**Ewa OKOŃ-HORODYŃSKA, Professor**
**Faculty of Management and Social Communication, Jagiellonian University**
**e-mail:** ewa.okon-horodynska@uj.edu.pl
**ORCID**: 0000-0002-2548-254X

**Anna ZACHOROWSKA-MAZURKIEWICZ, PhD, Professor of Jagiellonian University**
**Faculty of Management and Social Communication, Jagiellonian University**
**e-mail**: anna.zachorowska@uj.edu.pl
**ORCID:** 0000-0003-4313-5207

**Rafał WISŁA, PhD, Professor of Jagiellonian University**
**Faculty of Management and Social Communication, Jagiellonian University**
**e-mail:** rafal.wisla@uj.edu.pl
**ORCID**: 0000-0002-7895-6243

**Tomasz SIEROTOWICZ, PhD**
**Faculty of Management and Social Communication, Jagiellonian University**
**e-mail:** tsierotowicz@uj.edu.pl
**ORCID:** 0000-0002-1462-8267

**DOI:** 10.15290/oes.2020.02.100.02

# EFFECTIVE MANAGEMENT OF HUMAN RESOURCES IN INNOVATION PROCESS – GENDER-RELATED ISSUE[1]

**Summary**

*Purpose* – Most of the subject literature provides information on the skills and competencies required to join teams and work in the innovation process. So far, there has been a research gap concerning the issue in question. The results of researching the issue can, however, be used to ensure more effective innovation development through a better-than-ever selection of individuals for each phase of the innovation process. The subject of research was to examine, identify and describe differences in the participation of men and women in the innovation process, taking into account not only competencies but also personal characteristics, attitudes and behaviour.

*Research method* – The research covered 1,164 innovative companies – beneficiaries of the European Union Cohesion Policy 2007-2013. The conceptual framework of the model described by the pre-25 variables has been verified. Applying the selected statistically significant variables and components ensures more accuracy for the model developed in the present study. Both the conceptual research context and preliminary analysis fulfil the assumptions for using principal component analysis and the Promax rotation method.

*Results* – The results prompt a new way of creating more effective teams in the process of innovation, with managers considering not only competencies but also attitudes, behaviours and gender-related issues.

[1] Article received on 01 June 2019, accepted on 25 March 2020.

*Originality /value* – The obtained results can be used to ensure more effective innovation development through a better-than-ever selection of individuals in each phase of the innovation process.

**Keywords**: gender diversity, effective human resources management, project innovation management, process of innovation

**JEL Classification**: O15, O31, O35, D91

## 1. Introduction

Innovation is perceived as equivalent to something new or modified [*Oslo Manual*…, 2018]. The processes of innovation and scientific research are not gender-neutral activities, and even if science, through its search for objectivity, tends to dismiss the gender dimension, it is deeply embedded in the way scientific research is conducted and in the development of new technologies, influencing the entire innovation process [Abels, 2012]. Thus, learning about the gender dimension in the innovation process should be considered important. Integrating gender into research requires a deep transformation in research design as well as in the paradigms and concepts underlying the research design. This may be the reason why research on gender and innovation has so far not been extensive.

In this Innovative Gender research project, we explore the unique features of women and men that influence the innovation process. Within the project, we conducted studies focused on innovativeness and creativity from the gender perspective, looking at the relationships between gender, research and innovation. In this paper, we present the outcome of the survey conducted in the enterprises that are beneficiaries of the EU Innovative Economy Programme in Poland. In the survey, we studied the importance of factors grouped in five areas of the innovation process: work environments; personal qualities; abilities, skills and competencies; attitudes and values; and roles and behaviours. The objective of the paper is to show that the process of innovation is not gender-neutral and that different characteristics, behaviours, skills and roles determine innovative activity by men and women. The results obtained from the conducted studies indicate that decisions made on professionals' involvement in different phases of the innovation process should take the aspect of gender into account. In this way, conditions for achieving more efficient and effective goals in the innovation process are created.

## 2. Literature review

Since this research project focuses on gender and the innovation process, it is worth starting with the definitions of the main concepts. Innovations are defined in the classic definition by Schumpeter [1934] as new combinations of production factors, such as the production of new goods, introduction of new processes, opening of new markets, access to new sources of raw materials and intermediates

and re-organisation of an industry. Therefore, the range of an innovation may include products, services, processes, positions, strategies, governance or rhetorical propositions and whether they are revolutionary, radical, emergent or incremental [Fogelberg, 2014].

As Amabile et al. [1996] stated, all innovations begin with creative ideas, and the successful implementation of new programmes, product introductions or services depends on a good idea. In the authors' opinion [Amabile et al., 1996], creativity is the production of novel and useful ideas in any domain, and innovation is the successful implementation of creative ideas within an organisation. Nevertheless, innovation cannot be reduced to considerations around creativity only, since new ideas are merely the first step on the road to creating a successful innovation [Foss, 2013; Cirera, Muzi, 2020].

Innovation is gaining increasing attention among researchers. However, cross-disciplinary aspects and an increasing number of publications on innovation make it a difficult research field to survey [Fogelberg, 2014]. In the research here, we focused on one aspect of innovation – the influence of diversity. Studies suggest that there is a positive relationship between diversity in a firm's knowledge base and their innovative capacities. Employee diversity creates a broader search space and makes the firm more creative and open to new ideas. Diversity expands the firm's knowledge base through an increase in the interactions between different types of competencies and knowledge. Thus, employee diversity has a positive effect on innovation [Østergaard et al., 2011]. The aspect of diversity that we are interested in is gender diversity.

Several studies and reports have stressed the acute problem of women being underrepresented in science in the business sector [Hunt et al., 2013]. The results of international empirical comparative studies indicate that, in general, there is a clear statistical pattern that women are less involved in the creation of scientific and industrial knowledge than men [Whittington et al., 2005; Freitsch et al., 2009; Sierotowicz, 2015].

These studies concentrate mainly on the representation of women and men in patent activity; innovation literature has been criticised for not taking gender into account [Foss et al., 2013, p. 299].

Gender has not been a frequent focus of innovation-based research [Alsos et al., 2013]. The concept of gender and innovation has only recently gained a wider interest among researchers. One of the reasons for this lack of gender studies is the apparent invisibility of people in innovation [Alsos et al., 2013]; when people are not visible in the discourse, gender easily becomes invisible. Thus, it is challenging to reveal the impact of gender on innovation when it remains hidden within processes, organisations and systems.

