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AN APPROACH OF CONJOINT ANALYSIS BASED ON ORTHOGONAL ARRAY FOR PREDICTING CUSTOMER'S SATISFACTION

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ABSTRACT

Evaluation of customer satisfaction is a factor that helps in many decision making strategies. This paper presents, Conjoint Analysis using orthogonal array for minimizing factors of customer satisfaction in the products. Conjoint analysis is a powerful technique for determining consumers purchase decisions. The fundamental step of conjoint analysis is the construction of experimental designs; these designs are expected to be orthogonal arrays. There are several ways to quantify the relative efficiency of experimental designs. These designs are expected to be orthogonal and balanced in an ideal cases. The aim of this study was to measure the customer satisfaction with quality of product.

Key words: *Conjoint analysis, orthogonal array, experimental designs, factorial design, fractional factorial design.*

I. INTRODUCTION

Conjoint (trade-off) analysis is one of the most widely-used quantitative methods in Marketing Research. It is used to measure preferences for product features, to learn how changes to price affect demand for products or service, and to forecast the acceptance of a product if brought to market [1]. Since the early 1970s conjoint analysis has enjoyed considerable academic and industry attention as a major set of techniques for measuring buyers' trade- offs among multi attributed products and services (Green and Rao 1971, Srinivasan and Shocker 1973b, Johnson 1974)[4]. Conjoint Analysis is a technique that evaluates optimum level of features and services that balance value to the customer against cost to the company and forecast potential demand in a competitive market situation[12].

A product or service area is described in terms of a number of attributes. For example a biscuits may have attributes of brand, price, energy, carbohydrates, sugars, protein, fat, fiber and so on. Each attribute can then be broken down into a number of levels. The data may consist of individual ratings, rank orders or preferences among alternative combinations [8]. In conjoint analysis, respondents have to evaluate a set of alternatives that are represented by factorial combinations of the levels of certain attributes. This paper presents Conjoint Analysis using Orthogonal Array for minimizing factors for customer satisfaction of products**.** For Conjoint Analysis we are using the following steps:

1. Selection of number of attributes.
2. Each attributes can then be broken down into a number of levels.
3. Using an orthogonal set of combinations.
4. Producing the combinations obtained from orthogonal set to respondents for obtaining the ranks.
5. Using these ranks in Conjoint Analysis technique to obtain Part-Worth utilities.

Using these utilities the product makers can make their decision about the relative importance attached to individual attributes and the combination utilities[1].

Factorial design

In a factorial design, all possible combinations of the levels of the factors are investigated in each replication. A factorial design is one in which every possible combination of treatment levels for different factors appear[16].In the context of the factorial design, the results of the component single-factor experiments are called the simple effects of an independent variable[15].When conducting an experiment, varying the levels of all factors at the same time instead of one at a time let you study the interactions between the factors.

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Fractional factorial design

A fractional design is a design in which experimenters conduct only a selected subset or "fraction" of the runs in the full factorial design. Fractional factorial designs are a good choice when resources are limited or the number of factors in the design is large because they use fewer runs than the full factorial designs. Often, experiments have a large number of factors to investigate and the size of full factorials limits their use to only a few factors that are the reasons to use fractional factorial design. Fractional designs are expressed using the notation I^{k-p}, where I is the number of levels of each factor investigated, k is the number of factors investigated, and p describes the size of the fraction of the full factorial used. Formally, p is the number of generators, assignments as to which effects or inter actions are confounded, i.e., cannot be estimated independently of each other[4]. 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[10].

Orthogonal array

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 $0,1, \dots, s-1$, say, so that every $N \times t$ subarray contains each of the s^t possible t-tuples equally often as a row (say $\boldsymbol{\lambda}$ times) N must be a multiple of s^t, and $\boldsymbol{\lambda} = \frac{N}{s^t}$is the index of the array Notation: $OA(N; k; s; t)$ or sometimes $OA(N; s^k; t)$[2][3].

In a conjoint analysis firstly we create the combinations of factor levels that are presented as product profiles to the subjects. Since even a small number of factors and a few levels for each factor will lead to an unmanageable number of potential product profiles, we need to generate a representative subset known as an orthogonal array. The Generate Orthogonal Design procedure creates an orthogonal array which is also referred to as an orthogonal design[13].

