ORIGINAL PAPER

ASSOCIATING THE RESULTS OF STATISTICAL MATHEMATICS TESTS IN THE STUDY OF EMPLOYEE MOTIVATION

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Abstract. *The whole approach of this paper revolves around the theme of employee motivation, having as the main objective to establish notable associations and implications that are worthy of being taken into account by the manager in establishing the appropriate motivational factors for employees. The purpose is to study the degree of association between the type of employer, private or public, and the type of personality of employees, namely proactive personality or not. To achieve this goal, it is propose a new mathematical method of statistical research using a coupling of the verifing statistical hypotheses tests regarding the determination of the error risk, this one being therefore calculated by a linear expression of the individual error risks. Also, is provided a series of results obtained from the processing of data observed through a survey study, results that lead to some motivational managerial implications. Being carried out during the current year, the survey certainly supplied observed data that were in accord with the actual economic and social context. Therefore, it should be emphasized that the two characteristics of interest pursued in this study, the type of employer and the proactive personality or not, were investigated for Romanian employees of companies operating in uncertain economic conditions.*

Keywords: *Statistical hypotheses tests; motivation; proactive personality; private and public employer.*

1. INTRODUCTION

Regardless of the field in which they operate, economic organizations are forced today to adapt to new conditions, to deal with frequent changes. This cannot be done without the commitment and motivation of employees, without their openness to improvement, so it is natural to study the ability of human resources to accept the improvement of individual professional skills.

Among a several number of other factors, the employees work commitment, is one of the interest points that the manager must constantly observe because it influences the employee's behavior and consequently the level of the individual and general productivity (Kiesler and Sakamura [1] and Amin et al. [2]). As Savall and Zardet show [3], the study of the factors involved in determining the type of behavior of employees at work, involves researching both the specific characteristics of each individual and also those collective characteristics specific to work groups in which they carry out their activity.

According to the definition given by Vallerand and Thill [4], a definition reiterated by Roussel [5], the motivation is that psychological and economic factor that characterizes the nternal and/or external energies that lead to the initiation, direction, intensity and the duration of a certain type of behavior.

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The polyvalentcy of the concept of motivation has generated over time a wide range of classifications of factors that determine motivation, so in the specialized literature there are various classification variants such as those provided by Kanfer [6], in which they are grouped into two classes, internal and external motivational factors. Frey and Osterloh [7], also use two classes, namely, intrinsic factors and extrinsic factors. However, one of the most recent classifications is the one given by Amin et al. [2], in which four classes of motivational factors, namely recognition of professional value, professional identity, opportunities and finances are considered.

In the recent literature, authors such as Bateman and Crant [8], Crant [9], or Wang et al. [10], emphasize the importance of employees who have proactive personality traits, this concept being closely correlated with concepts such as employees work commitment or the performance of work teams and organizations.

This article is subordinated to a new important trend that has appeared recently in the research dedicated to the application in practice of mathematical statistical tests, a trend in which authors such as Ji et al. [11], propose the use of new tests whose statistics are designed as a linear combination of classical test statistics, to obtain in this way, the improvement of the statistical approximation quality. In the next two sections is presented the methodology and the results of a study that is conducted during of the year of 2021, in which is observed a group of Romanian employees to obtain results related to the preferred intrinsic motivational factor placed, on vertical, in the context of the current socio-ecoomic environment influence, on the types of organization and going deeper, on individuals. Here comes the mathematical contribution of author regarding the calculation of the first-degree error risk that appeared after the application of the classical tests for verifying the statistical assumptions of concordance for categorical variables. The fourth section is intended for the conclusions detached from this study and in the last section, is presented the possible directions in which could develop the results highlighted in this study.

