World Applied Sciences Journal 30 (10): 1334-1339, 2014
ISSN 1818-4952

DOI: 10.5829/idosi.wasj.2014.30.10.14048

Incomplete Block Design in the Estimation of Consumer Preferences of Trade Organizations

[1]*I.A. Skrinikova*, [2]*R.R. Kadukova and* [3]*V.V. Shamray*

[1]Economic Sciences, Docent, Hod of Advertising and Marketing, Institute of the Service Sector and Business Studies, Branch of Don National Technical University
[2]Economic Sciences, Docent of Advertising and Marketing Chair, Institute of the Service Sector and Business Studies, Branch of Don National Technical University
[3]Institute of the Service Sector and Business Studies, Branch of Don National Technical University

INTRODUCTION

Expert methods in market conditions are widely used in spheres where other methods are relatively difficult to use due to the lack or total absence of statistical and other information, as well as for quantitative estimation of the events or phenomena for which other methods are difficult to apply.

Examination is common in marketing to determine consumer preferences in different products. One of these approaches is incomplete block design that can be used in the absence of the opportunity to realize all the options. Incomplete block designs are widely used in chemical, technological, metallurgical, biological researches, in agriculture, medicine, psychology and sociology [1]. In this case, the blocks (B_1, B_2, B_3, B_4 and B_5) can be, for example, different batches of raw materials, reagents, substances, chemical compounds, etc. and the elements (a_1, a_2, a_3, a_4 and a_5) - various methods of treatment [1].

In combinatorial analysis incomplete block designs called incomplete block schemes (or block-schemes) and IB-schemes [1]. Placement of elements in incomplete block-scheme is subject to certain rules relative to the number of elements and its pairs occurrences.

Design, in which each element and each pair of elements belong to the same number of blocks, called balanced or BIB-design (balanced incomplete design) (En.: Balanced Incomplete Block design). Such designs due to its inherent balance properties allow to use the same standard error during comparing each pair of elements. Incomplete block gives you the opportunity to reduce the number of experiments [3]. Thus, in the BIB design each block B_i contains the same number of elements *q*, each element a_i belongs to the same number of blocks (*r*) and for each pair of elements - a_i and a_j, number of blocks which contain this pair, equal to λ (for example, a_1 and a_2 can be found in blocks B_1, B_2 and B_3, a_1 and a_5 - in blocks B_2, B_3, B_4, etc.). Thus the following relation is provided [3]:

$$N = bq = \nu r; \tag{1}$$

$$R\ (q - 1) = \lambda\ (\nu - 1) \tag{2}$$

where,

N - Total number of trials;
b - Total number of blocks;
ν - Total number of elements;
q - Number of units in the block;
r - Number of repeats in a row;
λ - Number of repeats of each pair of elements.

Incomplete block designs called symmetric if $b = \nu$ and $r = q$. Such designs called SBIB-schemes. While applying incomplete block designs in expert estimation, blocks are called experts, the number of blocks will meet the quantitative composition of experts, each expert has ability to evaluate the different number of examination objects, which determines the number of elements in the block.

Corresponding Author: I.A. Skrinikova, Economic Sciences, Docent, Hod of Advertising and Marketing, Institute of the Service Sector and Business Studies, Branch of Don National Technical University

Design can be called - complete block if during the experiment in each block all elements are studied (each expert evaluates all objects). Unfortunately, not always possible to apply it, on the one hand, due to the limited resources, which can be available for the experiment, while, on the other hand, we can faced a sufficient amount of data in each block (in each expert). When in the block it is studied only some of the objects the incomplete block designs is used.

In the case of using block-schemes in the expert evaluation, it is advisable to ensure implementation of the following requirements: each expert evaluates the same number of elements; each element is checked with the same number of experts; each pair of objects, one expert should compare the same number of times. All these requirements are met by using a balanced incomplete block design [3].

