RESEARCH AND ANALYSIS OF WORKING CONDITIONS IN INDUSTRIAL OCCUPATIONS

VOLUME 3
WORK AND INDUSTRY 4.0 IN THE CONTEXT OF INDUSTRIAL REVOLUTION

Małgorzata DOBROWOLSKA
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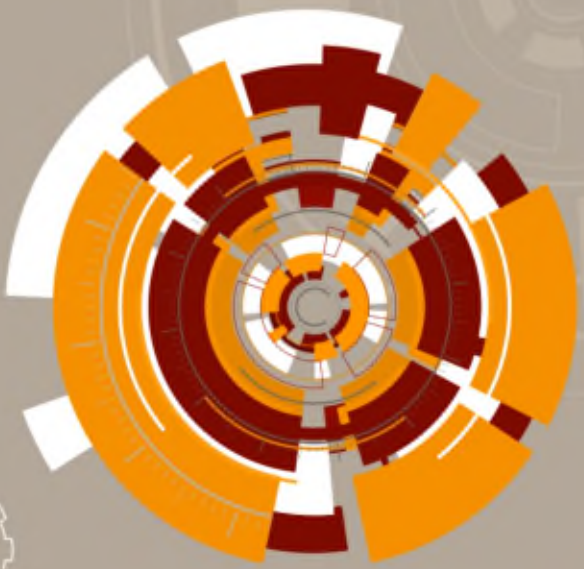

THE FUTURE

MONOGRAPH

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CONTENTS

SPIS TREŚCI

The monograph financed in the framework of the "Laboratory for Research and Analysis of Working Conditions of Industrial Occupations" project. The project was accepted for financing through a competition announced on 24 January 2019 by the Minister of Science and Higher Education as a part of the "DIALOG" programme, established by the Communication of the Minister of Science and Higher Education of 23 January 2019 within the framework of the programme named "DIALOG".

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INTRODUCTION

The monograph presents issues related to the broadly understood industrial technology 4.0 in the world. It is a theoretical and empirical answer to the challenges of the 4.0 sector - dynamically developing and at the same time poorly known in terms of psychological research in this area. The authors of this monograph represent an interdisciplinary team of experts from various scientific fields: technical and engineering, psychology of work and organisation. They also took into account the sociological, philosophical, managerial, and economic perspectives, including contextual threads in psychological and technological considerations, showing a broader perspective, which is particularly valuable for understanding the changes in technological and social progress. The interdisciplinary cooperation initiative resulting with this publication comes from the need to integrate knowledge on the functioning of Industry 4.0 also in its soft aspects related to the functioning of human resources in organisations with a high degree of automation and using the latest technological solutions.

The psychology of work and organisation pays particular attention to understanding of the organisational phenomena and behaviours for increasing the efficiency of enterprises. The monograph presents empirical research carried out in three European countries

(Poland, Germany, Slovakia) in organisations that are examples of the latest technological solutions in the Industry 4.0.

In terms of psychology, certain psychological variables being the individual conditions, cause employees to have more strength, optimism, perseverance, and self-confidence, which allows them to effectively balance burdensome social and professional situations resulting from professional challenges.

In psychology, personal resources include e.g. social support, styles of dealing with stress, positive orientation – location of control, and ego-steadiness. They are of great importance for the individual, because in contact with an emergency, they can be activated by the individual to solve the situation, and this increases the chance to master difficult events. Consideration of personal resources, subjective health potentials, and psychological labour costs becomes more important when examining occupational groups that are particularly vulnerable to stress and feeling of danger at work. The authors of the monograph are interested in employees of Industry 4.0, who work in a difficult environment of full automation, demanding working conditions and numerous stressors. In this industry, not much attention is yet paid to human resources, which – working together in various teams (organic and inorganic) – experience both challenges and difficulties resulting from professional work. The monograph presents the results of empirical research on the subtle relationship between numerous psychological variables, such as positive orientation, ego-compression, D-type personality, personality traits, perception of the professional environment and, among others, feeling the consequences of professional work - psychological stress and feelings of danger.

In the opinion of the authors, the theoretical and application character of the monograph is of particular value. The results of the research could serve as practical solutions to support selected professional groups, especially management staff responsible for building personnel strategies in companies. Only a balanced approach to the development of business and technology, not only through the creation of the latest solutions resulting from automation, but also responsible and clear shaping of personal solutions, can effectively affect the long-term effectiveness of employees and their psychological well-being.

The aim of the first chapter is to develop a shared conceptual framework of the Fourth Industrial Revolution that could supply a base of comprehension for other sections of the book. Therefore, the chapter will cover historical, technological, economical, organisational, and decisional aspects related to the Industry 4.0, concerning what can be named as Industry 4.0 and ultimately Work 4.0. Then, the contribution of this chapter is mainly conceptual to the others.

Our perspective of analysis adopted for the study of the Industry 4.0 and its technologies is not close neither to technological determinism nor to technological solutionism. In the first case, we do not agree that society and human history are determined by the physical and biological laws of technology rather than by human will. Even technology being so important for us, it is above all a social product. The latter considers that all our problems have (as a hidden assumption) an efficient tech solution in the framework of Industry 4.0, and above all with the singularity that will be produced soon by artificial intelligence (AI). The technological singularity would occur when AI overcomes human intelligence in all forms. Considering the dramatic advancement of AI in the last ten years, and the possibility for a singular point similar to the steam machine in this decade, our position is far away from considering that the AI system will display and carry out an attitude of control and dominance over human nature. Therefore, we dedicate a brief analysis of the human-centred design of AI and smart systems.

Starting with this framework, the purpose of this chapter is to make a broad introduction to the Fourth Industrial Revolution or Industry 4.0, dealing with the nature and the dynamics of disruptive digital technologies, evolving at the heart of Industry 4.0. The analysis of some peculiar characteristics of these technologies clarifies some of the social and economic patterns adopted, as economic and social platforms that will also be analysed. On the other hand, it is important to understand the relationships between Work 4.0 and Industry 4.0, focusing on issues concerning the research and analysis of different aspects related to the industrial occupations of the future. Finally, some social impacts on the human decision making process will be reviewed, but also on human capabilities, and relationships at individual and group levels.

The aim of the second chapter is to present selected psychological, psychosocial, and organisational variables of key importance from the perspective of getting to know the research group, i.e. employees of the professions of Industry 4.0. The authors focused on selected variables, referred to in the literature as personal resources, efficiency potentials, and predictors of professional effectiveness. It would be impossible to subject to empirical verification all the interesting authors' aspects of professional activity of the employees of Industry 4.0. In a synthetic way, determined by the care of introducing the Readers into the area of work and organisation psychology, psychological concepts, and some of the theoretical premises, constituting the basis for the analysis of specific variables, were presented.

The third chapter presents the results of empirical research carried out in the research group of workers representing the professions of Industry 4.0. A particular author of the presented research material is its international character. The research was carried out in a

group of Polish, Slovakian, and German workers employed in organisations representing Industry 4.0, characterised by a high level of automation and intensive development of new technologies in the workplace. A practical challenge was to carry out a complex quantitative research in field conditions. In the field of work psychology and organisation, the implementation of empirical research is an extremely difficult undertaking. It requires reaching real workplaces and companies from a given sector or industry. Finding respondents who meet the criteria of the examined group (specificity and nature of the organisation) often means many months' attempts to reach employees. The same was the case with own research presented in this monograph. The inequality of the compared groups of employees (Polish, Slovakian, and German) results precisely from the difficulty of finding the right group of respondents willing to participate in the multi-method survey. This chapter presents the research methodology, the aim of the research, and research questions. The psychological tools used in the research were reviewed. A wide and rich empirical material was also presented - results of own research, which the authors treat as exploratory data. Due to the fact that there is still an insufficient amount of data and results of research on psychological variables among employees of Industry 4.0, the authors treat the obtained results as a starting point for further, complex research, also of comparative nature. The results of the research describe the attitudes, behaviours, and functioning of employees in Industry 4.0 in terms of their personal resources, personality traits, stress, and risk management strategies and many other psychological variables.

The whole work is therefore a demonstration of the changes in human work in connection with the Fourth Industrial Revolution at the beginning of the automation processes that are happening now in the world. This book presents a proposal for the so-called research and analysis of industrial professions of the future, which have been carried out in three selected countries in companies which are included in Industry 4.0. However, the stage at which we are in the process of transformation, is the beginning of the full automatisation of organisations, one of the directions of which the reduction of the human factor is in favour of new technologies. The monograph is an attempt to show the changes in the conditions and specificity of the industrial professions of the dynamically developing works of the future.

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WPROWADZENIE

Monografia przedstawia zagadnienia związane z szeroko rozumianą technologią przemysłową 4.0 na świecie. Jest teoretyczną i empiryczną odpowiedzią na wyzwania sektora 4.0, dynamicznie rozwijającego się, a jednocześnie słabo poznanego pod względem badań psychologicznych w tym zakresie. Autorzy reprezentują interdyscyplinarny zespół ekspertów z różnych dziedzin nauki: technicznej i inżynierskiej oraz psychologii pracy i organizacji. Uwzględniono także perspektywę socjologiczną, filozoficzną, menedżerską i ekonomiczną, włączając wątki kontekstowe w rozważaniach psychologicznych i technologicznych, co jest szczególnie cenne dla zrozumienia zmian w postępie technologicznym i społecznym. Inicjatywa współpracy interdyscyplinarnej, której wynikiem jest niniejsza publikacja, wynika z potrzeby zintegrowania wiedzy na temat funkcjonowania przemysłu 4.0 także w jego miękkich aspektach związanych z funkcjonowaniem zasobów ludzkich w organizacjach o wysokim stopniu automatyzacji i wykorzystujących najnowsze rozwiązania technologiczne. Przedstawiono badania empiryczne przeprowadzone w trzech krajach europejskich (Polska, Niemcy, Słowacja), w firmach będących przykładami najnowszych rozwiązań technologicznych w branży 4.0.

W psychologii pracy i organizacji szczególną uwagę zwraca się na zrozumienie zjawisk i zachowań organizacyjnych dla zwiększenia efektywności przedsiębiorstw. W aspekcie psychologicznym niektóre zmienne psychologiczne, będące uwarunkowaniami indywidualnymi, powodują, że pracownicy mają większą siłę, optymizm, wytrwałość

i pewność siebie, co pozwala im skutecznie równoważyć uciążliwe sytuacje społeczne i zawodowe wynikające z wyzwań zawodowych.

W psychologii zasoby osobiste obejmują m.in. wsparcie społeczne, style radzenia sobie ze stresem, pozytywną orientację, umiejscowienie kontroli i ego-stabilność.

W kontakcie z sytuacją kryzysową mają one duże znaczenie dla jednostki, bowiem mogą być przez nią aktywowane do rozwiązywania sytuacji zwiększając szansę na opanowanie trudnych zdarzeń. Autorów pracy interesują pracownicy przemysłu 4.0, operujący w trudnym środowisku pełnej automatyzacji, wymagających warunków pracy i licznych czynników stresogennych. W branży tej nie przywiązuje się jeszcze dużej wagi do zasobów ludzkich, pracujących razem w różnych zespołach i doświadczających zarówno wyzwań jak i trudności wynikających z pracy zawodowej. W monografii przedstawiono wyniki badań empirycznych nad subtelną zależnością między licznymi zmiennymi psychologicznymi, takimi jak: pozytywna orientacja, ego-kompresja, osobowość typu D, cechy osobowości, postrzeganie środowiska zawodowego oraz m.in. odczuwanie konsekwencji pracy zawodowej - stres psychologiczny i poczucie zagrożenia. Szczególnie cenny jest teoretyczny i użytkowy charakter monografii: wyniki badań mogą służyć jako praktyczne rozwiązania wspierające wybrane grupy zawodowe, w tym kadrę zarządzającą odpowiedzialną za budowanie strategii personalnych w przedsiębiorstwach. Zrównoważone podejście do rozwoju biznesu i technologii - nie tylko poprzez tworzenie najnowszych rozwiązań wynikających z automatyzacji, ale także odpowiedzialne i czytelne kształtowanie rozwiązań personalnych – może skutecznie wpływać na długofalową efektywność pracowników i ich samopoczucie psychiczne.