2. METHODOLOGY

This study uses the chi-square test to establish the association between two nominal categorical characteristics of interest, namely X - type of employer and Y - type of proactive personality, each with two categories. According to Levin [12], Bolboaca et al., [13] and Agresti [14], this test uses X^2 Pearson statistics, for 2×2 contingency tables, given by:

$$X^2 = \sum_{i=1}^{2} \sum_{j=1}^{2} \left(u_{ij}\right)^2 \tag{1}$$

where u_{ij}, represents the Pearson residuals corresponding to the table cells,

$$u_{ij} = \frac{n_{ij} - \hat{\pi}_{ij}}{\sqrt{\hat{\pi}_{ij}}} \tag{2}$$

in which n_{ij} are the observed absolute frequencies and $\hat{\pi}_{ij}$ are the expected frequencies, estimated for the theoretical frequencies π_{ij}, being calculated using the formula:

$$\hat{\pi}_{ij} = \frac{(n_{i1} + n_{i2}) \times \left(n_{1j} + n_{2j}\right)}{n} \tag{3}$$

with n the sample volume and $i \in \{1,2\}$, $j \in \{1,2\}$.

For large sample size, in which the null hypothesis H_0 is tested, the statistic of the test follows $\chi^2_{(2-1)\times(2-1)}$ distribution and the type I error risk, is $P\left(\chi^2_{(2-1)\times(2-1)} \geq X^2 \middle| H_0\right) = \alpha_{\chi^2}$ being named p-value.

Also, given the size of the contingency table, 2×2, associated with present study of two binary categorical theoretical variables, it is considered beeing appropriate to research as well, the results provided by Fisher's exact test [15, 16]. It uses the probabilistic law of hypergeometric distribution:

$$P(\pi_{11} = n_{11}) = p_0 = \frac{\binom{n_{+1}}{n_{11}}\binom{n_{+2}}{n_{1+} - n_{11}}}{\binom{n}{n_{1+}}} \tag{4}$$

where, n_{i+}, n_{+j} are the absolute marginal frequencies, $i \in \{1,2\}$, $j \in \{1,2\}$ [17, 18]. The type I error risk is $P(\pi_{11} \geq n_{11}) = \alpha_F$ being named p-value [19, 20].

Then,

$$\alpha_F = \sum_{j \in \{j \in \mathbb{N} | p_j \leq p_0\}} \frac{(n^j_{1+})! \times (n^j_{2+})! \times (n^j_{+1})! \times (n^j_{+2})!}{n! \times (n^j_{11})! \times (n^j_{12})! \times (n^j_{21})! \times (n^j_{22})!} \tag{5}$$

For categorical data that provide p -values below the significance level of 0.05 for one of the two tests mentioned above, and in addition is verified the condition that the other value exceeds 0.05 but remains below the value of 0.1, it is propose for the calculation of the error risk of type I, the following formula:

$$\begin{aligned} \alpha = \omega_1 min\left(P\left(\chi^2_{(2-1)\times(2-1)} \geq X^2 \middle| H_0\right), P(\pi_{11} \geq n_{11})\right) \\ + \omega_2 max\left(P\left(\chi^2_{(2-1)\times(2-1)} \geq X^2 \middle| H_0\right), P(\pi_{11} \geq n_{11})\right) \end{aligned} \tag{6}$$

with $\omega_1, \omega_2 \in [0,1]$, $\omega_1 + \omega_2 = 1$.

This value obviously verifies the inequality:

$$\begin{aligned} min\left(P\left(\chi^2_{(2-1)\times(2-1)} \geq X^2 \middle| H_0\right), P(\pi_{11} \geq n_{11})\right) \leq \alpha \\ \leq max\left(P\left(\chi^2_{(2-1)\times(2-1)} \geq X^2 \middle| H_0\right), P(\pi_{11} \geq n_{11})\right) \end{aligned} \tag{7}$$

