IMPLEMENTATION OF INDUSTRY 4.0 IN ENGINEERING COMPANIES

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Abstract: The purpose of the article is to verify dependence between potential threat of industry 4.0 and present skills and knowledge of workers in engineering companies. There were defined four hypotheses, focused on connection between knowledge of industry 4.0 concept and potential threats of job loss from different points of view. To verify these hypotheses there was used questionnaire survey, distributed in engineering companies in Czech Republic, Germany and Canada. Gained data was put under statistical evaluation by Pearson's chi-square test of independence and correspondence analysis for displaying connection between knowledge of industry 4 and country of company.

Keywords: Industry 4.0, globalization, industrialization, unemployment, circular economy

1 Introduction

In present time there are increasing interest about industry performance, which provide both of higher productivity of staff and corporate prosperity. Due the globalization there is requirement for industrialization and leaving companies with little difficult technologies to developing countries. Therefore, there is expecting coming of new technologies leading to structural in employment. According to Peschner and Fotakis (2013) in European Union would not ensure target employment rate till 2022. Specific situation would be in Czech Republic, which reach problem of enough potential workers in 2018, in Hungary and Slovak Republic in 2020 (Pauhofová, Stehlíková, 2017). This situation and reasons enable creation of initiative for industry 4.0 in Germany. This initiative, is required by market economy, because by radical benefit of industrial revolution can move revolution sense, supporting potential increasing of production effectiveness.

By industrial revolution term is usually considered back-view to evolution of industrial environment and manufacturing. Therefore, industry 4.0 is rated as running process. Suggestion of new industry 4.0 platform leads to action plan, called as High strategy 2020. This platform provides cooperation across wide range of organizations, leading to development of industry 4.0 concept on the way of building strong competitiveness in participant countries (Ministerstvo průmyslu a obchodu, 2016).

The industry 4.0 concept is considered as kind of set of activities, which are focused on corporate investments, applied science and standardization of production. It is based on integrated cyber security of digitalization processes. There are defined changes in social field because of the implementation of industry 4.0 and digitalization. Therefore, there are expected new trends of employing, which corroborates actual industrial revolution. According to technology and social changes there are expected creation of new job position and at the same time abolishment of actual positions (Rojko, 2017).

2 Theoretical background

Globalization of corporate environment support development of technics and technologies around all industry fields. Individual industry revolutions developing of technologies and technics for industrial production. Actual situation in industrial production reflects new era of production approach. Present concept of production – industry 4.0 – is based on high digitalization of employment. According to Cline (2017), over one third of producers are going to implement elements of digitalization into their production. In industrial development there was several steps, which lead to present situation (see Picture 1). First industry revolution changed manufacturing practices by employing machineries (at the end of 18th century). In industry 2.0 there was applied mass production and assembling lines instead of manual fabrication with machinery support (at the end of 19th century). Third step in industry development (industry 3.0) was started in 1970s due lean philosophy with support of cyber parts (e.g. computers, networks, internet), what prepare situation for outsourcing of production and digital transformation. During all industrial steps there were required skills, abilities and experiences of workers (depended on the workers' alignment.

Picture 1 Developing of industry revolutions

Industry 4.0 ***(today)***	cyber physical systems internet of thing networks
Industry 3.0 ***(1969)***	cyber physical systems internet of thing networks
Industry 2.0 ***(1870)***	mass production assembly line electrical energy
Industry 1.0 ***(1784)***	mechanization steam power weaving loom

Source: adapted according Cline, 2017

Industry 4.0 helps to create smart factory vision as reaction to market requirements. The substance of smart factory is high integrated, automatized and continuously optimized working environment in connection to production devices into cybernetic-physical systems. Investments into development and implementation of innovative solutions would be in difficult projects, which help to stabilize long-term competitiveness of Czech industry. Producers of equipment, software and industrial companies need specific platform, which provide development, function verification and compatibility of new solutions in semi-industrials conditions and in interaction within actual technologies (Fettig et al., 2018; Ematinger, 2017; Koren, Shpitalni, 2010; Nayak, Dürr, Rothermel, 2015).

