Analysis of the demand for competencies on the Polish labour market in the context of Industry 4.0

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Abstract

The main purpose of the article is to analyse the demand for employee competencies on the labour market in Poland in the context of Industry 4.0. Due to the fact that employers search for candidates who possess a certain set of competencies, the aim of this type of research should be focused rather on the need for a certain sets of related competencies than on competencies considered independently. Taking thesis formulated above as a starting point, authors uses the term "competency schema" understood as a set of interrelated competencies together with information defining the significance of each competency and the nature and strength of links between them. The results of the research allowed us to identify the main competency schemes on the Polish labour market, to analyse existing competency schemas in spatial terms (including the division of Poland into voivodships), to analyse existing competency schemas due to the most popular job positions and to analyse identified competency schemas in the light of the assumptions of the Industry 4.0 concept. The research was based on the analysis of job offers regarding the Polish labour market. Identification of employers' expectations towards candidates' competencies was carried out by means of exploratory text analysis, while network analysis was used to study competency schemas. All calculations were carried out using programmes written in the R language.

Keywords: *competencies, competency schemas, labour market*
JEL Classification: *J24, C81*

1. Introduction

Today, Industry 4.0 brings various challenges like technological, strategic, business and people-related ones. In the conditions of Industry 4.0, human resources become one of the main assets of a company and significantly determine its competitive advantage on the market. Moreover, the dynamics of changes on the labour market is increasingly faster, which also means a quick outdating of the existing competencies and a growing demand for new ones. Therefore, skilful determination of the expectations towards employees' competencies and the hiring competent employees appoints the direction of organisational development. In addition, it is particularly important for the enterprise competitiveness to monitor the demand for competencies, including identification of trends regarding changes of the demand for labour. Thus, it becomes important to create possibilities of identification of the employer demand for competencies and the supply of competencies.

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Due to the fact that employers search for candidates who possess a certain set of competencies, the aim of this type of research should be focused rather on the need for certain sets of related competencies than on competencies considered independently. On the basis of this assumption authors use the term "competency schema" which can be defined as a set of interrelated competencies together with information indicating the significance of each competence and the nature and strength of relations between them. Competency schemas can be represented as weighted graphs, in which nodes represent competencies, edges describe the relations between them, weights assigned to nodes indicate the importance of individual competencies in the given schema, and weights assigned to edges inform about the strength of relationships between competencies. The main purpose of the article is to analyse the demand for employee competencies on the labour market in Poland in the context of Industry 4.0. The research was based on the analysis of job offers regarding the Polish labour market. Identification of employers' expectations towards candidates' competencies was carried out by means of exploratory text analysis, while network analysis was used to study competency schemas. All calculations were carried out using programmes written in the R language.

2. The characteristics of Industry 4.0

One of the most novel ideas that has been applied to companies in recent years is "Industry 4.0". It is a wide term that implies a drastic change in the way companies operate. Industry 4.0 promotes, among other things, interoperability, autonomous decision-making, flexibility, agility, efficiency and cost reductions (Pérez, 2016). The term "Industry 4.0" was officially presented at the 2012 Hannover Fairs in Germany as one of ten "Future Projects" that form Germany's High-Tech Strategy 2020. Originally it was meant to describe technological changes in manufacturing and to set out priorities of a consistent policy framework to preserve the global competitiveness of the German industry. The title 4.0 indicates that Industry 4.0 is considered as the fourth industrial revolution, a logical continuation of the previous three ones (Kusmin, 2018).

Hermann et al (2015) defines Industry 4.0 as a collective term for technologies of value chain organizations. He categorises its components into Internet of Things, Cyber Physical Systems, Internet of Services and Smart Factory. The main purpose of Industry 4.0 is to achieve improvement in terms of automation and operational efficiency, as well as effectiveness (Ślusarczyk, 2018). Industry 4.0 is a result not only of the development of new technologies but it is also a result of new entrepreneurial mindset. Basically, the Industry 4.0 rises from Industrial policies' of the well-developed countries that have introduced innovations, entrepreneurship and human capital as the most important elements of contemporary business culture (Sterev, 2017).

