	1	0.5882	0.1194	0.39521	0.876
41	10	1	0.5294	0.1211	0.33818	0.829
45	9	1	0.4706	0.1211	0.28423	0.779
49	8	1	0.4118	0.1194	0.23329	0.727
51	7	1	0.3529	0.1159	0.18543	0.672
58	6	1	0.2941	0.1105	0.14083	0.614
59	5	1	0.2353	0.1029	0.09987	0.554
65	4	1	0.1765	0.0925	0.06320	0.493
66	3	2	0.0588	0.0571	0.00879	0.394
73	1	1	0.0000	NA	NA	NA

Table-21: Group-2 Idea.

Time	No. of risk	No. of event	Survival	Std. error	Lower 95% CI	Upper 95% CI
25	23	1	0.9565	0.0425	0.87671	1.000
26	22	1	0.9130	0.0588	0.80485	1.000
29	21	1	0.8696	0.0702	0.74227	1.000
30	20	1	0.8261	0.0790	0.68484	0.996
31	19	2	0.7391	0.0916	0.57980	0.942
36	17	1	0.6957	0.0959	0.53088	0.912
46	16	1	0.6522	0.0993	0.48389	0.879
48	15	1	0.6087	0.1018	0.43862	0.845
50	14	1	0.5652	0.1034	0.39496	0.809
56	13	1	0.5217	0.1042	0.35279	0.772
58	12	1	0.4783	0.1042	0.31209	0.733
59	11	1	0.4348	0.1034	0.27284	0.693
61	10	2	0.3478	0.0993	0.19876	0.609
68	8	1	0.3043	0.0959	0.16407	0.565
71	7	1	0.2609	0.0916	0.13112	0.519
74	6	1	0.2174	0.0860	0.10011	0.472
79	5	1	0.1739	0.0790	0.07137	0.424
80	4	3	0.0435	0.0425	0.00639	0.296
81	1	1	0.0000	NA	NA	NA

Table-22: Group-3 Vodafone.

Time	No. of risk	No. of event	Survival	Std. error	Lower 95% CI	Upper 95% CI
33	8	1	0.875	0.117	0.6734	1.000
40	7	1	0.750	0.153	0.5027	1.000
55	6	1	0.625	0.171	0.3654	1.000
60	5	1	0.500	0.177	0.2500	1.000
61	4	1	0.375	0.171	0.1533	0.917
62	3	1	0.250	0.153	0.0753	0.830
71	2	1	0.125	0.117	0.0200	0.782
77	1	1	0.0000	NA	NA	NA

Table-23: Group-4 BSNL.

Time	No. of risk	No. of event	Survival	Std. error	Lower 95% CI	Upper 95% CI
25	8	1	0.875	0.117	0.6734	1.000
28	7	1	0.750	0.153	0.5027	1.000
67	6	1	0.625	0.171	0.3654	1.000
68	5	1	0.500	0.177	0.2500	1.000
69	4	1	0.375	0.171	0.1533	0.917
73	3	1	0.250	0.153	0.0753	0.830
76	2	2	0.0000	NA	NA	NA

Table-24: Group-5 Reliance.

Time	No. of risk	No. of event	Survival	Std. error	Lower 95% CI	Upper 95% CI
26	15	1	0.993	0.0644	0.815	1.000
28	14	1	0.867	0.0878	0.711	1.000
33	13	1	0.800	0.1033	0.621	1.000
45	12	1	0.733	0.1142	0.540	0.995
55	11	1	0.667	0.1217	0.466	0.953
59	10	1	0.600	0.1265	0.397	0.907
63	9	2	0.467	0.1288	0.272	0.802
67	7	2	0.333	0.1217	0.163	0.682
76	5	1	0.267	0.1142	0.115	0.617
77	4	4	0.0000	NA	NA	NA

Table-25: Group-6 Tata DoCoMo.

Time	No. of risk	No. of event	Survival	Std. error	Lower 95% CI	Upper 95% CI
29	13	1	0.9231	0.0739	0.7890	1.000
30	12	1	0.8462	0.1001	0.6711	1.000
33	11	1	0.7692	0.1169	0.5711	1.000
36	10	1	0.6923	0.1280	0.4819	0.995
38	9	2	0.5385	0.1383	0.3255	0.891
39	7	1	0.4615	0.1383	0.2566	0.830
49	6	1	0.3846	0.1349	0.1934	0.765
56	5	1	0.3077	0.1280	0.1361	0.695
57	4	2	0.1538	0.1001	0.0430	0.550
67	2	1	0.0769	0.0739	0.0117	0.506
79	1	1	0.0000	NA	NA	NA

Conclusion

This paper illustrates customer satisfaction in the field of cellular services. Survival analysis is a good, sound and flexible tool to analyze the length of contact and time to retain or switch by the customers in the company. Survival analysis can help to provide test the success of new procedures in encouraging and maintaining the customer base in the marketing. The output of survival analysis can be fed into various forms of customer lifetime analysis for finding reliable and accurate conclusions i.e. Survival analysis allows investigation of the probability of lapsing and purchasing by the customer. According to SN ratio in Taguchi design gender has the largest effect but age and profession of the customers have the smallest effect. With the current descriptive application of the survival technique most of respondents' preferred Idea services. Most of the male customers, salaried customers and 26-35 age groups customers have been censored within follow up time We find overall tests of the equality of survival times across groups, for that we checked association between groups by using Log Rank (Mantel-Cox), Breslow (Generalized Wilcoxon) and Tarone-Ware. We analyze with this test P>0.05 i.e. there is no significant effect of satisfaction level of customers with gender, age group and profession.

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