International Journal of Modern Manufacturing Technologies
ISSN 2067–3604, Vol. XIV, No. 3 / 2022
https://doi.org/ 10.54684/ijmmt.2022.14.3.105

# HIERARCHICAL PCA FOR FORMAL GROUP BEHAVIOUR MODELLING

**Raluca-Petronela Lazarescu, Adrian Vilcu**

"Gheorghe Asachi" Technical University of Iasi, Department of Economical Engineering
Blvd. Mangeron, No. 59A, 700050, Iasi, Romania

Corresponding author: Raluca-Petronela Lazarescu, raluca-petronela.lazarescu@academic.tuiasi.ro

***Abstract:*** Organizational behaviour involves systematic studies regarding the individual behaviour inside groups, including the nature of groups, development of group structures and between groups and implementation of the change process. The paper presents a practical approach about how the gender of students influences the organizational group behaviour with the main objectives to evaluate the organizational behaviour on two groups (M/F) and to create a qualitative and quantitative pattern for organizational behaviour inside formal groups. The authors used the questionnaire of Hellriegel, Slocum and Woodman as an instrument that includes three types of behaviour – behaviour focused on tasks/objectives, behaviour focused on relationships, and behaviour focused on own interests. We used statistical methods - the T test – to see the differences between M/F and statistical factorial modelling – PCA method to identify the predominant items to define a new model for organizational behaviour. The necessity of the research comes from the dynamic of behaviour inside a group which involves (individual) internal and external (relations and tasks) essential factors.
***Key words:*** PCA method, Hellriegel questionnaire, Slocum questionnaire, Woodman questionnaire, factorial analysis.

## 1. INTRODUCTION

Organ and Bateman [1] define organizational behaviour could be defined in three ways: organizational behaviour as a set of psychosocial phenomena; organizational behaviour as an area, object of study described and explained as a series of concepts and theories, investigated with specific methods, subject to investigation and generalization; organizational behaviour as a centre of interest for different groups – emphasizing the value and usefulness of organizational behaviour, as being significative both for itself and for team members, as well as for other groups. Johns [2] states that: "organizational behaviour refers to the attitudes and behaviours of individuals and groups in the organization." Mc Shane and Von Glinow [3] state that: "organizational behaviour is the study of what people think, feel and do in organizational contexts".
Research [4] argued that organizational behaviour means from a psychological point of view, the totality of adaptive reactions of the individual or group, the global manifestations of the individual psychic activity or organizational group. These reactions and manifestations are either directly observable or indirectly inferable; however, in one case and another, they can be influenced and directed.
According to [5] organizational-managerial psychology has three main tasks regarding organizational behaviour, namely: anticipating organizational behaviour; explanation of organizational behaviour; management (control) or management of organizational behaviour.
According to Hellrieger and Slocum [6], organizational behaviour" is the study of individuals and groups within the context of an organization and the study of internal processes and practices that influence the effectiveness of individuals, teams, and organizations". The main themes of organizational behaviour: "the characteristics of the individual, such as their beliefs, values, and personality; the individual's processes, such as perception, motivation, decision-making, judgment, commitment and control; the characteristics of the group, such as its size, composition and structural properties; group processes, such as decision-making and leadership; the organization's processes and practices, such as goal setting, evaluation, feedback, rewards and performance, turnover, absenteeism, and stress" [7].
Organizational behaviour is particularly interested in determining why people are more or less motivated, satisfied or determined to resign. Organizational behaviour refers to how organizations can survive and adapt to change. The field of organizational behaviour refers to all attitudes and behaviours of individuals in groups, in organizations. Those who study organizational behaviour are interested in people's attitudes, how dedicated they are to the goals of the organization, or how much they support the promotion of women or minorities to leadership positions. Behaviours such as innovation, cooperation, conflict, resignation or ethical fallouts are important areas of study for organizational behaviour.