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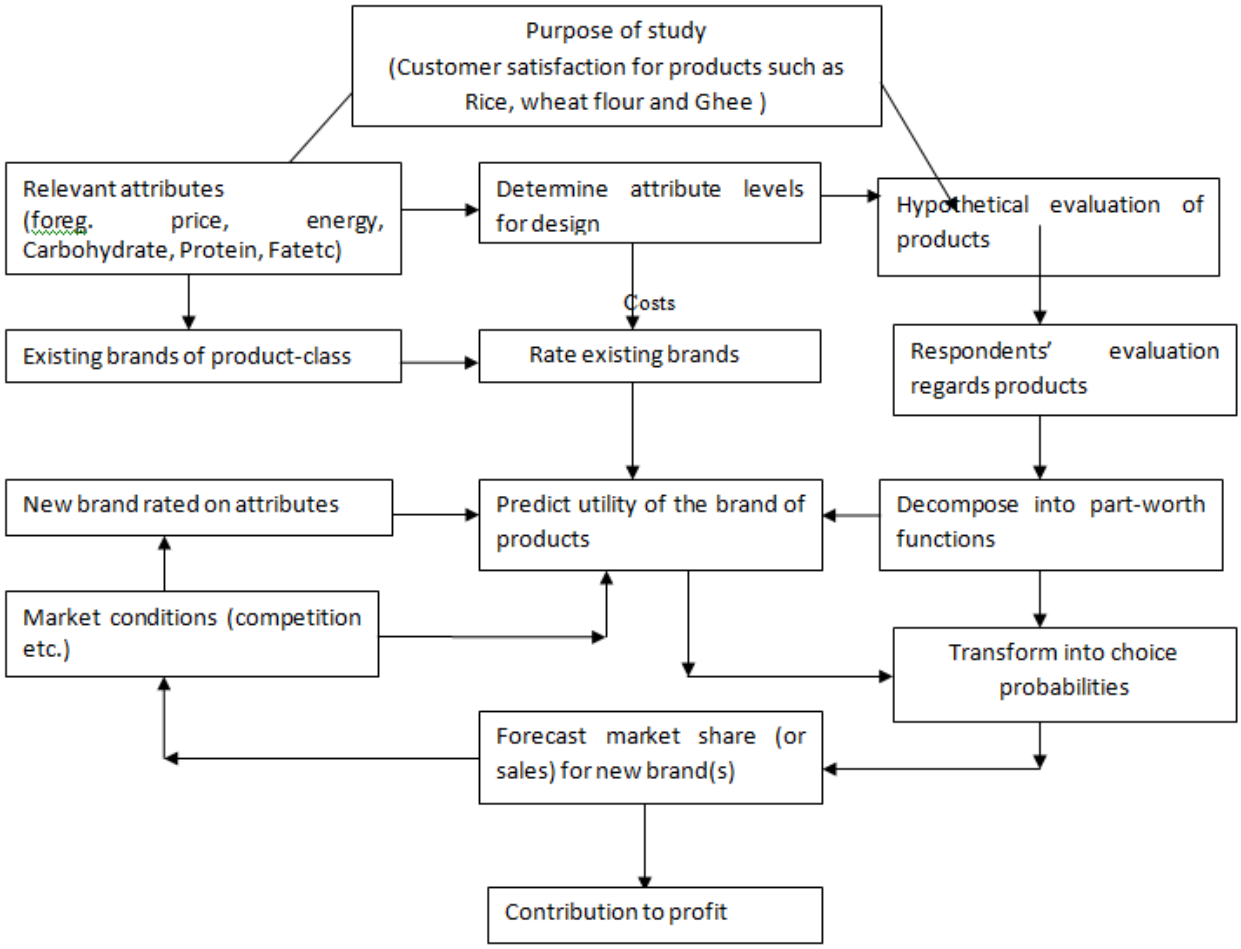
II. STUDY DESIGN OF PRODUCTS FOR CUSTOMER SATISFACTION



Application of conjoint analysisusing for customer satisfaction

In applications of conjoint analysis, products or services (profiles) are described through a set of attributes with the idea of measuring the preferences of the respondents.

In the case of having *P* attributes with *N* levels each, the number of profiles or stimuli that must be evaluated is:

$$\underbrace{N * N * N \ldots . * N}_{n\ times} = NP$$

For example, if we have 3 attributes with 4 levels each, the number of profiles to be evaluated is$4^3 = 64$. If there are two more attributes with the same number of levels, in other words, 5 attributes with 4 levels each, the number of stimuli will increase significantly. If the number of levels varies between the attributes, for example *P* attributes with *N* levels and *M* attributes with *l* levels, then the number of stimuli to be evaluated is:

$$\underbrace{N * N * \ldots . * N}_{n\ times} * \underbrace{l * l * \ldots . * lm}_{n\ times} = NP * lM$$

For example, if we have 2 attributes with 2 levels and 3 attributes with 2 levels, the total number of profiles to be evaluated will be $2^2 * 2^3 = 32$[1].

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Selection of attributes in the conjoint analysis for Rice brand

This work is based on the Conjoint Analysis using orthogonal array for minimizing factors for customer satisfaction of products especially Rice, and Wheat flour. Conjoint analysis is extremely popular in market research. For that we generate some attributes and its different levels by which we develop combinations through orthogonal array and take customers review then apply conjoint analysis on it.

Here we are using three different brands of rice i.e., Dawat Basmati Rice, India Gate Basmati Rice, Patanjali Basmati Rice and there nutritional information and cost i.e. energy, carbohydrate, protein, fat, sodium, fiber, calcium, iron and price of three rice brands. With the help of orthogonal array we generate factors and its levels which show the different quantity of nutritional information i.e., three type of brands (Dawat , India Gate , Patanjali), price(Rs.126, Rs.142, and Rs.125 per kg), energy (350kcal, 344kcal, 356kcal) similarly other levels of different attributes are given in table 1.1. Conjoint analysis is effective for finding consumer preference in all these ten attributes and orthogonal array can help to make effective customer combinations layout. A consumer could prefer may be a rice brand which is Dawat basmati rice, price Rs.125(1kg) and energy having 344kcal, carbohydrates 77gm, protien10.2gm, fat 0.5gm, sodium 0gm, fiber 1.4gm, calcium 5.6mg and iron 1.08mg or it could be certain other combination of these given levels.

