

Effects of Industry 4.0 on Human Capital and Future of Jobs

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Abstract. The ever-increasing digitalization, automation and robotization of business processes will lead to a proliferation of workplaces with a high level of complexity, which will lead to the need for continuous staff training. The challenge for businesses will be able to adapt to changing environmental conditions to remain competitive. Despite increasing attention being paid to the job and skills changes brought about by Industry 4.0, research in this area is still scarce. The aim of the present theoretical research is therefore to introduce the issue of Industry 4.0, and its impact on the workforce and the future of jobs. Through the available domestic and foreign literature, we have provided a theoretical overview of recent studies, that address the issue of the impact of Industry 4.0 on the labor market. Findings point to trends in the disappearance of certain jobs and the creation of new jobs, that concept of Industry 4.0 offers in the form of opportunities. Our search also resulted in a summary of the worker's competences, which meet the requirements of the Industry 4.0 era, as well as a set of key solutions for businesses in human resource management.

Keywords: Industry 4.0, Human Capital, Future of Jobs.

JEL classification: M12, M19, M29

1 Introduction

The topic of the Fourth Industrial Revolution, the evolution of jobs, and consequently changes in human capital issues is of increasing interest to researchers [8], policy makers [42], and managers from corporate practice [30]. Adoption of the automation and technologies in digital environment in manufacturing – like cyber-physical systems, cyber-security, Big Data, augmented reality, Internet of Things, cloud computing, simulation, robotics, additive manufacturing, systems integration [34] - predict to significantly affect work processes and the work environment [20]. The new

era will lead into changes within jobs in terms of content, and new job occupations will emerge. Based on the above fact, higher skill requirements will be demanded from employees [15,42]. Despite increasing attention being paid to this topic, research addressing the impacts of the fourth industrial revolution on jobs and skills is lacking [8,16].

What will the further development of the industry look like? Will further development offer new job opportunities or destroy jobs? What will the further development of job profiles look like? And what categories of skills will be in need? The answers to mentioned key questions will need to be replied by business leaders and policy makers to seize the opportunities presented by Industry 4.0 by ensuring an adequately skilled workforce [30]. As a result, the qualifications and skills of the workforce needed to meet the demands of the modern era will vary significantly [7,18,25,26].

In the following theoretical research, we will focus on the emerging changes triggered by the impact of Industry 4.0 on the workforce, and we will also discuss the topic of the future of jobs. Through a study of the literature, we will provide answers to the individual research questions within the framework of the issue at hand.

2 Literature Review

2.1 Four Industrial Revolution

The concept of the fourth industrial revolution, otherwise known as Industry 4.0, was first introduced at the Hannover Messe in 2011, captivating not only manufacturers but also the scientific community [39]. The scientific literature characterizes the concept Industry 4.0 in different ways. One group of authors explain Industry 4.0 [19] as the digital integration of manufacturing processes, in which processes of production are automated and products, services and equipment are connected. Ongoing revolution is run by the Internet, through which not only human being but also machines will be in contact in a cyber-physical system. Other authors [48] argue that the evolution of manufacturing processes is run by market demand for more effective technologies and processes, cost reduction and quality standards, or technological advances. According to Qin and Liu [29], Industry 4.0 performs a significant role in intelligent data collection and interpretation, proper decision making and its timely implementation, which will result in faster data collection and interpretation procedures. Industry 4.0 is a trend of automation and data exchange in manufacturing technology. While the third industrial revolution (Industry 3.0) concentrated on the automation of specific business processes, Industry 4.0 focuses on the digital transformation of companies. This implies a comprehensive digitization of all physical assets and the creation of another digital environment, including the value chain [40]. The generation, analysis and seamless communication of data represent the core benefits, that Industry 4.0 brings, with the aim of bringing together a wide scale of innovative technologies to create value. In the context of Industry 4.0, modern technical systems will be intertwined with processes of organization to transform industries, which will lead into the interconnection of people, machines, and smart objects in real time [5, 6,17, 44].

The idea of Industry 4.0 is attractive in many countries and businesses. This is supported by programmes implemented by national governments, such as "Industrie

4.0" in Germany, "Made in China 2025" in China, "Smart Factory" in the UK, "Advanced Manufacturing Partnership" in the USA [27] "Smart Industry Concept" in Slovakia [35] and many others. However, the implementation of innovative technologies such as those brought about by Industry 4.0 is challenging and complex, especially for developing countries and industries or areas with a lack of technological advancement [38].

Thus, we can say, that Industry 4.0 unconditionally produces new opportunities for businesses, but at the same time many challenges arise from the continuing automation and digitalization [17].