## 2. ORGANIZATION OF RESEARCH

### 2.1 The purpose/main objective of the research

The research objective is to identify the differences between males and females regarding the organizational behaviour inside groups and to create a qualitative and quantitative pattern for organizational behaviour inside formal groups using the PCA method.

### 2.2 Hypothesis

There are differences between males and females in organizational behaviour. There is a predominant organizational group behaviour of the students.

### 2.3 Subjects/sample

The target population of the study is formed by students. The sample is considered uniform weight. The relation between items and respondents is 1:3. The participants are 53 third-year students studying at "Gheorghe Asachi" Technical University of Iași, Romania, from the Faculty of Chemical Engineering and Environmental Protection, Faculty of Machine Manufacturing and Industrial Management, Faculty of Electrical Engineering, Faculty of Industrial Design and Business Management, study program: Business Engineering and Management. The participants were informed regarding the questionnaire contents, the scale and they were encouraged to use the feedback in case of misunderstands.

### 2.4 Method

The instrument used to develop the research was the questionnaire of Hellriegel, Slocum and Woodman including 18 items for three types of behaviour – behaviour focused on tasks/objectives, behaviour focused on relationships and behaviour focused on own interests. The questionnaire uses a Likert scale: 0 - strongly disagree, 1 - disagree, 2 - neutral,3 - agree, 4 - strongly agree.

The authors used a method to analyse the internal consistency of the evaluation instrument – the organizational group behaviour questionnaire - Alpha Cronbach [8] (αC) and the PCA [9] method to create the organizational behaviour model applied hierarchical (two levels) – the first level decreases the variables′ numbers corresponding to each of three dimensions of the questionnaire such as the informational quantity of the input variables to be found in the intermediary factors. Figure 1 shows the application of the PCA method on 2 levels for research modelling.

Applying the PCA method on the second level comes to decrease the intermediary factors identifying those who are redundant for the three dimensions – because the main factors for each dimension are uncorrelated. Therefore, the statistical method for the group behaviour contains the most relevant input variables which define it and also the dimension and the influence (total score) of them on the output.

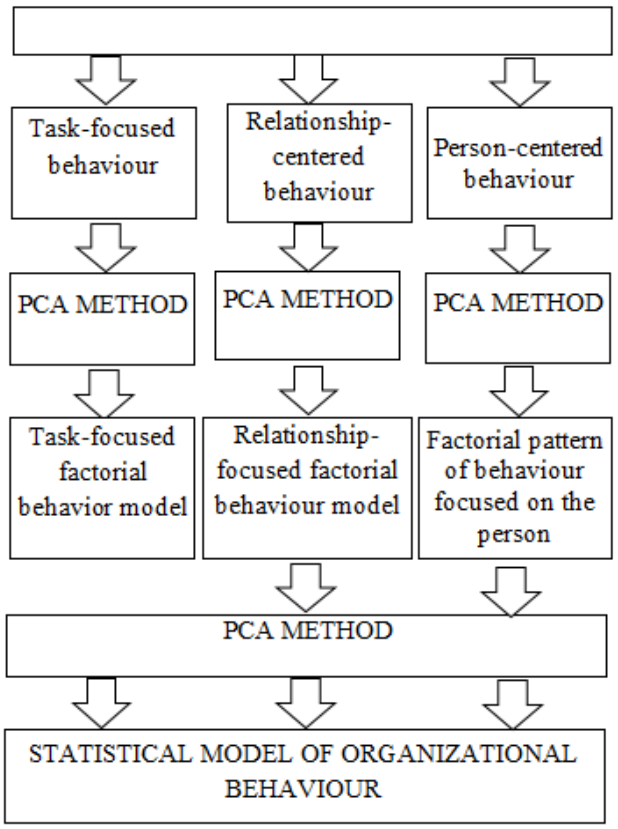


Fig. 1. PCA ranked for modelling behaviour within the group

## 3. EXPERIMENTAL RESULTS

The answers to the questionnaire were introduced in IBM SPSS Statistics version 22.