Now the marketer is interested in determining how consumers value with these specific attributes? What is most important nutritional property for consumer the price, energy, fat, carbohydrates, protein etc.? Is customer wants to pay low price or they are willing to pay higher price to secure some of the other features? Or what should be the other attributes to be considered while offering the product in the market? Conjoint analysis attempts to answer what are the individual utilities for the rice, price, energy, fat, iron, carbohydrates etc. determining in preferences in choices. For this we use orthogonal array to compute the utility for different levels of each variables used.

Conjoint orthogonal array design involves selecting a certain number of profiles resulting from all possible combinations of the levels. For that in SPSS orthogonal design are generated selected 30 cards or combinations of the variables under study. Then we rank them from 1 to 5 and collect customer preferences in these 30 combinations. Now we create a new data file of 200 respondents with their product preferences and apply conjoint analysis for finding utility of the product.

Case study 1: An application for the selection of attributes in the product Rice

In the current investigation, conjoint analysis is used to understand how common attributes influences customers in selection of rice. According to a study on three rice brands (Dawat Basmati Rice, India Gate Basmati Rice and Patanjali Basmati Rice) found that the price of rice brand is more important for customers when purchasing product as well as other nutrition like energy, protein, iron, carbohydrates fat etc. nutrition is also important to customers in its particular quantity.

Table 1.1: Attributes levels for a full-profile of Rice

Attributes	Level 1	Level 2	Level 3
Brand	Dawat Basmati Rice	India Gate Basmati Rice	Patanjali Basmati Rice
Price	Rs.126(1kg)	Rs.142(1kg)	Rs.125(1kg)
Energy	350kcal	344kcal	356kcal
Carbohydrate	78gm	77gm	77.2gm
Protein	8.8gm	6.7gm	10.2gm
Fat	0.47gm	0.5gm	0.64gm
Sodium	1.7gm	0gm	2.8gm
Fiber	1.6gm	1.4gm	2.97gm
Calcium	5.6mg	0mg	7.9mg
Iron	1.08mg	0mg	0.4mg

The above table 1.1 shows the information about three different brands of rice. We generate some attributes which shows the quality, price, and other nutritional information of a particular brand, i.e., we collect information about price, energy, carbohydrate, protein, fat, sodium, fiber, calcium, iron of three rice brands i.e., Dawat Basmati Rice, India Gate Basmati Rice and Patanjali Basmati Rice.

The possible set of combinations from the levels of attributes accounts to 3 x 3x 3 x 3x 3 x 3 x 3 x 3x 3 x 3 = 59,049 . The 59,049 combinations are reduced to a manageable set using the orthogonal design to ease evaluation. The final 30 set of hypothetical combinations of rice brands are representing in the table below:

Table 1.2

RICE	PRICE	ENERGY	CARBO.	PROT.	FAT	SOD.	FIBER	CAL.	IRON	POT.	MAG	PHO.	CARDS
2	3	1	2	3	3	1	3	2	2	1	3	1	1
1	3	3	2	1	2	1	3	1	3	3	2	3	2
3	2	3	2	3	1	2	1	1	2	2	2	1	3
3	2	2	1	1	3	3	3	2	1	3	2	1	4
2	1	2	1	3	2	1	1	2	3	2	2	2	5
1	3	2	1	2	1	2	2	2	2	1	2	3	6
3	3	2	2	2	1	1	3	3	1	2	1	2	7
2	2	2	2	1	3	2	1	3	3	1	1	3	8
3	1	3	1	2	3	1	1	3	2	3	3	3	9
3	3	1	1	3	3	2	2	1	3	3	1	2	10
2	3	3	1	1	2	2	2	3	1	2	3	1	11
1	2	3	1	3	1	3	3	3	3	1	3	2	12
3	1	1	2	1	1	3	2	2	3	2	3	3	13
1	1	1	1	1	1	1	1	1	1	1	1	1	14
1	1	3	3	2	3	2	3	2	3	2	1	1	15
1	2	2	3	1	3	1	2	1	2	2	3	2	16
3	1	2	3	3	2	2	3	1	1	1	3	3	17
2	3	2	3	2	1	3	1	1	3	3	3	1	18
3	3	3	3	1	2	3	1	2	2	1	1	2	19
3	2	1	3	2	2	1	2	3	3	1	2	1	20
2	2	1	1	2	2	3	3	1	2	2	1	3	21
2	1	3	2	2	3	3	2	1	1	1	2	2	22
1	1	2	2	3	2	3	2	3	2	3	1	1	23
1	3	1	3	3	3	3	1	3	1	2	2	3	24
2	1	1	3	1	1	2	3	3	2	3	2	2	25
2	2	3	3	3	1	1	2	2	1	3	1	3	26
1	2	1	2	2	2	2	1	2	1	3	3	2	27

2	1	2	3	2	1	2	2	2	3	1	1	2	28
2	2	1	3	1	1	1	3	3	3	3	1	2	29
1	3	3	1	1	3	3	1	2	1	3	2	1	30
2	2	3	1	2	2	3	1	1	1	3	1	2	31

The above combinations of rice and its nutrition are set as card 1. Similarly, we can see 31 combinations of cards, in which we take consumers opinion for different cards and then find the satisfaction level of consumers and the preference of consumers i.e., the preference for the combination of attributes reveals the part worth utilities of individual attributes. In a conjoint analysis the part worth utilities of individual attributes are calculated based on the selection or ranking of a defined set of combinations of attributes values.