2.2 Consequences of Industry 4.0 for human capital

It is clear, that the work performed by skilled labor in the workplace of the future will be very different from the situation in those of today. Based on the above, the qualification needs and skills of the skilled workforce, that will be necessary to perform tasks in companies responding to Industry 4.0 requirements will also differ [1,18,45]. The study by Gehrka et al. [8] proposed an approach to develop recommendations for the qualifications and skills of the future worker under Industry 4.0 conditions. The approach is based on a three-level analysis. The first level consists of four factors, that have a significant impact on human capital and will significantly change the way businesses operate in the future. These are: tools and technologies, organization, and structure, working environment, intra-organizational and inter-organizational cooperation. The first level factors determine the second level, which represents skilled labor tasks. The third level is the skills and qualifications of the workforce, which builds on the second level. More specifically, the qualifications and skills required for a skilled workforce to perform a job effectively are determined primarily by the job tasks.

The costs associated with workforce training are just one of the other elements, that businesses need to allocate their financial resources to [13]. Before the actual introduction of automation and robotics, companies should implement many changes - from technology to human resources. Important changes include, for example, changes to existing production systems and models in companies [32]. An important change will be to adapt workers' skills to the demands of processes of automation, including reconfiguring training programmes to support workers acquire the necessary digital and soft skills, and substituting current processes and systems with ones, that are better suited to adapting to innovative technologies, as well as providing temporary support for those, who will lose impact due to automation [32,41].

The innovations coming with the Industry 4.0 era will also change the relationship between workers and employers. Tasks, projects, that are distributed through cloud platforms will be carried out by independent workers. These include professions such as: UBER driver, or Airbnb host. In the process, they will not be subject to obligations such as minimum wage, employment tax and social insurance as for those classified as self-employed [28].

The employment threat is the concern, that robots will substitute human workers in the future, which lead to increasing unemployment. However, rather than arguing, that the production of robots will result in unemployment, the workforce needs to

acclimatize to the needs of the new age and exploit its potential in areas such as robotics and automation, on the one hand, and areas such as the social sciences, anthropology, the service sector, the field of organic products, agriculture, education, the livestock trade, and the technology trade, on the other hand. New professions, new processes, new production methods, new products and innovative technologies are to be created by people. The revolution of the production process into a digitalization process will not only have negative consequences, quite the opposite. Common workers, managers, and entire companies should react to this process with a strategy of transformation and groundbreaking changes [28].

Based on current trends and experiences from previous industrial revolutions, it is clear, that the impact of Industry 4.0 on the workforce is inevitable. Every industrial revolution has brought efficiency and productivity gains [47]. According to some researchers [11], there is a significant displacement of human labor from an increasing number of jobs [12], which may lead to the trend envisioned by Keynes and known as "technological unemployment" [24]. Mentioned theory states that technological progress will substitute human jobs more rapidly than can create new ones [3,24]. In contrast, other research papers describe positive changes associated with the increase of automation. In the researchers' understanding, the preservation of human health will represent a greater benefit in the long run [4]. For example, the mentioned benefits related to automation are replacement of hazardous and risky jobs, better quality, higher safety, lower costs, and ecologically friendly solutions [9]. According to some views, the automation of the workforce does better than harm, as machines take over responsibilities, that are potentially unsafe or harmful for workers, such as welding or painting cars. In addition to mentioned points, some duties or jobs could also be supplemented by technological solutions, such as the use of virtual reality to decrease possible accidents to zero, or even the enforcement of sensor-driven quality control on production lines to replace monotonous work [4,9,21,31].

Based on the study by Szabó-Szentgróti et al [47], we can divide the positive and negative effects induced by Industry 4.0 in the context of human capital into the following table:

Table 21. Positive and negative effects of Industry 4.0

Positive Effects	Negative Effects
More free time	Rising structural unemployment and inequality
Replacement of human labor with technology does not automatically mean a reduction in employment opportunities	Reduction in the number of job opportunities
Rising productivity, creating new jobs	Shortage of experienced people for an constantly changing labor market
Cost-effective and ecological aspects: higher quality, improved safety, ecologically friendly solutions, replacement of hazardous jobs	Slowdown in global economic growth
Cost reduction	New skills and training requirements

3 Aim and Methods

The aim of the theoretical research is to raise awareness of Industry 4.0 through scientific literature and articles and to highlight the changes in human capital brought about by the impact of the new phenomenon, as well as to draw attention to the future of jobs and the changing labor market.