From general point of view, industry 4.0 includes combination of various technologies such additive production, cutting, robotic manipulation, automated stocks, smart conveyor systems and others. Due both of flexible connections of universal production devices and sophisticated driving systems there is possible to use same equipment in different operations, which are planned in optimal ways according to specific needs. All sophisticated systems and advanced software include possibility for new product digitalization, their simulation and virtual establishing of new production line on the way of both product's and production process optimization before beginning of production. By this whole process there is likely to reduce time for production and its costs before launching product. As kind of support there is used cloud-stores for data collection from whole production to make an analyse of these data and improve individual areas such quality management or precaution of equipment, which are typically considered as key part of industry 4.0 for modern and future production (Český institut informatiky, robotiky a kybernetiky, 2018).

The purpose of the industry 4.0 was developed from german initiative to create cooperation between academics and companies in production area as reply for market requirements in context of performance claims (Bundesministerium für Wirtschaft und Energie, 2017). In Czech national initiative, prepared by Ministerstvo průmyslu a obchodu České Republiky. (2015) there is described philosophy of industry 4.0 reflects various concepts, which are similar to each other, e.g. Industrie du future (France), Fabrica Intelligente (Italy), Industrial Internet

(USA). All national initiatives focus on implementation digital technologies and internet into whole production systems, which require new thinking approaches of staff, their skills, abilities and other important elements. Tomek and Vávrová (2017, p.10-13) describe the concept of industry 4.0 as combination of rational and irrational thinking on the producer's side to make relevant value for customers, which are more self-confident, enquiring and more judicial to offering (Hecklau et al., 2016).

According to Gatullo et al. (2019) there is possible to look on Industry 4.0 from point of view, how it influence different management approaches. These approaches are as follow:

1. Virtualization (it helps to create replica of real environment by application of GPS system to control physical flows);
2. Service orientation (service orientation should be rated as future base on the way to realize customers' requirements which help them to solve their problem; combination of virtual space, humans, services and internet offer product composition to customers);
3. Time capability (production data are collected in real time, which convey prompt reaction to failures or their risk; all necessary documentation must be updated in real time);
4. Modularity (modular approach facilitate immediate reaction in case of changing product setup; production documentation must be modular to integrate new procedures, technologies and other required items);
5. Interoperability (it provides communication between individual elements of virtual world such human, production units and systems which could be marked as crucial);
6. Decentralization (required materials from side of company are decentralized to lower levels; in case of failures there is applied centralization to higher levels to help to solve the failure).

These steps represent corporate strategy which must reflect actual situation in various fields such technology development, innovation's context, employment's needs or used business model. Fettig et al. (2018) and Reischauer, Schober, Obermaier (2016) describe implementation of industry 4.0 as challenge to fulfill corporate vision to reach kind of autonomy, enabling progress of staff skills on the pathway to making opportunities, strengthening competitiveness and improve staff working-life balance. By virtualization as one of important part of Industry 4.0 there is possible to find the most crucial area in production and prepare preventative solution on the way of precede working injuries and safe working environment (Winge et al., 2019). By implementation of industry 4.0 conditions there would be improved situation in preventing working environment, which could provide safety environment, higher productivity and satisfied employees (Lundberg, Rollenhagen, Hollnagel, 2009; Lindberg, Hansson, Rollenhagen, 2010; Reichel, De Schoenmakere, Gillabel, 2016).

Automatization, virtualization and other parts of industry 4.0 afford apprehension, what will happen after implementation. This fear is actually boosted up by requirements for environment friendly production and reusing or repairing technologies for new purposes. This approach is based in so called circular economy, which intensifies in corporate practices with no regards to industry or country.

Circular economy helps to discover new availing of used products, generated waste or used materials on the way of creating new products. Because of raw-material shortage, there is important to get new form of source materials for advancement of companies, industries, regions and of course whole countries (Benton, Hazell, Hill, 2015).

Circular economy brings in connection to industry 4.0 new potential values for all stakeholders' group on the way to connect them whit high responsibility for people, nature and other environments (Reichel, De Schoenmakere, Gillabel, 2016; Reike, Vermeulen, Witjes, 2018).

Circular economy consider all kinds of waste such ground to reuse and redesign these wastes. Specific vigilance interrogates long-term products, for which have to be find new alternate usage against to landfilling or burning. By potential utilization of waste instead of new sources there is increasing requirements on relevant workers and their knowledge, abilities and other skills in connection to their profession (Kiørboe, Sramkova, Krarup, 2015; Ingebrigtsen, Jakobsen, 2007).

3 Methodology

There was realized questionnaire survey between workers in engineering companies in Czech Republic and Germany. These companies operate in Brno and Stuttgart. The purpose of the research was to verify, if workers have awareness of industry 4.0 and potential changes of this industry revolution. For this survey there were asked 350 workers, from which decided to participate 110 workers from engineering companies (return rate was 31,43 %). To processing, there were used only 95 questionnaires forms, which were complete fulfilled.