Celem pierwszego rozdziału jest podanie wspólnych ram koncepcyjnych Czwartej Rewolucji Przemysłowej, celem stanowienia podstaw do zrozumienia dalszych rozdziałów książki – jest wkładem głównie koncepcyjnym dla dalszej części opracowania. Rozdział ten obejmie aspekty historyczne, technologiczne, ekonomiczne, organizacyjne i decyzyjne związane z Przemysłem 4.0 i Pracą 4.0. Perspektywa analizy przyjęta do badania przemysłu 4.0 i jego technologii nie jest bliska ani technologicznemu determinizmowi, ani technologicznym rozwiązaniom. Biorąc pod uwagę intensywny rozwój sztucznej inteligencji (SI) w ciągu ostatnich dziesięciu lat stanowisko autorów jest dalekie od uznania, że system SI będzie wykazywał i realizował postawę kontroli i dominacji nad ludzką naturą. Dlatego też przedstawiono krótką analizę konstrukcji SI i systemów inteligentnych zorientowanych na człowieka. Wychodząc z takiego założenia, celem pierwszego rozdziału jest szerokie wprowadzenie czytelnika do tematyki Czwartej Rewolucji Przemysłowej i Przemysłu 4.0, dotyczącej natury i dynamiki destrukcyjnych technologii cyfrowych, ewoluujących w samym sercu Przemysłu 4.0. Analiza niektórych

specyficznych cech tych technologii wyjaśnia niektóre z przyjętych wzorców społecznych i ekonomicznych. Ważne jest również zrozumienie relacji pomiędzy Pracą 4.0 i Przemysłem 4.0 w oparciu o zagadnienia dotyczące badań i analizy różnych aspektów związanych z zawodami przemysłowymi przyszłości. Przeanalizowano również pewne społeczne wpływy na proces decyzyjny człowieka, oraz na jego zdolności i relacje na poziomie indywidualnym i grupowym.

Celem drugiego rozdziału jest przedstawienie wybranych zmiennych psychologicznych, psychospołecznych i organizacyjnych o kluczowym znaczeniu z punktu widzenia poznawania grupy badanej (pracowników zawodów związanych z przemysłem 4.0). Autorzy skupili się na wybranych zmiennych, określanych w literaturze jako zasoby personalne, potencjały efektywności oraz predyktory efektywności zawodowej. W sposób syntetyczny przedstawiono koncepcje psychologiczne oraz niektóre założenia teoretyczne, stanowiące podstawę do analizy poszczególnych zmiennych.

W rozdziale trzecim przedstawiono wyniki badań empirycznych przeprowadzonych w grupie badawczej pracowników reprezentujących zawody związane z przemysłem 4.0. Szczególnym atutem prezentowanego materiału badawczego jest jego międzynarodowy charakter: badania zostały przeprowadzone w grupie pracowników polskich, słowackich i niemieckich, zatrudnionych w organizacjach charakteryzujących się wysokim poziomem automatyzacji i intensywnym rozwojem nowych technologii. Praktycznym wyzwaniem w było przeprowadzenie kompleksowych badań ilościowych w warunkach terenowych, co w dziedzinie psychologii i organizacji pracy realizacja jest niezwykle trudne jako wymagające dotarcia do rzeczywistych miejsc pracy i firm z danej branży. Znalezienie respondentów spełniających kryteria badanej grupy często oznacza wielomiesięczne próby dotarcia do pracowników – to samo dotyczyło badań własnych przedstawionych w monografii. Nierówność porównywanych grup pracowników (polskich, słowackich i niemieckich) wynika właśnie z trudności znalezienia odpowiedniej grupy respondentów chętnych do udziału w badaniu. W rozdziale trzecim przedstawiono metodologię badawczą, cel badania, pytania badawcze oraz dokonano przeglądu narzędzi psychologicznych wykorzystywanych w badaniach. Przedstawiono również szeroki i bogaty materiał empiryczny, tj. wyniki badań własnych, które autorzy traktują jako dane eksploracyjne: ponieważ wśród pracowników przemysłu 4.0 nie ma jeszcze wystarczającej ilości danych i wyników badań nad zmiennymi psychologicznymi, autorzy traktują uzyskane wyniki jako punkt wyjścia do dalszych, złożonych badań, również o charakterze porównawczym. Wyniki badań opisują postawy, zachowania i funkcjonowanie

pracowników przemysłu 4.0 w zakresie ich zasobów osobowych, cech osobowości, strategii zarządzania stresem i ryzykiem oraz wielu innych zmiennych psychologicznych.

Całość opracowania prezentuje zmiany w pracy ludzkiej dokonujące się w związku z Czwartą Rewolucją Przemysłową obecnie zachodzącą na świecie. Niniejsza książka przedstawia propozycję tzw. badań i analiz zawodów przemysłowych przyszłości, które zostały przeprowadzone w trzech wybranych krajach w przedsiębiorstwach działających w obszarze Przemysłu 4.0. Etap, na którym znajdujemy się obecnie w procesie transformacji, jest początkiem pełnej automatyzacji organizacji, której jednym z kierunków jest redukcja czynnika ludzkiego na rzecz nowych technologii. Monografia jest próbą ukazania zmian w warunkach i specyfice zawodów przemysłowych w dynamicznie rozwijającej się Pracy Przyszłości.

1. THE 4TH INDUSTRIAL REVOLUTION IN THE CONTEXT OF INDUSTRY 4.0 AND WORK 4.0

1.1. Introduction

The digitalisation process right now is the most powerful driver of innovation and will continue to be over the next few decades, triggering digital innovation at the core of the next wave of innovation (Kagierman, 2015). Accelerated by the worldwide pandemic, and enabled by information and communication technologies (ICT), digitalisation means the networking of people, processes, and artefacts even at a global scale. ICT ". . . is moving so fast that even experts struggle to keep track, and even more so, to understand its global impact" (Lasry and Kobayashi, 2018: 9).

These disruptive digital technologies, evolving at the heart of the so-called Industry 4.0, have some peculiar characteristics. First, the rate of evolution is very high in terms of the appearance of new software, algorithms, and devices. The combinatorial character of innovation in this phase is one of the main drivers of these rapidly changing digital technologies. Another important issue is the pervasiveness of their penetration and impacts in terms of the economic sectors and social fields, which influence and feed the structural change of economy and society. Third, there are also traditional characteristics like the improvements in productivity, changes in working processes, and energy efficiency, like in all industrial revolutions. Last but not least, some of these digital technologies (e.g. artificial intelligence) have very important impacts on the organisational decision-making process, promising not just to modify the working process of white collar workers, but also it will impact on human decisions at individual and group level. This is probably just the tip of the iceberg of the so-called trans-human age[1].

[1] Here, trans-humanism refers to a philosophical doctrine that analyzes and promotes technologies that could overcome the limits of human nature (Toraldo and Toraldo, 2019: 54).

It is important for the understanding of this chapter, that the perspective of analysis for the Industry 4.0 and its technologies is not close neither to technological determinism nor to technological solutionism, the latter in the sense proposed by Morozov (2013: 5-8)[2]. That is to say that all our problems have (as a hidden assumption) efficient solutions in the framework of Industry 4.0. In this context, the purpose of this chapter is to make a broad introduction to the Fourth Industrial Revolution or Industry 4.0, to understand the relationships between Work 4.0 and Industry 4.0, focusing on issues concerning the research and analysis of different aspects related to the industrial occupations of future. Besides, the chapter reviews social impacts and the decision-making process. The aim is to develop a shared conceptual framework in this field, that could supply a base of comprehension for other sections of the book. Therefore, the chapter will cover historical, technological, economical, organisational, and decisional aspects related to what can be named Industry 4.0, and ultimately Work 4.0. The contribution of this chapter is mainly conceptual to the others.

It is important to highlight that this chapter focuses on topics that are treated in many books and journal articles. The literature in this field is in a transition process, from the early studies of German academics to the current development of new impacts worldwide (Bartocci Liboni et al., 2019). Some of this literature approach the emerging technologies for describing them, as well as the systemic rationale behind them. Others analyse political issues like privacy, technological sovereignty, state surveillance, or industrial policies for promoting Industry 4.0. Some authors approach economic issues and business models, some that study the impacts on labour or historical context, and some that analyse the ideology and values behind the Industry 4.0 concept. This chapter pretends to combine in a systemic way all the faces of the same issue: Industry 4.0.

As the first topics, this chapter will cover a review of the diverse origins in the increasing rate of evolution for these disruptive digital technologies, including a brief history of Industry 4.0 and a non-technical description of ICT technologies at the heart of this fourth industrial revolution. Besides, if the technological rate of evolution is greater than the human rate of learning, this situation would be the first in the history of the human race, and the consequences could be very important for organisations, people, and the working processes, more than the measurable or forecast impacts of the evolution of the technology itself. As Klaus Schwab (2016: 14-15) affirms, the changes in any dimension of the society are so deep, that never in human history has existed an age with so many promises and dangers.

[2] Morozov (2013) pointed out to the mistaken belief that technology can benignly and efficiently solve all our problems and produce a trouble-free world. In other words, an easy technological solution exists for all problems.

Then, we will discuss the pervasive character of the Industry 4.0, analysing in specific its possible effect on the economic and social sectors. The digital economy is arising on the horizon in the last sixty years (Schiller, 1999), even though nowadays it has adopted the particular form of digital "platformisation" of the economy (Just, 2018). These transformations are accelerated right now by the pandemic that is embracing all over the world, pushing virtual and digitalised forms to the forefront for almost all the countries. We will try to deepen the meaning of this economic change for customers, suppliers, producers, and value chains, for a national economy as a whole, with brief comments for the international trade and global economy.

On the other hand, we will focus on analysing the traditional impacts of industrial revolutions. We will study new sources of productivity introduced by Industry 4.0, the incorporation of new sources of energy and efficiency, and finally the impacts on the working processes, the so-called "Work 4.0". This approach is connected with the other chapters of this book, which analyse the empirical data from three different countries for workers in Industry 4.0 environment.

Finally, we explore the meanings of changes in the organisational decision-making process. This will affect not just the productivity issues but also the learning process at the individual and group level, the addresses and models for organisational change, the working process, and the relationships among persons and society. The meaning of trans-human modes of life will be also briefly included in this analysis. Some critical voices will be recovered here for pointing out that the exploitation of private data without respect for privacy rights is a ". . . significant threat to human nature in the twenty-first century as industrial capitalism was to the natural world in the nineteenth and twentieth" (Zuboff, 20019: 1).

1.2. Increasing rate of evolution for disruptive digital technologies

According to the National Academy of Science in the USA, a disruptive technology is defined as "an innovative technology that triggers sudden and unexpected effects" (Cronin, 2020: 7). Disruptive technologies change existing product-technology paradigms, launching new products and creating new industries (Rai-Choudhury, 2000: 489) and opportunities. They transcend ordinary product or technology capabilities and introduce new competitive paradigms (Management Association, 2019: 2086). Rather than a linear evolution, they develop much faster, with a greater impact than well-known technologies,

enabling change (Gupta and Tham, 2019). Initially, they are usually not very well considered because they are usually under the state-of-art results, but when they improve fast and consistently, they attract the attention because of their potential.

In the following lines, we will analyse the origin of the disruptive digital technologies, for trying to understand their dynamics of evolution. This epigraph will cover also some of the technological, economic, and organisational aspects of these disruptive digital technologies, and the increasing rate of evolution for them, starting with a brief historical analysis of the emergence of the Industry 4.0.

1.2.1. Brief historical introduction

The emergence of digital technologies such as the Internet of Things (IoT), artificial intelligence (AI), robotisation, and Big Data analytics are transforming industrial processes and products, as well how value chains are articulated and deployed on a global scale. It is interesting to note that most of the main digital technologies of the Industry 4.0 (AI, robots, nanotechnology, 3D printing) were created in the second half of the last century (Skilton and Hovsepian, 2018: 31). These profound changes in the way of producing, consuming, and interacting set the basis for what is known as the Fourth Industrial Revolution, Industry 4.0, or smart manufacturing.