### 3.1 The internal consistency of the instrument for each of the three dimensions.

For each of three dimensions related to organizational behaviour, the authors identified the items that had been significantly for it in an additive way. The items must reflect a specific behaviour so they must have a common variance, to correlate between them and the individual with the final result of each behavioural dimension. The correlation between items and the total score of each dimension gives information regarding the item relevance for the global result of the questionnaire. The instrument has internal constancy when each item is relevant.

To measure the fidelity and precision of the instrument, the authors identify the value of coefficient (αC) for each dimension and the total coefficient $D_1$=$\sum_1^8 I_i$, $D_2 = \sum_9^{13} I_i$, $D_3 = \sum_{14}^{18} I_i$, $D_{total} = \sum_1^{18} I_i$ (table 1).

Table 1. The consistency of the instrument

| | Dimension D1 | Dimension D2 | Dimension D3 | Dimension Dtotal |
|---|---|---|---|---|
| $\alpha C$ | 0.778 | 0.763 | 0.685 | 0.690 |

The values of coefficient αC for the first two dimensions are over 0.7 so the scale consistency is confirmed. The value of dimension 3 (0.685) is on the consistency limit. The total internal consistency value of the questionnaire is 0.690 – too close to the limit value [10], so the authors continue the study using the statistical analysis method.

**3.2 Mean comparison of the two groups (M/F).**

The authors used statistical T test to see the differences between male and female participants regarding the behaviour [11]. The T test is a decision method used to validate/invalidate a specific safety degree of the inferred statistical hypothesis at the rate of stateless significance $p \leq 0.05$ (statistical link is highly significant, the trust referring the obtained results is 95%).

Table 2 shows that are unsignificant differences regarding the importance of variability of the two types of respondents (items 1, 2, 4, 5, 6, 8) at a significance rate α=0.05 and F_critic (30.24)=1.8887. These values indicate that the important means for six items vary in the same way for the two types of respondents. For these items, the authors used the T test for independent samples with equal variance. For items (3, 7) – the variability of the answers is significantly different for the two groups (M/F) the authors used the T test for independent samples with different variance.

Table 2. T-test for mean equality dimension 1

| Levene's Test for Equality of Variances | | t-test for equality of means | | | | |
|---|---|---|---|---|---|---|
| | | F | Sig. | t | Sig.(2-tailed) | Mean Diff |
| Item1 | Equal variances assumed | 1.180 | .283 | .146 | .884 | .03623 |
| Item2 | Equal variances assumed | .000 | .990 | -.517 | .607 | -.13768 |
| Item3 | Equal variances not assumed | 5.420 | .024 | -.593 | .556 | -.12319 |
| Item4 | Equal variances assumed | .001 | .980 | .320 | .750 | .08261 |
| Item5 | Equal variances assumed | .721 | .400 | .206 | .837 | .05362 |
| Item6 | Equal variances assumed | 1.593 | .213 | -.973 | .335 | -.26667 |
| Item7 | Equal variances not assumed | 3.982 | .051 | .381 | .705 | .09710 |
| Item8 | Equal variances assumed | 1.210 | .277 | -.112 | .911 | -.03333 |

For items 1-8 did not appear significant statistical differences regarding the importance mean of the two types of respondents (the distribution values are between [-1.645;1.645] for a probability p>0.05). Therefore, both groups M/F appreciate at the same level the importance of this behavioural dimension.

