A „NEW“ NON-PARAMETRICAL STATISTICS INSTRUMENT: FRIEDMAN TEST. THEORETICAL CONSIDERATIONS AND PARTICULARITIES FOR MARKETING DATA

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Abstract

The purpose of marketing research results is not to obtain results and to transfer them to decision structures within an organization but – according to statistics law – the inference in the general population. Statistics offers marketing researchers classical statistics data, parametric, applicable for metric data but also numerous tests adapted to qualitative data particularities respective non-parametric tests.

Nonparametric statistics provides many tools or statistical tests for marketing data, the *Friedman* test, along with other tests often used in market studies - *Wilcoxon, Kolmogorov - Smirnov, Mann - Whitney, Kruskal – Wallis*, etc. - being less discussed and applied to ordinal marketing data.

The application of the Friedman test has few *particularities*, in comparison with other non-parametric tests and implicitly with those destined to test ordinal tests, connected to the formulation of the hypothesis, calculus formula, application conditions, usage modalities, and some other aspects which will be dealt with in this research paper.

We propose in this paper complementary use of the another nonparametric test, respectively *Kolmogorov – Smirnov test* – the latest one giving the possibility of presenting in detail the differences between, for example, the subjects' preferences resulted from applying Friedman test, according to different socio-demographic characteristics or variables.

Key words: nonparametric statistics test, Friedman test, marketing data, Kolmogorov-Smirnov test

JEL Code: C12, C14, M31

Introduction

Non-parametric statistics offers numerous tools for marketing data, Friedman test, in comparison with other tests more often applied in the market study practice – Wilcoxon, Kolmogorov – Smirnov, Mann – Whitney, etc. – being less approached for ordinal marketing data. In 1959, R.L. Anderson suggests for the first time, a statistical rank of type χ^2 to non-parametric analyses of designing randomized blocks (Schach, 1979) but the first mentioning of the Friedman test dates from 1937, year in which Milton Friedman publishes the article „*The use of ranks to avoid the assumption of normality implicit in the analysis of variance*".

In foreign literature which we studied is mentioned for the first time by W. J. Popham and K. A. Sirotnik (1973, p. 277) in the work *Educational statistics – use and interpretation.* Other authors, who made methodological references an exemplified the application of this test for economical variables, are chronologically: in 1982, L. Lebart, A. Morineau and J. – P. Fénelon in the work Traitement *des données statistiques – méhodes et programs*, in 1988 G. R. Loftus and E. F. Loftus in the work „*Essence of statistics*, in 1990 D. S. Tull and D. I. Hawkins in the work *Marketing research. Measurement & method*, in 1998 G. Pupion and P. C. Pupion in the work *Test non-parametrique avec applications à l'economie et la gestion,* in *2003* Evrard, Y., Pras, B., Roux, E. - *Market – etudes et recherche en marketing – 3e edition,* and in 2006 by A. Jolibert şi Ph. Jourdan in the work *Marketing research – méthodes de recherche et d'études en marketing.*

The application of the Friedman test has few *particularities*, in comparison with other non-parametric tests and implicitly with those destined to test ordinal tests, connected to the statment/ formulation of the hypothesis, calculus formula, application conditions, usage modalities, and some other aspects which will be dealt with in this reasearch paper.

1. Friedman test – theoretical considerations and particularities for marketing data

G. Pupion and P. C. Pupion (1998, p. 88 - 90) mention Friedman test as *Friedman variance analyses through ranks* and present two modalities of using the test; the first, the case of a population in which is measured a characteristic which is divided in *k* sub-populations and the second one being the linear model with two factors, used when it is studied the influnce of two factors A and B of different nature on X measure of a

characteristic, but is different from ANOVA because it doesn't make assumptions over the distribution (for example the normal distribution). Also most authors recommend it when one of ANOVA hypothesis is not fulfilled, such as the deviance from distribution normality. We consider that by not making assumptions over the distribution, is not as powerful as ANOVA and so *the power of this test can be assured by providing a representativity of the sample group subjects used in research.*

A. Jolibert and Ph. Jourdan (2006, p. 210) mention this as a non-parametric test destined just to ordinal variables in the case of more than two independent group samples or pairs, the case of bivariance analyses and consider it (2006, p. 231) as an extension of *Wilcoxon test* with more than two pair group samples mentioning the fact that the number of the cases has to be the same in the same sample.