Main objective of the paper is discover potential relations between defined variables (as follow). There are assigned hypotheses in connection to exception of potential threats of industry 4.0 in 10-years future:

- H1: Does exist connection between skill education and potential future threat?
- H2: In case of more professions ability there is potential future threat.
- H3: Cognizance of workers' about industry 4.0 concept could provoke potential future threat.
- H4: Foreknowledge of industry 4.0 concept raise potential future threat.

Gained data were processed by IBM SPSS Statistics 25. Then, there was applied calculation of dependency between two nominal variables by means of contingency tables and Pearson's chi-squared test. Pearson's chi-square test for independence of variables provides basic view on relationship between variables and help to show specific intensity of the dependency. For supporting of the results, there is applied correspondence analysis as visual displaying of the connection knowledge of industry 4.0 and country of companies, which explains situation in technical education (not only in schools, but in lifelong education and training).

Correspondence analysis describes relation between two nominal variables in pivot table and individual categories. In pivot table there is category combination which should become significant or not. If any categories are similar or associated, there are located in graph near themselves. There are nominal variables as input into correspond analysis, and kind of premise, that there is no ordering between variables. Correspond analysis processes dimensional homogenous data which consist only positive values or zeros. Chi-square range has become coefficient which excludes zeros, and help to define relations between rows and columns (McGarigal, Cushman, Stratford, 2000; Beh, 2010, 2008; Kudlatz et al., 2014).

The pivot table in correspondence analysis requires data matrix n×2 with two categorical variable: r values for A ($a_1, a_2, \dots, a_r$) and s values for B ($b_1, b_2, \dots, b_s$). The table consists n_{ij} frequency of chosen variables, which afford amount of cases, including both of a_i and b_j. For purpose of the table there was used relative frequency for relevant cases. As result of theoretical frequency evaluation there was turned chi-square statistics with adequate distribution and (r-1)×(s-1) degrees of freedom, which lead to decision, if between chosen variables in sample population could be defined dependency (Beh, 2010; Kudlats et al., 2014).

4 Results

Due processing of the gained data there was employed Pearson's chi-square test of independence between chosen variables, which afford to define potential influence of these variables. During analysis, there was applied test of dependency with paucity of external influence. On base of described theory, there is assigned hypothesis (see chapter 2), which had to be transformed into statistical hypothesis. These statistical hypothesis are designed of null form (as follow). In case of acceptation of alternative hypothesis, there is change in explanation from *"there is no dependence"* to *"there exist dependence"*, which could be consider as statistical hypotheses (and could be put under statistical evaluation):

- $H1_0$: working in educated profession does not arise threat;
- $H2_0$: control skills of more professions does not evoke threat;
- $H3_0$: workers' opinion of industry 4.0 does not provoke threat;
- $H4_0$: foreknowledge of industry 4.0 does not set up threat.

Main problem of Industry 4.0 concept is that it is still unknown by industrial environment, managers of manufacturing companies and as well by appropriate employees. In case they know this concept, they usually have kind of myth in their minds. Therefore, authors want to answer if working experiences, theoretical knowledge can impress potential acceptation of the concept in individual corporate fields (with no reference to the kind of industry).

There were participated 95 employees, which are employed in three locations, in German (Stuttgart area) and in Czech Republic (Brno area) and in Canada (Windsor are, Ontario). These locations were chosen on connection to their focus in heavy-machinery industry. For purpose of the research were asked their employees, from which coincide to participate and deliver fulfill questionnaire only 95 persons. Their answers were categorized and put under evaluation by chosen statistical methods.

To verify defined premises, a pivot table was created for question "Do you except threat of position in next 10 years" with (1) working in educated profession; (2) control skills of more professions; (3) workers' opinion of industry 4.0; (4) foreknowledge of industry 4.0. Individual values of potential connection between variables are displayed in Table 1.

Pivot table shows relations between factors of threat expectation in the future and consciousness of industry 4.0 as concept. It is obvious that employees consider their working positions as substantial for the company and they don't feel any potential threat because of the implementing of automatization. The biggest group includes respondents describes situation, that after automatization there will be still required high qualified workers (34 persons). In the second group of respondents there are 33 workers, which need of qualified workers. The third group didn't mention any specific reason for future need (17 persons).