Alsos et al. [2013] conducted studies in which they searched for articles devoted to innovation and gender in scientific journals from the Scopus database. They found 106,994 articles that included the word 'innovation' in the title, in the abstract or as a keyword, but when they combined the word 'innovation' with the word 'gender', the number of articles matching the criteria decreased to 615, with no

journal containing more than four articles with such a focus. The number of articles combining the words 'innovation' and 'women' was 1,306. This is, however, not the whole picture, since a high proportion of these articles focusing on gender and innovation were found within medicine, nursing, psychology or technology/engineering. The authors continued with an examination of the literature on economics. They discovered that, within economics, the most prominent studies were those based on science and innovation areas, using quantitative methods, including surveys and/or register data.

The European Commission [*Regular Reports from*…, 2001] noticed that the perception of technology and science is gender-blind. Innovation and creativity are also considered as such. Nevertheless, relationships between women and men can affect seemingly gender-neutral contexts [Fogelberg, 2014]. Ranga and Etzkowitz [2010] took this argument further, claiming that innovation is not gender-blind, but inherently gender-biased because of an implicit, socially constructed assumption that women are less innovative than men as a function of traditional gender relations, rooted in the social perception of technology being associated more with men than women.

Foss et al. [2013] cited Acker [2006], who claimed that innovation processes are gendered. They also assumed that the process of innovation is gendered in that masculine ideas are implemented to a greater degree than feminine ones. Following the argument that the likelihood of introducing innovation is greater in organisations in which a minority group has a critical mass to contribute to the innovation process [Østergaard, 2011], in a male-dominated organisation, gender has a moderating effect on the relationship between idea generation and implementation because female employees will face more hurdles [Foss et al., 2013]. Research shows that creative performance requires both masculine and feminine components [Foss et al., 2013]. Østergaard's [2011] study shows a strong positive and significant relationship between gender diversity and innovation. The results of that study show that very low or very high levels of diversity are not significantly different from each other; nevertheless, a moderate degree of diversity (where a minority group has a critical mass to contribute to the innovation process) appears to have a higher likelihood of introducing an innovation.

Alsos et al. [2013] noticed that the combination of adopting the gender perspective as a variable in innovation is probably the dominant approach in empirical research on gender and innovation. This perspective is reflected in studies of innovation in male- and female-owned businesses as well as in the literature on gender differences in patenting and commercialisation in the university context. Foss et al. [2013] used gender as a variable in the innovation process perspective. They showed that women are equally innovative in generating new ideas as men, but their ideas are less frequently implemented in organisations. The gender dimension of innovation is usually considered to be a peripheral element of the process, which narrowly focuses on issues like inclusion/exclusion of women in research and development or innovation. Women's roles in innovation are often not seen as a part of the process, even when they are a key link in the chain [Ranga, Etzkowitz,

2010]. Cooper [2012] explains that women are not perceived as innovators. Consequently, their ideas are not heard or are deemed inferior to men's ideas and, therefore, never proceed to the implementation phase. Alsos et al. [2013] concluded that it is not that women lack innovation capability but that organisational practices condition or inhibit women's innovative behaviour.

Amabile et al. [1996] assumed that social environment can influence both the level and frequency of creative behaviour. Foss et al. [2013] stressed the fact that an organisation's structure and work environment are conducive to the innovation process. Colleagues' mutual consideration of ideas and support for innovation have been demonstrated to positively affect innovative behaviour [Foss et al., 2013]. Work pressure also influences creativity. This influence could be either positive or negative, depending on the degree of work pressure. Extreme workload pressure undermines creativity, while a certain degree of pressure has a positive effect [Amabile et al., 1996]. Research by Larry Foss showed that work pressure has a positive influence on the generation of new ideas [Foss et al., 2013; Buljubasic, 2020].

Dyląg and Szafrański [2015] focused their research on personal qualities and values disaggregated by gender. They concluded that women and men share some values, such as self-respect, health and honesty, but there are also differences between them. Women value meaning in life, while men point towards inner harmony. Interestingly, men indicate values that are considered to be least important by women, namely social power, authority and sacrifice. Concerning innovativeness, there were no statistically significant differences between men and women not only in creativity but also in values like curiosity and openness to change. Other research concerned abilities, skills and competencies and reported that in the European Union women account for 40% of all scientists in higher education and 46% of all PhD graduates [du Vall, Majorek, 2015]. Kopycińska [2015] and Zachorowska-Mazurkiewicz [2016] wrote about labour market segmentation, in which women concentrate in areas such as education and health care, and men concentrate in the construction sector. All the areas researched have a potential impact on innovative activities by women and men.

The different roles and positions of women in society could determine innovative activity by women [Carrasco, 2014; Joshi et al., 2020]. As mentioned above, attitudes and values also play an important role in innovative activities. Female managers display a collaborative and cooperative approach in leading organisations, and female business owners have a stronger preference for collaborative network orientations than their male counterparts [Foss et al., 2013]. It also appears that competition is often associated with the male-gendered element of the innovation process, while women are perceived more as consensus builders [Ranga, Etzkowitz, 2010]. Since innovation is related to entrepreneurship, reconciliation of work and family life can also be expected to be an obstacle to innovative activities by women [Carrasco, 2014]. Thus, it could be assumed that the more institutions help to reconcile family and working lives, the more innovations women will carry out. Also, many women in science-related careers leave before reaching their hypothetical glass ceiling for reasons such as job structure and flexibility, and the proportion of

women and men in the workplace. Thus, the more egalitarian the working environment is, the more innovation women produce [Carrasco, 2014].