Table 3. t-test for mean equality dimension 2

| Levene's Test for Equality of Variances | | t-test for equality of means | | | | |
|---|---|---|---|---|---|---|
| | | | | | | |
| Item9 | Equal variances assumed | .329 | .569 | -.244 | .808 | -.05217 |
| Item10 | Equal variances not assumed | .329 | .569 | 1.386 | .172 | .33478 |
| Item11 | Equal variances not assumed | 2.123 | .151 | .672 | .505 | .17391 |
| Item12 | Equal variances assumed | .202 | .655 | .614 | .542 | .12464 |
| Item13 | Equal variances not assumed | 2.184 | .146 | 1.930 | .060 | .48841 |

The items (10, 11, 13) – specific for dimension 2 (table 3) – are characterized by a different variance of responses between the two groups of respondents, statistically significant difference Fcalc>Fcritic (30.24)=1.8887 for a statistical safety p>0.05. According to items 9, 12 the responses of the two groups do not differ by their variation. For items 9-12 the responses mean for M/F groups do not differ statistically significantly $p \in [-1.645; 1.645]$ and for item 13 the mean values for the 2 groups of respondents differ, and the difference is statistically significant (p=1.930>1.645), group M considering the criterion "I encourage everyone's participation" more important in the relationship-based behaviour (mean = 3.52) than group F (mean = 3.05).

Table 4. t-test for mean equality dimension 3

| Levene's Test for Equality of Variances | | t-test for equality of means | | | | |
|---|---|---|---|---|---|---|
| | | F | Sig. | t | Sig. (2-tailed) | Mean Diff. |
| Item14 | Equal variances assumed | .192 | .663 | .598 | .552 | .24928 |
| Item15 | Equal variances assumed | .149 | .701 | .154 | .878 | .05362 |
| Item16 | Equal variances assumed | .803 | .374 | 1.747 | .087 | .51739 |
| Item17 | Equal variances not assumed | 2.207 | .144 | -.541 | .591 | -.17681 |
| Item18 | Equal variances assumed | .125 | .725 | .211 | .833 | .07826 |

Criterion 16 (table 4) signs a difference in the attitude of involvement of the 2 groups of respondents, in favour of F compared to M (+0.517).

### 3.3 Factorial analysis

Taking into account the multitude of items (variables for the statistical model) initially taken into account in the analysis, the statistical modelling stage has as objectives:

- the classification of the model variables,
- the detection of the relations between the variables,
- the reduction of the number of variables without losing the variance of the initial variables, so that in the end to obtain a factorial relationship that defines the behaviour within the group, [12].

Table 5. Correlation matrix for the 3 dimensions (level 1)

| Correlation Matrix | | Item1 | Item2 | Item3 | Item4 | Item5 | Item6 | Item7 | Item8 |
|---|---|---|---|---|---|---|---|---|---|
| Dimension1 det.=0.07 | Item1 | 1.000 | .619 | .417 | .350 | .502 | .312 | .172 | -.017 |
| | Item2 | .619 | 1.000 | .373 | .346 | .406 | .465 | .356 | .118 |
| | Item3 | .417 | .373 | 1.000 | .257 | .231 | .353 | .144 | .207 |
| | Item4 | .350 | .346 | .257 | 1.000 | .287 | .129 | .154 | .299 |
| | Item5 | .502 | .406 | .231 | .287 | 1.000 | .221 | .276 | .349 |
| | Item6 | .312 | .465 | .353 | .129 | .221 | 1.000 | .678 | .253 |
| | Item7 | .172 | .356 | .144 | .154 | .276 | .678 | 1.000 | .376 |
| | Item8 | -.017 | .118 | .207 | .299 | .349 | .253 | .376 | 1.000 |
| | | Item9 | Item10 | Item11 | Item12 | Item13 | | | |
| Dimension 2 det.=0.29 | Item9 | 1.000 | .495 | .380 | .435 | .405 | | | |
| | Item10 | .495 | 1.000 | .547 | .283 | .290 | | | |
| | Item11 | .380 | .547 | 1.000 | .378 | .383 | | | |
| | Item12 | .435 | .283 | .378 | 1.000 | .393 | | | |
| | Item13 | .405 | .290 | .383 | .393 | 1.000 | | | |
| | | Item14 | Item15 | Item16 | Item17 | Item18 | | | |
| Dimension 3 det.=0.316 | Item14 | 1.000 | .414 | .479 | .117 | .343 | | | |
| | Item15 | .414 | 1.000 | .216 | .112 | .253 | | | |
| | Item16 | .479 | .216 | 1.000 | .090 | .397 | | | |
| | Item17 | .117 | .112 | .090 | 1.000 | .594 | | | |
| | Item18 | .343 | .253 | .397 | .594 | 1.000 | | | |