Table 1 Pivot table of variables in linkage to potential future threat

			No answer	**no, my profession would be still required (lack of qualified workers)**	**no, my profession would be still required**	**no, my profession would be still required over automatization**	**yes, automatization decrease difficulty of work**	**yes, robots replace workers due standardization and automatization**	**Total**	
H1	**educated profession**	*qualified by experience*	1	8	6	19	1	0	**35**	**95**
		yes	3	25	11	15	5	1	**60**	
H2	**multi-profession skills**	*no answer*	0	0	1	0	0	1		**95**
		no	1	13	1	15	3	0		
		yes	3	20	15	19	3	0		
H3	**comprehension of industry 4.0**	*no answer*	1	0	1	0	0	1		**95**
		fiction	0	3	1	1	0	0		
		behind us	0	1	0	1	0	0		
		computer coming	0	1	0	0	0	0		
		Robots	0	9	4	9	0	0		
		digitalization	3	19	11	23	6	0		
H4	**foreknowledge of industry 4.0**	*hear first time*	3	19	9	11	0	0		**95**
		do not know details	1	14	5	19	1	0		
		know details	0	0	3	4	5	1		
	Total		**4**	**33**	**17**	**34**	**6**	**1**		

Source: own work by authors

According to premises there is kind of limitation because some cells have zero value, which usually requires merging of separated answers. All of these values were put into determination of proposed affinities and evaluation by Pearson's chi-square test for variable independence.

From realized test of independence, there was employed Pearson's chi-square test for independence. Due the processing of the data there was important to reach significance level of 95 %. This level could be described as the situation, in which exist 5 % fault in case of choosing alternative hypothesis. This error value is recall as significance, regard as level of reliability. If the value of significance is less than 0,05, than is possible to accept alternate hypothesis and is possible to conclude existence of dependence between chosen variables.

To confirm defined hypotheses H1-H4 there are displayed relevant results in table 2. According to these values there were gained two dependencies (in the significance level of 95 %). The intensity of the dependency is given by contingency coefficient. The values of contingency coefficient range in <0; 1>, where values closed to 0 represent weak power of dependence; values closed to 1 convey strong relationship. Based on results in Table 2 there were confirmed only two hypotheses:

- There exist dependency between multi-profession skills and future 10-years' threat (significance = 0,000). The intensity of the dependency is 0,611. Hypothesis $H2_0$ is declined and is chosen alternate hypothesis.
- Between foreknowledge of industry 4.0 and future 10-years' threat is also defined dependence, which confirm value of significance = 0,002. The power of this dependence is in 0,538. Hypothesis $H4_0$ is declined and is chosen alternate hypothesis.

For hypotheses H1 and H3 there are no statistical validation to believe, that there is dependence. Their significance values are over 0,05 and is not possible to corroborate their relationship between variables. In case of H3 observed value is closed to limit significance value (sig.=0,055) and could be required to monitor this connection.

Table 2 Gained values of processed test of independence

	Pearson value	Significance	Intensity
H1: Future 10-yers' threat and educated profession	6,412	0,268	0,290
H2: Future 10-yers' threat and multi-profession skills	41,673	0,000	0,611
H3: Future 10-yers' threat and comprehension of industry 4.0	37,235	0,055	0,589
H4: Future 10-yers' threat and foreknowledge of industry 4.0	28,463	0,002	0,538

Source: own work by authors

Main problem of the industry 4.0 concept is that lot of managers and employees don't know specification and relevant definition, which help them to improve their work setup and single work. From point of view of country of company there it is obvious that industry 4.0 would be well known mainly in Europe. Arntz, Gregory and Zierahn (2016) mention that workers in OECD countries fear of the automatization, which replace them in production. Therefore, it is necessary to rebut apprehension and destroy myths, connected to industry 4.0. This situation confirm work of Krzywdzinski, Jürgens and Pfeiffer (2015). Table 3 consists values of knowledge Industry 4.0 according to countries of workers, which participated in the survey.

Table 3 Forknowledge of industry 4.0 according to country of company

	GE	**CZE**	**CA**	**Total**
First meet	4	33	6	43
	4,21 %	*34,74 %*	*6,32 %*	
Know without details	15	24	1	40
	15,79 %	*25,26 %*	*1,05 %*	
Know details	7	5	0	12
	7,37 %	*5,26 %*	*0,00 %*	

Source: own work by authors

To display the connection of industry 4.0 knowledge and country there is applied correspondence analysis. Gained map, as the result of the correspondence analysis, shows connection between country of company and industry 4.0 knowledge in two-dimensional plain. For creating correspondence analysis and its map, there is necessary to employ load indicators, which describe information about specifications of categories, located in the table. This information is assigned in percentage values. Values of these loading indicators are acquired such ratio figures of the frequencies in rows (n_{i+}) and columns (n_{+j}) according to all categories in the table (n).