To analyze the issue at hand, we will use available domestic and foreign sources, that explain in detail the topic of Industry 4.0, changes in the field of human resources in the context of the impact of Industry 4.0, and the future of job positions. With the help of the acquired information, we will arrive at a theoretical explanation of the issue.

We applied basic scientific methods to develop a theoretical paper. We have used: analysis, synthesis, generalization, induction, and deduction. From the information gained, we have developed a significant theoretical knowledge base on the future of human capital and jobs, that meet the requirements of Industry 4.0. Through a thorough analysis of the issues addressed, we arrived at the following research questions:

1. What changes will the pressure of digitalization, automation and robotization cause in jobs? What jobs will disappear and what jobs will be created?
2. What competencies are required from the workforce in Industry 4.0?
3. How should companies respond to the increasing pressure of Industry 4.0?

4 Results

The widespread use of robotics, automation and digitization will have significant consequences for competences, jobs, skills, and professions. The improvement of Industry 4.0 will be supplemented by changes in the roles and requirements of workers in the companies [10,46]. Industry 4.0 will present many opportunities, but also risks connected with it, such as the lack of fundamental changes in labor market governance and the socio-ethical dimension of implementing the breakthrough concept of Industry 4.0. Thus, the biggest challenge of Industry 4.0 will not be technology, but people [43]. Therefore, in the following part of the theoretical research we will reply to the individual research questions, in which we will approach the problem of the impact of Industry 4.0 on human capital:

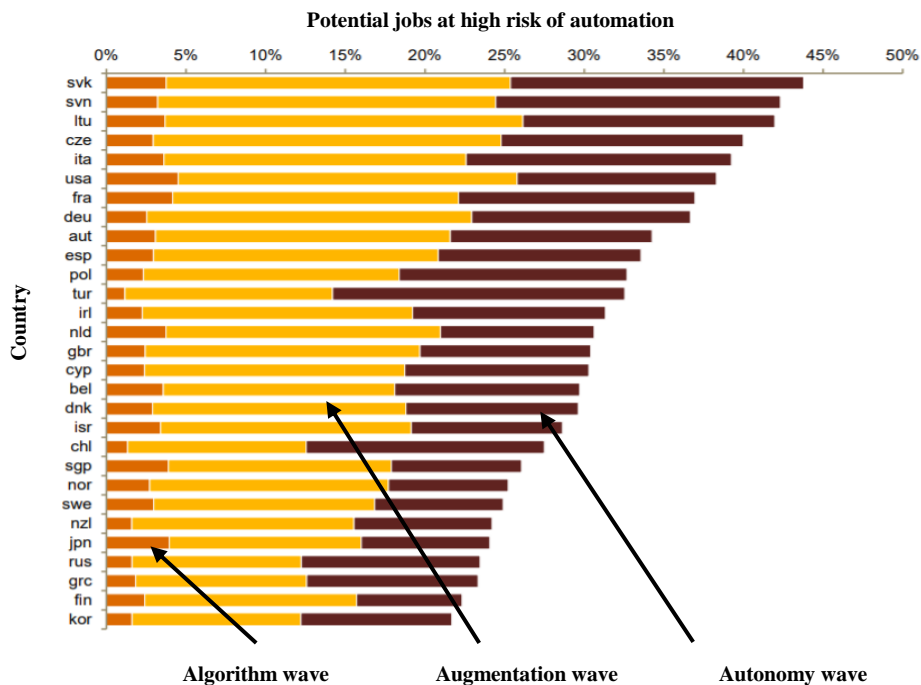
1. What changes will the pressure of digitalization, automation and robotization cause in jobs? What jobs will disappear and what jobs will be created?

Robotics, artificial intelligence, and more forms of automation are improving at a rapid pace and have the possibility to bring major benefits to the economy by increasing

productivity and creating brand new and better products and services. A PWC study says, that new technologies could add up to 14% of GDP by 2030, or around \$15 trillion. These prognoses will also lead into the labor market. The study goes on to outline, how the whole process of implementing Industry 4.0 will evolve in three overlapping waves by 2030:

- **Algorithm wave:** aimed at automating simple computational assignments and exploring structured data in areas such as information communication finance. This wave is already underway.
- **Augmentation wave:** aimed at automating monotonous duties such as form filling, communication and information exchange through technology support, and statistical analysis of unstructured data in semi-controlled environments like robots and drones in warehouses. This wave is already underway but is likely to reach full maturity in the coming period.
- **Autonomy wave:** aimed at systematizing physical work and manual dexterity and problem solving in dynamic real-world situations ,that require agile responses, e.g., in manufacturing and transportation (driverless vehicles). This wave will reach its peak in 2030 [41]

Automation will disrupt labor markets, but its impact varies considerably from country to country. Eastern European economies are the most dominant (over 40%), where manufacturing, which is usually simpler to automate, still accounts for a



relatively high share of total employment. The figure below shows the potential rate of job automation by country in each wave.