It states that the error risk of type I given by formula (6) will have a value below 0.05, $\alpha \leq 0.05$, if the weights ω_1 and ω_2 are:

$$\omega_1 = \frac{t-1}{t}, \omega_2 = \frac{1}{t} \quad for\ any\ t \geq [t'] + 1 \quad , t \in \mathbb{N} \tag{8}$$

where

$$t' = \frac{max\left(P\left(\chi^2_{(2-1)\times(2-1)} \geq X^2 \middle| H_0\right), P(\pi_{11} \geq n_{11})\right) - min\left(P\left(\chi^2_{(2-1)\times(2-1)} \geq X^2 \middle| H_0\right), P(\pi_{11} \geq n_{11})\right)}{0{,}05 - min\left(P\left(\chi^2_{(2-1)\times(2-1)} \geq X^2 \middle| H_0\right), P(\pi_{11} \geq n_{11})\right)} \tag{9}$$

to prove this statement, is noted:

$$\alpha_1 = min\left(P\left(\chi^2_{(2-1)\times(2-1)} \geq X^2 \middle| H_0\right), P(\pi_{11} \geq n_{11})\right), \text{ with } \alpha_1 < 0.05$$

$$\text{and } \alpha_2 = max\left(P\left(\chi^2_{(2-1)\times(2-1)} \geq X^2 \middle| H_0\right), P(\pi_{11} \geq n_{11})\right), \text{with } 0.05 < \alpha_2 \leq 0.1$$

The inequality $t \geq t'$ implies that $t \geq \frac{\alpha_2 - \alpha_1}{0,05 - \alpha_1}$

Because $\alpha_1 < 0.05 \Longrightarrow t(0.05 - \alpha_1) \geq \alpha_2 - \alpha_1$

Relationship that is equivalent to:

$$\frac{t-1}{t}\alpha_1 + \frac{1}{t}\alpha_2 \leq 0.05$$

thus,

$$\alpha = \omega_1 min\left(P\left(\chi^2_{(2-1)\times(2-1)} \geq X^2 \middle| H_0\right), P(\pi_{11} \geq n_{11})\right) + \omega_2 max\left(P\left(\chi^2_{(2-1)\times(2-1)} \geq X^2 \middle| H_0\right), P(\pi_{11} \geq n_{11})\right) \leq 0.05.$$

3. THE RESULTS OF DATA ANALYSIS FROM A SURVEY CONDUCTED FOR ROMANIAN EMPLOYEES

This section includes both details related to the data observed following a survey that that was conducted earlier this year on Romanian employees, as well as the results obtained from processing this data with the IBM SPSS Statistics program package. Regarding the survey, the random sample was consisted of a total of 100 employees, both women and men, selected from all age groups between 18 and 67 years. Also, the individuals were chosen both from those who carry out their activity in the public sector, but also from those in the private sector, such as employees of some companies having the object of activity, sales, financial-banking, production, etc.

The questions of the questionnaire followed the description of several characteristics of the employees such as the position in the organization, the job insecurity, the proactive personality, the achievement of co-value or the agreed motivational factor. The characteristic of interest that shaped the type of employer corresponded to the fourth question of the questionnaire, namely: '*Your employer is*:' for which the answer option '1' was '*private*' and option '2' was '*public*'. To measure the possession of proactive personality traits, it was designed a question inspired by the way of proving this characteristic of interest used by Lin et al. [21], but was considered more appropriate to use a question that would have binary answer variants. Moreover, here was avoided the use of the certain definite answer variants, '*yes*' and '*no*', by formulating two answer variants to highlight more the predisposition, the inclination towards having or not the features of this personality type. Thus, to the sixth question of the questionnaire: '*At work, do you have the initiative to propose changes or improvements to the way you work?*', two answers were considered, 1: '*Rarely*' and 2: '*I often get involved'*. The processing of the observed data aimed to test of the hypothesis: *H_0: 'There is no association between the proactive personality type and the employer private/public type.'*

Tables 1-4, as well as Fig. 1, are outputs obtained after applying the IBM SPSS Statistics program package. As can be seen from Table 1, all respondents provided valid answers and the common frequencies, both absolute and relative, are revealed by Table 2 for whose information the bar chart representation is gived by the Fig. 1.

Table 1. Summary of valid answers for the survey questions, no 4 and no 6, corresponding to the theoretical variables X - type of employer and Y - type of proactive personality.