We can consider the features of evaluation of consumer preferences for tablet computers with the help of incomplete block design. The aim of the study - the definition of consumers' preferences on qualitative characteristics of tablet computers and its grouping in terms of quality. Methodology of the study was as follows: preliminarily specialist selected brands of computers that were commercially available at most stores which sell computers and accessories. In this study we analyzed the following brands:

a_1 - Apple iPad with display Retina Wi-Fi 32Gb + Cellular. This devise has Retina display with resolution 2048x1536 pixels - in total it is about 3 million points. A6X processor ensures the performance of the devise in a double size compared to its predecessor. Apple iPad with Retina display is equipped with a compact, durable and functional connector - Lightning. There is a wireless Wi-Fi, as well as built-in 4G and 3G-modem. Built-in Memory 32Gb.

a_2 - Samsung Galaxy Note 10.1 2104 Edition 32Gb, tablet is based on the Android 4.3 operating system, capacitive multi-touch screen diagonal - 10.1 ", 2560x1600, built-in memory 32Gb, wireless Wi-Fi, Bluetooth, 3G, support microSDXC memory card.

a_3 - Explay sQuad 9.72 3G, designed on the basis of the Android 4.1 operating system, capacitive multi-touch screen diagonal - 9.7 ", 2048x1536, built-in memory 16Gb, wireless Wi-Fi, 3G, support microSDHC memory card.

a_4 - Huawei MediaPad 10 Link 8Gb Wi-Fi, designed on the basis of the Android 4.1 operating system, capacitive multi-touch screen diagonal - 10.1", 1280x800, wireless Wi-Fi, Bluetooth, built-in memory 8Gb, support microSDHC memory card.

a_5 - Lenovo IdeaTab S6000 16Gb, designed on the basis of the Android 4.2 operating system, capacitive multi-touch screen diagonal - 10.1", 1280x800, wireless Wi-Fi, Bluetooth, built-in memory 16Gb, support microSDHC memory card.

a_6 - Acer Iconia Tab A1-811 8Gb + 3G, designed on the basis of the Android 4.2 operating system, capacitive multi-touch screen diagonal - 8", 1024x768, built-in memory 8Gb, wireless Wi-Fi, Bluetooth, 3G, support microSDHC memory card.

Although each of the presented above computers has set of characteristics that determine the quality, however, during choosing of a product, in this case a tablet computer, the consumer uses its own scoring system, own indicators of preference items, most of which very often he cannot even lay down. All this resulted in the application of expert estimations method in this study.

In order to get the information the field experiment was held in one of the shops which sell computers and accessories, during this experiment, visitors were asked to evaluate three brands of tablet computers on a ten point scale: score of 10 points awarded to the computer with the highest quality features, 1 point deserved computer with very low quality. Price and other factors in this study were not considered.

Previously it was determined the total number of experts who participated in the examination, in this study the total number of people were 10. To collect information the survey methods or experiment was used. In the case, if the expert is familiar with the characteristics of the suggested brands of tablet computers, the survey method was used and expert in the questionnaire put points, which, in his opinion, deserve valued objects. If expert did not know the characteristics of the proposed brand or brands that he never used, to the customer an appropriate computer for testing and evaluation was offered. To participate in the examination, visitors and shoppers who were in the shop of home appliances and electronics "Search" on Dec. 22 from 10am to 8pm were attracted. Examination results presented in Table 1.

Further processing of the results was performed which determine the final grade on each object and evaluate its reliability by analysis of variance.

Table 1: Results of expert estimation of tablet PCs

	Experts										
Type of products	E_1	E_2	E_3	E_4	E_5	E_6	E_7	E_8	E_9	E_{10}	Results (Ti)
a_1	10	9	10	10	10	-	-	-	-	-	49
a_2	5	6	-	-	-	10	10	9	-	-	40
a_3	-	-	2	7	-	7	6	-	6	-	28
a_4	-	-	4	-	8	8	-	8	-	7	35
a_5	3	-	-	-	8	-	8	-	7	8	34
a_6	-	4	-	8	-	-	-	7	9	8	36
Results (B_j)	18	19	16	25	26	25	24	24	22	23	G=222
B^2_j	324	361	256	625	676	625	576	576	484	529	5077

Table 2: Division of tablet computers brads by quality groups

Hight quality		Medium qaulity		Low quality	
Element	Score	Element	Score	Element	Score
a_1	49	a_4	35	a_3	28
a_2	40	a_5	34		
		a_6	36		

Final grade (T_i) on each object (a_i) determinated by summing up the points which were given by the experts:

$$T_i = \Sigma y_{ij} \tag{3}$$

where, y_{ij}- points which were given by *j* expert to *i* element.