Fig. 1 Potential job automation rates by country across waves

Source: PWC. Will robots really steal our jobs? An international analysis of the potential long term impact of automation, <https://sci-hub.se/10.1109/ITMS51158.2020.9259295> , last accessed 2021/8/6 (2019).

A study by the Mckinsey Global Institute [33] adds that between 400 and 800 million workers worldwide will be replaced by automation by 2030. The activities most susceptible to automation include physical activities in predictable environments, such as operating machinery or preparing fast food. Data collection and data processing are other categories of activities, that can be performed increasingly better and faster with the help of machines. It would replace a large amount of work such as mortgage lenders, accountants, back-office activities. The workforce will have to adapt to the new conditions and change careers, and learn the new skills needed. The MIT Technology [36] study adds, that Industry 4.0 will change the environment of many jobs and create new jobs in the future. It will also offer new opportunities for workers with qualifications and skills related to the new technologies, that make up the Industry 4.0 concept. The impact of the intense pressure of the ongoing revolution has led into new jobs, that are increasingly appearing on the job market, such as: growth hackers, data scientists, customer specialists, artificial intelligence specialists, wind turbine service technicians, social media assistants, landfill biogas systems technicians, green marketers.

In the next three years, more jobs are estimated to be added in emerging occupations. Increase will be seen in care giving (37%), sales, marketing, and content creation (17%), data analytics and artificial intelligence (16%), engineering and cloud computing (12%), and culture (8%). Current prognoses for occupations associated to ecological protection and climate change stay low. Only 117,200 new jobs (1.9%) are supposed to be created globally between 2020 and 2022 [13].

According to a study by the World Economic Forum [50], it is predicted that around 54% of employees will need to retrain or upskill by 2022. Professional skills, including analytical thinking and innovation, as well as effective and purposeful learning, will carry on gaining in importance. Employers cite workforce training as one of their top priorities. Around 50% of them need their current workforce to stay in their jobs and use innovative technologies in their work, which means, that they do not plan to make redundancies. In addition, 41% want to distribute funds for staff retraining and 33% said they would only fund training for those workers, who need retraining and upskilling.

Increased technological progress will lead to a significant increase in productivity, decreasing the number of employees needed to reach a given level of output. Though some jobs will disappear, the level of collaboration among people and technologies will increase drastically [30]. Work will be able to be done in efficient places in more efficient times, respecting the needs of the employee, the customer, the individual and the whole team [22]. It will also provide new opportunities for the integration of people with physical disabilities [23].

2. *What competencies are required from the workforce in Industry 4.0?*

The automation and digitalization of the economy will lead to the requirement of upskill workers in industry. Increasing digitalization will make manufacturing processes more challenging and complex [49]. Grzybowska, Lupicka [14] present the results of a survey in selected companies in the automotive and pharmaceutical industries, where eight core competencies, that meet the requirements of Industry 4.0 are listed. These are: entrepreneurial thinking, conflict resolution, creativity, problem solving, decision making, research skills, analytical skills, efficiency orientation. The research highlighted the significance of knowledge improvement as an indicator of the potential of the company. Workers with business thinking skills are particularly needed, because they have a tendency to think innovatively, take responsibility for their work and are productive. This finding also emphasizes the importance of developing creativity and creative thinking. The importance of skills related to decision-making, problem-solving, conflict resolution and efficiency orientation is emphasized. This thinking is probably based on the notion, that the ability to make most advantageous and effective decisions is the only way to improve productivity and acquire strategic advantage. In the study by Hernández de Menéndez [31] points to technical, methodological, social, and personal competences. Technical competences represent media, coding, technical skills, understanding of IT security and continuous acquisition of the latest knowledge. Methodological capabilities represent creativity, entrepreneurial thinking, problem solving, decision making, conflict resolution, analytical skills, research skills, and efficiency orientation. The social competence group includes intercultural skills, language skills, communication skills, teamwork skills, networking skills, ability to compromise, and leadership skills. Personnel capabilities consist of flexibility, tolerance of ambiguity, ability to work under pressure, motivation to learn, sustainable thinking, and compliance.

