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THE IMPACT OF INDUSTRY 4.0 ON THE EMPLOYMENT STRUCTURE IN PRODUCTION PLANTS

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Purpose: The aim of the study is to present the changes taking place in the employment structures of production plants, occurring as a result of the implementation of modern production management and control systems as well as the automation of production processes in line with the assumptions of Industry 4.0**.**
Design/methodology/approach: The study uses methods of analyzing literature sources and quantitative research with the use of interviews among production plants implementing new technologies in line with the assumptions of Industry 4.0.
Findings: As a result of the analysis, the results were obtained indicating the direction of changes taking place in the employment structures of production plants implementing automation of production processes in line with the assumptions of Industry 4.0.
Social implications: The conducted analysis may increase social awareness of the need to adapt the skills and competences of employees to the needs of the market in the Industry 4.0.
Originality/value: The article presents an alanlize indicating the direction of changes taking place in the employment structure in production plants implementing the assumptions of Industry 4.0, which were compared with the assumptions of the literature.

Keywords: Industry 4.0, employment structure, market needs.

Category of the paper: Case study.

1. Introduction

Recently, a dynamic development of technology has been observed, allowing for revolutionary changes in the way production plants operate. Changes in the technological area, as well as those concerning the philosophy of management, relate to virtually all areas of business operations. The technological possibilities that we currently have at our disposal and the prospect of their development mean that an unprecedented industrial revolution is taking place before our eyes (Woźniak et al., 2019). The great interest in the new approach is due to the potential benefits of using solutions appropriate for a given production plant. Changes taking place in the area of technology of production works, but also management systems, cause, among others, an increase in the production capacity of the plant while reducing the waste (Rüßmann et al., 2015). To obtain a competitive level in the area of manufacturing process management, it is necessary to digitize production processes with artificial intelligence processes (Bieńkowski, 2018). This fact becomes the basis for the implementation of Industry 4.0 (Zhong et al., 2017). The ability of decision-makers to quickly adapt a production plant to the prevailing standards in the technological sphere and the method of process management is the basic factor enabling the survival on a market characterized by a high level of competition. Adapting production plants to the prevailing technological standards in line with Industry 4.0 requires a huge commitment of all employees, regardless of their position (Rymuszewska et al., 2017; Pedone, Mezgar, 2018). It is recognized that adapting to the ongoing changes may be particularly difficult for small and medium-sized enterprises (Müller et al., 2017). The implementation of new systems and reorientation of the method of conducting production works requires a partial or, in some cases, complete reconstruction of the organizational structure of the production plant, taking into account the human factor, as a key substitute for a properly functioning production process. Due to the scale of changes that take place in the structure of employment in a production plant and the role of a human being in the light of the implementation of the assumptions of Industry 4.0, many works have been written to describe the potential consequences that directly result from increasing the level of automation and reorienting the production management method (Müller et al., 2017, 2018b; Bendkowski, 2017; Birkel et al., 2019; Kiel et al., 2017). Research is also carried out (Müller, 2019) in the field of analysis and identification of difficulties that an employee may encounter in the case of implementing Industry 4.0 solutions and the associated consequences.

The purpose of the article was identification the changes taking place in the employment structures of production plants, occurring as a result of the implementation of modern production management and control systems as well as the automation of production processes that fit into the framework of Industry 4.0. The conducted analysis was based on the analysis of data from production plants with a high level of automation and computerization of production processes, in line with the philosophy of Industry 4.0. The collected information will allow to present the current situation on the labor market and the needs of production plants for a strictly defined profile of an employee.

2. The essence of Industry 4.0

Industry 4.0 marks the fourth industrial revolution, which is defined as a new standard of organization and control management throughout the product life cycle chain (Vaidhya, 2018). The aim of the fourth industrial revolution is to meet the individual needs of customers and to develop other areas of the industry such as research and development of production concepts (Sang, 2018). In order to achieve the assumed goals, it is necessary to build intelligent IT platforms that will allow the monitoring of selected data in real time, which will directly facilitate the process of identifying potential inconsistencies in the manufacturing process (Almado-Lobo, 2015; Bahrin et al., 2016). Industry 4.0 is a generic term for sets of strategic frameworks and initiatives, and a technical term that refers to the newly emerging, digitization of business assets, processes and services (Radanliev et al., 2021). It is assumed that the fourth industrial revolution in the coming decades will be the engine of industrial development (Richert et al., 2016).