Table 1.3: Utilities

Attributes		Utility Estimate	Std. Error
Brand	India gate basmati rice	-.029	.051
	Dawat basmati rice	.061	.021
	Patanjali basmati rice	-.032	.051
Price	Rs.125 (1kg)	.058	.051
	Rs.142 (1kg)	.054	.051
Energy	350 kcal	.046	.151
	356 kcal	-.036	.051
Protein	10.24 gm.	.049	.151
	8.80 gm.	-.004	.051
Calcium	0 mg	-.040	.251
	5.6 mg	.039	.051
Fat	0.64 gm.	.011	.051
	0.5 gm.	.043	.052
	0.47 gm.	-.054	.051
Sodium	1.7 gm.	.000	.051
	0 gm.	.042	.315
(Constant)		2.965	.036

From table 1.3, most of the customers prefer the market leader Dawat basmati rice rather than India gate and Patanjali brands, customers prefer low price for product, energy level prefer 350 kcal, protein (10.24gm) and calcium(5.6mg) essential, low sodium and fat utility should be prefer by customers 0.5 and 0.64gm in the product.

Table 1.4: Importance Values

Brand	15.399
Price	14.156
Energy	15.489
Protein	13.980
Calcium	13.828
Fat	14.209
Sodium	12.939

The importance of a factor is represented by the range of its levels divided by the sum of the ranges across all factors. This calculation provides a relative importance of each attribute based on the size of the range of its part-worth estimates. From the table 1.4, the results show that the attributes energy and brand are relatively more important to customers, followed by fat 14.20%, price 14.15%, protein 13.98%, calcium 13.82% and the least

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preferred attribute is sodium at 12.93%. The customer's choice of preference of attributes is best brand with energy, affordable price and with less fat, high protein.

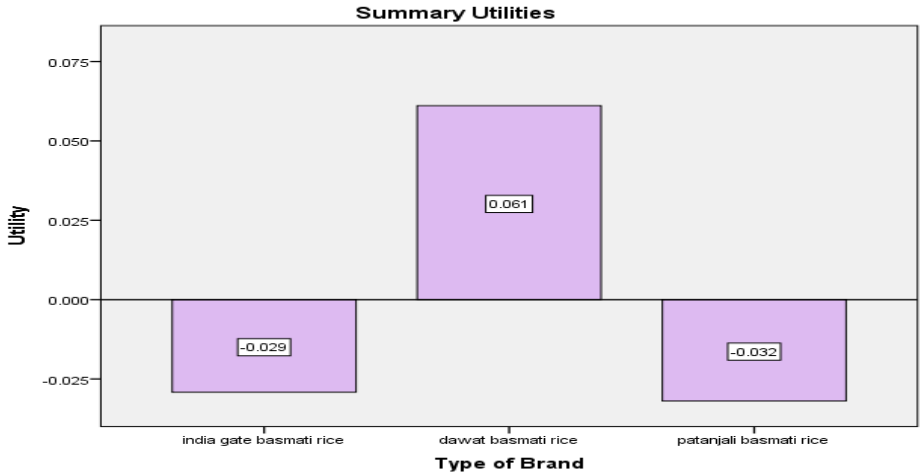
Table 1.5: Correlations

	Value	Sig.
Pearson's R	.696	.000
Kendall's tau	.480	.000
Kendall's tau for Holdouts	-.333	.301

The correlation table 1.5 displays two statistics, Pearson's R and Kendall's tau, which provide measures of the correlation between the observed and estimated preferences as a check on the validity of the utilities.

The validation on the utilities is obtained from above table. The correlation between the observed and estimated preferences is very high value of 0.696, which is significant to the scope of using Conjoint Analysis.

Now, with the help of Part-Worth utility scores, the preferences for most valued combination can be obtained. For example, the most preferred combination by the respondents is Dawat basmati rice with low price i.e., Rs.125(kg), presence of low energy level (350 kcal) is the priority, presence of high protein is essential (10.24 gm), calcium (5.6 mg) is essential than other, fat (0.5 gm) in the product, and the sodium is not prior in their product.



The graph 1.1 shows the utility of the brand which shows that the Dawat basmati rice is the most preferable brand by customers.