The main characteristics of Industry 4.0 that are very important to contemporary organization are (Lee et al, 2014; Schuh et al., 2015; Pérez, 2016; Sterev, 2017):

- vertical integration of smart production systems,
- horizontal integration of global value chain networks,
- cross-disciplinary through-engineering value chain,

- acceleration through exponential technologies as artificial intelligence,
- virtualization which means that companies are able to monitor their physical processes,
- interoperability which means that all internal and external systems used in company are connected,
- autonomation which means that "Industry 4.0" technologies and concepts are enabling machines and algorithms of future companies to make decisions and perform learning-activities autonomously,
- real-time availability which means that for organisational tasks it is necessary that data is collected and analysed in a real time,
- flexibility which means that due to new and more complex demand requirements, processes such as products development, products production processes or decision making procedures need to be performed faster,
- service orientation which means that the companies' Web services can be utilised by other participants,
- energy efficiency which means that climate change and scarcity of resources are megatrends that must be taken into consideration by the future industry players.

3. Competencies and competency schemas in the theoretical approach

The subject literature does not agree as to what the professional competencies of employees are. The multiplicity of approaches results mainly from the fact that this issue is analysed by specialists representing different scientific disciplines: management, psychology and sociology. The issue of competencies appeared in the subject literature at the turn of the 1960s and 1970s with the publication of works of two management psychologists: White (1959) and McClelland (1973) (Oczkowska et al, 2017). White (1959) depicted the human trait he called competence. McClelland (1973) claimed that although intelligence has an undoubted impact on human behaviour, the characteristics of a person (such as motivation or self-perception) that can be observed during life and professional situations, determine whether the behaviour will be effective or ineffective better than intelligence itself. McClelland (1973) pointed out that neither psychological tests nor school grades and testimonies may predict whether a person will succeed at work. It prompted McClelland (1973) to look for other methods of predicting work results. The identification of ways of thinking and behaviours of people who achieve a high level of effects at work has become one of them.

The definitions of competencies presented in the subject literature are not homogeneous, they are interpreted differently. In the opinion of Boyatzis (1982) competencies are the capacity of a given person to display behaviours compliant with the requirements of the job position specified by the organisational environment parameters, which, in turn, yields the desired results. According to Levy-Leboyer (1996) competencies are related to practical actions in specific situations and have the ability to being developed in the work process. As a dynamic structure they evolve under the influence of changes in the economy and in human life. Therefore, in

the opinion of Bengtsson (1996), competencies make people capable of changing professions or raise their level of understanding the technology. It is worth noting that the concept of competencies is a multi-dimensional in its nature and much wider than the concept of qualifications itself. This is emphasised by Pawlak (2003), according to whom, competencies mean both confirmed by documents ability to work, as well as the abilities and skills that the candidate can confirm by performing the assigned tasks correctly.

The authors formulate the thesis that the analysis of possessed or required competencies shouldn't be carried out separately for each competence, but should always involve a certain set of them taken together. In the given set of competencies, the importance of each of them can be diverse, and this aspect can be expressed in the model by different weights assigned to them. Also, the character and the strength of relations between consecutive competencies may be varied. Taking thesis formulated above as a starting point, the authors uses the term "competency schema" understood as a set of interrelated competencies together with information defining their significance and the nature and strength of links between them.

It is worth pointing out the difference between the concept of "competency schema" proposed here and the term "competency profile" often used in the subject literature. The competency profile is a list of competencies along with the level of their fulfilment (Whiddett et al., 2007; Juchnowicz et al., 2014). The meaning of the concepts of the competency schema and the competency profile is not equal. The competency schema defines not only competencies and the level of their fulfilment, but also defines the connections between competencies describing their character (direction) and their strength.