Huge interest in the subject of Industry 4.0 is caused by the deep conviction that the solutions proposed by this revolution will allow for the growth of individual production indicators, determining the position of a given entity on a highly competitive sales market (Kagermann, 2014). As already mentioned, Industry 4.0 is also often called the "fourth industrial revolution", thus referring to the previously occurring changes taking place in industry, i.e (Lis, Małysa, 2021):

- Industry 1.0 – an industrial revolution aimed at mechanization of production processes using water and steam powered machines.
- Industry 2.0 – increasing efficiency through the use of division of labor and electrification of machines.
- Industry 3.0 – automation of production processes using IT technology.

The concept of the fourth industrial revolution was first used in 2011 in Germany by a group associating representatives of science, business and politics. The initiative taken was related to the increase in the competitiveness of German companies on the global market (Kagermann, 2014). The increase in competitiveness is caused by assumptions based on the full integration of systems, computer networks and people with maximally (as far as possible) automated production processes using information technologies and the ubiquitous unification of the world of machines with constantly developing new data transmission technologies (Hermann et al., 2015). In Industry 4.0, cyber-physical systems are treated as general-purpose technologies that are based on the so-called "Internet of Things" (Lasi et al., 2014). The Internet of Things represents a developed and interconnected control system that uses a sensor and other connected devices to collect, exchange and analyze data to improve performance, energy management and other economic benefits (Boyes et al., 2018). Cyber-physical systems offer human-to-human relationship mechanisms, human-object and object-object interactions, which in the context of industrial production can be defined as cyber-physical production systems (Schlechtendahl et al., 2015). The use of cyber-physical systems in industry covers both production areas and logistics processes, while supporting the entire the production chain through real-time monitoring, forecasting, remote diagnostics of potential errors and remote control (Müller et al., 2018; Nicolescu et al., 2018).

The essence of the discussed industrial revolution is the reorientation of the decision-making side from the hands of people to the competences of artificial intelligence. Such action causes blurring the boundaries between what is digital and what is biological (Lis, Małysa, 2021). The assumptions of the new organization of work through the implementation of systemic activities in the area of Industry 4.0 are aimed at increasing the flexibility and efficiency of production works. The concept of automation of production processes supported by artificial intelligence tools allows for a comprehensive approach to the process by creating and using informal networks of knowledge and specialist knowledge cooperating with the human factor (Archibugi, 2015).

3. The role of man and the fourth industrial revolution

In the Industry 4.0 concept, human knowledge and skills play the most important role. One of the greatest concerns regarding the implementation and maintenance of the technological foundation that is the basis of the implemented industrial concept from the perspective of the human role is not a technological barrier, but a change in the organizational culture and the acquisition of new competences by employees (Bieńkowski, 2019).

The assumptions of Industry 4.0 assume that the role of man, his skills and qualifications will be the key to the effective implementation of the philosophy of Industry 4.0 in highly modern factories of the future (Gehrke et al., 2015). Progressive computerization production and focus on advanced technologies will be associated with significant changes in the professional qualifications profile of employees (Bendkowski, 2017). The requirements for the qualifications and skills of employees will be higher than today, because companies will use new technologies and intelligent media, therefore the method of educating employees will also change (Harkins, 2008; Huba, 2016). The selection of the right staff and the development of the current staff and their continuous training is a key factor and, at the same time, a challenge for the management of production plants (Armstrong, 2014).

In the Industry 4.0 concept, employees must perform more technologically complex tasks, such as cooperation with machines. The main task of employees is to observe and regulate highly automated complex processes and to supervise them rather than the physical execution of production works (Deuse, 2015). Therefore, the analysis of large amounts of data, design, control and interaction with machines in the case of Industry 4.0 are the basic elements of the future tasks of production plant employees (Gehrke et al., 2015). Due to the increase in automation and the change of the human role in the production process, in many cases the potential threat resulting from the implementation of Industry 4.0 is the reduction of employment (Ittermann et al., 2015). According to research conducted by the Fraunhofer Institute, most enterprises assume that the employment level in industry will remain unchanged

(Kurz, 2015). Undoubtedly, however, it can be said that regardless of the increase or decrease in employment in the context of the philosophy of Industry 4.0, the role of man in the organization is changing. The article (Bendkowski, 2017) presents two scenarios that describe the potential roles of humans in the highly automated factory of the future. The first scenario assumes full automation of production processes. Planning, scheduling and management of production resources will be carried out by social engineering production systems. The workforce will be reduced to a small group of highly specialized experts, whose primary responsibility will be to install and maintain systems coordinating production works. The group of blue-collar workers will be reduced, and they will perform basic activities that do not greatly affect the production capacity of the plant. The second scenario assumes that employees with specific skills control the production process with the support of intelligent computer systems. The discussed scenario describes the interaction and control of processes and employees with the assumption that a person is the decision-making party. In the works (Herrmann et al., 2014; Peukert et al., 2015) highlight the potential social benefits resulting from the implementation of industry 4.0 principles, which include compensation and increase in wages, which may directly translate into increased motivation in employees.