## 3. Method

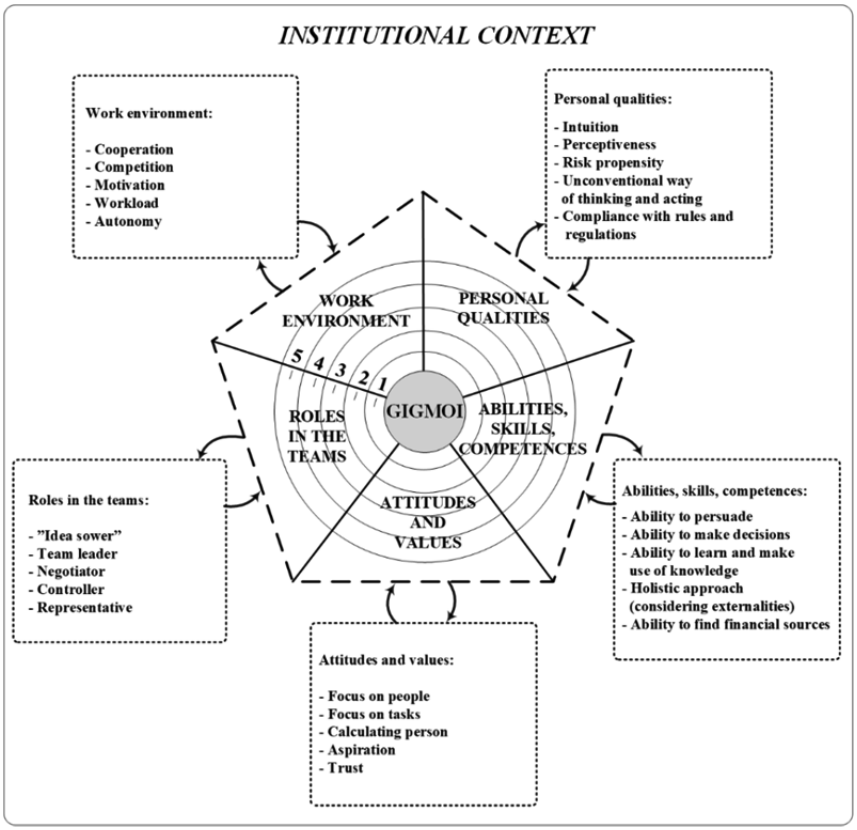
The literature review has inspired investigation concerned with gender and innovation. In order to investigate the significance of gender in the process of innovation, the basic idea of the innovative genome concept [DeGraff, Quinn, 2007; Cameron et al., 2014] was rethought.

### 3.1. Conceptual framework and assumptions

In order to research gender relations in the process of innovation, the original model had to be transformed (chart 1), thanks to which a new formula and research capabilities were obtained, leading to original results.

**CHART 1**

**GIGMOI – Genomic integrated gender model of open innovation**




Source: own elaboration.

The basic concepts consist of only four areas with opposite characteristics of participants in the innovation process, without gender recognition and not being open enough to external environment. Therefore, the concepts cannot be used to conduct research in gender-related area. The new formula of innovation genome comprises five basic stages of the process of innovation: (1) generating ideas, (2) idea accumulation and protection, (3) choice of the best ideas to be implemented, (4) development, (5) innovation (circles from 1 to 5) with five socio-psychological areas superimposed on it: (1) work environment, (2) personal qualities, (3) abilities, skills and competences, (4) attitudes and values, (5) roles and behaviours, all used for men and women separately in the open innovation environment. Splitting it into five stages allows to add significantly more characteristics important in the innovation process. After introducing the changes, it is possible to extrapolate from this model and connect two main economic categories which form the subject of the studies undertaken. Namely, the process of innovation based on creativity and its determinants, and gender from the perspective of the diverse and complex relationship between men and women and the importance of their participation in the process of innovation. Previously obtained results [Ranga, Etzkowitz, 2010; *Statistical profiles of women's*…, 2015] indicate that work environment (atmosphere, relationships, attitudes, incentives and rewards), personal qualities, roles, abilities and skills are the most powerful determinants of the efficiency and effectiveness of the innovation process; 50.06% women and 57.20% of men indicated these conditions.

Institutional solutions promoting innovative activities are much less important. For this reason, it is necessary to investigate the internal environment of the process of innovation. Therefore, the following assumptions were adopted: the process of innovation is not gender-neutral (H1), profiles of men and women in the process of innovation can be described using specific characteristics, behaviours, skills, and roles (H2), specific characteristics, behaviours, skills, and roles are different for men and women.

### 3.2. Data

The research covered 1,164 Polish innovative companies – beneficiaries of the European Union Cohesion Policy 2007-2013. The survey was conducted between 15 October and 15 December 2015. The respondents were men and women employed in these enterprises and involved in different ways in the process of innovation. They played a wide spectrum of roles in the process of innovation, from being team members to holding managerial positions. The questionnaire was distributed independently to women and men. As a result, two independent samples of data were created.

In addition to questions regarding gender, age and education, each questionnaire contained questions related to all 25 variables in the process of innovation (annex). Each variable represents one quality, attitude or behaviour characterised by a single person (both women and men) involved in the process of innovation. Each question was presented as a five-point option – from strongly disagree to strongly agree

to the variable's (quality, attitude or behaviour) importance in each stage of the innovation process (i.e. Likert scale, scoring 1 to 5). In each case, the scores summarised the answers in all five stages of the innovation process. Five hundred sixty two cases have been collected in two independent groups of women (N=283) and men (N=279), which form two independent data samples. In the group of women, age ranging from 18 to 64 (M=33, SD=7.7) – 86% of women participants had a university degree. In the group of men, age ranging from 18 to 65 (M=36, SD=9) – 87% of men participants had a university degree. The initial analysis of samples allows the conclusion to be drawn that the samples are appropriate for use with an exploratory analysis method [Cattell, 1978; MacCallum et al., 1999; Henson, Roberts, 2006; Hair et al., 2014].

### 3.3. Method

The conceptual framework of the model (chart 1) described by the pre-25 variables has been verified. Achieving the specified research objectives has been made possible by explaining, in a statistically significant way, the variance of each variable (not only shared variance) and the emergence of a set of groups of variables, which are carriers of information and the best explanation of the model constructed, where a loading value for each variable in the group explained the level of participation of women and men in the innovation process.

Thus, the underlying research question would then be: What is the set of variables, their loading values and component structure which provide the best statistically significant explanation of the model built?

### 3.4. Preliminary analysis

In order to verify the model, SPSS 23 and Amos 23 have been used. A Shapiro-Wilk's test ($p>.05$) [Shapiro, Wilk, 1965; Razali, Wah, 2011] and a visual inspection of their histograms, normal Q-Q plots and box plots showed that among all of the 25 variables covered by the test, none of them – for either women or men – was approximately normally distributed. The calculation results closest to normal distribution were identified in the women sample for the variable named "Negotiator", where for the Shapiro-Wilk's test significance value = 0.019, with a skewness of -0.207 (SE=0.145) and a kurtosis of 0.166 (SE=0.289) [Cramer, 1998; Cramer, Howitt, 2004; Doane, Seward, 2011]. Concluding the preliminary considerations, the data samples are not normally distributed, but suitable for one of the exploratory analysis methods to be used.