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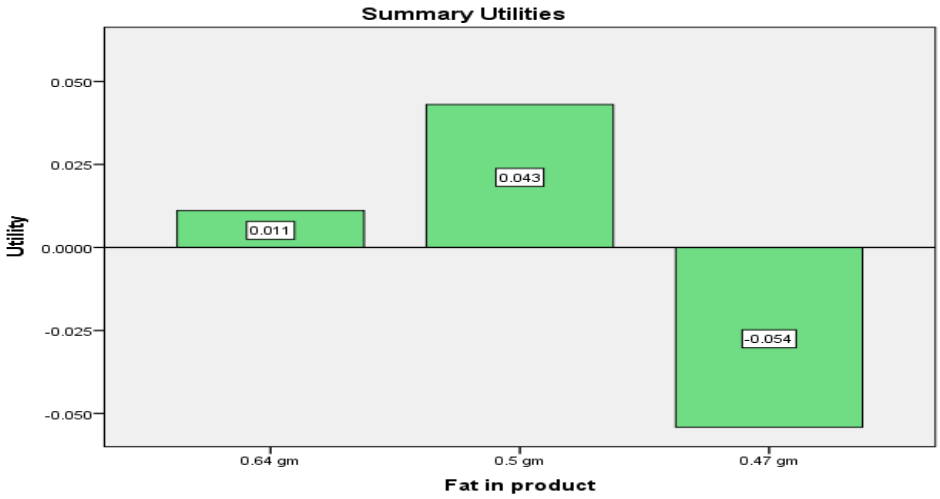
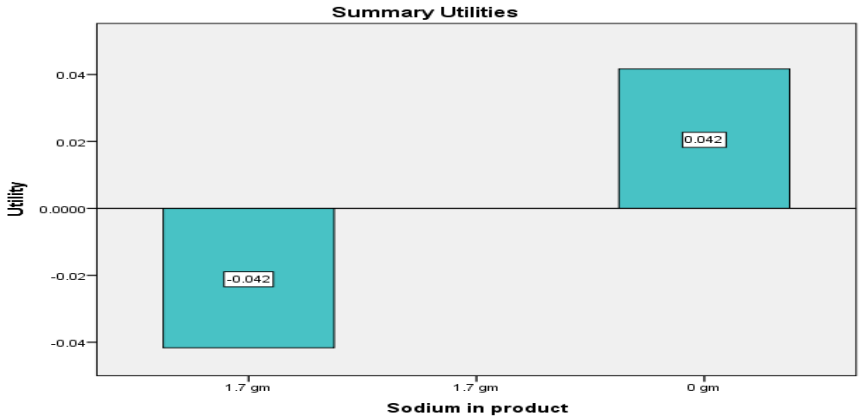


The graph 1.2 shows that the utility of fat in product which shows that the fat i.e., 0.5gm is most preferable by customers.



The graph 1.3 shows that the utility of sodium in product which shows that the sodium i.e., 0gm is most preferable by customers

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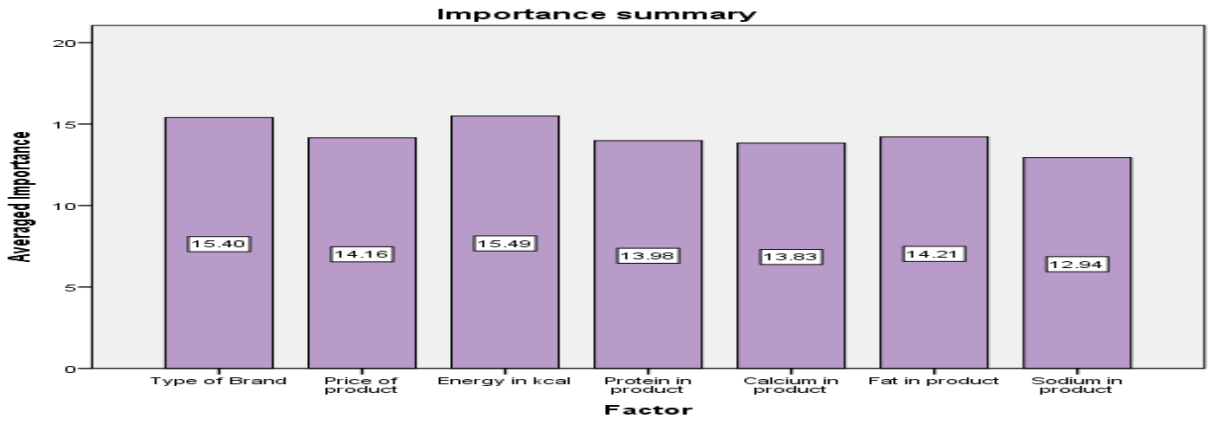

The graph 1.4 shows that the attributes, energy and brand are relatively more important to customers, followed by fat 14.21%, price 14.16%, protein 13.98%, calcium 13.83% and the least preferred attribute is sodium at 12.94%. The customer's important attributes are first brand than energy than price than others feature fat, protein, calcium and sodium.

Case study 2: An application for the selection of attributes in the product wheat flour

Conjoint analysis is used to understand how common attributes influence customers in selection of wheat flour. According to a study on three wheat flour brands (Patanjali, Silver coin, Aashirwad) found that the price of wheat flour brand is more important for customers when purchasing product as well as other nutrition like energy, protein, sugar, fiber, carbohydrates fat etc. nutrition is also important to customers in its particular quantity.

Table 2.1: Attributes levels for a full-profile of product wheat flour

Attributes	Level 1	Level 2	Level 3
Brand	Patanjali	Silver coin	Aashirwad
Energy	364.5 kcal	362 kcal	312.19 kcal
Calcium	146 mg	34.51 mg	81.7 mg
Carbohydrate	76.44 gm.	73.80 gm	73.27 gm
Sugar	0 gm	0.11 gm	2.04 gm
Fiber	12.28 gm	14.08 gm	5.10 gm
Protein	3.10 gm	13.27 gm	11.82 gm
Fat	0.73 gm	1.77 gm	0.51 gm
Price	Rs.300 (10 kg)	Rs.280 (10 kg)	Rs.286 (10 kg)

The above table 2.1 shows the information about three different brands of wheat flour. We generate some attributes which shows the quality, price, and other nutritional information of a particular brand, i.e., we collect information about price, energy, carbohydrate, protein, fat, fiber, calcium of three wheat flour brands i.e., Patanjali, Silver coin, Aashirwad. The possible set of combinations from the levels of attributes accounts to 3 x 3x 3 x 3x 3 x 3 x 3 x 3x 3 = 19,683. The 19,683 combinations are reduced to a manageable set using the orthogonal design to ease evaluation, minimize the 30 set of hypothetical combinations of wheat flour brands taken in orthogonal layout.