The origin of the concept of Industry 4.0 was born at the Hannover Fair in 2011, one of the most important industrial meetings in the world. On the next year, the German Government presented the High Technology Strategy, in which industrial production was promoted through the digital connection of machines, processes, and products (Digital Transformation Monitor, 2017). This initiative was based on the report made by a working group in acatech[3] that explicitly mentions for the first time the concept of Industry 4.0, with which it named the set of actions aimed at achieving the interconnected and intelligent factory.

This governmental initiative searches for positioning and tapping Germany into the potential is a new type of industrialisation. This German industrial policy initiative has strongly influenced on how a growing number of developed and developing countries carry out their industrial and technological policies. Therefore, Industry 4.0 concept is a strategic

[3] This final report was "Recommendations for implementing the strategic initiative INDUSTRIE 4.0", elaborated by the Industrie 4.0 Working Group, and led by *acatech*, the National Academy of Science and Engineering of Germany. It was published one year later by Kagermann et al. (2013). See it in: https://en.acatech.de/publication/recommendations-for-implementing-the-strategic-initiative-industrie-4-0-final-report-of-the-industrie-4-0-working-group/

response that developed countries are deploying to address the ubiquitous and mobile potential of the Internet, the availability of gigantic volumes of data, the development of smart and connected Internet of Things (IoT) devices, and the integration of processes through cyber-physical systems of automation and connection of production processes. Certain authors and international organisations have also popularised the name of "the fourth industrial revolution" (Schwab, 2016: 7) to refer to the same phenomenon[4].

The name of the Fourth Industrial Revolution implies the existence of three previous ones, which are important to explain the former. The First Industrial Revolution, which occurred in the eighteenth and early nineteenth centuries, was based on the introduction of the steam engine and the development of machine tools that made it possible to significantly improve the mechanisation and energy power of the production processes, respectively, multiplying the productivity. With Great Britain as its origin, this revolution produced a series of technological changes that had an immense impact on societies. The consequences were both economic, social, cultural, and environmental (Stearns, 2013: 1). These great changes meant a break with the socioeconomic and labour structures that existed up to that moment, changes that expanded globally.

At that time, there were strict rules in the industrial plants that governed daily routines, even regulating workers' lives during the working day, almost like a military regime. Besides, most factory working conditions were terrible, comparable to slave work (Frader, 2006: 58-64). Even women and children worked underground in coal mines, powering this industrial revolution, with awful labour conditions (Allitt, 2014: 46-47; Frader, 2006: 62). Ultimately, the most important contribution of this revolution was the industrialisation's role that changed the framework of world history (Stearns, 2013: 2).

The Second Industrial Revolution, between the second half of the 19th century and the first part of the 20th century, was based on electricity, steam-powered manufacturing, the railroad, the electric motor, the internal combustion engine, practical application of chemistry, on new ways of conceiving work processes, and on the assembly line (Imai and Weinstein, 2000). Starting in 1860, the Second Industrial Revolution took place, which meant the triumph of machinery and large industry against small factories, increased production and the expansion of the world market for products. A large number of new technologies was invented at that time. The related innovations and their potential paved the road for a rapid technical change in the next 70 years (Atkenson and Kehoe, 2001).

[4] Some authors highlighted that instead of a revolution there is an evolutionary trajectory for the Industry 4.0 (Yin et al., 2018; Kagerman et al., 2013; Xu et al., 2018).

It is interesting to mention that the measured productivity increased after several decades after this revolution began. One hypothesis is that this delay was due to the slow diffusion of new technologies among manufacturing plants, due in turn to manufacturers' reluctance to abandon their accumulated expertise with old technologies. The technologies were embodied in machines and processes of existing plants. *With disembodied technology, faster technical change results immediately in faster growth of measured productivity* (Atkenson and Kehoe, 2001).

The improvement of working conditions came with the development and strengthening of trade unions and political movements, which occurred above all during the "first globalisation" of capitalist economic liberalism, that is, between 1870 and the beginning of the First World War (Berger, 2003; McCormick, 2012: 49-53). Frederick Taylor took up the concept of division of labour from Adam Smith[5] and developed it until the job was turned into an almost elementary set of tasks, giving rise to what is known as high vertical specialisation of workers, which is contrasted with horizontal specialisation or polyvalence, promoted the latter by the schemes prior to Taylorism-Fordism and then by the Japanese or Lean Production schemes. In turn, the Taylorism-Fordism approach generated a clear displacement of power from the level of production and execution to the level of management and administration of the company (cf. Uricoechea, 2002: 209 ff.).

Some of the basic principles of the organisation of work in the Second Industrial Revolution are the standardisation of products and processes, the division of labour carried to levels unthinkable by Adam Smith, the measurement of variables to manage such as time, costs, productivity, profitability, among others. The implementation of these principles, plus the addition of the introduction of the assembly line by Henry Ford, led to the birth of mass production. Conceptually, mass production implies large volumes of production to exploit economies of scale, consequently low unit costs, the use of highly specialised equipment and machinery, and vertically specialised workers.

Mass production was articulated by Henry Ford in his plant located in Detroit, based on some key enabler drivers, like the interchangeability of parts and components, standard processes and products, and the moving assembly lines empowered the development which provided low-cost products through large scale manufacturing (Hu, 2013: 3). There is a consensus among economic historians that the impacts of these innovations lasted until the 1970s (Gordon, 2012). One of the drawbacks of mass production was that workers did not feel identified with the products or failed to recognise the value of their work to the final products. These weaknesses were solved in the next industrial revolution.

[5] The originality of Adam Smith was in bringing the division of labour to the centre of discussion of economic progress and its link with productivity (Groenewegen, 1987: 901-902).

This new productive system was possible due to the interweaving of a set of productive factors, with mutually reinforcing relationships among them, in such a way as to generate a sustainable productive dynamic over time. The following diagram in Figure 1 shows the central factors of mass production and their synergistic and circular relationships.

The Third Industrial Revolution began in the middle of the 20th century with the development of transistors, semiconductors, and large computers, on the basis of which an important automation process was also developed. This Industrial Revolution was distinguished by the invention and use of programmable computers and machines in production (Hacioglu, 2017: 547). Generally considered to be at the end of the twentieth century, it was launched by new information and communication technologies (ICT) using information technology to automate production. Therefore, the Third Industrial Revolution can be characterised as the digital age of information and communication technology (ICT), starting in the late 1950s with the first mainframe computers and continuing in many countries until today (Kraus et al., 2019).

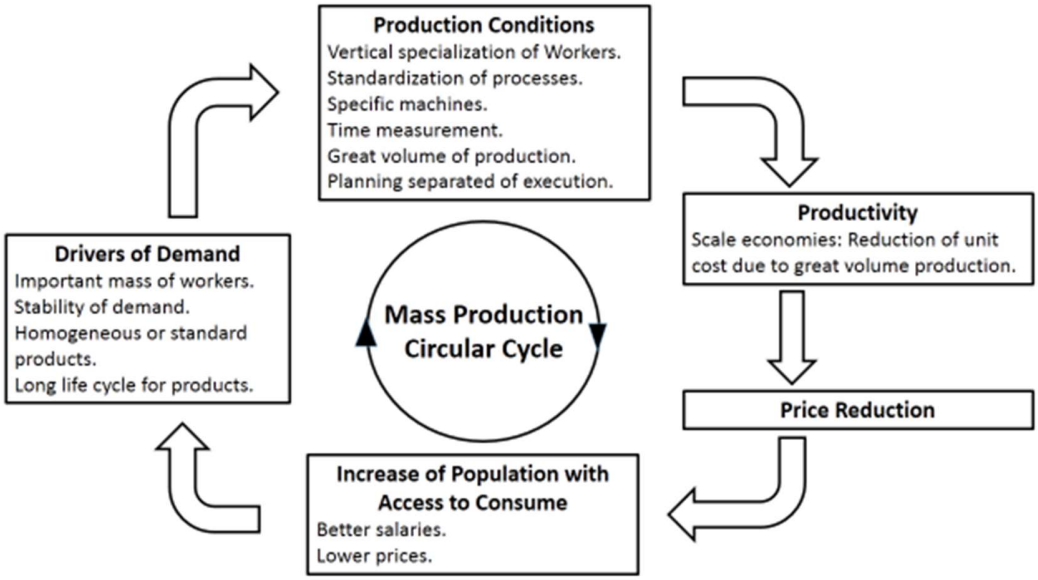

Fig. 1. Mass Production Circular Cycle
Source: own elaboration.
Rys. 1. Cykl okrężny produkcji masowej
Źródło: opracowanie własne.

The Third Industrial Revolution is also associated with the invention of the worldwide web and Internet around 1995. ICT allowed to replace routine and repetitive clerical work as early as 1960. Many microelectronic devices, particularly PLCs (programmable logic

controller), were labour saving inventions for automation, and ICT services were already widely available before 1995 (Gordon, 2012: 3). On this occasion, unlike the previous two revolutions, it was led by non-European countries, such as Japan and the United States. The main exponents of this new industrial era were made up of advances such as fibre optics, the development of nanotechnology and the Internet, including the unquestionable development of other areas such as biomedicine, biotechnology, aerospace technology, and robotics, which should also be highlighted.

The mass-production model that was generated with Taylorism-Fordism began to come to an end with the two oil shocks that occurred in 1974 and 1981. The changes occurred mainly in the markets, becoming fragmented and saturated, and had responses with modifications in the production model. The changes that were carried out, operating simultaneously on the market and the production, were the following (Arciénaga, 1998: 2-4):

- At macroeconomic level, starting in 1980, the crisis in the central and peripheral countries opened many national economies to competition, on an increasingly global scale.
- This situation, in turn, has generated aggressive strategies to maintain or increase the presence of companies in both their national and international markets, although paradoxically this increased the importance of national bases for a projection of companies on this new scale competition (Porter, 1990).
- The markets were no longer stable and predictable to become changing markets with high volatility, which made them difficult to predict and very dynamic.
- The process of technological innovation / diffusion has been the central dynamic of countries and companies to adapt to changing market conditions, through the flexible production of a variety of products.
- Innovation has helped reduce the life cycle of products, as well as shortened development times for new products.
- The leading role in innovation has led to new organisational forms that allow the exploitation of new sources of productivity and economic efficiency, the flexible organisation representing a tool of the first magnitude for competition.
- The production model had to be transformed from rigid standardisation to flexible heterogeneity, which resulted in a flexible specialisation production model.
- Flexible specialisation was the key to generating a variety of products and their customisation that would allow satisfying the most demanding consumers.
- Flexible specialisation is based on Just in Time or Lean Production and flexible automation technologies (PLC, robots, machine tools, FMS, LAN, etc.). Unlike

Fordism Taylorism, JIT is based on multi-skilled workers participation, which precisely favours organisational flexibility (and not just technological ones).

- Changes in the production model were reflected, first, in the production factors' market, which implied the growth of subcontracting and productive decentralisation processes.
- First in central countries and then in peripheral ones, consumer satisfaction with standardised and / or homogeneous products mutated into differentiated products. That is to say, the demand gained more power compared to the supply of goods and services.
- The differentiation of the product has implied from the rapid response to the client, customising the product according to the taste of the consumers. It also involved the improvement of the quality as a way of satisfying the client, the design as a way of adapting new or improved products, or the use of the brand to accompany the commercial differentiation of the product.

Figure 2 below summarises this new flexible specialisation model that allows for a variety of products and flexible production. This model can make use of economies of scale for some of the components, but it incorporates new sources of productivity, in particular economies of scope, economies of non-quality savings, information economies, and long-term partnership with suppliers, the participation of multipurpose workers as a new source of creativity and problem solving, among others.