Table 5 shows the correlation matrix between the 8 variables with values between – 0.017 and 0.678, values that signify that there are statistically significant correlations (grey boxes) between the items. The determinant has a value of 0.07 > 0.00001 (nonsingular matrix) different from the unit matrix.

Table 6. The factorial modelling on the 3 dimensions

| KMO and Bartlett's Test | | D1 | D2 | D3 |
|---|---|---|---|---|
| Kaiser-Meyer-Olkin Measure of Sampling Adequacy. | | .690 | .750 | .602 |
| Bartlett's Test of Sphericity | Approx. Chi-Square | 128.422 | 61.274 | 56.951 |
| | Df | 28 | 10 | 10 |

In Table 6 are the values of the K.M.O. [13] tests for all 3 dimensions 0,690; 0.750;0.602, all larger than 0.5, values that validate the matching of the sample of items grouped on the 3 dimensions, on the factorial model, and Bartlett's Test of Sphericity [14] is significant for all dimensions (Sig.<0.05) which confirms that the correlation matrices (all correlations between variables taken as a group) are significantly different from the unit matrix.

Table 7. Generating the main components (3 out of 8) and explaining their variance

| Dim | Comp | Extraction Sums of Squared Loadings | | | Rotation Sums of Squared Loadings | | |
|---|---|---|---|---|---|---|---|
| | | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % |
| D1 | D1_1 | 3.208 | 40.103 | 40.103 | 2.312 | 28.899 | 28.899 |
| | D1_2 | 1.307 | 16.333 | 56.436 | 1.793 | 22.409 | 51.309 |
| | D1_3 | 1.067 | 13.335 | 69.770 | 1.477 | 18.462 | **69.770** |
| D2 | D2_1 | 2.601 | 52.015 | 52.015 | 1.759 | 35.189 | 35.189 |
| | D2_2 | .812 | 16.249 | 68.264 | 1.654 | 33.074 | **68.264** |
| D3 | D3_1 | 2.240 | 44.791 | 44.791 | 1.831 | 36.622 | 36.622 |
| | D3_2 | 1.171 | 23.416 | 68.207 | 1.579 | 31.585 | **68.207** |

Table 7 presents the main components (3 out of 8) and explains their variance.
Table 8 are presented the matrices of the coefficients of the main components on each of the 3 dimensions, which express in a proportion of approximately 70% the variance of the input variables for each dimension.

Table 8. Matrix of the coefficients of the main components

| | Dimension D1 | | | | Dimension D2 | | | Dimension D3 | |
|---|---|---|---|---|---|---|---|---|---|
| | D1_1 | D1_2 | D1_3 | | D2_1 | D2_2 | | D3_1 | D3_2 |
| Item1 | .462 | -.122 | -.125 | Item9 | .193 | .221 | Item14 | .487 | -.097 |
| Item2 | .344 | .084 | -.131 | Item10 | .665 | -.294 | Item15 | .393 | -.088 |
| Item3 | .253 | -.002 | -.002 | Item11 | .475 | -.081 | Item16 | .408 | -.033 |
| Item4 | .135 | -.251 | .462 | Item12 | -.207 | .601 | Item17 | -.202 | .654 |
| Item5 | .159 | -.103 | .325 | Item13 | -.186 | .574 | Item18 | .057 | .502 |
| Item6 | .031 | .526 | -.194 | | | | | | |
| Item7 | -.128 | .536 | .012 | | | | | | |
| Item8 | -.272 | .110 | .651 | | | | | | |

The 2nd (output) level of application of the PCA method is applied to further reduce the tilers resulting from the first level (the input level). Thus, the correlation between the main factors from the different dimensions of the general model is reduced.
Table 9 linearly shows the independence of the factors belonging to the same dimensions, there being a weak correlation between the components in different dimensions Correlation (D2_2, D1_2) = 0.457. Kaiser test confirms the poor correlation between the resulting main components on the first reduction level (0.346) (Table 10).