Eighteen out of the twenty-five initial variables for the women sample fulfil the best values of the parameters included in the PCA procedure. The visual inspection of variable correlation matrix reveals numerous correlations above 0.3 and there is no variable with all correlations below 0.3; the Determinant ($a=0.001$) fulfils no multicollinearity condition ($a>0.00001$) [Field, 2012]. The Kaiser-Meyer-Olkin Test

(KMO=0.919) allows the sample adequacy condition to be accepted (KMO>0.6) [Kaiser, 1970; Kaiser, Rice, 1974; Hair et al., 2014], with anti-image correlation matrix diagonal values (MSA>0.7) [Dziuban, Shrinkey, 1974]. The Bartlett's Test of Sphericity p-value (Sig =0.000) fulfils the significance condition ($p<0.05$) [Bartlett, 1950] and validates the PCA procedure for the women sample. The Kaiser' criteria [Kaiser, 1960] (Eigenvalue>1), the Scree plot test [Cattell, 1966] and the Monte Carlo Parallel Analysis ($p<0.05$ for a thousand permutations) of the data set for non-normally-distributed samples [O'Connor, 2000] reveal three components at the 54.28% of the total variance explained, which is an acceptable result in the humanities [Pett et al., 2003; Hair, 2014]. Since the research is devoted to the human activity of women, which signifies a coherent unity, the reasonable assumption is that the components can be correlated. Hence, in order to select the most appropriate rotation, both uncorrelated and correlated components were verified. Despite this assumption, using the Promax rotation with Kaiser normalization, which assume the correlation of components [Kline, 1994; Norman, Streiner, 2003; Steiner et al., 2015; Dien et al., 2005], allows the best results to be obtained. It also represents the model matrix of female participation in the process of innovation.

Seventeen out of the twenty-five initial variables of the male samples fulfil the values of the parameters included in the PCA procedure. A KMO=0.896 shows the sample adequacy condition. The Bartlett's Test of Sphericity p-value (Sig=0.000) fulfils the significance condition and validates the PCA procedure for the male sample. The Kaiser' criteria (Eigenvalue>1), the Scree plot test and the Monte Carlo Parallel Analysis ($p<0.05$ for a thousand permutations) of the data set for non-normally-distributed samples reveal four components at the 56.08% of the total variance explained.

Applying the selected statistically significant variables and components ensures more accuracy for the model developed in the present study. Both conceptual research context and preliminary analysis fulfil the assumptions for using Principal Component Analysis (PCA) [Costello, Osborne, 2005; Zinbarg et al., 2006; Larsen, Warne, 2010; Field, 2012]. The results of PCA usage are presented in subchapter 4.

## 4. Results – women and men participation models in innovation process

As a result of the PCA procedure described in the previous subchapter, two models were obtained (charts 2 and 3). The models take into account the variables after verification. The variables are grouped into three components (for women) and four (for men). In each of the components the values of the loadings indicate a statistically significant level of explanation of variance of each of the variables describing the roles, attitudes, and competencies of women as well as men involved in the innovation process in the companies investigated.

In the model for women, seven variables were considered statistically insignificant. These are: Competition, Workload, Autonomy, Perceptiveness, Compliance with rules and regulations, Ability to persuade and Representative. In turn, in the

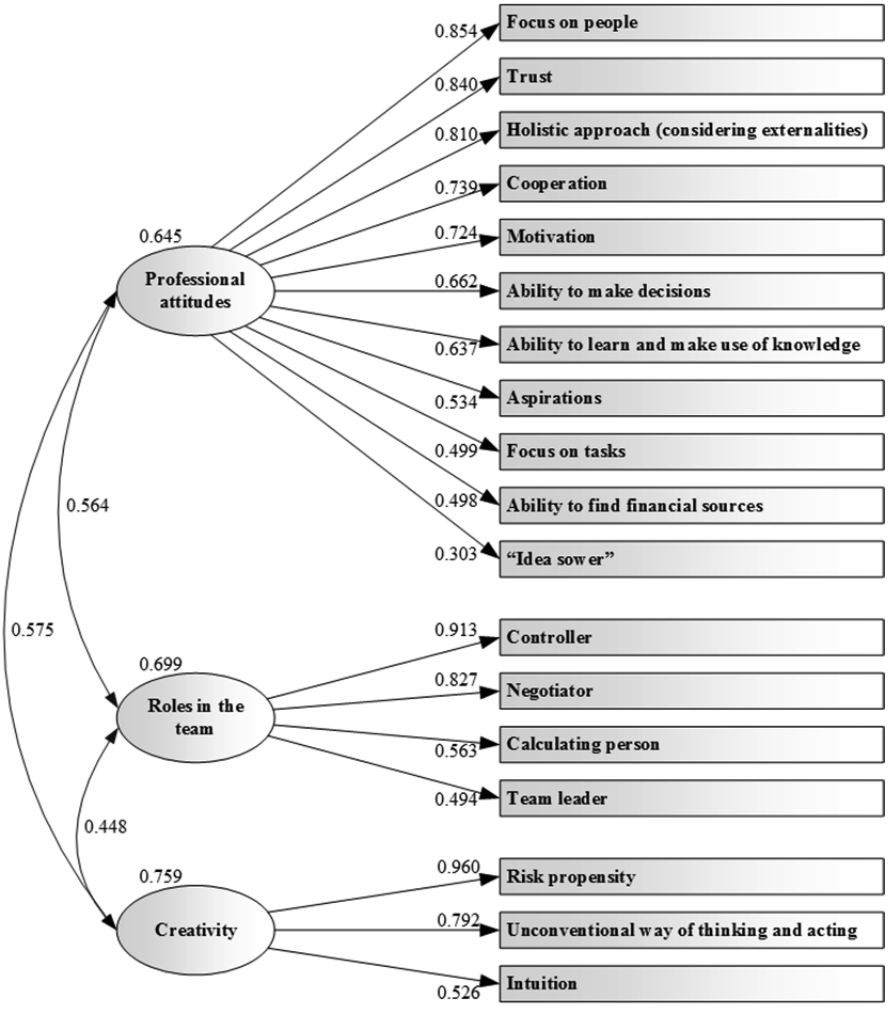
model for men, eight variables were considered insignificant. These are: Cooperation, Competition, Workload, Perceptiveness, Risk propensity, Compliance with rules and regulations, Calculating person and Representative.

Chart 2 (model 1) presents values of each variable loading in a dedicated component.