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Table 2.2: Utilities

Attributes		Utility Estimate	Std. Error
Brand	Patanjali	-.004	.043
	Silver coin	-.032	.043
	Aashirwad	.036	.043
Energy	364.5 kcal	.055	.043
	362 kcal	.023	.043
	312.19 kcal	-.077	.043
Calcium	146 mg	-.036	.043
	34.51 mg	.013	.043
	81.7 mg	.024	.043
Carbohydrates	76.44 gm	-.033	.043
	73.80 gm	.001	.043
	73.27 gm	.031	.043
Sugar	0 gm	-.021	.043
	0.11 gm	.021	.043
	2.04 gm	-.001	.043
Fiber	12.28 gm	.015	.043
	14.08 gm	.011	.043
	5.10 gm	-.026	.043
Protein	3.10 gm	-.042	.043
	13.27 gm	-.026	.043
	11.82 gm	.068	.043
Fat	0.73 gm	.047	.043
	1.77 gm	-.044	.043
	0.51 gm	-.003	.043
Price	Rs.300(10 kg)	-.094	.043
	Rs.280 (10 kg)	.014	.043
	Rs.286 (10 kg)	.080	.043
(Constant)		3.034	.031

From table 2.2, the customers prefer the market leader Aashirwad from the other brands, customers prefer average price for their product, presence of high energy level is the priority, presence of average protein is essential, preference of average calcium is essential than other, high fat in the product is not their priority, and the average sugar in their product should be essential, low carbohydrates is essential in their products.

Table 2.3: Importance Values

Brand	11.550
Energy	11.626
Calcium	11.533
Carbohydrates	9.713
Sugar	10.651
Fiber	11.098
Protein	11.763
Fat	10.772
Price	Rs.11.294

The importance of a factor is represented by the range of its levels divided by the sum of the ranges across all factors. This calculation provides a relative importance of each attribute based on the size of the range of its part-worth estimates. From the table 2.3, the results show that the attributes protein and energy are relatively more

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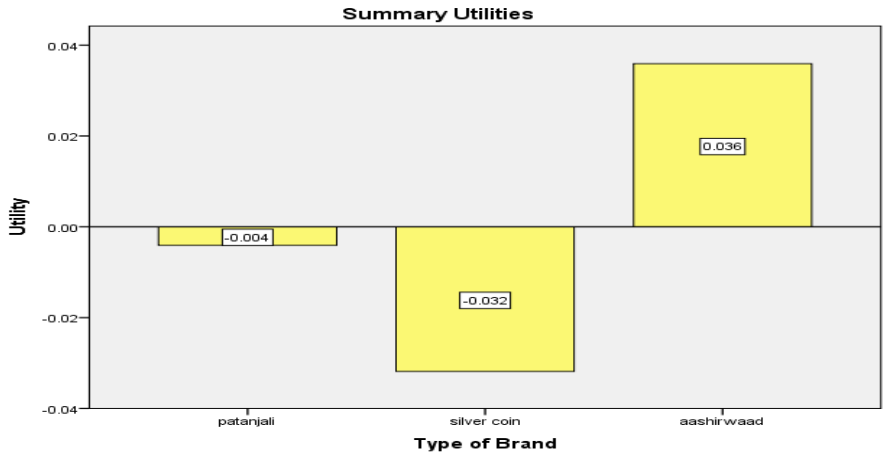
important to customers, followed by brand 11.55%, calcium 11.53%, price 11.29%, fiber 11.098%, fat 10.77, sugar 10.65% and the least preferred attribute is carbohydrates at 9.71%. The customer's choice of preference of attributes is best protein with energy, affordable price and with less fat, protein, calcium and with very less carbohydrates.

Table 2.4: Correlations

	Value	Sig.
Pearson's R	.816	.000
Kendall's tau	.569	.000
Kendall's tau for Holdouts	.333	.301

The correlation table 2.4 displays two statistics, Pearson's R and Kendall's tau, which provide measures of the correlation between the observed and estimated preferences as a check on the validity of the utilities. The validation on the utilities is obtained from above table. The correlation between the observed and estimated preferences is very high value of 0.816, which is significant to the scope of using Conjoint Analysis. Now, with the help of Part-Worth utility scores, the preferences for most valued combination can be obtained. For example, the most preferred combination by the respondents is Aashirwad wheat flour with average price i.e., Rs.286 (10 kg), presence of high energy level (364.5 kcal) is the priority, presence of protein is essential (11.82 gm), preference of low calcium (34.51mg) is essential than other, fat (0.73 gm) is their priority, average sugar (0.11 gm) is preferred by customers and the average carbohydrates (73.27 gm) in their product.