Table 9. Correlation matrix between the main components on the first entry-level.

| | D1_1 | D1_2 | D1_3 | D2_1 | D2_2 | D3_1 | D3_2 |
|---|---|---|---|---|---|---|---|
| D1_1 | 1.000 | .000 | .000 | .155 | .179 | -.366 | .330 |
| D1_2 | .000 | 1.000 | .000 | .405 | .457 | -.243 | .078 |
| D1_3 | .000 | .000 | 1.000 | -.052 | .295 | .181 | -.194 |
| D2_1 | .155 | .405 | -.052 | 1.000 | .000 | -.084 | -.123 |
| D2_2 | .179 | .457 | .295 | .000 | 1.000 | -.218 | -.118 |
| D3_1 | -.366 | -.243 | .181 | -.084 | -.218 | 1.000 | .000 |
| D3_2 | .330 | .078 | -.194 | -.123 | -.118 | .000 | 1.000 |

Table 10. Tests for the application of the factor model on level 2

| KMO and Bartlett's Test | | |
|---|---|---|
| Kaiser-Meyer-Olkin Measure of Sampling Adequacy. | | .346 |
| Bartlett's Test of Sphericity | Approx. Chi-Square | 60.848 |
| | Df | 15 |

Table 11 explains the hierarchy level 2 of the mathematical model. Thus, the 7 components resulting from level 1 are reduced to 4 output components that retain up to 77.992% of the variance of the output of the first level. Note that each output component on level 2 is made up of items of different sizes: DO_1=f1(D1_2, D2_1), DO_2=f2(D1_3, D2_2), DO_3=f3(D3_1), DO_4=f4(D1_1, D3_2). This is statistically argued by the fact that the main components resulting in the first level of the hierarchy are linearly independent of each other on each dimension (they are unrelated), the only possible correlation being between components in different sizes. Table 12 contains the weighting coefficients of the output components from the first level that form the mathematical models for the main components on the 2nd level, the output level.

Table 11. Retention of main components on level 2 reduction - total Variance Explained

| Comp | Initial Eigenvalues | | | Extraction Sums of Squared Loadings | | | Rotation Sums of Squared Loadings | | |
|---|---|---|---|---|---|---|---|---|---|
| | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % |
| DO_1 | 1.874 | 26.768 | 26.768 | 1.874 | 26.768 | 26.768 | 1.453 | 20.757 | 20.757 |
| DO_2 | 1.487 | 21.248 | 48.015 | 1.487 | 21.248 | 48.015 | 1.391 | 19.874 | 40.631 |
| DO_3 | 1.175 | 16.779 | 64.795 | 1.175 | 16.779 | 64.795 | 1.363 | 19.469 | 60.100 |
| DO_4 | .924 | 13.197 | 77.992 | .924 | 13.197 | 77.992 | 1.252 | 17.892 | 77.992 |

Table 12. Matrix of the coefficients of the main components on the reduction level 2

| | DO_1 | DO_2 | DO_3 | DO_4 |
|---|---|---|---|---|
| D1_1 | -.094 | .102 | -.336 | .422 |
| D1_2 | .566 | .133 | .064 | .080 |
| D1_3 | -.110 | .622 | .226 | .038 |
| D2_1 | .621 | -.185 | .118 | -.045 |
| D2_2 | .056 | .530 | -.190 | -.010 |
| D3_1 | .082 | .106 | .742 | .184 |
| D3_2 | .047 | -.026 | .218 | .788 |

The 4 output components of the model DO_1...DO_4 enter with the same proportion in the relationship that defines the behaviour within the group for the sample of respondents (figure 2.).