The component loadings value signifies the total variance explained for each variable included in the dedicated component (range 0-1). Components represent groups of variables which are qualities, attitudes and behaviours of women in the innovation process.

**CHART 2**

**Women's participation model in the innovation process**




Source: author's work, with Amos use.

Based on the variables included in the components and their average loadings, the components are: Professional attitudes, 0.645; Roles in the team, 0.699 and Creativity, 0.759. The average component loadings allow the variation explanation in the original data to be preserved while reflecting the scale of the item [Comrey, Lee, 1992; Tabeachinck, Fidell, 2001; DiStefano et al., 2009]. The Professional attitudes component contains eleven variables with a variance explanation ranked 0.303-0.854. The Roles in the team component contains four variables with a variance explanation ranked 0.494-0.913. The Creativity component contains three variables with a loading accounted 0.526-0.960.

Table 1 represents the component correlation matrix of women's participation in the innovation process.

**TABLE 1**

**Component correlation matrix of women's participation in the innovation process of companies**

| Component | Professional attitudes | Roles in the team | Creativity |
|---|---|---|---|
| Professional attitudes | 1.000 | - | - |
| Roles in the team | 0.564 | 1.000 | - |
| Creativity | 0.575 | 0.448 | 1.000 |
| Extraction Method: Principal Component Analysis. | | | |
| Rotation Method: Promax with Kaiser Normalization. | | | |

Source: author's work, with SPSS use.

The reliability statistics were validated by the Cronbach Alpha Test (*a>0.7*) [Cronbach, 1951, 1970; Cortina, 1993; Kline 2000; George, Mallery, 2003; Cronbach, Shavelson, 2004; DeVellis, 2012]. The test results show the reliability of the results obtained and support the interval consistency of the items justifying their use in a summated scale. There is no way to obtain a higher value of the Cronbach Alpha Test in any of the components by removing a variable, which signifies optimum reliability. The value of the alpha test ($\alpha>0.7$) proves that the obtained results are statistically significant.

The Professionalism component combines attitudes which can be characterised in two subsets of variables. The first one is characterised by the external attitude of women towards collaborators participating in the innovation process. This subgroup includes: Focus on people, Trust, Holistic approach and Cooperation. The second subgroup exemplifies individual personal skills and an internal attitude. This subgroup includes: Motivation, Ability to make decisions, Ability to learn and make use of knowledge, Ability to find financial sources, Aspirations, Focus on tasks and being an "Idea sower". The Roles in the team component is characterized by a spectrum of roles ranging from the most formal, which is a Controller, to the most informal, which is a Team leader. A symptomatic discrepancy is noteworthy. On the one hand, the Trust variable has a very important position among the attitudes of

women in relation to the environment, on the other hand, in the Roles in the team component the most prominent role of women is the Controller. How can we reconcile the attitude of Trust with the role of the Controller? The informal role of the Team Leader is based on mutual trust, which must appear as if spontaneously in the course of teamwork in the innovation process. In this context, we can say that the overriding attitude is Trust, which promotes the evolution of the role of the Team Leader but does not exclude the role of the Controller. This combination of attitudes and roles constitutes a new approach to preparing employees for participation in the innovation process. It requires appropriate preparation, both within hard and soft, not arbitrary, but specific competencies in terms of Trust, Controller and Team Leader. It requires the ability to act as the Controller while maintaining Trust, which keeps the way to building a Team Leader's position open. The last component – Creativity – includes the skills and abilities of women to cope with risks. This component contains Risk propensity as the most important skill, in which women's participation in the innovation process should be combined with Unconventional thinking and acting, and, most importantly, with Intuition. The attitudes contained in this component require a balance in being used by women in the innovation process. On the one hand, an indicator of the area in which woman moves when taking part in the innovation process is Risk propensity. In the context of this area there is room for women's Intuition, which, on the one hand, is a manifestation of unconventional thinking, but, on the other hand, can often indicate the need for unconventional acting.

Chart 3 (model 2) presents the values of each variable loading in the dedicated component. Based on the variables included in the components and their average loadings the components are: Professional attitude, 0.686; Values and attitudes, 0.694; Creativity, 0.658 and Roles in the team, 0.656.

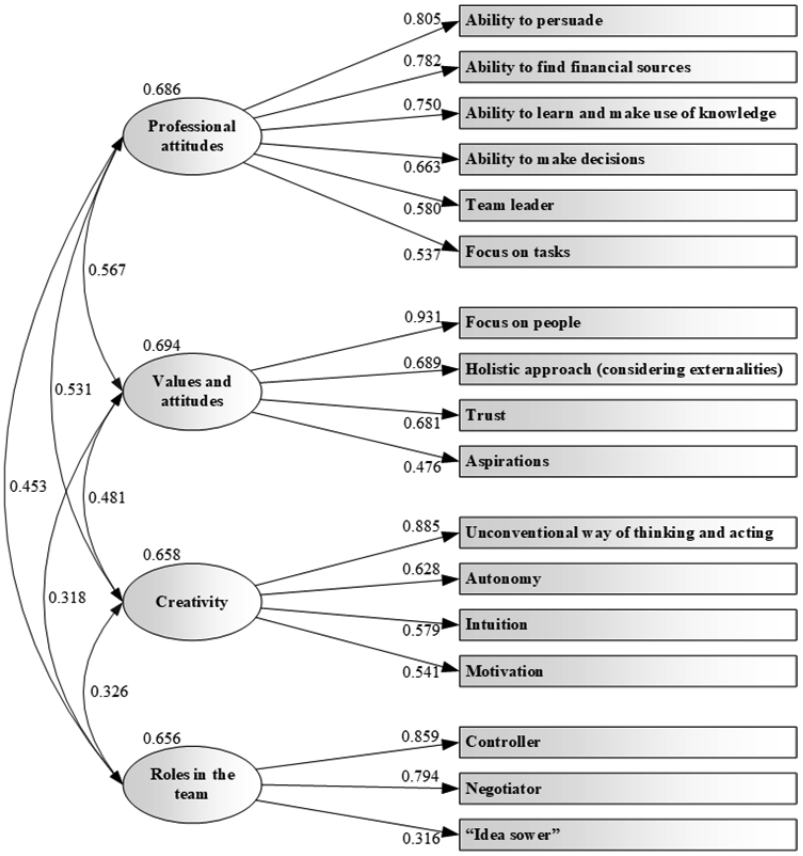
The average component loadings allow the variation explanation in the original data to be preserved while reflecting the scale. The Professional attitudes component contains six variables with variance explanation ranked 0.537-0.805; Values and attitudes component contains four variables with variance explanation ranked 0.476-0.931; Creativity component contains three variables with loading accounted 0.541-0.885 and Roles in the team component contains three variables with loading ranked 0.316-0.859.