4. Graph-based approach to competency schema definition

We will consider a set of competencies:

$$\boldsymbol{C} = \{C_1, C_2, ..., C_M\}$$

and a set of job offers:

$$\boldsymbol{O} = \{O_1, O_2, ..., O_N\}$$

The analysis of offers enables to define the *offer-competency matrix* $\boldsymbol{M}$:

$$\boldsymbol{M} = [m_{ij}]$$

where $m_{ij} = 1$ if the j-th competency is mentioned in the i-th offer, and $m_{ij} = 0$ if the information about the j-th competency does not appear in the i-th offer.

We assume that two competencies C_i and C_j are connected if they appear in the same offer O_k. Connections between competencies are represented by the *competency co-occurrence graph* which has weighted and undirected character and is represented by the adjacency matrix $\boldsymbol{G}$:

$$\boldsymbol{G} = [g_{ij}]$$

where g_{ij} element informs how many times the competency is mentioned in the given offer set $\boldsymbol{O}$, and g_{ij} (where $i \neq j$) shows how many times competencies C_i and C_j appeared together in the same offer.

Some relations between competencies can be very infrequent and have insignificant character in a given job offer set. Assuming that irrelevant connections are represented by weights assigned to edges smaller than a given threshold (90th percentile calculated for weights assigned to edges), the *competency interrelationship graph* (*CIR graph*) can be defined by an adjacency matrix $\boldsymbol{R}$:

$$\boldsymbol{R} = [r_{ij}]$$

where $r_{ii} = g_{ii}$, $r_{ij} = g_{ij}$ if $g_{ij} \geq t$, and $r_{ij} = 0$ if $g_{ij} < t$.

The *CIR* graph represented by the adjacency matrix $\boldsymbol{R}$ shows the importance of every competency (diagonal elements of the adjacency matrix) and the importance of connections between them (off-diagonal elements of the adjacency matrix). In the general case, the *CIR* graph can be disconnected. It means that two competencies which are not connected by one path may exist simultaneously.

The *CIR* graph constitutes the basis for the *competency schema* definition. The competency schema can be defined as a connected component (connected sub-graph) of the competency interrelationship graph.

5. The analysis of the demand for competencies on the Polish labour market

The identification of competency schemas describing the demand for competencies on the Polish labour market is the main goal of the empirical part of the research.

To reach the goal stated above the authors used a set of job offers retrieved from the https://www.pracuj.pl/ web site. The set which contains 8000 job offers was prepared using web scraping technique. Job offers were retrieved in January 2019. Only offers active at the time of scrapping procedure were acquired. Later on, all offers prepared in languages different than Polish were omitted. The remaining set of offers was comprised of 6667 documents.

Using the exploratory text analysis technique presented in (Lula et al., 2018) the process of identification of competencies in every document was performed. The analysis was focused of identification of four groups of competencies: individual, social, managerial and professional. Cumulatively 61 various competencies were considered.

The above step allowed us to build the *offer-competency matrix* $\boldsymbol{M}$. Later on, the algorithm presented in the previous section was used in order to build *competency co-occurrence graph*. During consecutive step of the analysis nodes representing the most frequent competencies were found and used to build the *competency interrelationship graph* (*CIR graph*) presented in Fig. 1.

To facilitate the analysis of the visualization of the *CIR* graph, the importance of competencies was represented by the size of nodes, and the importance of connections was expressed by

the width of edges. Competency schemas can be obtained by erasing edges representing insignificant connections (with weights smaller than a given threshold) and analysing the connectivity of the graph obtained as the result. For an exemplary threshold used for the calculation, insignificant edges were drawn in orange.