Case Processing Summary						
	Cases					
	Valid		Missing		Total	
	N	Percent [%]	N	Percent [%]	N	Percent [%]
4) Your employer is: * 6) At work, do you have the initiative to propose changes or improvements to the way you work?	100	100	0	0	100	100

To test the hypothesis, it was initially applied the Chi-Square Test, and as the results provided by Table 3 show, the Chi-Square Test p-value is 0.0455 which for a significance level equal to 0.05, would indicate the existence of an evidence in favor of rejecting the working hypothesis, which confirms the association of the personality type of the employees, with the type of employer. However, it must be taken into account that, as the IBM SPSS output from the same table shows, the conditions for applying the Chi-Square Test are met. Thus, regarding the values of the estimated frequencies, the condition of the test is met because the minimum expected count is 5.00, and regarding the percentage of estimated frequencies exceeding the value 5, it has the value of 100%. However, both the 2×2 size of the contingency table and the relatively small selection volume, 100, indicate the need to reinforce the conclusions by conducting additional case studies or by applying Fisher-Irwin's Test. Applying Fisher-Irwin's Test, as Table 3 reveals, yields a p -value of 0.0916, a value that is still below 0.1 and not far distanced from the Chi-Square Test p-value, then it does not provides an obvious evidence of acceptance of the null hypothesis.

Table 2. Contingency table for the variables X and Y.

4) Your employer is: 1 private, 2 state * 6) At work, do you have the initiative to propose changes or improvements to the way you work? Crosstabulation					
			6) At work, do you have the initiative to propose changes or improvements to the way you work?		Total
			1	2	
4) Your employer is:	1	Count	2.0	48.0	50.0
		% within 6) At work, do you have the initiative to propose changes or improvements to the way you work?	20.0%	53.3%	50.0%
	2	Count	8.0	42.0	50.0
		% within 6) At work, do you have the initiative to propose changes or improvements to the way you work?	80.0%	46.7%	50.0%
Total		Count	10.0	90.0	100.0
		% within 6) At work, do you have the initiative to propose changes or improvements to the way you work?	100.0%	100.0%	100.0%

Regarding the error risk of type I, applying formula (9) is obtained:

$$t' = \frac{0.0916 - 0.0455}{0.05 - 0.0455} = 10.2$$

and according to formula (8), for any $t \geq [10{,}2] + 1 = 11$ and for weights $\omega_1 = \frac{t-1}{t}, \omega_2 = \frac{1}{t}$, is obtained $\alpha \leq 0.05$. Attributing to t the value 11 and according to (6) was obtained the

weight for the first test, $\omega_1 = \frac{10}{11}$, which is ten times higher than the second test, $\omega_2 = \frac{1}{11}$, and:

$\alpha = \frac{10}{11} \times 0.0455 + \frac{1}{11} \times 0.0916 = 0.049 \cong 0.05$; with $0.0455 \leq 0.049 \leq 0.0916$ value that corresponds to the rejection of the null hypothesis as well.