Table 2 represents the component correlation matrix of men's participation in the innovation process.

The Cronbach Alpha Test results ($a>0.7$) showed the reliability of the results obtained and support the interval consistency of the items justifying their use in a summated scale.

**CHART 3**

**Men's participation model in the innovation process**




Source: author's work, with Amos use.

**TABLE 2**

**Component correlation matrix of men's participation in the innovation process of companies**

| Component | Professional attitudes | Values and attitudes | Creativity | Roles in the team |
|---|---|---|---|---|
| Professional attitudes | 1.000 | - | - | - |
| Values and attitudes | 0.567 | 1.000 | - | - |
| Creativity | 0.531 | 0.481 | 1.000 | - |
| Roles in the team | 0.453 | 0.318 | 0.326 | 1.000 |
| Extraction Method: Principal Component Analysis. | | | | |
| Rotation Method: Promax with Kaiser Normalization. | | | | |

Source: author's work, with SPSS use.

The Professional attitude component includes hard and soft skills. For men they are the most important determinants of personal conditions in the innovation process. These competencies are tied to performing the role of a Team leader and the ability to focus on tasks. Acting as a Team leader is then combined with a high level of competence. The Values and attitudes component contained variables characterising, beyond aspirations, attitudes towards other people participating in the innovation process. In this component, the most important attitude is Focus on people, associated with Holistic approach and Trust of others. The Creativity component represents individual, independent thinking and behaviour of men in the innovation process. Unconventional way of thinking and acting, linked with an appropriate level of Autonomy and Motivation, and using Intuition should be accompanied by the bold actions of men involved in the innovation process. Noteworthy is Motivation, which should be considered not only as a personal characteristic attitude of men, but as a feature of the environment in which individual initiative is adequately rewarded. The Roles in the team component contains three variables that can characterise the formal role of men in the innovation process. The most important of them is the Controller, and then there is the Negotiator and the "Idea sower". Noteworthy is the "Idea sower" variable, which for many men is identified with a formal role.

## 5. Discussion

Conducting research, managing the innovation process, and committing tangible and intangible assets, including the methods of obtaining them, are among the areas of activity which often determine the competitive advantage of a company. Thus, a significant part contains information which is sensitive from the decision-making point of view of the development of a competitive advantage. Decision makers, such as managers and team leaders, must specify goals and targets allowing teams to use their emergence, self-organization and adoption abilities in order to unleash maximum possibilities and achieve these goals in the most effective and efficient way. At this point, it is a substantially different role of decision makers in the innovation process [Sawyer, 2012; Cropley, Cropley, 2015]. In order to change the way of the decision making process, it is necessary for managers to take into account additional characteristics of all participants, professionals and scientific personnel by including gender-related features which indicate the advantages of women and men in some phases of the process. Such features represent business secrets and are not eagerly communicated outside the company. The main objective of the research project was to identify areas that may be new, previously untapped sources of innovation, resulting from the different participation of women and men in the innovation process and their influence on the decision-making process at different stages of the innovation process.

The application of PCA procedures allowed for a set of variables to be identified separately for men and women participating in the innovation process of companies. Hence, what is also known is the list of variables which, through the applica-

tion of PCA, were not considered statistically significant descriptors of the participation of women and men in the innovation process in enterprises. A statistically significant set of 18 variables grouped into three components was identified for women, and for men – 17 statistically significant variables grouped into four components.

The study aimed to capture the essential characteristics, attitudes and behaviours which are both common and different for men and women in the process of innovation taking place in enterprises. The applied PCA method enabled their indication. The models presented are an attempt to develop a holistic approach to such complex issues as gender participation in the innovation process. It should be noted that the process itself works differently in different companies. Hence, it is not a completely repeatable phenomenon. On the contrary, despite common steps, characteristics and purposes, it contains a high level of uniqueness. Nevertheless, systematic research in the direction and area initiated here may bring a deeper understanding of the roles of men and women in the future, which, in turn, will make it possible to translate them more accurately in order to accelerate innovative development.

## 6. Conclusions – towards gender-related decision making in innovation process

In the model of female participation, the variables that predominate are those characterising attitudes external to colleagues, formal and informal roles and the coping skills of women in higher-risk situations, which are undoubtedly related to the process of innovation. Results obtained in the conducted research can be useful for managers involved in innovation projects. They imply that women and men play much more effective and efficient roles in different phases of the innovation process. Thus, their participation in this process should be taken into account by managers while selecting candidates in order to build more efficient and effective teams in the desired phases, along with the specific roles played in the innovation process. Each phase is characterised by different requirements, and in each phase, different specifications – resulting from female and male participation models – should be taken into account. The model of male participation in innovation processes emphasises such prerequisites as competencies in the first place and the related choice to act as an informal Team leader. This model also stresses the importance of unconventional thinking and behaviour, which is subject to an appropriate degree of autonomy and means of motivating this kind of activity. Finally, this model emphasises the formal roles (among which the Controller and the Negotiator occupy a leading position) in the desired phases of the innovation process. The main difference that arises, based on the obtained participation models, is taking risk and dealing with it. In the female model, this issue is of statistically significant importance, but with men, it is almost absent. This is also confirmed by variables removed from the analysis; for men, variables such as Risk propensity and the Calculating person do not constitute statistically significant traits, attitudes and behaviours in the

innovation process. However, in both models, variables such as Competition, Workload, Compliance with rules and regulations, Perceptiveness and Representation were considered to be statistically insignificant in the innovation process. These variables seem to confirm that the participation of women and men in the same innovation process should not be based on competition. This indicates the need for cooperation in the context of the work performed. At the same time, it is indicated that Compliance with rules and regulations does not play a significant role, which is associated with the need to look for the best solutions in the innovation process. It is substantially more likely to be associated with Unconventional thinking and acting than Compliance with rules and regulations.