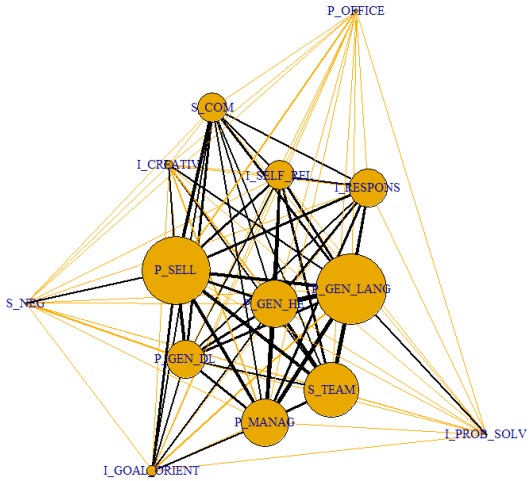

Fig. 1. General competency interrelation graph for the Polish labour market

The results show that the set of the most important competencies is composed of *P_SELL* (competencies related to selling and marketing), *P_GEN_LANG* (competencies relating to knowledge of foreign languages), *P_GEN_HE* (possession of higher education), *S_TEAM* (teamworking), *P_MANAG* (managerial competencies), *P_GEN_DL* (possession of a driving licence), *I_RESPONS* (responsibility), *S_COM* (communication skills), *I_SELF_REL* (self-reliance), *I_CREATIV* (creativity) and *I_GOAL_ORIENT* (goal orientation). All these competencies are connected very strongly. It is the most important competency schema describing the demand for competencies on the Polish labour market analysed as a whole. It is worth underlining that these competencies have rather general character and are not strongly connected with the Industry 4.0 concept.

Furthermore, the similar analysis of job offers related to *IT* sector was performed. This sector was chosen as a representation of an area characteristic for Industry 4.0 idea. In this study a set of 249 job offers was used. Using the same procedure as described above, the competency interrelation graph for *IT* sector was built. It was presented in Fig. 2.

The results show that for the *IT* sector the set of the most important competencies includes *P_GEN_LANG* (competencies relating to knowledge of foreign languages), *S_TEAM* (teamworking), *SEC_ICT* (competencies related to ICT sector), *P_SELL* (competencies related to selling and marketing), *I_RESPONS* (responsibility), *P_GEN_HE* (possession of higher education), *P_GEN_DL* (possession of a driving licence), *S_COM* (communication skills) and *I_SELF_REL* (self-reliance).

On the contrary to results obtained for the whole set of job offers, for *IT* sector professional competencies related to *ICT* area were considered as very important.

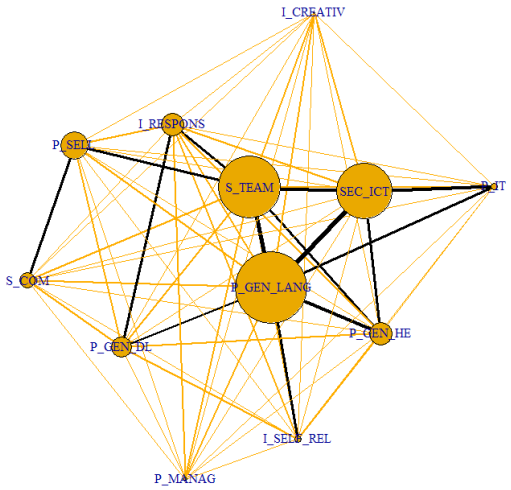

Fig. 2. Competency interrelation graph for *IT* sector of the Polish labour market

Conclusions

The results show that competency schemas constitute a useful tool for labour market analysis. Here they were used for description of the demand for competencies. But their applications are not limited to this task and the same concept may be used for the description of the competency supply. By the comparison of these two perspectives, the competency gap (and its representation in the form of competency schemas) can be estimated.

It is worth concluding that the scope of analysis has a huge impact on the results. Performing the analysis of the whole set of job offers, the results show that individual, social and managerial competencies play the crucial role on the labour market. Competency schemas identified during the study do not include professional competencies. But this fact should not be treated as a justification of the opinion that professional competencies play secondary role on the labour market and in the education process. The importance of professional competencies is clearly apparent when the scope of analysis is limited to one sector. Then professional competencies have crucial character.

The authors believe that the concept of competency schemas introduced here allows us to describe and analyse the demand and the supply for competencies better than the concept of competency profiles. Schemas do not only inform about all aspects of competencies which are described by profiles, but also show their co-occurence, which can play the crucial role in preparation of educational processes.

The authors are going to develop ideas presented here in their future works.

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