The impact of Industry 4.0 on human roles in a production plant is not yet known. Thanks to new technologies, the implementation of innovative control systems and the evaluation of existing production practices, we will not know the social consequences related to the implementation of the concept of Industry 4.0 until the future.

4. Purpose, scope and methodology of research

The aim of the study was identification the changes taking place in the employment structures of production plants, occurring as a result of the implementation of modern production management and control systems as well as the automation of production processes that fit into the framework of Industry 4.0. The conducted analysis was based on the analysis of data from production plants with a high level of automation and computerization of production processes, in line with the philosophy of Industry 4.0.

In order to carry out the analysis, first, production plants were selected, characterized by a high level of automation of production processes and an extensive IT network allowing for remote control of production processes and information flow. All analyzed production plants operated in the automotive industry, which over the years introduced numerous improvements in the implementation of automated production processes and changes in the level of management included in the assumptions of Industry 4.0. The decisive factor when choosing a given production plant was a significant increase in the degree of automation of individual production operations (at least 40% more than in the historical data). In each of the production plants, by people with knowledge of the employment structure, questions were asked about the amount of employment in selected occupational groups and the level of education of employees (interview method). Then, the current state was compared with the historical state recorded in each of the production plants. Due to the different date of establishment of the analyzed plants, the period of historical data was between 5 and 10 years. For the purposes of the research, nine production plants with various levels of employment were analyzed (Figure 1).

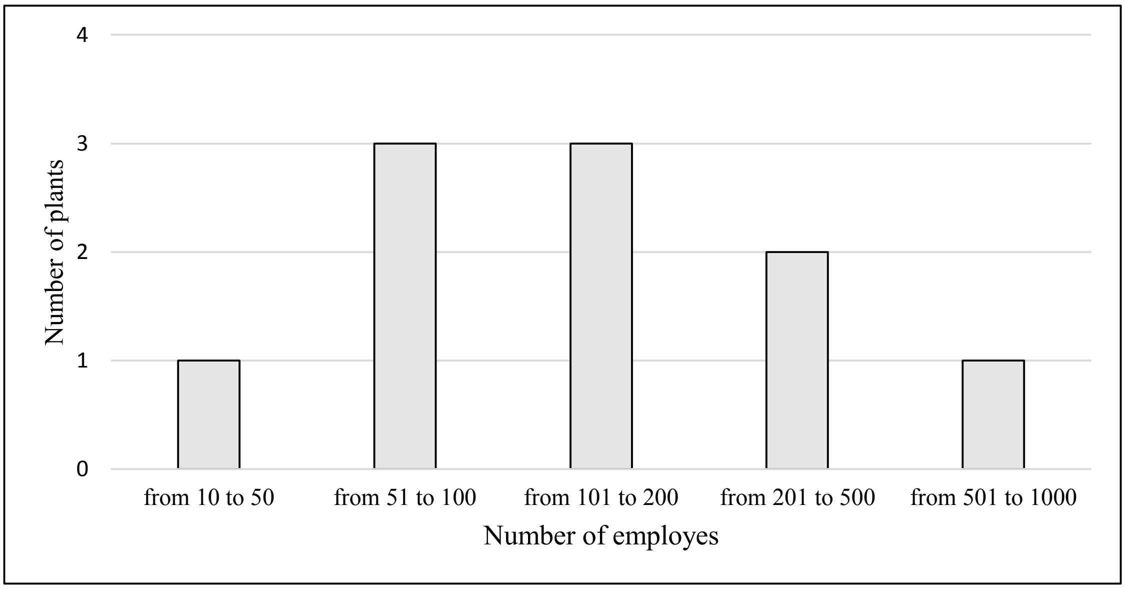

Figure 1. Employment in the analyzed production plants.

In each of the companies, the employment structure was divided and compared according to the positions held, which include, among others:

- Production workers (PW) – people who work physically on the production line, maintenance and warehouse.
- Engineers (E) – people managing production processes in terms of process control, production design and product technology, quality engineers.
- Administration staff (AS) – finance, HR, marketing, etc.
- Customer service (CS) – sales.