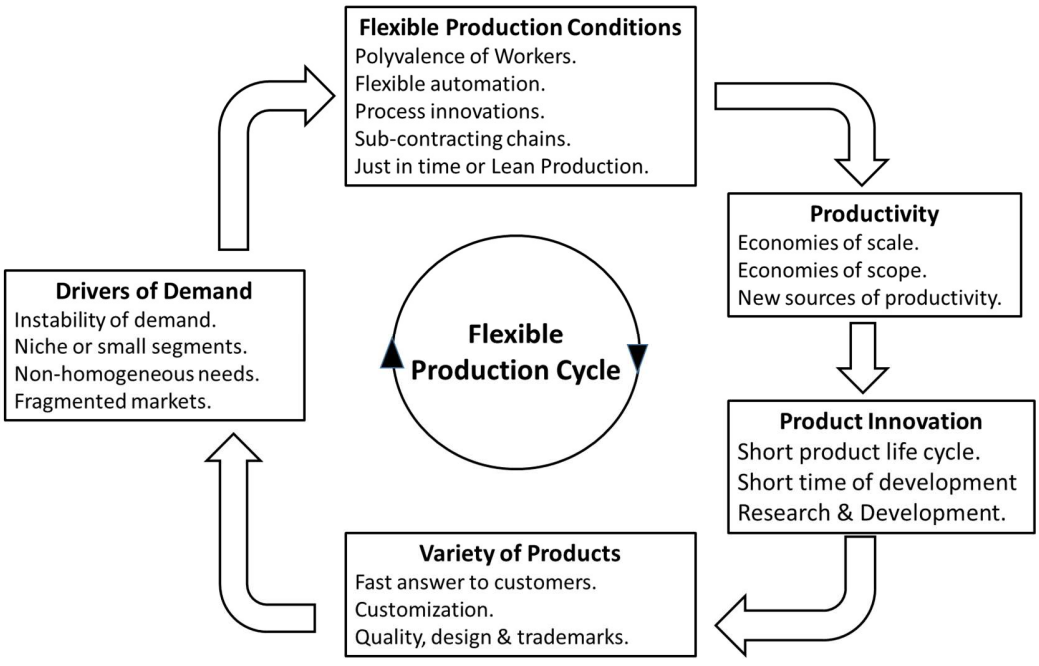

Fig. 2. Flexible Production Cycle Model
Source: own elaboration.
Rys. 2. Model elastycznego cyklu produkcyjnego
Źródło: opracowanie własne.

Finally, Industry 4.0 emerges within the framework of the Fourth Industrial Revolution, with the maturation of technologies such as interactive robotics, augmented reality, cloud computing, and artificial intelligence, as well as new technologies based on the Internet and big data. Prior to the widespread use of the Industry 4.0 concept, there was no construct or taxonomy to discuss the 4th industrial revolution.

As it was mentioned, since the beginning of the last decade, we have found ourselves in a new technological and industrial panorama, led by German industrial policy of combining digital technologies and the interconnection of objects and processes in the industrial field. There were also some previous initiatives in the USA. These were mainly developed in the sphere of the National Science Foundation, on the basis of projects. Another important institution is the National Institute of Standards and Technology (NIST) that works on the similar concept of Smart Manufacturing[6] and the Department of Energy (DOE) (Kuo et al., 2019).

Even though these two countries worked since the beginning on the same field, the main difference is that there was a comparative weak political support in the USA to this initiative, and on the contrary, the German government heavily supported the development of the industrial sector with new cutting-edge digital technologies (Rojko, 2017: 80). The following diagram shows the different initiatives that give birth to Industry 4.0 at the international level in a temporal axe, taking into account the main leading countries in this field.

[6] According to the NIST, Smart Manufacturing are systems that are "fully-integrated, collaborative manufacturing systems that respond in real time to meet changing demands and conditions in the factory, in the supply network, and in customer needs." See: https://www.nist.gov/blogs/manufacturing-innovation-blog/so-what-exactly-smart-manufacturing

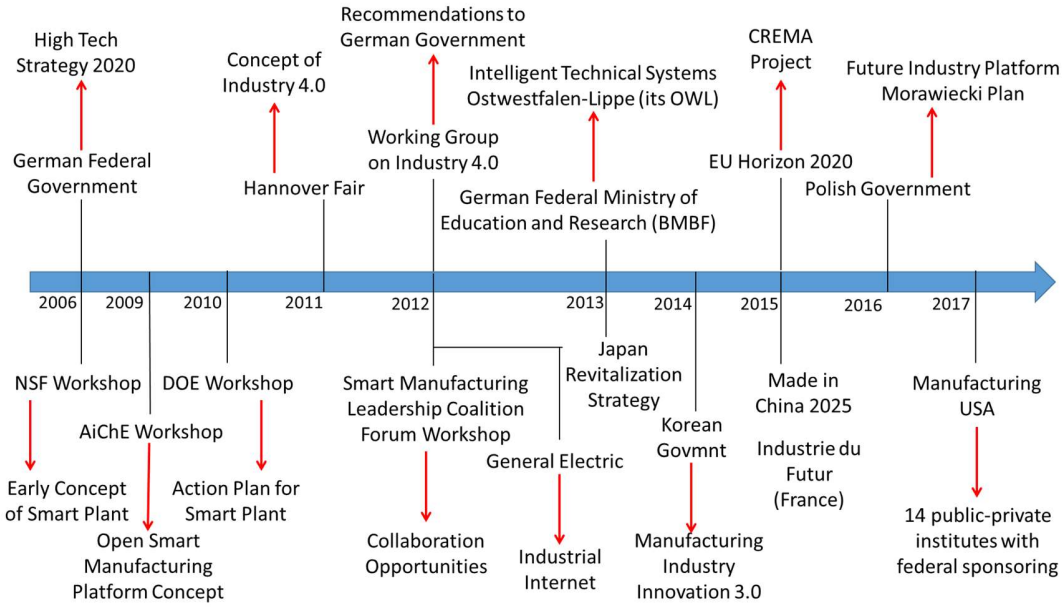

Fig. 3. Historical Events in Industry 4.0
Note: NSF = National Science Foundation (USA); AiChE = International Association of Chemical Engineering (USA); DOE = Department of Energy (USA).
Source: own elaboration on the base of European Commission (2017, a, b, 2018), Smart Manufacturing Institute (USA, https://www.cesmii.org/), Wikipedia.org, Skilton and Hovsepian (2018), and Kuo et al. (2019).
Rys. 3. Wydarzenia historyczne w Przemyśle 4.0
Uwaga: NSF = National Science Foundation (USA); AiChE = International Association of Chemical Engineering (USA); DOE = Department of Energy (USA).
Źródło: opracowanie własne na podstawie European Commission (2017, a, b, 2018), Smart Manufacturing Institute (USA, https://www.cesmii.org/), Wikipedia.org, Skilton i Hovsepian (2018) oraz Kuo et al. (2019).

However, not everything in Industry 4.0 goes through the technological aspects. The collaborative and interactive environment and suitable strategies are of great importance to facilitate innovation and the deployment of an Industry 4.0 strategy. In this sense, Schroeder (2018) highlights the existence of what could be called an innovation ecosystem in Germany, where various initiatives and strategies from the political and economic sectors coexisted from the beginning, as well as the participation of interested groups and the scientific community, which culminated in the Industry 4.0 German strategy.

This new digital revolution is showing, as the first results, that it can generate remarkable flexibility for the manufacturing processes, a better adaptation of the products to the value concepts of the clients, an increase in the speed of arrival of said products to the markets, a drastic and continuous improvement in quality, a considerable reduction in process cycle times, significant increases in the rate of use of machinery, and, above all,

notable increases in productivity and incorporation of marginal value (European Commission, 2017: 2).

With the advances and structural changes involved in the Industry 4.0 paradigm, there are still few studies on the management problems that such changes bring, particularly those generated by cyber-physical systems in relation to production and work processes (Gerlitz, 2015: 181). The conjunction of digitisation with industrial processes also opens up uncertainties about interoperable standards to pass data from product design and definition, to equipment and to the production process. As a way to remedy this deficiency, in the USA, the National Institute of Standards and Technology (NIST) collaborates in mapping the landscape of smart manufacturing standards and works with the industry to encourage the development of voluntary standards and best practices around problems of interoperability (Casalet, 2016). Germany is also working on the same problems, for instance with the Reference Architectural Model Industry 4.0 (RAMI 4.0)[7].

1.3. Technological, economic, and organisational aspects of Industry 4.0

Next, we will analyse some characteristics and patterns of the fourth industrial revolution, completing the historical description of the previous epigraph. For this purpose, we focus on the particular way in which this fourth revolution articulate some key variables, like production, productivity, innovation, and demand. First of all, it is important to highlight that the Fourth Industrial Revolution is becoming more sophisticated and complex due to the fast of dynamics of digital innovation. Industry 4.0 is a multi-agent system (MAS) that includes AI algorithms, CPS, smart devices, collaborating robots or cobots, sensors, controllers, etc. At the core of the Industry 4.0 is the smart factory (Nayyar and Kumar, 2019: 25).

Smart factories involve the efficient use of information and data, from the floor, up to the management level, to take better decisions minimising operational inefficiencies, to smart automation of processes, for creating better products, to increase the rapidness of answering to clients, and to coordinate with all the value chains. For such purposes, smart factories implement quite different technologies, like smart sensors, artificial intelligence (AI) software, industrial Internet of Things (IIoT) devices, and cyber-physic systems (CPS),

[7] This reference model combines different existing standards, like the IEC 62.890 (Life Cycle Value Stream) and the IEC 62.264 y IEC 61.512 (Hierarchy Levels).

transforming the physical processes into digital ones, with a constant flow of data. (Mittal et al., 2017).

Smart factories mean automated manufacturing facilities with massive use of smart sensors for capturing data, big data analytics and AI for decision-making, real-time monitoring with Industrial Internet of Things (IIoT) devices, smart process automation with CPS, wireless networks for communication without delays, horizontal and vertical integration of processes, cyber-security to avoid hacks, augmented reality for maintenance, and collaborative robots (cobots). A factory can get smarter progressively by setting digital links between workers, machines, and processes (Meijer et al., 2014; Ustundag and Cevikcan, 2018; Mittal et al., 2017; Popkova et al., 2019).

This digital transformation of production and industrial plants is in turn transforming inter-firm processes, value chains, products, patterns of consumption, and finally business models. As we described above, many countries and big firms have implemented strategies to promote a digital transformation of their industries to remain competitive in an aggressive commercial world.

The following Figure 4 shows a kind of cycle that can be established between internal and external variables to the firm, similar to those treated for the Second and the Third Industrial Revolution.

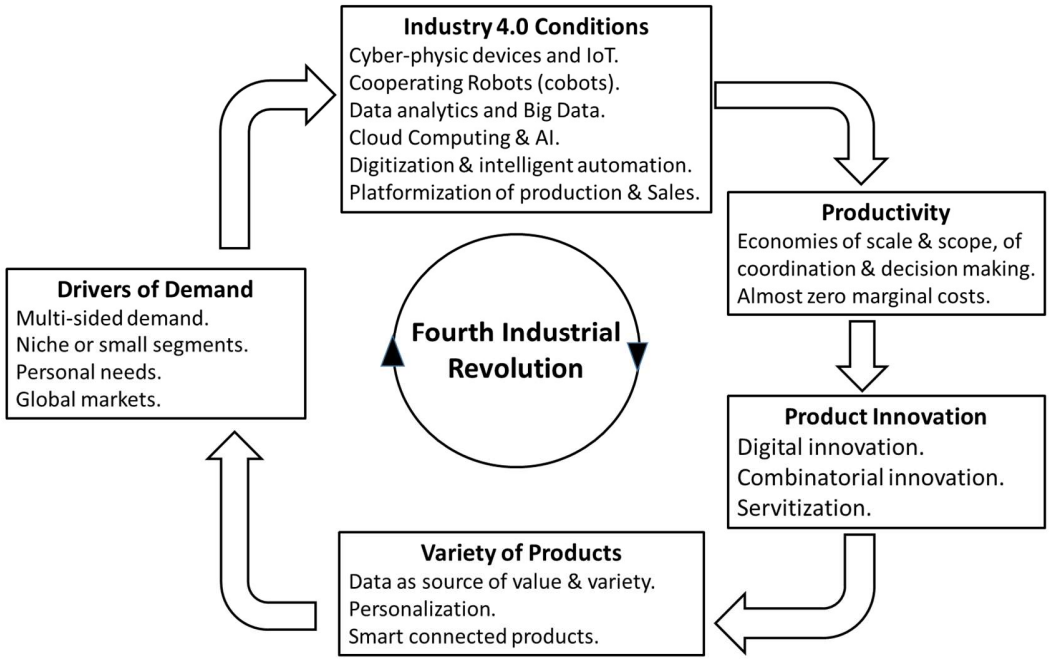

Fig. 4. Industry 4.0 or 4th Industrial Revolution
Source: own elaboration.
Rys. 4. Przemysł 4.0 lub Czwarta Rewolucja Przemysłowa
Źródło: opracowanie własne.