Y. Evrard, B. Pras and E. Roux (2003**,** p. 362) place it near an extension of the median test destined to ordinal data gathered on *k* pair samples and name it the *Friedman two factor variance analyses.*

D. S. Tull and D. I. Hawkins (1990, p. 562) classify Friedman test as being an univariance method close to studying ordinal data on more than nonindependent samples, of any size, named by the two authors *Friedman two – way ANOVA*[1].

G. R. Loftus and E. F. Loftus (1988, p. 565) classify Friedman test as being a non-parametric test destined to study more than two conditions applied within the subjects[2].

The Formulation of the hypothesis for Friedman test has in special literature numerous connotations, thus G. Pupion and P. C. Pupion (1998, p. 89) consider two formulations - in the case of using a population in which is measured a characteristic which is divided *k* sub - populations:

- One for the base hypothesis - *factors A_1….A_n don't have stochastic any influnce,*
- The other for general hypothesis - factors *A_1…. A_n don't have different stochastic*

[1] Friedman test is classified in this category together with the following tests ; Kolmogorov – Smirnov test for sample , Mann – Whitney test, the median test , Kolmogorov – Smirnov test for two samples , the test of the sign , Wilcoxon test for pair samples and Kruskal – Wallis test one – way ANOVA

[2] These authors compare Friedman test with the other non-parametric tests considering that this one ,'solves ,' the problems unapproached by the other tests , respective that , when we study more than two independent samples , testul Mann – Whitney test is inadequate , and when we study two sets of observations on the same individuals we have Wilcoxon test, testul Friedman practically answering the same problems as Wilcoxon test but for the case of more than two sets of observations.

influences.

For A. Jolibert and Ph. Jourdan (2006, p. 231) the null hypothesis is formulated over the *equality of conditions* (*treatments*). According to Y. Evrard, B. Pras and E. Roux (2003**,** p. 387), the hypotheses in work for this non-parametric test are:

- *The results from the inside of a block are not influenced by the results from the interior of another block* and
- *Inside each block the results can be ordered, the measuring scale being the ordinal one* and are considered to be, in the opinion of the three authors, identical with the ones of *the Cochran Q Coefficient* with the difference that it is applied to ordinal data.

M. Friedman (1940) thus formulates the null hypothesis: *the original entries in each row are from the same universe.*

Connected to the *application formula,* G. Pupion and P. C. Pupion (1998, p. 89 – 90) consider that Friedman statistics formula is only Kendall statistics for k classifications, being in fact equal with $k(n-1)W_{k,n}$ and for *k* big enough to be used asymptotally $F_{k,n} = \chi^2_{n-1}$ because $F_{k,n} \to \chi^2_{n-1}$ when k→ ∞, thus Friedman statistics is in fact equal with: $F_{k,n} = 12S_{k,n} / k(n^2 + n)$ and concludes that Friedman statistics is a Fisher type law $F^{(n-1)}_{(k-1)(n-1)}$.

In studied foreign literature which has as a subject non-parametric tests, there are authors (Vendrine, 1981, p. 51 – 54) who extended researches, approaching the relation between an ordinal variable and a nominal variable – a situation often met in the practice of market studies, for example by means of the sign and rank test of Wilcoxon for pair samples and the test of the ranks sum of Wilcoxon for independent samples.

Some authors – L. Lebart, A. Morineau and J. - P. Fénelon (1982, p. 138) – also approached the data presented under the shape of ranks through Fisher tests, one of these being Wilcoxon – Mann – Whitney test, Friedman test being presented as a generalization of these tests, respective the procedure of the Wilcoxon test to compare two treatments can be generalized for the case *n* treatments.

Friedman statistics χ^2_r *has an approximate distribution with classical* χ^2 *statistics* with the difference that, the number of freedom degrees it's calculated not as a product between the number of the lines and columns minus 1 - *(l-1)(c-1*) - but only the number of the columns (treatments) minus 1. Consequently, the theoretical values of Friedman statistics are

taken from the teoretical values table of χ^2, statistics according to the level statistics significance chosen for the study. Demšar (2006, p. 13) also appreciates that the number of the treatments has to be big enough, respective bigger than five.