Then, an analysis of the level of education of employees was carried out, broken down into basic (B), primary (P), secondary (S) and higher education (H). The last verified element was the analysis of the number of people employed in the company over time. Due to the different level of quality of the information obtained in individual production plants, in 3 cases it was not possible to obtain information on the level of education of employees employed in the past.

5. Research results

As a result of the conducted analysis, average data on the employment structure in individual production plants were obtained, taking into account the positions held by employees and the level of their education now and in the past. The presented quantitative results also take into account the highest and the lowest levels recorded in the studied group (Figure 2, Table 1).

Table 1.
Employment structure of employees of production plants in the past and today

Group	Current average employment [%]	Historical average employment [%]
Production workers (PW)	61	72
Engineers (E)	9	10
Administration staff (AS)	19	12
Customer service (CS)	11	6

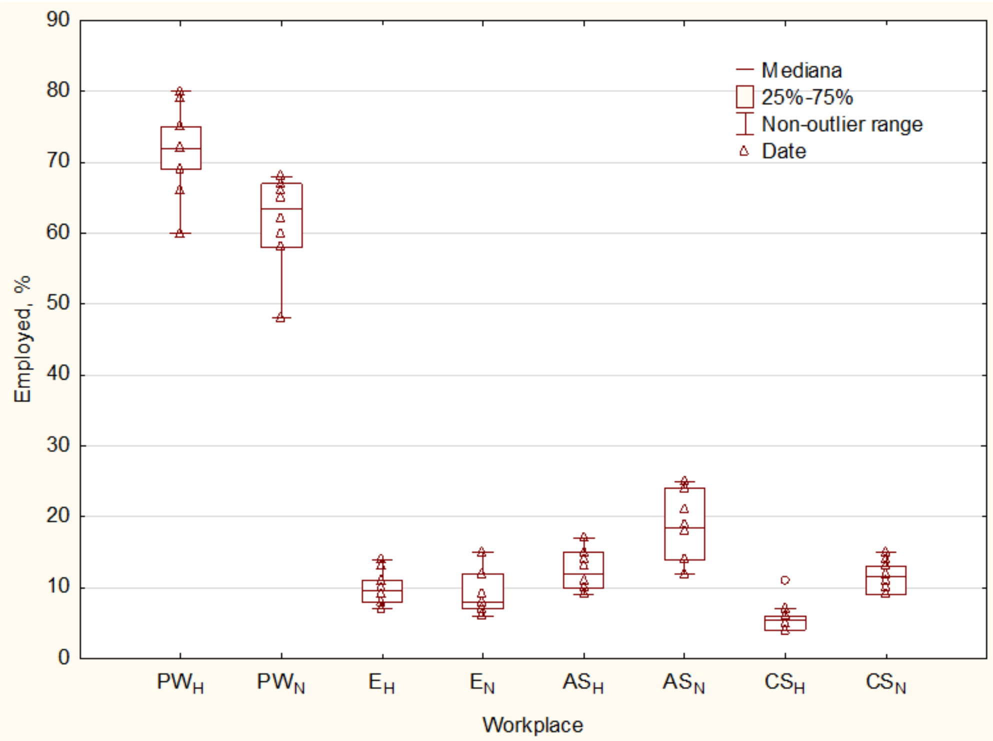

Figure 2. Employment structure of employees of production plants (where "H" – historical data, "N" – curent data).

The compiled data made it possible to indicate significant differences in the employment structure of production plants now and in the past. The biggest difference concerns the percentage increase in the administrative staff and sales compared to the historical data. There was also a significant decrease in the number of production workers, which seems to confirm the assumed trend described in (Kagermann et al., 2011). The high level of automation of individual production operations integrated with remote production control systems reduces the number of production stations to which manual workers are involved. The percentage decline in employment in a large group of production workers carries one of the threats described, among others, in (Müller, 2019). It concerns the potential possibility of a decline in employment, which is directly related to an increase in the level of unemployment in the labor market.

In the case of the analysis of the level of education, the largest percentage change concerned the share of employees with higher education. Currently, the average level of employees with higher wages was recorded at the level of 39%, while in the previous years this share was 19%, which confirms the assumptions presented in (Müller et. al 2018b) concerning the greater demand for specialized staff in the case of implementing the assumptions of industry 4.0 (Figure 3, Table 2).

Table 2.
Education of employees of production plants in the past and today.