The above diagram shows how technological, economic, and organisational variables are interrelated in Industry 4.0. As in mass-production and flexible production paradigm, there is a kind of cycle that reinforces the interactions of different factors, and makes this circular cycle sustainable in the digital economy. Next, in section 3, we discuss deeper other characteristics of the digital economy, particularly the importance of the platforms that are central to this new economy.

As it can be observed in Figure 4, the changing conditions in production are key to obtaining increases in productivity. Rapid advances in ICT, 5G for wireless communication, nano-materials and sensors, cobots for cooperating workspaces with human workers, data gathering and data processing, and cyber-physical systems are dramatically increasing the productivity and lowering the costs of advanced manufacturing processes, improving their performance. IIoT platforms[8] add new sources of productivity because they can coordinate the whole value chain. AI is also accelerating its development and making more efficient decision-making processes, contributing to the general enhancement of productivity[9].

It is important to highlight that Industry 4.0 is applicable also to products. Additional to traditional innovation processes, there are some specific ways to innovate in the digital economy. Like at the beginning of the First Industrial Revolution, there is an important combinatorial process to innovate in the Fourth Industrial Revolution. Instead of pulleys, shafts, and gears, the components are now called artificial intelligence, Internet of Things, sensors, cobots, big data analytics, machine learning, etc. (Arthur, 2009; deVries, 2003).

However, there are also digital innovations that can be conceptualised as those creations and mis-en-place of novel products and services, or market offerings, business processes, or models that require some significant changes on the part of adopters, and are embodied in or enabled by ICT (Hinnings et al., 2018: 52; Nambisan et al., 2020: 2). Due to the innovation process itself being subject to digitisation, some authors claim the need to reformulate the accepted theories of innovation, otherwise, it would not be possible to capture the rapidly changing nature of innovation processes in a digital world (Nambisan et al., 2017: 223).

[8] In the next paragraph 3.3 in this chapter, there is more explanation about the economies of scale and the economies of coordination provided by digital platforms.

[9] A small number of large corporations are developing advanced AI research, like the "Partnership AI" formed by Google, Facebook, Amazon, IBM, and Microsoft, and the "Open AI" backed by Elon Musk with US 1 billion dollars. See https://www.theguardian.com/technology/2016/sep/28/google-facebook-amazon-ibm-microsoft-partnership-on-ai-tech-firms Access on 13/06/2020.

Due to the pervasive character of digital technologies, their applications to product innovation modified the structure and/or architecture of products, adding new layers that make them smart or autonomous, and connectivity to make them networked (Porter and Heppelmann, 2014). These layers can be interconnected, representing devices, networks, services, and contents, all created by digital technologies. The main results are products with novel functions, enhanced price/performance ratios, and new ways of design, production, distribution, and use, like, for instance, Apple's iPhone and Amazon's Kindle (Yoo et al., 2010: 724-726). The traditional representation of the product structure of Kotler, updated by Kotler and Armstrong (2016), can be reformulated for products that possess new digital functions. This new product structure is represented in Figure 5.

Another important new process of innovation is the so-called servitisation process. This is also related to digital innovations, but the emphasis is on the physical products and the concomitant services that can be derived from them by exploiting their data of design and functioning, and the relationship with customers. Servitisation in traditional manufacturing firms is an important tool for differentiation and value creation (Baines et al., 2009; Baines et al., 2007; Lenka et al., 2017).

For servitisation, firms are highly dependent on digitalisation capabilities that allow them to interact and co-create value with their customers. These interactions with customers imply that manufacturers should provide a very customised combination of product plus service, with tangible solutions for clients (Lenka et al., 2017: 92; Porter and Heppelmann, 2014). Therefore, servitisation expands the physical product potential, the firm's dynamic capabilities for competing with differentiation and value creation, and for delivering solutions and personalised products to the customers.

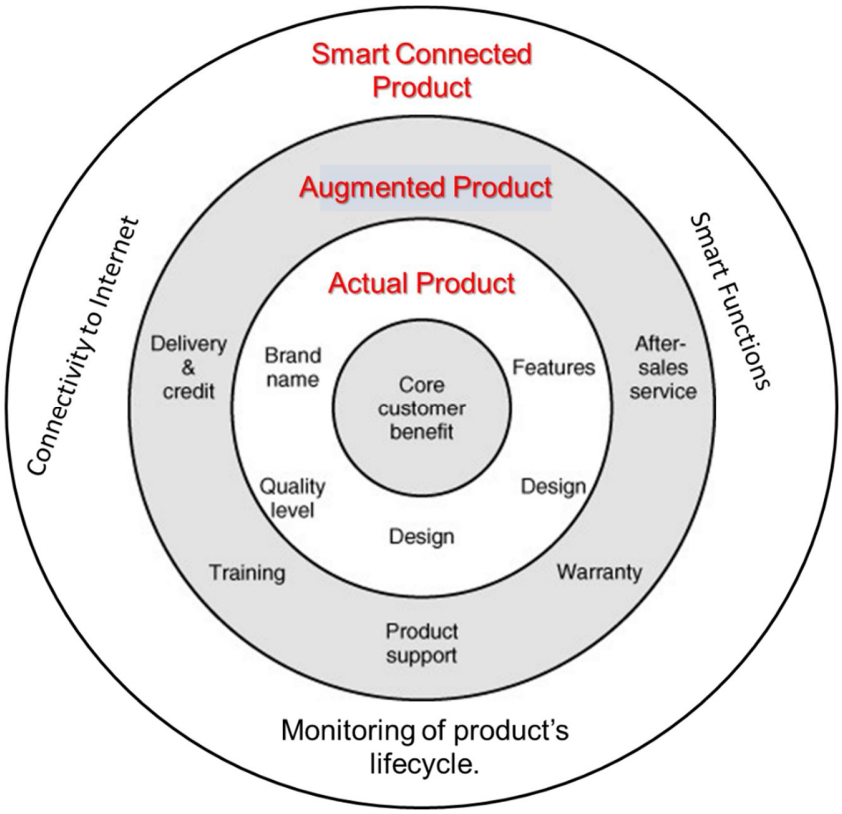

Fig. 5. Structure for Smart Connected Products
Source: own elaboration on the base of Kotler and Armstrong (2016: 258) and Porter and Heppelmann (2014).
Rys. 5. Struktura dla inteligentnych produktów połączonych
Źródło: opracowanie własne na podstawie Kotler i Armstrong (2016: 258) oraz Porter i Heppelmann (2014).

IoT devices, associated with products, can track the product's performance, gain insight into usage trends, adapt the product autonomously, save helpful data, warn before maintenance or repairs, and tackle the problems that could arise from the beginning. Therefore, IoT associated with a physical product can capture and process vital data of it, making it a smart and connected product (Porter and Heppelmann, 2014). Thus, IoT is an enabler for expanding products through intangible digital functions like data processing and scheduling of resources by connecting them to the cloud.

On the other hand, as it was mentioned, companies are under mounting pressure to improve their productivity and become more responsive to an open aggressive competence, and the changing customer expectations, as well as needs. For this purpose, the virtual value chain model treats information as a supporting element of the value-adding process along the virtual chain, and also as a source of value creation itself for products. Originally, the value chain model just uses information as a supporting base for coordination. On the other hand, virtual value chains are accelerating manufacturing automation solutions to bolster

productivity and profitability, and reduce costs across the supply chain. As a result, enterprises adopting Industry 4.0 strategies are evolving from centralised systems to more decentralised ones and automatically controlled platforms that allow managing virtual value chains. The virtualisation process is in the centre of scene[10].

Following the pioneering work of Rayport and Sviokla (1995), there are five important tasks in the creation of virtual value chains: gathering data, organising data, selecting data, synthesising information, and distributing information. With these stages, companies detect market opportunities and exploit them with new products and services in the virtual value chain. Therefore, the most important input in the setting of the virtual value chain is data and information.

The virtualisation of the value chain allows the firm to offer better scalability and flexibility to its clients in delivering the products and services. Virtualisation is closely related to cloud computing because the ubiquity and scalability provided by this technology allows manufacturers to trespass the limits of the location of the physical infrastructure and operate from any location without noticing by customers (Bonuccelli, 2017). Mobile and the Internet of Things (IoT) are also important for virtuality.

Unlike physical value chains, virtual value chains have other interesting characteristics such as the law of digital assets[11], new economies of scale and new economies of scope, transaction-cost compression[12], and rebalancing of supply and demand (Rayport and Sviokla, 1995). All the links of the chain produce data and information, from inbound logistics, production, sales, marketing, and outbound logistics. When companies can capture and integrate this information, they are in conditions to visualise the physical value chain in virtual terms, from end to end. The data and information produced in each stage of the virtual value chain allow for many new extracts from the flow of information, and each extract could constitute a new product or service. In this way, the virtual value chain facilitates the production of digital assets through the integration of physical place and virtual space.

[10] Virtualisation can be defined as the logical abstraction of the four physical computing resources (storage, processing power, memory, and network). A virtual system pretends to be a physical one. Cloud computing technologies have accelerated and deepened this process. See Buyya (2010), chapter 5, or Sitaram and Manjunath (2011), chapter 9.

[11] Digital assets are anything that could be expressed in a binary format, like data and information. However, virtual value chain can present also native assets, like digital music, images, movies, electronic funds, etc. These assets lack physical substance, but can be owned or controlled to produce value for customers and the firm (Kim et al., 2019: 182). The law of digital assets says the, unlike physical assets, digital assets are not consumed while using and as a consequence can be used over and over again.

[12] This means that transaction costs within the virtual value chain are lower than those in the physical value chain.

The information generated in the course of traditional operating activities helps managers see their physical value chains as an integrated system rather than as a set of discrete though related activities. This property is the visibility of the virtual value chain. Besides, companies substitute physical activities for virtual activities, which means the creation of a parallel value chain in the marketspace. This other property is called the mirroring capacity of virtuality. Finally, once firms can manage value-adding activities across both value chains, they can develop new customer relationships. All these three characteristics and the previous description can be synthesised in Figure 6.