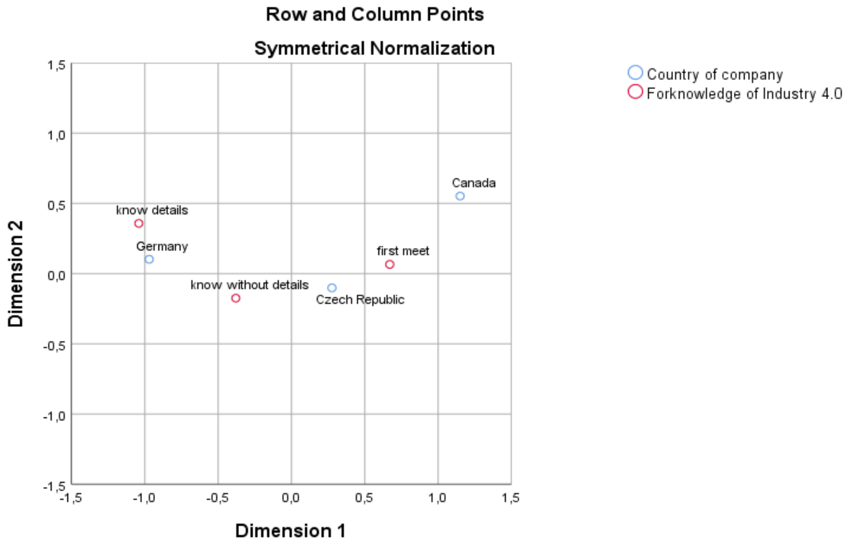
Correspondence map needs to get dimensions score, that indicate the percentage of represents' information athwart specified categories in the computing table. These scores should be figured such kind of ratio, similar for both of row (n_{i+}) and column (n_{+j}) frequencies of all defined individual categories in basis table.

Score values of individual variables are defined in two different dimensions, which are indeterminate in space due reduction of multi-dimension space (within reduced data in both of rows and columns). This reduction of variables does not degrade specific information of raw data, which were put into the reduction process. For confirmation of correspondence analysis there are used so called inertia indicators, which represent proportion of comprehensive information on the relevant point of view of new dimensions. The value of inertia indicators is independent on the number of original dimensions (Hebák et al., 2007; D'Esposito et al., 2014).

According to algorithm in correspondence analysis there is defined relationship between country origin of country (where companies operates) and knowledge of industry 4.0 as individual variable categories. The result of correspondence analysis (as column and row points by two-dimension solution) is depicted in Figure 1. The usage of symmetrical normalization helps to verify relationship between variables. Likelihood of application was confirmed by significance value of Chi-square test, which was gained at value 0,029.

According to results, displayed in Picture 2, it is obvious, that knowledge of industry 4.0 concept is well known mainly in Germany, where this concept was developed. There are two divergent groups of relationships. For companies, which operate in Czech Republic, are usually closely connected with companies in Germany. In case of Canadian companies this concept is quite unknown for them (according to observed data in research).

Picture 2 Symmetrical correspond map of knowledge of industry 4 and country of company



Source: own work by authors

6 Conclusions

According to Černíková (2018) industry 4.0 concept is regarded as key area for future development of business activities on the way of creating representative assets (both tangible and intangible). This future development of business activities requires adequate knowledge in individual national industrial environment and accurate number of skilled employers.

In general point of view, employees are afraid of loss of their job because of the automatization and digitalization of production system in their company. This fear is based mainly on the innocence of the concept. The concept of industry 4.0 provides relevant information, which are needed for fast adaptation of production processes and other technical aspects, divided from present technological progress (Rojko, 2017).

Main objective of the paper is confirm assigned hypotheses in connection to exception of potential threats of industry 4.0 in 10-years future (see Table 2):

- H1: Does exist connection between skill education and potential future threat? [rejected]
- H2: In case of more professions ability there is potential future threat. [confirmed]
- H3: Cognizance of workers' about industry 4.0 concept could provoke potential future threat. [rejected]
- H4: Foreknowledge of industry 4.0 concept raise potential future threat. [confirmed]

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