Group	Current average employment [%]	Historical average employment [%]
Higher (H)	39	19
Medium (M)	42	39
Professional (P)	15	30
Basic (B)	4	12

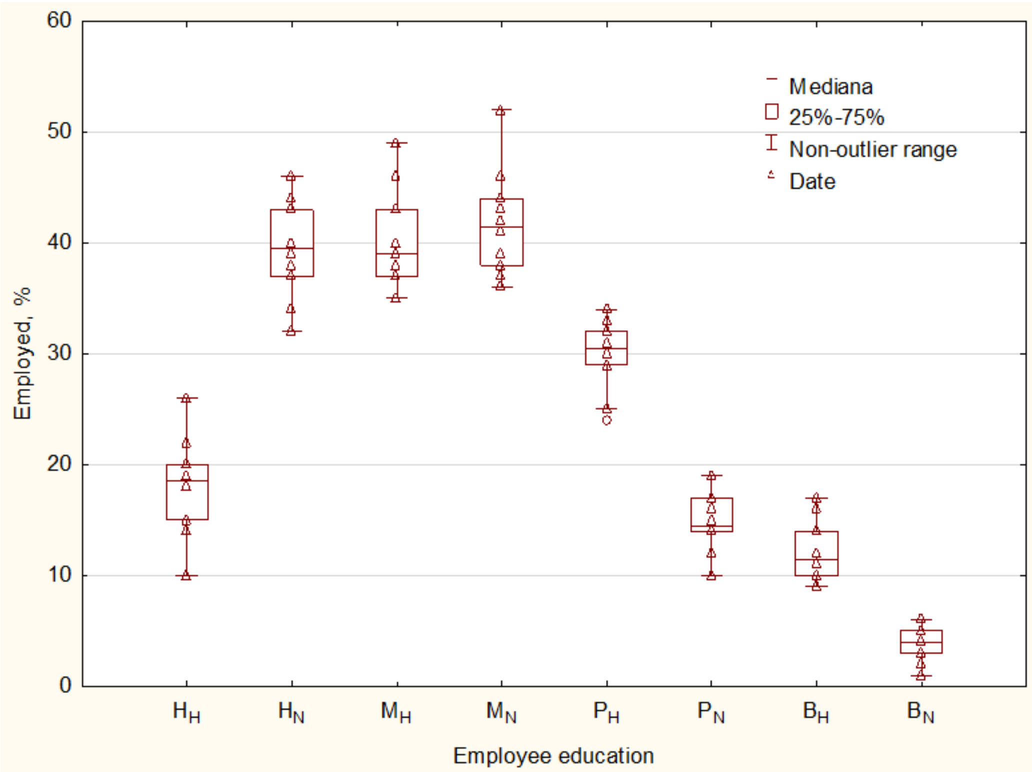

Figure 3. Education of employees of production plants where "H" – historical data, "N" – curent data).

One should also pay attention to a significant decrease in the case of employees with vocational and primary education. Currently, secondary vocational and elementary education in the analyzed production plants is 15% and 4%, respectively, while in the past it was 30% and 12%, respectively. Such a significant change may be related to the reduction of selected positions, e.g. in production, resulting from replacing human work with a machine. The social risk related to the decline in employment of employees with a lower level of education, resulting, inter alia, from the reduction of many positions, is described in (Birkel et al., 2019; Kiel et al., 2017).

The obtained results in terms of the analysis of the percentage level of education seem to confirm the theses presented in the BGC (Boston Consulting Group) forecasts (Bendkowski, 2017). Indicating that due to the increase in automation and computerization of production processes and control, a larger number of specialized staff is necessary.

6. Summary

The increase in the level of automation of production processes resulting from the need to adapt to competition and the ubiquitous computerization of all production processes forces changes taking place in the employment structure. The requirements for the skills and competences of employees are evolving, many new positions are created that did not exist before, for example, manual workers who are replaced by robots or machines with a high level of automation. The occurring changes increase the level of production efficiency and the quality of the finished product, but may have a negative impact on certain groups of workers, which in many cases were the foundation in manufacturing plants (manual workers). As a result of the literature analysis and quantitative research aimed at identifying changes taking place in the structures of production plants with a high level of automation, it was found that:

- Currently, the average number of production employees has decreased by approximately 11% from the pre-deployment highly automated advanced production systems.
- There was an increase by 20% of employees with higher education compared to previous years.
- There has been a decline in the percentage of employees with basic and primary education as compared to the historical data (before the introduction of automated manufacturing systems).
- The data obtained from the quantitative analysis confirm most of the forecasts made in the literature on the subject of significant changes in the employment structures of production plants as a result of the implementation of advanced production systems with a high degree of automation and a change in the orientation of the management method in line with the assumptions of Industry 4.0.

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