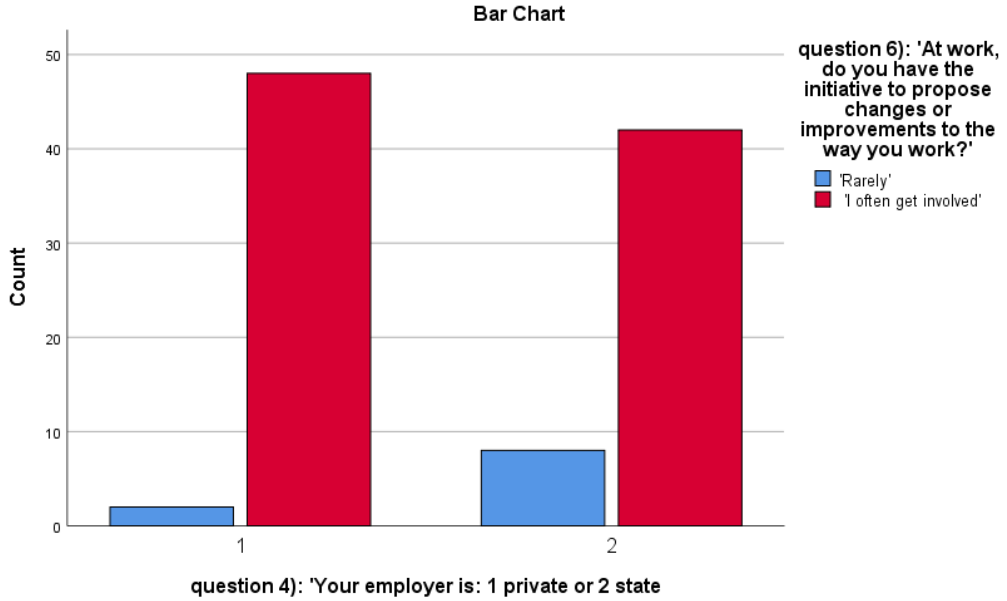

Figure 1. Bar Chat representation of the results from the Contingency Table 2.

Table 3. The outputs of applying the Chi-Square Test and Fisher's Test.

Chi-Square Tests					
	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	4.000[a]	1	0.0455		
Continuity Correction[b]	2.778	1	0.096		
Likelihood Ratio	4.255	1	0.039		
Fisher's Exact Test				0.0916	0.0458
Linear-by-Linear Association	3.960	1	0.047		
N of Valid Cases	100				
a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 5.00.					
b. Computed only for a 2x2 table					

From the Table 4 data, it can be seen that the value of the estimated relative risk (Odds Ratio, OR) is 0.219, which leads us to the conclusion that for people whose employer is private, the chance of having a proactive personality is more than four times higher than for those whose employer is public.

Regarding the relative risk values (RR), as shown in Table 4, these correspond to confidence intervals that include the value 1, so it can be expressed, as a prospective conclusion, that there is a difference in terms of risk between the two groups of individuals, composed of employees who have proactive personality traits and respectively employees who do not have these personality traits. Thus, since the RR value for the first group is 0.250, while for the second group it is 1.143, it can be concluded that there is a prospective tendency for the rate of employees with proactive personality to be higher among employees in the private sector compared to that of public employees.

Table 4. Odds Ratio (OR) and Relative risk (RR).

Risk Estimate			
	Value	95% Confidence Interval	
		Lower	Upper
Odds Ratio for 4) Your employer is: (1 / 2)	0.219	**0.044**	**1.088**
For cohort 6) At work, do you have the initiative to propose changes or improvements to the way you work? = 1	0.250	**0.056**	**1.119**
For cohort 6) At work, do you have the initiative to propose changes or improvements to the way you work? = 2	1.143	1.000	1.306
N of Valid Cases	100		

4. DISCUSSION AND PRACTICAL IMPLICATIONS

This study and the results obtained by using this proposed method of combining mathematical statistical tests, lead to the statement that, at present, it can associate the type of employees' proactive personality, with the type of employer. On the one hand, the causes of this association can have their origin in the individuality character of the employees who had these personality traits and who chose a certain type of employer, in the case of present research, private, also having expectations regarding the possibility of this type of employer to highlight or even encourage this type of personality. Another cause could be that the management of public organizations itself is not sufficiently aware of the importance of this type of personality traits when hiring human resources or during their activity. But in order to be able to verify these points of view, it is necessary to carry out a punctual study focused on one or more such organizations.

Corroborating the results obtained in this paper with a series of previous results, Constantinescu [22], in which the intrinsic motivational factor preferred by Romanian employees with proactive personality, in the current economic conditions, was proved to be that of professional identity, it can be added that the managers of private companies could use the actions of employee training given that in this way will be obtained in addition to motivating human resources, other important benefits such as the improving of certain economic indicators, for example the productivity or, on the organization level, the improving of the fast adaptability in front of the more and more frequent economic changes what characterizes the last period.

5. CONCLUSION

The future research will consider developing the studies applied to particular cases, dedicated studies, focused on certain societies. Also, consider of real interest the extension of the observation of the organization type by following both the private-public characteristic but also the characteristic of the organization based on self-esteem (OBSE) or not.

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