The total points B_j was calculated by summarizing three statistic data which were exposed by *j* expert within the block. At the end we received BIB-system with the following parameters:

b=10, ν=6, q=3, r=5, λ=2, N=νr=bq=30

where,

- b - Number of blocks (in the current study - the total number of experts, b=10);
- ν - Collection of the studied and evaluated elements (in the current study – tablet PCs, *ν*=6);
- q - Number of units in the block (in the current study - number of computer brands, estimated by each expert, q=3);
- r - Number of repeats in a row (in the current study – number of experts who estimated *i* tablet brand, r=5);
- λ - Number of repeats of each pair of elements (in the current study – number of repeats of the same pairs of tablet computers, estimated by various experts, λ=2);
- N - Total number of experiments, (N=30).

In the current study the maximal final grade (T_i) equal to 49 points, got the object a_1 - Apple iPad. Minimal grade - 28 points - the object a_3 - Explay sQuad.

According to the final grades, presented brand of tablet computers can be grouped as follows: - high quality products, products with medium quality and low quality (Table 2).

Since BIB- systems don't have the property of orthogonality, it require more complex statistical analysis. During the calculation of the element effects and blocks effects, as well as the corresponding mean values, it is necessary to make the correction of the experimental data [1]. Therefore, the next step is to verify the accuracy of the examination results by refutation/confirmation of the hypothesis about abcence of difference between the elements in groups and the presence of differences between groups with the help of Fisher's ratio test. In this case, it is necessary to determine whether there are differences between such elements as: a_1 and a_2; a_4 and a_5; a_5 and a_6; a_3 and a_4 in order to arrange proper distribution of the represented tablet computers brads by quality groups.

In order to do this, we need to make some additional calculations. First, we will calculate B_i – the final sum for those blocks in which there is an element a_i. In our case it is the sum of the five finals on blocks in which each element was evaluated.

$B_1 = 18 + 19 + 16 + 25 + 26 = 104;$
$B_2 = 18 + 19 + 25 + 24 + 24 = 110;$
$B_3 = 16 + 25 + 25 + 24 + 22 = 112;$
$B_4 = 16 + 26 + 25 + 24 + 23 = 114;$

$B_5 = 18 + 26 + 24 + 22 + 23 = 113$;
$B_6 = 19 + 25 + 24 + 22 + 23 = 113$.

The B_i value should be taken into account during the calculation of the Q_i value (intrablock elements effect), with the help of which the internal information on the elements is estimating:

$$Q_i = 3T_i - B_i \tag{4}$$

$Q_1 = 3 \text{ x } 49 - 104 = 43$;
$Q_2 = 3 \text{ x } 40 - 110 = 10$;
$Q_3 = 3 \text{ x } 28 - 112 = - 28$;
$Q_4 = 3 \text{ x } 35 - 114 = - 9$;
$Q_5 = 3 \text{ x } 34 - 113 = - 11$;
$Q_6 = 3 \text{ x } 36 - 113 = - 5$.

The Q_i sum in matrix should be zero:

$$\sum_{1}^{6} Q_i = 0$$

Once the T_i, B_i and Q_i is determined, we can proceed with adjustment of the total elements (T_i'') based on interblock and intrablock information:

$$T_i'' = T_i + \mu\omega_i \tag{5}$$

where, ω_i –value that provides accounting of the block effects:

$$\omega_i = (v - q)\, T_i - (v - 1)B_i + (q - 1)G; \tag{6}$$

$$G = \sum_{1}^{v} \mathrm{T_i} \tag{7}$$

μ - weight coefficient:

$$\mu = \frac{(b-1)(E_b - E_e)}{v(q-1)(b-1)E_b + (v-q)(b-1)E_e} \tag{8}$$

In our case G = 222. Taking this into account:

$$\omega_1 = 3T_i - 5B_i + 2G \tag{9}$$

$$\omega_1 = (6 - 6)\text{x}49 - (6 - 1)\text{x}104 + (3 - 1)\text{x}222 = 71$$

$$\omega_2 = 3\text{x}40 - 5\text{x}110 + 444 = 14$$

$$\omega_3 = 3\text{x}28 - 5\text{x}112 + 444 = -32$$

$$\omega_4 = 3\text{x}35 - 5\text{x}114 + 444 = -21$$

$$\omega_5 = 3\text{x}34 - 5\text{x}113 + 444 = -19$$

$$\omega_6 = 3\text{x}36 - 5\text{x}113 + 444 = -13$$

Checking shows that:

$$\sum_{i}^{6} \omega_i = 0.$$

During the calculations, values of the relative intrablock information is taking into account (efficiency factor), which is determined from the relation:

$$E = \frac{V(q-1)}{q(v-1)} \tag{10}$$

This indicator estimates the impact of unaccounted factors on the amount of points from those experts who made the evaluation of the *i* element. In this case, E = 0.80.

The E_b and E_e values, awareness of which is necessary in order to determine μ, can be find after analysis of variance, the results of which are presented in Table 3.

$$E_b = \frac{82{,}1}{9} = 9{,}1$$

$$E_e = \frac{3{,}8}{15} = 0{,}25$$

According to equation (7), we can find μ:

μ=0,08

Now we have all values for determining the T_i'' values:

$$\mathrm{T_i}'' = \mathrm{T_i} + \mu\omega_i \tag{11}$$

$$T_1'' = 49 + 71x0{,}08 = 54{,}68$$

$$T_2'' = 40 + 14x0{,}08 = 41{,}12$$

$$T_3'' = 28 + (-32)x0{,}08 = 25{,}32;$$

Table 3: Results of variance analysis

	Variance		Number of freedom degree (f)		Medium variance	
Variance source	Calculating formula	Value	Calculating formula	Value	Calculating formula	Value
Blocks (unadjusted)	$S_1 = \frac{\sum_1^b B_j^2}{q} - \frac{G^2}{rv}$	49,5	$f_b = b - 1$	9	$E_b = \frac{S_2}{f_b}$	9,1
(adjusted)	$S_2 = \frac{\sum_1^b B_j^2}{q} + \frac{\sum_1^v Q_i^2}{q^2 rE} - \frac{\sum_1^v T_i^2}{r}$	82,7	$f_b = b - 1$	9	$E_e = \frac{S_{error}}{f_{error}}$	0,25
Elements (unadjusted)	$S_3 = \frac{\sum_1^v T_i^2}{r} - \frac{G^2}{rv}$	49,6	$f_3 = v - 1$	5	$E_3 = \frac{S_4}{f_3}$	9,92
Elements (adjusted)	$S_4 = \frac{\sum (T_i'')^2}{r} - \frac{G^2}{rv}$	49,6	$f_3 = v - 1$	5		
Intrablock error	$S_{error} = \sum_i \sum_j y_{ij}^2 - \frac{\sum_1^b B_j^2}{q} - \frac{\sum Q_i^2}{q^2 rE}$	3,8	$f_{error}(vr + 1) - (b - v)$	15		
Total	$S_{total} = \sum_i \sum_j y_{ij}^2 - \frac{G^2}{rv}$	135,2	$N - 1$	29		

Table 4: Intermediary calculations for experimental data processing

a	T_i	B_i	Q_i	ω_i	T_i''	$\bar{T}_i''$	T_i^2	Q_i^2
a_1	49	104	43	71	54,68	10,9	2401	1849
a_2	40	110	10	14	41,12	8,2	1600	100
a_3	28	112	-28	-32	25,32	5	784	784
a_4	35	114	-9	-21	33,32	6,6	1225	81
a_5	34	113	-11	-19	32,48	6,5	1156	121
a_6	36	113	-5	-13	34,96	6,9	1296	25
Total	222	666	0	0	221,88	44,1	8462	2960

$$T_4'' = 35 + (-21)x0{,}08 = 33{,}32;$$

$$T_5'' = 34 + (-19)x0{,}08 = 32{,}48;$$

$$T_6'' = 36 + (-13)x0{,}08 = 34{,}96.$$

Now we can calculate the average value of grades by the elements:

$$\bar{T}_i'' = \frac{T_i''}{r} \quad (12)$$

$$\bar{T}_1'' = \frac{54{,}68}{5} = 10{,}9;$$

$$\bar{T}_2'' = \frac{41{,}12}{5} = 8{,}2;$$

$$\bar{T}_3'' = \frac{25{,}44}{5} = 5;$$

$$\bar{T}_4'' = \frac{33{,}32}{5} = 6{,}6;$$

$$\bar{T}_5'' = \frac{32{,}48}{5} = 6{,}5;$$

$$\bar{T}_6'' = \frac{34{,}96}{5} = 6{,}9;$$

The results of calculations are summarized in the Table 4.

Knowing the T_i value we can find the adjusted sum of squares by the elements (S_4), the value which is necessary to identify E_y and further Fisher's ratio test. The value S_4 = 49,6, while E_e = 9.92.

During Fisher's ratio calculations, the value of adjusted error is takent into account:

$$E_e' = E_e(1 + (v - q)\mu) \quad (13)$$

$$E_e' = 0{,}25(1 + (6 - 3)x0{,}08) = 0{,}31$$

Estimated value of the Fisher's ratio test:

$$F_{est} = \frac{E_3}{E_e'} \quad (14)$$

Table 5: Results of the comparison of the elements

	Estimated value of the Fisher's ratio test			
Compared elements	Formula	Value	Table value of the Fisher's ratio test	Conclusion
a_1 & a_2	$F_{est} = \frac{(T_1'' - T_2'')^2}{2 \times 5 \times 0{,}31}$	4,4	4,54	$a_1 = a_2$
a_4 & a_5	$F_{est} = \frac{(T_4'' - T_5'')^2}{2 \times 5 \times 0{,}31}$	0,27	4,54	$a_4 = a_5$
a_5 & a_6	$F_{est} = \frac{(T_5'' - T_6'')^2}{2 \times 5 \times 0{,}31}$	1,98	4,54	$a_5 = a_6$

$$F_{est} = \frac{9{,}92}{0{,}31} = 32$$

Table value of the Fisher ratio $f_e = 6-1 = 5$ and $f_{error}=\upsilon r+1-(b+\upsilon) = 15$ equal to 2.9. Since $F_{est} > F_{tabl}$, we can assume that the differences between certain elements are significant.

Further, comparing of the individual elements using Fisher ratio test which determined by the formula is held:

$$F_{est} = \frac{(T_1'' - T_2'')^2}{2rE_e'} \tag{15}$$

Analyzing the information which is provided in Table 5, we can conclude that for each pair of compared elements the calculated value is less than table value of the Fisher's ratio test, hence with 95% confidence we can assume that $a_1 = a_2$, $a_4 = a_5 = a_6$. Thus, the following elements are grouped in a right way: a_1 & a_2 - group 1; a_4, a_5 & a_6 - group 2.

Further, we need to compare a_3 & a_4 elements:

$$\mathbf{F}_{est} = \frac{(\mathbf{T}_3'' - \mathbf{T}_4'')^2}{\mathbf{2 \times 5 \times 0{,}31}} = \frac{(\mathbf{25{,}32 - 33{,}32})^2}{\mathbf{3{,}1}} = \mathbf{20{,}6}$$

Since the calculated value of the Fisher's ratio more than table one ($F_{est} > F_{tabl}$), so between a_3 and a_4 elements there is significant difference, it can not get into the same group, hence a_3 element belongs to the third group. Thus, it can be argued that the grouping of objects presented in Table 2 corresponds to its quality characteristics.

Summarizing the results of the examination, we can make the following conclusions: the highest quality have the Apple iPad and Samsung Galaxy Note; the average quality tablets are Huawei MediaPad, Lenovo IdeaTab and Acer Iconia Tab; the low-quality tablet is Explay sQuad.

REFERENCES

1. Markova, E.V., 1970. Incomplete block designs. Moskov: MGU Publisher.
2. Yandex-market. [Electronic resource]. - URL:http:// market.yandex.ru/ catalogmodels.xml
3. Khamhanova, D.N., 2006. Theoretical basis for ensuring the uniformity of expert measurements. Ulan-Ude: ESSTU Publisher, pp: 170.