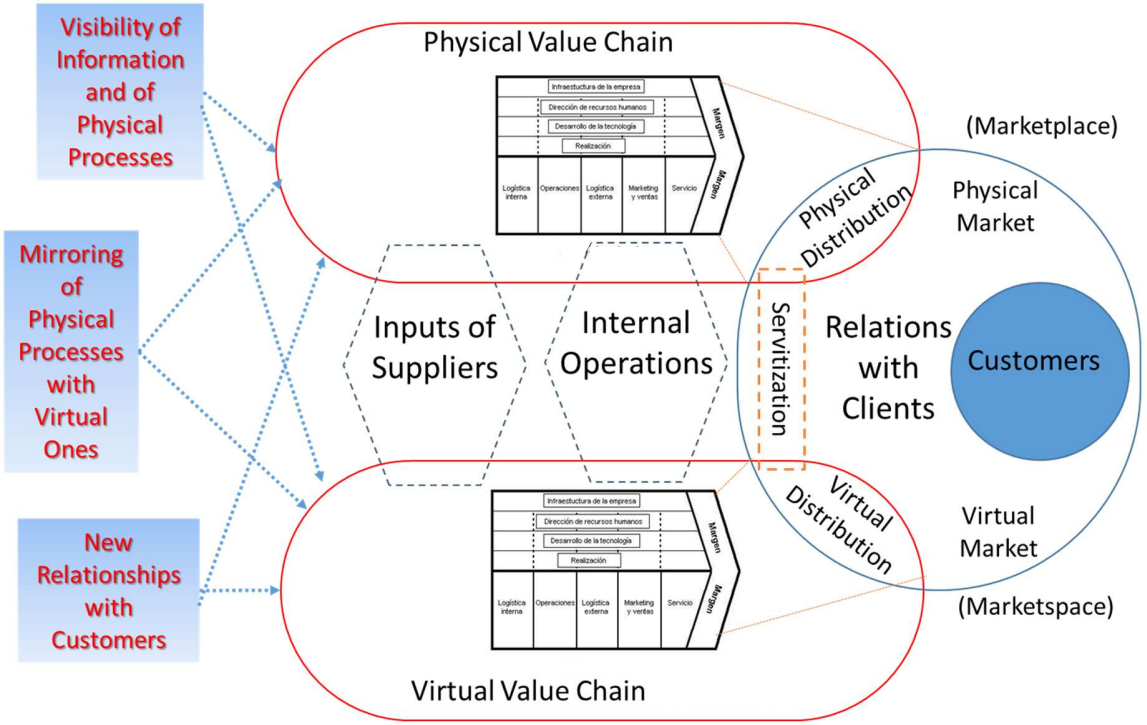

Fig. 6. Virtual and Physical Value Chain
Source: own elaboration on the base of Rayport and Sviokla (1995).
Rys. 6. Łańcuch wartości wirtualnych i fizycznych
Źródło: opracowanie własne na podstawie Rayport i Sviokla (1995)

In the digital journey initiated by the Fourth Industrial Revolution, two key processes should be addressed: digitalisation and virtualisation. In the lines above we have provided some explanation of the virtual process in its particular application, in a value chain. Next, the digitalisation process will be explained briefly. For disambiguating the concept, it is important to show the differences between digitalisation and digitisation. According to the Oxford English Dictionary, while digitalisation is usually conceptualised as the use of digital technologies and digitised data in different processes or sectors or territories

(organisation, industry, country, etc.), digitisation is the conversion of analogue into digital data.

Digitalisation is a central process in the economy and society as a whole (Castells, 2010). The controversy is just if the use of digital technologies is for modifying existing specific business processes or for creating entirely new business, or new business models. The concept of digitalisation is also related to digital transformation. The latter is a process of change that requires not only the digitalisation process (for incorporating digital technologies), but also a cultural and organisational change for this purpose. Therefore, digital transformation is a much broader concept (Hess et al., 2016; Hanelt et al., 2015).

1.4. Description of Industry 4.0 technologies

For finishing this epigraph, the following paragraphs will focus on a description of the different technologies that are embraced in Industry 4.0. What is remarkable is that technologies per se do not configure a cutting-edge production system. There are other factors to consider, like product design, the type of market demand, the technologies available for manufacturing, the technologies of materials, and the data or information available (Arciénaga, 1998: 346-349).

Industry 4.0 is not just a process of gathering data along the production process, from end to end, with different sensors and technologies. Data collection does nothing by itself. The central issues are how to create value with data analytics and how to work in a networked production system, a networked firm, and at the value chain level. Every organisation today needs to be data-driven. This means that the firm has a clear and compelling understanding of the power of digital analytics. In this sense, the Industry 4.0 strategy fits very well in every organisation seeking to harness digital data intelligence and maximise its business value, with data analytics and the transformational potential of big data (Fountaine et al., 2019; Henke et al., 2016: 22-25).

The Fourth Industrial Revolution is a harmonious and flexible combination of several technologies. These involve from physical machines, devices, and sensors, up to the digitalisation of production processes and systems. In the latter case, it is worth to mention technologies like the digital twins of production processes and systems, the Internet of Things (IoT), Ethernet protocols and connections of fibre optics for the flow of information, Big Data and 5G to create cyber-physical systems (CPS) and smart factories, cloud computing in combination with new mathematical algorithms for data analytics, artificial

intelligence, augmented and virtual reality for maintenance and other functions, blockchain for logistics, digital agents, various automated systems (computer controllers, PLCs, smart sensors, etc.) that allow the automatic exchange of data and information.

In machine learning, computers have the ability to learn from data inputs instead of their original programming. Artificial neural networks can identify patterns with deep learning systems (a subfield of machine learning), allowing them to recognise an image or teach themselves to solve a problem[13]. The performance of this neural network improves deeply (apparently without limits) with more data and larger models that in turn require more computation to train (Alom et al., 2018: 1-2). Machine learning, deep learning, advanced robotics, big data, and exponential growth in computing power are coalescing into a second machine age (Brynjolfsson and McAfee, 2016).

In the Figure 7, the diagram shows the different technologies that were becoming part of Industry 4.0 with its constant evolution since the beginning. Those oval delimited in red are the pillar technologies that gave origin to this new paradigm (Jeschke et al., 2017: 3). Other technologies, like PLCs, RFD, Ethernet, fibre optics. ERP or simulations, were developed in isolation and previously (Skilton and Hovsepian, 2019: 31). Even artificial intelligence has been in development since 1960s. Figure 7 also illustrates the combining nature of Industry 4.0, including all the technologies and developments that can be integrated and interconnected in a digital form. Next, there is an explanation of the main technologies. We will present them in an easy to read format.

[13] Almost all the value today of deep learning is through supervised learning or learning from labeled data. A supervised learning algorithm analyzes the training data (inputs and outputs of a process) and infers a function on this base, which can be used for mapping new cases and learning (Alom et al., 2018: 2).

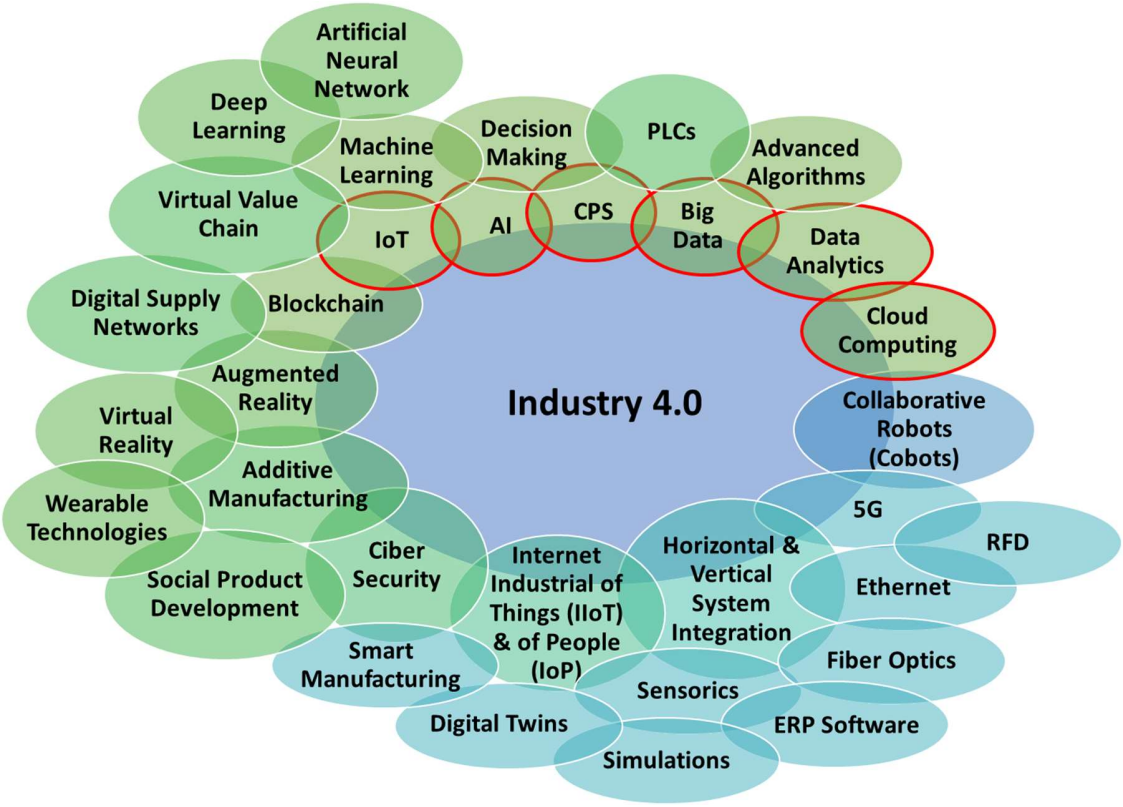

Fig. 7. Technologies Integrating the Industry 4.0
Source: own elaboration on the base of Jeschke et al., (2017), Nayyar et al. (2019), Lu and Weng, (2018), and Ustundag and Cevikcan (2018).
Rys. 7. Technologie integrujące Przemysł 4.0
Źródło: opracowanie własne na podstawie Jeschke et al., (2017), Nayyar et al. (2019), Lu i Weng, (2018) oraz Ustundag i Cevikcan (2018).

The following is a brief description of the main technology components of Industry 4.0 represented in Figure 7 (delimited by red circles) (cfr. Skilton and Hovsepian, 2019; Buyya et al., 2018; Jeschke et al., 2017; Nayyar et al., 2019; Lu and Weng, 2018, Ustundag and Cevikcan, 2018):

- A crucial technology for the management of smart manufacturing processes and organisations is the Internet of Things (IoT) technology. IoT continuously connect physical objects to the Internet, generating a heterogeneous system. These interconnections allow objects to gather, process, and exchange data, which allows in turn, among other things, for real-time control of processes and devices[14]. A typical IoT

[14] In 2012 the International Telecommunication Union elaborated the Recommendation ITU-T Y.2060, which provides an overview of the IoT, clarifies the concept and scope of the IoT, identifies the fundamental characteristics and high-level requirements of the IoT, and describes the IoT reference model, including in an appendix information about the ecosystem and business models. See the Recommendation in: http://handle.itu.int/11.1002/1000/11559 Access on 10/08/2020.

device consists of sensors for collecting data and actuators that operate upon a context or an environment. The physical objects could be mechanical or electronic devices, sensors, RFID, actuators, computers, wireless devices, PLCs, vehicles, buildings, production processes, etc. In the case of production, it is also known as the Industrial Internet of Things (IIoT). The IIoT articulates the digital world with that of machines, combining the industrial system with the advancement of computing, and facilitating the collection of large volumes of data through machines and their smart sensors.

- Data analytics is the process of withdrawing meaning and value from raw data by means of software technology. In this sense, data analytics is another important part of Industry 4.0. This technology is possible due to the advancements in sensors as primary sources of data, the development of advanced algorithms, the increase in the storage capacity and processing of a large volume of data through these algorithms, the application of artificial intelligence software for analysis and decision-making, and the connections between workers, devices, machines and processes. Data analytics also includes descriptive statistics, data visualisation, and data communication for supporting management in decision-making, planning, and reporting.
- In turn, cyber-physical systems or CPS are advanced mechatronic production systems that get smarter by their connectivity to the IoT or the IIoT. CPS are intelligent networked systems that are designed to sense and interact with the physical world. The interactions are in real-time, involve security issues, are focus on reliable performance, and could include humans as users. The physical world refers mainly to embedded sensors, processors and actuators, but physical objects with embedded systems could be products, devices, building, industrial facilities, vehicles, logistics tools. The cyber part of the system involves collaborating computational elements that control physical objects with an interactive communication, with the embedded system. For this purpose, CPS are made up of intelligent control systems, wireless or fibre optic communications, and cloud computing. In other words, these three technologies are merged to generate CPS, which coupled with IoT can operate on Internet-based business processes, and even on social networks. CPS have a virtual copy of themselves, called the digital twin. In historical terms, RFID appeared in the logistic field and can be considered one of the first CPS.
- Big data refers to the collection of different kinds of data that are gathered by advanced systems in any organisation. Usually, the big volume of information data exceeds the processing capacity of traditional databases. Originally, big data included structured data, but now it also embraces unstructured or semi-structured data from organisation, production, social networks, and/or other sources (texts, images, time series data,

financial data, weather, industrial parameters like temperature, clickstreams, and/or videos). Big data shows the five "Vs" characteristics: volume (terabyte or petabyte of massive data), velocity (high rate of generation and processing of data), variety (data comes from different sources and formats), veracity (raw data usually required validations), and value (possibilities for extracting value with data analytics). In turn, digital data is usually named as the "new oil," but the properties of digital data are quite different from material fossil resources. The latter are perishable and excludable, i.e., they disappear with consumption and exclude others to do so if an economic agent is consuming it first. In contrast, digital data can be shared uncountable times, without excludability and any loss in quality or utility from the original data (Yeung and Lodge, 2019: 10-11).