The presented models unambiguously show that the participation of women and men is diverse. Women bring significantly higher levels of trust, focus on people, risk propensity with a holistic approach and an ability to make decisions to the innovation process than men. Men, compared to women, bring considerably greater levels of concentration on competence, focus on tasks and unconventional ways of thinking and acting. The ability to combine a sufficiently large range of risk propensity, focus on people and trust, which are brought by women, with the competencies of an unconventional way of thinking and acting, which are brought by men, in conditions of cooperation and trust, emphasised by both sexes, may become the means of faster development and synergy obtainment hitherto unused in the innovation process.

The presented conclusions are a set of new and helpful guidelines that should be used by managers in the decision-making process to make more comprehensive use of the skills of women and men in the innovation process.

## References

Abels G., 2012, *Research by, for and about Women: Gendering Science and Research Policy* [in:] *Gendering European Union. New Approaches to Old Democratic Deficits*, Abels G., Mushaben J.M. (eds.), Palgrave Macmillan, Basingstoke.

Acker J., 2006, *Gender Regimes: Gender, Class, and Race in Organizations*, "Gender & Society", vol. 20(4), pp. 441-464, DOI: 10.1177/0891243206289499.

Alsos G.A., Ljunggren E., Hytti U., 2013, *Gender and innovation: state of the art and a research agenda*, "International Journal of Gender and Entrepreneurship", vol. 5(3), pp. 236-256, DOI: 10.1108/IJGE-06-2013-0049.

Amabile T.M., Conti R., Coon H., Lazenby J., Herron M., 1996, *Assessing the Work Environment for Creativity*, "Academy of Management Journal", vol. 39(5), pp. 1154-1184, DOI: 10.5465/256995.

Bartlett M.S., 1950, *Tests of significance in factor analysis*, "British Journal of Psychology", vol. 3, Part I, pp. 77-85.

Buljubasic T., 2020, *Developing Innovation: Innovation Management in IT Companies*, De Gruyter, New York.

Cameron K., Quinn R., DeGraff J., Thakor A., 2014, *Competing Values Leadership*, Edward Elgar Pub, New York.

Carrasco I., 2014, *Gender gap in innovation: an institutionalist explanation*, "Management Decision", vol. 52(2), pp. 410-424, DOI: 10.1108/MD-07-2012-0533.

Cattell R.B., 1966, *The scree test for the number of factors*, "Multivariate Behavioral Research", vol. 1(2), pp. 245-276, DOI: 10.1207/s15327906mbr0102_10.

Cattell R.B., 1978, *The Scientific Use of Factor Analysis*, Plenum, New York.

Cirera X., Muzi S., 2020, *Measuring innovation using firm-level surveys: Evidence from developing countries*, "Research Policy", vol. 49(3), DOI: 10.1016/j.respol.2019.103912.

Comrey A.L., Lee H.B., 1992, *A first course in factor analysis*, Erlbaum, Hillside.

Cooper R., 2012, *The gender gap in union leadership in Australia: a qualitative study*, "Journal of Industrial Relations", vol. 54(2), pp. 131-146, DOI: 10.1177/0022185612437836.

Cortina J.M., 1993, *What Is Coefficient Alpha? An Examination of Theory and Applications*, "Journal of Applied Psychology", vol. 78(1), pp. 98-104, DOI: 10.1037/0021-9010.78.1.98.

Costello A., Osborne J.W., 2005, *Best Practices in Exploratory Factor Analysis: Four Recommendations for Getting the Most from Your Analysis. Practical Assessment*, "Practical Assessment, Research, and Evaluation", vol. 10(7), pp. 1-9, DOI: 10.7275/jyj1-4868.

Cramer D., 1998, *Fundamental Statistics for Social Research*, Routledge, London.

Cramer D., Howitt D., 2004, *The SAGE Dictionary of Statistics*, SAGE, London.

Cronbach L.J., 1951, *Coefficient alpha and the internal structure of tests*, "Psychometrika", vol. 16, pp. 297-334, DOI: 10.1007/BF02310555.

Cronbach L.J., 1970, *Essentials of Psychological Testing*, Harper & Row, New York.

Cronbach L.J., Shavelson R.J., 2004, *My current thoughts on coefficient alpha and successor procedures*, "Educational and Psychological Measurement", vol. 64(3), pp. 391-418, DOI: 10.1177/0013164404266386.

Cropley D., Cropley A., 2015, *The psychology of Innovation in Organizations*, Cambridge University Press, New York.

DeGraff J., Quinn S., 2007, *Leading Innovation: How to Jump Start Your Organization's Growth Engine*, McGraw-Hill, New York.

DeVellis R.F., 2012, *Scale development: Theory and applications*, Sage, Los Angeles.

Dien J., Beal D.J., Berg P., 2005, *Optimizing principal components analysis of event-related potentials: matrix type, factor loading weighting, extraction, and rotations*, "Clin Neurophysiol", vol. 116(8), pp. 1808-1825, DOI: 10.1016/j.clinph.2004.11.025.

DiStefano Ch., Zhu M., Mîndrilă D., 2009, *Understanding and Using Factor Scores: Considerations for the Applied Researcher. Practical Assessment*, "Research & Evaluation", vol. 14(20), pp. 1-11, DOI: 10.7275/da8t-4g52.

Doane D.P., Seward L.E., 2011, *Measuring Skewness: A Forgotten Statistic?,* "Journal of Statistics Education", vol. 19(2), pp. 1-18, DOI: 10.1080/10691898.2011.11889611.

du Vall M., Majorek M., 2015, *Taking gender seriously Present trends and recommendations for scientific environment,* [in:] *Statistical profiles of women's and men's status in the economy, science and society*, Okoń-Horodyńska E., Zachorowska-Mazurkiewicz A. (eds.), Jagiellonian University Press, Krakow.

Dyląg A., Szafrański M., 2015, *Contemporary value profiles of women and men – Polish pilot survey,* [in:] *Statistical profiles of women's and men's status in the economy, science and society*, Okoń-Horodyńska E., Zachorowska-Mazurkiewicz A. (eds.), Jagiellonian University Press, Krakow.

Dziuban C.D., Shirkey E.C., 1974, *When is a correlation matrix appropriate for factor analysis?*, "Psychological Bulletin", vol. 81, pp. 358-361, DOI: 10.1037/h0036316.

Field A., 2012, *Discovering Statistics Using IBM SPSS Statistics*, SAGE, London.

Fogelberg E.A., 2014, *A gender perspective as a trigger and facilitator of innovation*, "International Journal of Gender and Entrepreneurship", vol. 6(2), pp. 163-180, DOI: 10.1108/IJGE-09-2012-0045.