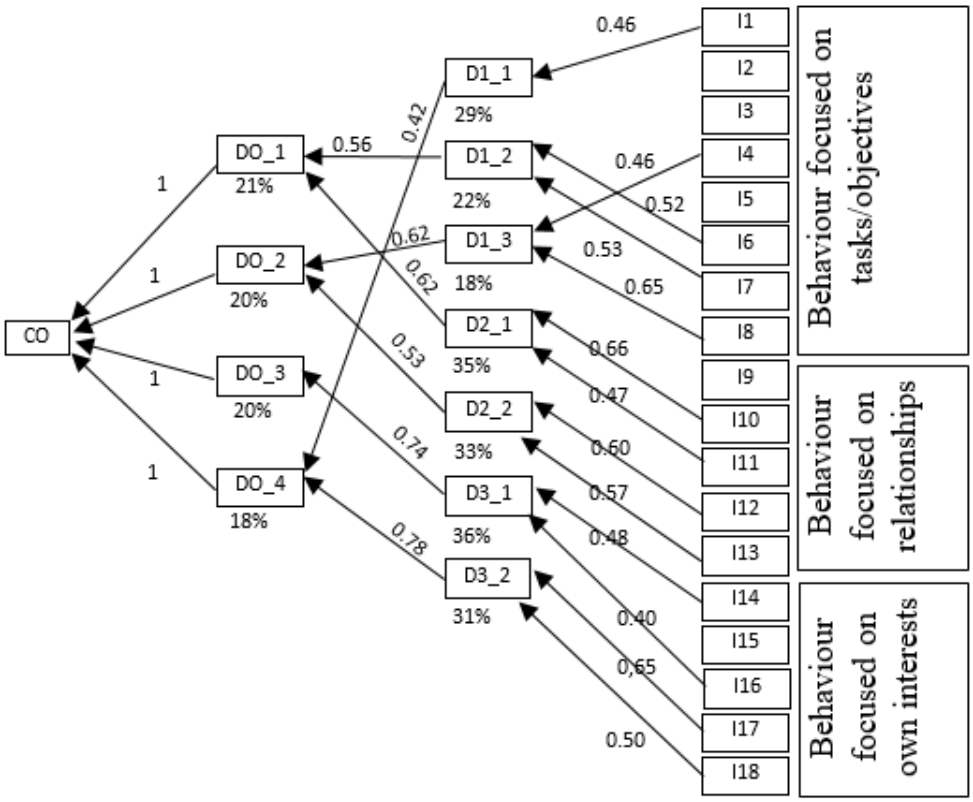


Fig. 2. PCA method - group behaviour for the sample of respondents

Thus, applying the reverse technique method we obtain percentage values are the amount of information taken from one level to another. The sum of the percentage values on each level is around 70%. Decimal values are the weight with which the variable enters the formula of factorial values.

## 4. CONCLUSIONS

Organizational behaviour relies on concepts, principles, rules and instruments that can explain, predict and control human behaviour at individual and group levels. Individual behaviour contains personal values, personality, attitudes, perceptions, competencies, motivation. But at the group level, each person may have the role of group creator and he/she may be influenced to change the individual behaviour and become modelled by the group pattern.

The conclusions of the research reveal that:

- the model may be applied using the PCA method to develop a comparative study for formal group behaviour;
- M/F groups do not register significant differences regarding aspects relative to the three dimensions (behaviour focused on tasks/objectives, behaviour concentrated on relationships and behaviour focused on own interests), excepting the items: "I encourage the participation of all persons" and "I avoid to be involved" – both things in favour of M instead of F;
- ordering the three dimensions using the mathematical point of view of the behaviours: behaviour focused on own interests, behaviour focused on relationships and behaviour focused on tasks/objectives;
- the identification regarding aspects that are missing from the organizational behaviour model, most of them part of the first dimension.