The graph 2.1 shows the utility of the brand which shows that the Aashirwadwheat flour is the most preferable brand by customers.

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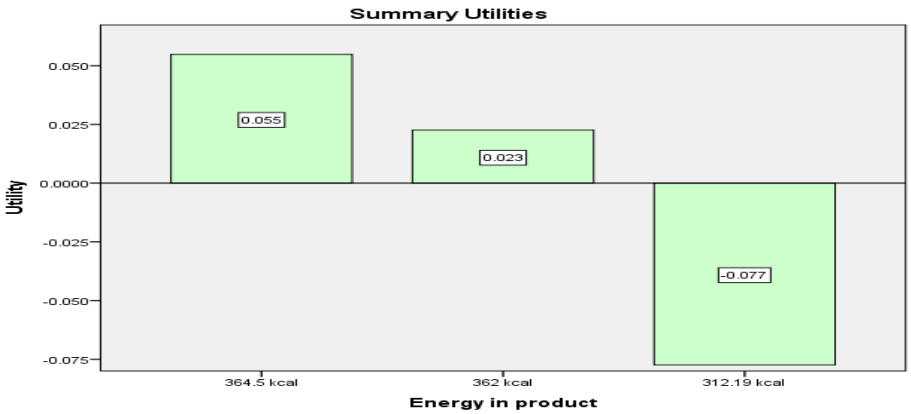
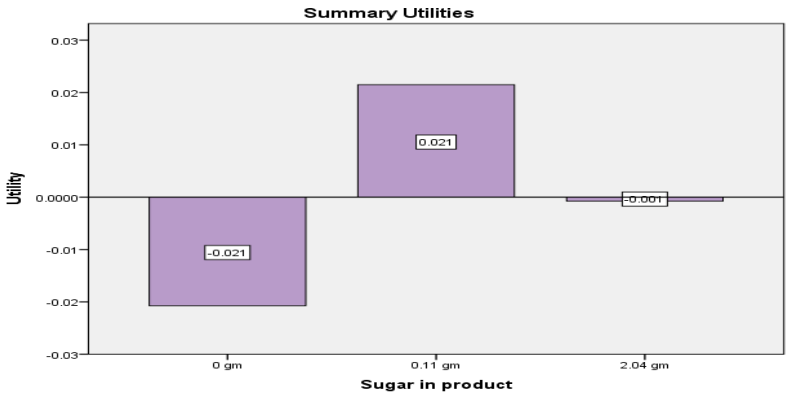
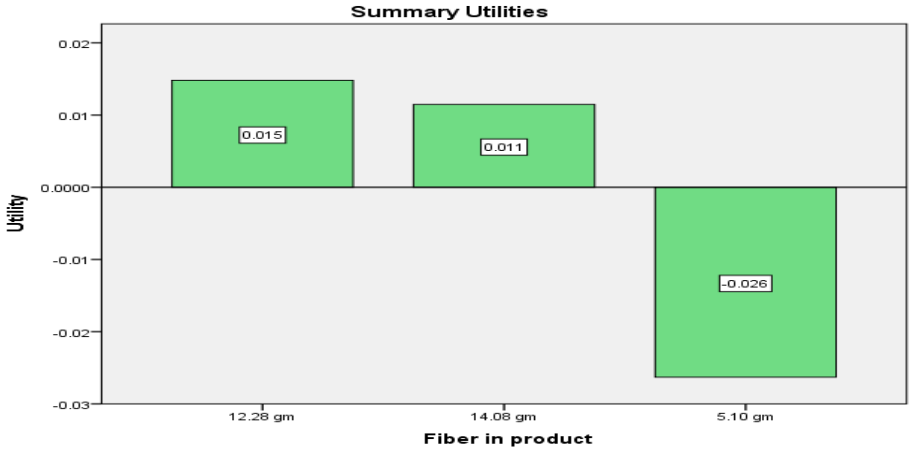


The graph 2.2 shows that the utility of energy in product which shows that the energy i.e., 364.5 kcal is most preferable by customers.



The graph 2.3 shows that the sugar in product which shows that the sugar i.e., 0.11gm is most preferable by customers.



The graph 2.4 shows that the fiber in product which shows that the fiber i.e., 12.28gm is most preferable by customers.