Foss L., Woll K., Moilanen M., 2013, *Creativity and implementations of new ideas: do organizational structure, work environment and gender matter?,* "International Journal of Gender and Entrepreneurship", vol. 5(3), pp. 298-322, DOI: 10.1108/IJGE-09-2012-0049.

George D., Mallery P., 2003, *SPSS for Windows step by step: A simple guide and reference*, Allyn & Bacon, Boston.

Hair J.F., Jr. Black W.C., Babin B.J., Anderson R.E., 2014, *Multivariate Data Analysis*, Pearson, Harlow.

Henson R.K., Roberts J.K., 2006, *Use of exploratory factor analysis in published research: Common errors and some comment on improved practice*, "Educational and Psychological Measurement", vol. 66, pp. 393-416, DOI: 10.1177/0013164405282485.

Hunt J., Herman H., Munroe D.J., 2013, *Why are women underrepresented amongst patentees?* "Research Policy", vol. 42 (4), pp. 831-843, DOI: 10.1016/j.respol.2012.11.004.

Joshi S., Wamba S.F., Garza-Reyes J.A., 2020, *Managing Service Operations: Strategies, Innovations and Sustainable Technologies*, Kogan Page, New York.

Kaiser H.F., 1960, *The application of electronic computers to factor analysis*, "Educational and Psychological Measurement", vol. 20(1), pp. 141-151, DOI: 10.1177/001316446002000116.

Kaiser H.F., 1970, *A second generation little jiffy*, "Psychometrika", vol. 35(4), pp. 401-415, DOI: 10.1007/BF02291817.

Kaiser H.F., Rice J., 1974, *Little jiffy, mark iv*, "Educational and Psychological Measurement", vol. 34, pp. 111-117, DOI: 10.1177/001316447403400115.

Kline P., 1994, *An easy guide to factor analysis*, SAGE, Thousand Oaks.

Kline P., 2000, *The handbook of psychological testing*, Routledge, London.

Kopycińska D., 2015, *The professional situation of women and men in Poland – declarations and reality,* [in:] *Statistical profiles of women's and men's status in the economy, science and society*, Okoń-Horodyńska E., Zachorowska-Mazurkiewicz A. (eds.), Jagiellonian University Press, Krakow.

Larsen R., Warne R.T., 2010, *Estimating confidence intervals for eigenvalues in exploratory factor analysis*, "Behavior Research Methods", vol. 42, pp. 871-876, DOI: 10.3758/BRM.42.3.871.

MacCallum R.C., Widaman K.F., Zhang S., Hong S., 1999, *Sample size in factor analysis*, "Psychological Methods", vol. 4(1), pp. 84-99, DOI: 10.1037/1082-989X.4.1.84.

Norman G.R., Streiner D.L., 2003, *Statistics*, PDQ, London.

O'Connor B.P., 2000, *SPSS and SAS programs for determining the number of components using parallel analysis and Velicer's MAP test*, "Behavior Research Methods, Instrumentation, and Computers", vol. 32, pp. 396-402.

*Statistical profiles of women's and men's status in the economy, science and society*, 2015, Okoń-Horodyńska E., Zachorowska-Mazurkiewicz A. (eds.), Jagiellonian University Press, Krakow.

*Oslo Manual: Guidelines for Collecting and Interpreting Innovation Data*, 2018, OECD Publisher, Paris.

Østergaard C.R., Timmermans B., Kristinsson K., 2011, *Does a different view create something new? The effect of employee diversity on innovation*, "Research Policy", vol. 40(3), pp. 500-510, DOI: 10.1016/j.respol.2010.11.004.

Pett M.A., Lackey N.R., Sullivan J.J., 2003, *Making Sense of Factor Analysis: The use of factor analysis for instrument development in health care research*, SAGE, Los Angeles.

Ranga M., Etzkowitz H., 2010, *Athena in the World of Techne: The Gender Dimension of Technology, Innovation and Entrepreneurship*, "Journal of Technology, Management & Innovation", vol. 5(1), pp. 1-12, DOI: 10.4067/S0718-27242010000100001.

Razali N.M., Wah Y.B., 2011, *Power Comparisons of Shapiro-Wilk, Kolomogorov-Smirnov, Lilliefors and Anderson-Darling Tests*, "Journal of Statistical Modeling and Analysis", vol. 2(1), pp. 21-33.

*Regular Reports from the Commission on Hungary's Progress towards Accession*, 2001, EC Publishers, Brussels.

Sawyer K., 2012, *Explaining Creativity: The Science of Human Innovation*, Oxford University press, Oxford.

Schumpeter J.A., 1934, *The theory of economic development*, Oxford University Press, New York.

Shapiro S.S., Wilk M.B., 1965, *An Analysis of Variance Test for Normality (Complete Samples)*, "Biometrika", vol. 52(3/4), pp. 591-611, DOI: 10.1093/biomet/52.3-4.591.

Sierotowicz T., 2015, *Patent activity as an effect of the research and development of the business enterprise sectors in the countries of the European Union*, "Journal of International Studies", vol. 8(2), pp. 31-43, DOI: 10.14254/2071-8330.2015/8-2/9.

Streiner D.L., Norman G.R., Cairney J., 2015, Health Measurement Scales: A practical guide to their development and use, Oxford University Press, Oxford.

Zachorowska-Mazurkiewicz A., 2016, *Praca kobiet. Perspektywa ekonomii głównego nurtu i ekonomii feministycznej*, Wydawnictwo Uniwersytetu Jagiellońskiego, Kraków.

Zinbarg R., Yovel I., Revelle W., McDonlad R., 2006, *Estimating Generalizability to a Latent Variable Common to All of a Scale's Indicators: A Comparison of Estimators for ωh*,

"Applied Psychological Measurement", vol. 30(2), pp. 121-144, DOI: 10.1177/0146621605278814.

**Annex – variables in the process of innovation**

| *Work environment* | *Personal qualities* | *Abilities, skills and competences* | *Attitudes and values* | *Roles and behaviours* |
|---|---|---|---|---|
| Cooperation | Intuition | Ability to persuade | Focus on people | "Idea sower" |
| Competition | Perceptiveness | Ability to make decisions | Focus on tasks | Team leader |
| Motivation | Risk Propensity | Ability to learn | Calculating person | Negotiator |
| Workload | Unconventional way of thinking | Holistic approach | Aspirations | Controller |
| Autonomy | Compliance with rules | Ability to find financial sources | Trust | Representative |

Source: own elaboration.