## 5. LIMITS AND FUTURE RESEARCH

The limits of the study would be the influence of certain factors: the dispositional state of the subject at the time of examination, his state of health or the degree of understanding of the items. Also, the relatively low volume of the sample of respondents, which must be linked to the fact that the baggage of factors may not be the most relevant concerning everyone's expectations, the sampling method used in the extraction of the group of respondents, in the sense that it does not ensure statistically significant representativeness for all categories of respondents, the lack of another perspective on the behaviour model within the group for respondents from other geographical, cultural and economic areas of Romania, as well as the threshold of choice of the independent variables that are part of the factorial model of the behaviour within the group is chosen subjectively and must be customized for each statistical study separately.

For future research, a suggestion would be to expand the sample of subjects to several age categories, possibly those who have experienced specific individual/collective trauma.

## 6. REFERENCES


1. Organ, D.W., Bateman, Th.S., (1986). *Organizational Behavior: An Applied Psychological Approach*, Business Publications, Inc.
2. Johns, G., (1998). *Comportament organizational*, Economica Publishing House, Bucharest.
3. McShane, S.L., von Glinow, M.A., (2000). *Organizational Behavior*. McGraw-Hill, Boston.
4. Zlate, M., (2004). *Tratat de psihologie organizational-manageriala*, Vol.I, pp. 133-134, Polirom Publishing House, Iasi.
5. Johns, G., (1998). *Comportament organizational*. pp.210, Economica Publishing House, Bucharest.
6. Hellriegel, D., Slocum, Jr., John W., (2009). *Organizational Behaviour*, pp. 4, Cengage Learning.
7. Johns, G., (2006). *The Essential Impact of Context on Organizational Behavior*, Academy of Management Review, 31(2).
8. Taber, K.S., (2018). *The Use of Cronbach's Alpha When Developing and Reporting Research Instruments in Science Education*, Research in Science Education 48, 1273–1296.
9. Groth, D., Hartmann, S., Klie, S., Selbig, J., (2012). *Principal Components Analysis*, *Computational Toxicology*, 527-547
10. Gliem, J.A., Gliem, R.R., (2003). *Calculating, Interpreting, and Reporting Cronbach's Alpha Reliability Coefficient for Likert-Type Scales*, Midwest Research to Practice Conference in Adult, Continuing, and Community Education, 82-88, https://scholarworks.iupui.edu/bitstream/handle/1805/344/Gliem%20%26%20Gliem.pdf?sequence=1&isAllowed=y, accessed: 3.02.2022.
11. Abraham, J., Barker, K., (2014). *Exploring gender difference in motivation, engagement and enrolment behaviour of senior secondary physics students in new South Wales*, Research in Science Education, 45(1), 59–73.
12. Lakens, D., Caldwell, A.R., (2021). *Simulation-Based Power Analysis for Factorial Analysis of Variance Designs*, Advances in Methods and Practices in Psychological Science, 4(1), pp. 1–14
13. Hadia, N.U., Abdullah, N., Sentosaa, I. (2016). *An Easy Approach to Exploratory Factor Analysis: Marketing Perspective*, Journal of Educational and Social Research, 6(1), 215-223.
14. Silva, D.L., Sabino, L.D., Lanuza, D.M., Adina, E.M., Villaverde, B.S., Pena, E.G., (2014). *Silva's Management Competency Theory: A Factor-Item Analytic Approach Utilizing Oblique Rotation Direct Oblimin Method under Kaiser-Bartlett's Test of Sphericity*, Proceedings of the World Congress on Engineering and Computer Science 2014 Vol I WCECS 2014, 22-24 October 2014, San Francisco, USA, http://www.iaeng.org/publication/WCECS2014/WCECS2014_pp300-305.pdf, accessed: 15.01.2022.


Received: June 29, 2022 / Accepted: December 15, 2022 / Paper available online: December 20, 2022 © International Journal of Modern Manufacturing Technologies