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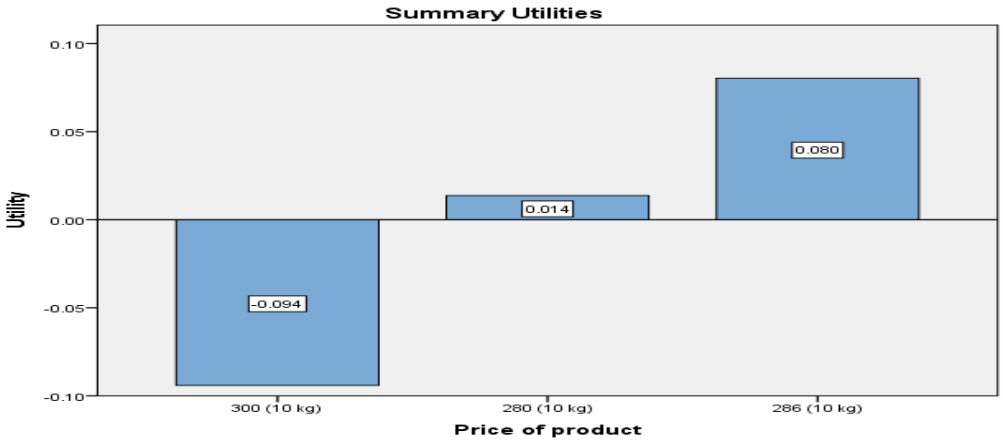
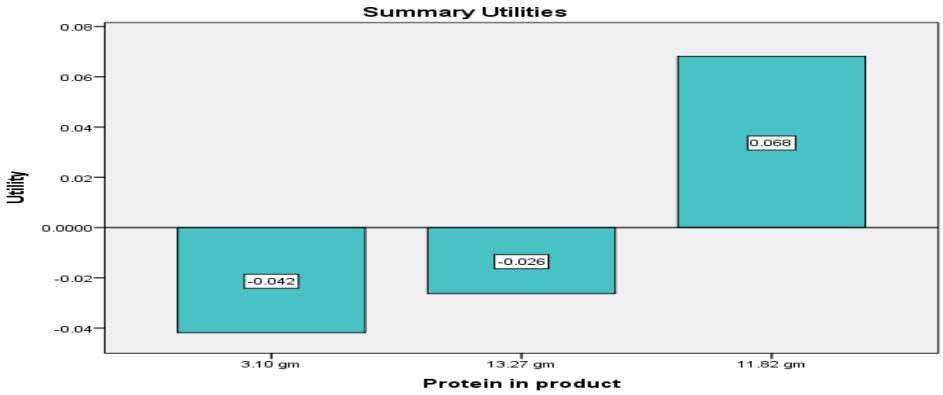


The graph 2.5 shows that the utility of price of product which shows that the price i.e., 286(10 kg) is most preferable price by customers and the other brand with 300(10 kg) shows very less preference.



The graph 2.9 shows that the utility of protein in product which shows that the protein i.e., 11.82 gm is most preferable by customers.

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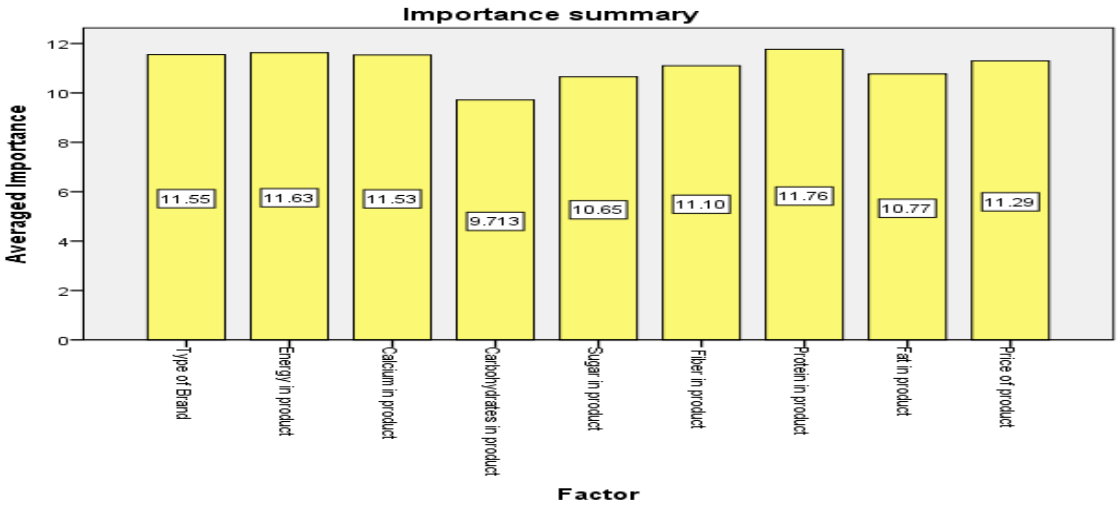

The graph 2.10 shows that the attributes protein and energy are relatively more important to customers, followed by brand 11.55%, calcium 11.53%, price 11.29%, fiber 11.098%, fat 10.77, sugar 10.65% and the least preferred attribute is carbohydrates at 9.71%.

III. CONCLUSION

From the discussion carried out above, the case facts lead to the following implications for the product manufacturer:

1. Customers first preference of attributes in three different products i.e., Rice and wheat flour tends to attach significance on the brand value of the product.
2. In rice product brand energy attributes are most preferred by customers when they are buying that particular brand in wheat flour, protein and energy is most important factors for customers while purchasing product.
3. In our analysis we found that the correlation between the observed and estimated preferences is very high in each three products of rice and wheat flour which are significant to the scope of using Conjoint Analysis.
4. In analysis we can see that the customer prefer low or average price, low fat and average or high protein in their particular products they are purchasing.

It is to observe that among all three rice brands (Dawat Basmati Rice, India Gate Basmati Rice and Patanjali Basmati Rice) Dawat Basmati Rice emerges as the most preferred choice, similarly in all three wheat flour brands (Patanjali, Silver coin, Aashirwad) Aashirwad emerges as the most preferred choice. As customer also wants the products at its lowest price with all nutrition in their particular levels for example, high protein and vitamins with low cholesterol and with low carbohydrates. So the company should be more responsible for their product quality for their customer's health and also for future profits of company.

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