Applications of the Friedman test for marketing data can be encountered at:

- G. Pupion and P. C. Pupion (1998, p. 99 – 100) applied to determin (didactical example) – within a car producer company – the influence of the price policy (as an explanation variable) over the number of the car sold in a certain time within the frame of three market segments according to the level of the income;
- A. Jolibert and Ph. Jourdan (2006, p.232) – following a didactic purpose – the satisfaction of six important customers over three years representing, "the conditions/the treatments";
- Y. Evrard, B. Pras and E. Roux (2003**,** p. 388) – the assesment of four advertising campaigns by three subject groups.

2. Kolmogorov – Smirnov (K-S) test – applying methological considerents for marketing data

This non-parametric test, being more often approached in the specialty literature both from theoretical and practical point of view, we will mention in this paragraph only its particularities for the marketing data respective the appliance methodology for marketing data.

Encountered in the studied specialty literature as an adjustment test on a specified law (Pupion şi Pupion, 1998, p. 109) or as an explanatory analyses of an ordinal variable (Fenneteau şi Bialés, 1993, p. 28), K – S test is an adjustment test between the observed frequences and theoretical frequences derived from H_0 and it has a *particularity* (Lambin**,** 1990, p. 246), the one of being adapted to data of ordinal nature.

By comparing K – S test with χ^2 *test* the first one presents *the advantage* that it doesn't imply the imposing of the condition of minimum frequencies in cells and it is also easy to calculate.

The K – S test, in unvaried variant (Vendrine, 1991, p. 38), it is used for testing the quality of an adjustment of a repartition function observed to a repartition function established apriority. This test can be used each time when the qualitative variables considered can be

ordered and when the effectives of different classes are too weak to authorize the use of χ^2 test**.**

Conclusion

M. Friedman (1940) stated in his article, the Friedman test doesn't use all the information provided by processed data , the author applying complementary, ANOVA and demonstrating that the loss of information in the Friedman test is not very big, considering very difficult the choice between the two methods and that the lost information is diminished if the number of the ranks on the set increases (more than two) as it was used in this research, respective the number of the ranks was bigger than the number of the treatments. Another theoretical aspect recommended by M. Friedman (1937) and which was taken into account in this paper for marketing data (ordinary data) is given *when the number of sets of ranks is moderately large (say greater than 5 for four or more ranks) the significance of* χ_r^2 *can be tested by reference to the available* χ^2 *tables.*

We also mention the fact that, in the studied specialty foreign literature, after applying Friedman test, most often it is applied *Wilcoxon test* or – in the case when the number of comparisons is bigger than three, it is used *Bonferoni test* or *Holm's Sequential Bonferoni* to control the type 1 error. In speciality foreign literature, most often Friedman test can be encountered as applied to medical domain, being used to perform and detect the cost differences between four methods for each of the services offered by a hospital, ulterior to Friedman test being applied *Wilcoxon signed ranks Z-tests* (Tan, Ineveld, Redekop, Roijen, 2009). The justification of subsequent Wilcoxon test applying can be explained by the fact that, Friedman test doesn't show that there are differences between groups and which group differs from another one, being imperative the use of a post-hoc test of type *Wilcoxon signed ranks test.* Another example of complementary use of these tests is encountered at Ethart – Vincent and l'Haridon (2011, p. 61-83). It is known that J. Demšar (2006, p. 1) considers the two tests as being non-parametric simple and robust to compare statistics of classifications, *Wilcoxon signed ranks test* to compare two classifications and Friedman test with post-hoc tests to compare more than two classifications for multiple sets of data .

Reffering to the post-hoc use of another statistics test, M. Friedman (1940) recommends that, when the null hypothesis is rejected, it can be used *Nemenyi test*, similar – in the author's opinion – with *Tukey test* for ANOVA.

In this paper, we recomended that the results of the Friedman tests (for marketing data) can constituted the base for applying *Kolmogorov – Smirnov test* (K - S) – the latest one giving the possibility of presenting in detail the differences between the subjects' preferences resulted from applying Friedman test, according to different socio-demographic characteristics of the subjects. Also, we recomended the complementary use of the Friedman and Kolmogorov – Smirnov tests for a better research of the (i.e. for marketing data) preferences referring to advertising (Gabor & Conţiu, 2012).

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