- Artificial Intelligence (AI) is an information technology based on many different fields, like computer science, statistics, information theory, cybernetics, neuroscience, linguistics, psychology, and learning science. "Technology is moving beyond the analytical to predictive and prescriptive powers with the rise of artificial intelligence" (Skilton and Hovsepian, 2019: 30). AI allows machines to interact with humans, data, and the environment, learning from this interaction, and even performing better than humans or machines. Today, one of the major components of AI is the natural language processing (NLP), which provides the capacity of interaction between computers and human beings. Another component of AI, machine learning, has been being applied in self-driving cars, chatbots, and other types of AI-based assistants. Chatbots or software personal assistants, which are AI algorithms for querying methods (based on NLP), have many applications in different fields. Besides, the future of work is drastically changing given the impacts of AI on the Industry 4.0 processes. There are many preoccupations with the elimination of many jobs due to the incorporation of AI to different processes (Skilton and Hovsepian, 2019: 301).
- Cloud computing is in essence a set of virtualised computing resources and services distributed through Internet. That is to say, cloud computing gives access to applications, data storage, and other computing resources delivered by distant Internet-based servers, rather than local devices. This key Industry 4.0 technology produces big impacts on the strategy of digital companies, by providing firms with cloud platforms that offer reliable and cost-efficient services to their customers. Cloud computing is at the base of the "platformisation" of the digital economy. It consists of interconnected and virtualised digital resources that are supplied as service for customers through specific agreements. The most common examples of cloud computing service models

are infrastructure-as-a-service, platform-as-a-service, software-as-a-service, content-as-a-service, and data-as-a-service (OCDE, 2014: 82).

Other technologies are gently occupying the centre of the scene. For instance, advanced communications, especially fifth generation or 5G technologies, are a core foundation of Industry 4.0. In the smart factory there can be no delay in the flow of information to a cobot or collaborative robot because it could cause accidents. It is recommended that there be no delay in communicating the product with its production environment, because product customisation is possible through continual and fast reconfiguration of design and manufacturing systems, in order to have cost-effective operations.

Technologies that guarantee data security are also vital, since they generate value for companies and meanings for stakeholders. For this reason, cyber-security is an aspect of relevance and concern for Industry 4.0. It is one of the biggest problems in the generalisation of the use of systems, such as CPS and data storage for exchange in the cloud.

However, Industry 4.0 is much more than data analytics and AI powered systems or a collage of several technologies. We have already mentioned at the end of epigraph 2.1 that when Industry 4.0 is applied to a smart factory, there is a hierarchical architecture for representing the different technologies that are involved (Chen et al., 2018). Components as CPS, IIoT, sensors, data storage, and AI applications rely on protocols. Protocols can be described as some sets of rules that allow different manufacturers' devices to communicate with each other using different "languages" or code for communications.

Figure 8 below shows the different levels of the architecture involving different technologies, both physical at the bottom and digital ones in the upper levels. Architectural models of smart factories or Industry 4.0 applications show how the interconnections between the systems that are articulated in such factories or applications are established, distinguishing different layers or levels with a hierarchical relation among them and the information flow between layers[15]. The consolidation of the Industry 4.0 requires a stable system of communication, coordination, and assessment. The hierarchical model provides with these requirements. Besides, the standardisation processes for IIoT and CPS protocols would come down the prices of Industry 4.0 components.

[15] Here, we will concentrate on the RAMI 4.0 model, which is the one more utilised. There are other models, like the Industrial Internet Reference Architecture (IIRA), developed by the Industrial Internet Consortium (Phoenix Contact, w/d), or the Stuttgart IT-Architecture for Manufacturing (SITAM) (Resman et al., 2019: 154). These last authorsproposed with their architectural model, called LASFA.

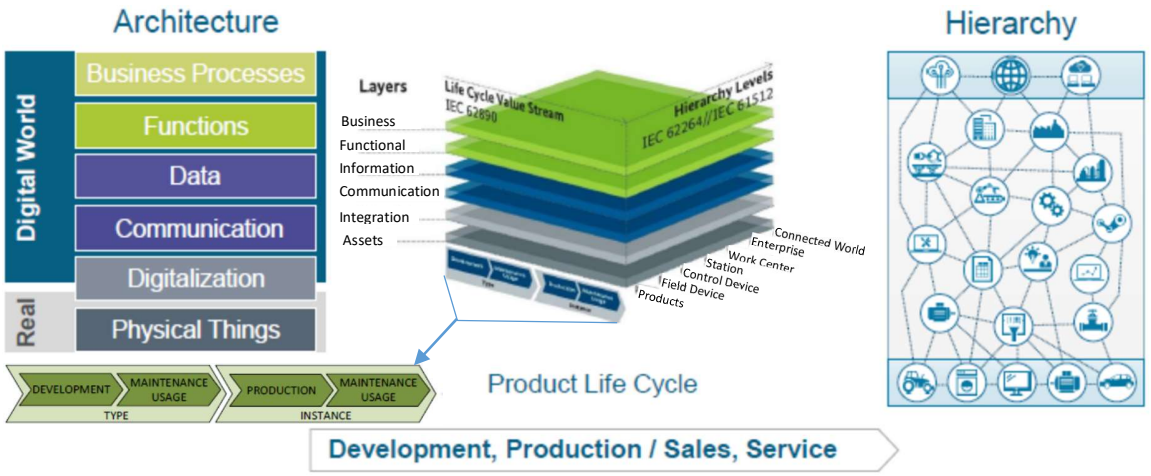

Fig. 8. Hierarchical Architecture of Industry 4.0
Source: Dr. Schweichhart (2015).
Rys. 8. Hierarchiczna architektura Przemysłu 4.0
Źródło: Dr Schweichhart (2015)

This model (Figure 8) has a three-dimensional approach to refer to Industry 4.0's technologies, functions, and interconnections (Phoenix Contact, 2020). The first dimension embraces the architecture that includes physical assets, digitalisation, functional descriptions, data mappings, communications, and business processes. This allows to divide a complex problem into more simple subsystems, facilitating the implementation issues (Chen et al., 2018). The second dimension involves the lifecycle and service life of the products and production systems, in conjunction with the value stream they comprise. The third dimension shows how functions and responsibilities are allocated within the factories or plants.

The first dimension or vertical axis can be described as follows (Zezulka et al., 2016; Schweichhart, 2015; Resman et al., 2019; Phoenix Contact, 2020):

- The first layer, for assets, include physical objects, such as raw materials, parts and components, sensors, machines, physical devices, documents, archives, diagrams, workers, auto-guided vehicles, etc.
- The integration layer refers to the digitalisation of physical objects into digital ones. The assets are connected with the digital world through for instance digital twins of processes and systems, the computer control of the process, system controllers, control of vehicles, human-machine interface devices, switches, PLCs, hubs, sensors, and RFID[16], among others.

[16] Radio-Frequency Identification.

- The communication layer delivers communications to connect the flow of information between the integration layer and the information layer. The communications use a uniform data format or standard for such purpose.
- The information layer organises the available data. It is usually referring to software applications that allow to manage raw data, figures, data matrices, sales, purchase orders, suppliers, logistic channels, materials and components. This layer deals with digital information and transmits it to higher layers.
- The functional layer is responsible for horizontal integration of different functions. This includes criteria for production rules and system control, product features, cloud services, coordination of components, testing beds, delivery channels, user inputs, and other minor functions (alert lights, fingerprint authentication, etc.).
- The last layer is the business, which includes information like goals, strategic objectives, business strategy, close and broad environment, budgets, commercial strategies, and competitors' data.

The second dimension, or horizontal axis, addresses the life cycle and value stream of the industrial production process. For such purpose, it distinguishes two phases: Type and Instance. The product can change from type to instance phase multiple times, for adding value for customers (Phoenix Contact, 2020; Resman et al., 2019; Schweichhart, 2015):

- Type phase is when the product is under development or in a redesign for customers.
- Instance phase is when the product is in production or is installed in a customer's system.

The third dimension or second horizontal axis (on the right-hand side of Figure 8) represents the Hierarchy Layers and reflects the firm's organisation for Industry 4.0. It is based on two international standards (IEC 62264 and IEC 61512), originally designed for control system integration in an organisation. Each layers are the following (Zezulka et al., 2016; Schweichhart, 2015; Resman et al., 2019; Phoenix Contact, 2020):

- Connected World: the factory can connect with external partners through service networks.
- Enterprise: all the functions are interconnected at the firm level. The ERP (Enterprise Resource Planning) software is a good sample of this level of integration and organisation of the functions.
- Work Centres: it represents the connections, transport, and data exchange of different cells of production, including their location, which in turn are integrated with machines, robots or cobots, and other intelligent devices at a work centre.

- Station: it shows the connections and flow of information at the station (integrated by different machine).
- Control Device: it includes the digital control of the information and data produced at a specific physical device.
- Field Device: it includes the control of flexible machines or systems with intelligent controllers or smart sensors, etc.
- Product: it involves product specifications and the production capacity, for organizing the production.

On the other hand, the demand in the Industry 4.0 is not limited to ICT but also for high value-added machinery and equipment, which is expected to increase in the near future because competition accelerate the needs for factories to become flexible, smart, and agile. Therefore, investments in R&D and smart factories turns out to be even more essential to improving any country's economic competitiveness and national prosperity. The demonstrated impacts of Industry 4.0 are mainly an increase in firm's efficiency, the availability of production assets, raising efficiency of equipment and production, and increasing value per employee. The improvement in productivity is still in discussion, with some authors warning about the low productivity increase with digitalisation (Gordon, 2016). On the other hand, the results in the short term of smart factories are the reduction of costs, lead times, delivery times, etc. (Resman et al., 2019).

1.5. Pervasiveness of Industry 4.0

Conceptually, technology is a system that integrates machines, working procedures, energy sources and information to create manufacturing processes or distribution activities for goods and services or social solutions for common problems. Today, digital technologies are increasingly independent of the knowledge, vagaries, whims or decisions of individual employees (Dormer, 1997: 7; Arthur, 2009).

Digital technologies lead us not just to improve technological processes, technological products, and organisational changes, but they are also modified and in turn modify more specific behaviours at economic, organisational and social levels, with feedback loops between technology and organisations. In this sense, the behaviours of digital technologies are systemic (Ellul, 2018: 170). The interpenetration of the digital technologies among them and with the working processes, economic activities, and social life can be categorised as

pervasiveness. It embraces both activities at different levels and sectors, and also the circulation of information among them, in a kind of circular patterns and not a linear one, like in the arising of digital technologies in the late nineties of the last century.

In this context, pervasiveness means also the global presence of technology and its far-reaching effects at economy and society as a whole. Pervasiveness refers here to the wide range of application of a certain technology, from its utilisation in different sectors to its functioning in several processes in existing systems (Cecere et al., 2014: 1828). In the case of digital technologies, Bresnahan and Trajtenberg (1995: 84) have identified the binary logic as the pervasive element for the application in numerous sectors and their technological dynamism, what they call general purpose technologies.

Not all technologies are the same. Digital technologies are not analysed just by their functional role, or their aesthetics results, or their economic impact, or global communication effects, but also because their application to all human activities, which can be objects and subjects of these technologies. Social groups change a technology but also technology changes groups' behaviour, so both mutually co-create one another in contexts where technology and organisations are highly interdependent (Callaghan et al., 2017: 89). On the other hand, all human activities present a kind of technological orientation, which include routines or a way of doing or tracing them with digital instruments. It seems there is no human sphere outside of these digital technologies (Ellul, 2018: 169). Therefore, we can characterise digital pervasiveness as a polyhedral concept, with many faces or dimensions.