Generation Z students (people born since 1995) are entering the labor force. This generation has qualities, that fit the emerging technologies of Industry 4.0. Their habits are different from previous generations; they choose 'cool' products instead of 'cool' experiences, they are business and tech-savvy, and they like to co-create culture. In particular, the competencies required of them include cultural and intercultural skills, interdisciplinary thinking, decision-making, lifelong learning, problem solving [2], and processing typical technologies of Industry 4.0 [37].

There is no consensus on well-defined competences responding to the Industry 4.0 environment. However, a critical competency, that future professionals must possess is the ability to use their knowledge in different areas of collaboration to add value. Businesses need to take into account, that employees need to acquire new competences by providing training programmes, that continuously support their development [31].

3. *How should companies respond to the increasing pressure of Industry 4.0?*

According to a study by Lorenz et al. [30], businesses should be able to requalify their employees frequently to keep up with the introduction of technological advances. Though many of them have programs in place to retrain employees, these attempts will

need to be extended and sophisticated. Efficient training programmes for specific work-associated skills should include on-the-job training (e.g., using augmented reality or observing experienced workers performing the task) as well as classroom instruction. Given the scale and range of retraining needed and the need for staff to flex their time, it will be essential to offer training programmes online. There will also be a need for training in a broader set of skills, as many staff will be working on a larger range of assignments. Fostering a positive outlook on change among workers will be needed to enable them to adjust to new processes and tasks. Concept Industry 4.0 is generating new types of connections among humans and machines – interactions, that will have a significant effect on the essence of work and organizational structures. To accommodate the increased variability of production schedules, businesses should consider new working models, that incorporate flexible schedules. Businesses will also require reorganizing decision-making powers. For example, a robot coordinator should not wait for directions from a manager before authorizing a robot to start emergency renovations to production machinery. In many cases, it will be beneficial for businesses to implement flatter organizational structures to handle more scattered use and control of data. Industry 4.0 will also need closer incorporation between the IT company and operations departments, so that software developers completely know how their solutions are worked in production and operators understand how these solutions impact their production lines. Interactions among developers and operators must therefore be designed to ensure, that complex IT tasks are handled seamlessly. Businesses must also make sure, that their staff stay responsible for innovation and coordination of complete processes, rather than trying to automate those processes. If businesses want to achieve in Industry 4.0, they should reflect new approaches to recruitment, that focus on skills rather than qualifications defined by titles and roles. As workers will be working on more tasks, that are not related to their basic education, recruiters will often need to look beyond formal titles to identify workers with the appropriate skills for specialized tasks. This means, that producers should highlight relevant qualities and skills in job specifications, as formal titles and education are less relevant. For example, rather than looking for a mechanic who is specialized to carry out a particular repair, manufacturers should look for a mechanic who is open to change and has knowledge in repairing machines during production hours, specific experience of working with a particular brand of machine and experience of using certain kinds of IT interfaces. To meet the various tasks ahead, companies need to pay considerable attention to 'strategic workforce planning'. This work starts with the systematic gathering of simple information on all workers and the classification of different types of workers into workgroups. Mathematical modelling can be used on the supply side to gain insights on attrition and retirement, and on the demand side to replicate workforce requests given the anticipated rates of Industry 4.0 implementation, productivity improvements and revenue growth of the company. The outputs from the supply and demand models can then be combined to create a complete gap analysis, that will provide insight into the necessary actions, such as people development, redeployment, insourcing or outsourcing, and the implementation of new recruitment targets, that businesses should adopt.

5 Conclusion

The progress of innovative technologies brings about improvements in the quality of life of people and the well-being of society. It is a major driving force in today's global economy [14]. Industry 4.0 connects people, systems, and objects to form optimized, dynamic, self-organizing, value-creating inter-enterprise networks, that affect all company processes. Despite of, most companies hesitate to start digital transformation processes due to significant barriers to implementation, which include uncertainty of financial benefits and lack of expertise [37].

The results of our theoretical research point to the essence of human capital in Industry 4.0 and the effect of Industry 4.0 on the future of jobs. The most significant finding of the theoretical research is, that the next decade will see the rapid replacement of monotonous simple jobs by automation, digitization, and robotics, but the impact of the strong pressure of the ongoing revolution will also lead into new jobs and offer interesting opportunities in the labor market. To be employable in the labor market, future employees will need to have future competences such as decision-making, problem-solving, cultural, and intercultural skills, interdisciplinary thinking, lifelong learning and the handling of standard Industry 4.0 technologies. To accelerate the whole process, companies will also have to respond by retraining their employees, adopting new working and organizational models, recruiting for Industry 4.0 issues, and implementing strategic workforce planning.

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