The position or the form that digital technologies embraces and relates to the physical world is another dimension of their pervasiveness. For instance, in the digital economy, the big platforms could adopt several side positions concerning the demand and the offer. It is a kind of multi-level and multi-sided perspective of digital technologies in relation to real economy (Just, 2018; Van Dijck, 2020). This perspective or approaching model aims to integrate the basics of digital economy; i.e. the several interactions of different stakeholders and processes that generate and participate in value creation and value capture. It is worth to mention that in this sense the digital economy tends to integrate all the economy and it is not a separate part of the whole.

The following Figure 9 tries to represent this peculiar property of interacting and pervasiveness that digital platforms have. The "position" in the virtual space allows digital platforms to present a high pervasiveness in the relationships and in the new forms of interacting, and the tendency to monopoly business practices[17].

[17] After a 16-month investigation about competition in the digital economy, the House Judiciary Committee's Antitrust Subcommittee launched recently (October 7, 2020) an important report with categorical judgement about the monopoly

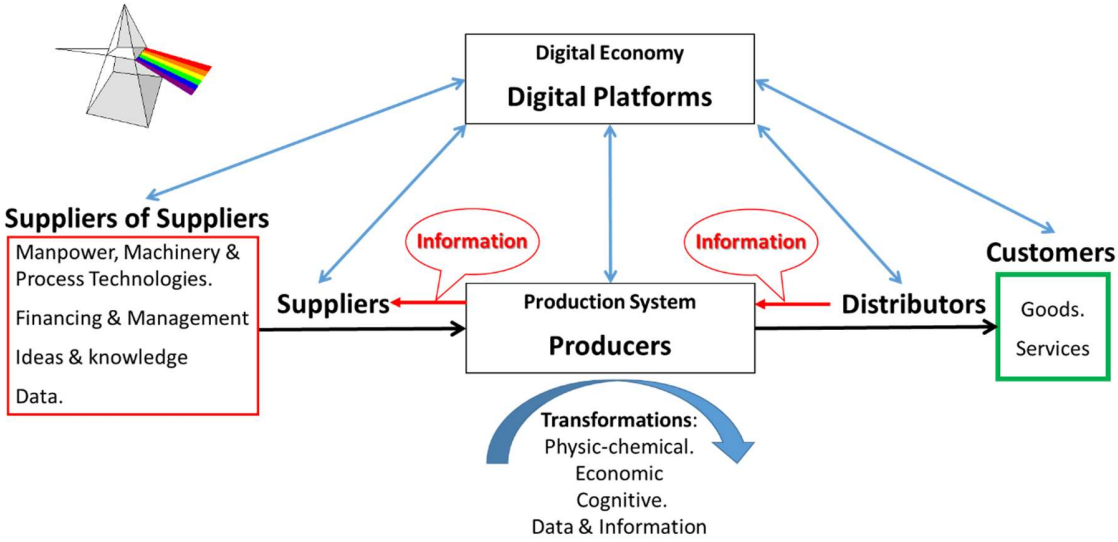

Fig. 9. Multilateral Interactions and Pervasiveness of Digital Platforms
Source: own elaboration.
Rys. 9. Wielostronne interakcje i powszechność platform cyfrowych
Źródło: opracowanie własne

The digital platforms interact with different levels and actors, increasing the dynamic relationships and interchange of goods, services, and data that can be found in a value chain when it is mediated by some digital platform. Digital platforms are no longer just an instruments for data interchange, but also provide economies of coordination and scale economies, data processing and storage, creating new knowledge and tools on the base of systemic information, facilitating complexes and systemic co-evolutionary processes among different actors, sharing of best solutions, or arranging, or scheduling the logistics of the value chain.

In other words, digital platforms could cover the whole range of activities that allow both value creation and value capture. In Figure 9, the red arrows and letters show the traditional linear functioning of value chain with logistic interchange of information. For comparing with the traditional non-digital economy, the blue arrows show a new way of interacting for digital platforms that include new roles to be played for incumbents and new entrance enterprises.

position and business practices of Apple, Amazon, Google, and Facebook. The report suggest possible remedies in three main lines: a) restore competition in the digital economy; b) strengthen the antitrust laws; and c) reinvigorate antitrust enforcement. See the report in: https://www.documentcloud.org/documents/7222836-Investigation-of-Competition-in-Digital-Markets.html Access on 08/10/2020.

In the following lines, we will try to explain the economic and social impacts of the pervasive character of the Industry 4.0 and the tendency for monopoly, analysed in brief in the previous paragraph. It will be treated specifically for the evolutionary and evolving economic and social structure that emerges from the digital economy, and particularly in the form of digital "platformisation" of the economy (Just, 2018; Van Dijck, 2020; Poell et al., 2019). Platformisation can be conceptualised as "the interpenetration of the digital infrastructures, economic processes, and governmental frameworks of platforms in different economic sectors and spheres of life" (Poell et al., 2019: 6). They evolve from a technological instrument to a new business model and to a key structure in the dynamic and pervasive digital economy.

1.6. Characteristics of digital economy

Digital economy was introduced as a construct by pioneering studies of Don Tapscott (1995) and Dan Schiller (1999). The concept and limits of the digital economy are still not well defined because of the evolving nature of the subject. Some reviews focused precisely on the nature of the different sectors and technologies that could be included in the digital economy. It can be defined as an economy based on new inputs like ubiquitous data, digital technologies, data processing, extensive use of information technology hardware and software, and supported on telecommunications technologies and infrastructure, all of which are applied in all areas of economy, including internal and external activities of organisations (Afonasova et al., 2018; Sutherland and Jarrahi, 2018). Therefore, digital economy is not based on traditional production factors (land, capital, and labour), but on knowledge-intensive factors (digital technologies, ubiquitous data[18], digital and non-digital knowledge) coupled with capital investments. The latter ones are all non-price factors for competitiveness (Arciénaga, 1998).

Following Bukht and Heeks (2017) partially, we can distinguish four groups of economic activities included into the digital economy. These four sectors are the following:

- The "digital and telecommunication infrastructure" that supports the whole digital economy.

[18] Data exist almost from the beginning of mankind, but ubiquitous data emerge from cloud computing technologies and the internet era. On the other hand, the digital data has very important differential properties in relation to material raw materials, as it was described in the epigraph 2.3.

- The “proper digital sector” that includes information and communication technologies (ICT), that produce the foundational digital goods and services.
- The “true digital economy” that produces digital goods and services (music, e-books, e-services, etc.), on the base of the digital technologies of the “proper digital economy”. This part of digital economy include digital platform services.
- The “digitalised economy”, which includes the application of ICTs in all economic fields.

In brief, Figure 10 below shows how these components of digital economy are articulated among them, starting from core infrastructure. As it can be perceived in this Figure, the digital economy was developed in several waves from a nucleus or core IT infrastructure, which irradiates its expansion from the pure digital field to the rest of the economy. Therefore, the digital economy is not a different part of the whole economy right now. On the contrary, the pervasiveness (as it will be justified next in 3.1.) of ITC technologies explains the constant movement of the digital economy to embrace all the economic and social activities very well, at a global level. Figure 10 represents a fourth-level nested model, starting from the core “sector” or layer, where each level would itself be nested within a greater digital economic scope, in an amplifying trajectories of digital ICTs. This multilevel model can be considered a two-way nesting where information and relationships flow from the external wide level of digital economy to the core layer, and they also flow back from the inner or core layer to the external one.

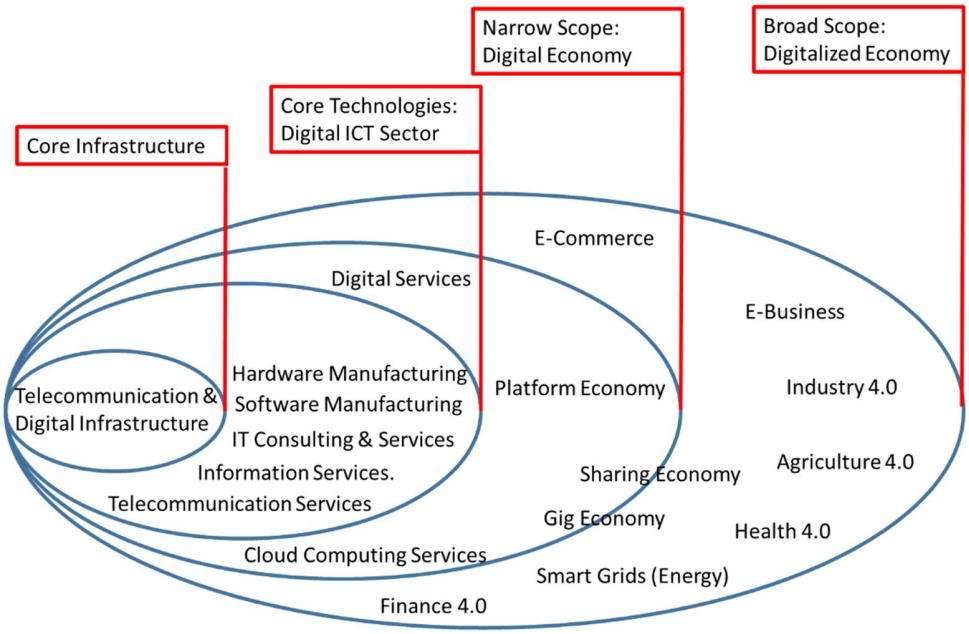

Fig. 10. Digital Economy
Source: Own elaboration on the base of Bukht and Heeks (2017)
Rys. 10. Gospodarka cyfrowa
Źródło: Opracowanie własne na podstawie Bukht i Heeks (2017)

Porter and Heppelmann (2014) explained that there are three connected waves that we could use here also to explain the dynamic structuration of the digital economy today (Figure 10). Starting in the late seventies, the first was the move of ICT to applications within the value chain, to improve processes of different nature. The second wave (mainly starting in the nineties) was the move of ICT to value chain integration and coordination, across functions, geography, and the boundaries of the firm, suppliers and customers. Finally, in the last fifteen years the third wave move ICT into products itself. They are smart connected products, i.e. they have autonomous or automatic smart functions and at the same time they are connect to the cloud.

Analysing Figure 10, telecommunication and digital infrastructure are key strategic components of the digital economy. Part of the digital agenda of any country and technological sovereignty discussions involve the consideration of this type of infrastructure. The evolution of digital infrastructure has three main steps: adoption, innovation, and scaling (Henfridsson and Bygstad, 2013). This "sector" includes the development of public digital infrastructures, and particularly public data infrastructures, which are of utmost importance for any country. The latter infrastructure presents high scale economies, and tends to be a natural technical monopoly. These two characteristics are also present in digital platforms as we will see. Digital infrastructures are a *sui generis* category

of IT artefacts that should be treated as a separate type (Tilson et al., 2010), thus it was put at the core position in Figure 10.

On the other hand, the second component includes core technologies. We have described many of them in epigraph 2. This "proper" digital sector has an economic evolution starting from information technology (IT) and software in the sixties, then the development of Internet and telecommunication infrastructure in the nineties, and finally in the beginning of this century the information and IT services, providing core technical services. Coupled with the digital infrastructure, both led the expansion at the commencement of the digital economy, above all in the nineties (Schiller, 1999).

The third sector includes what can be mentioned as the narrow part of the digital economy. This embraces the first generation of physical products that were digitally transformed rapidly, like music recording[19], books, videos, newspapers, gaming and video gaming, online advertising, but also primary data services (storage and data collection)[20], the development of software as a service, and platform connections. In this case, physical products are completely digitised, and commercialised through digital platforms. These products were the first to be sold in digital platforms in the previous decade, and they are characterised by a purely digital materiality (Kallinikos et al. 2013), in contrast with the products of the fourth sector[21]. As these last authors state, these completely digital products have many similarities to software products, in the sense that they are incomplete and in a kind of perpetual making of new versions.

There are also the sharing economy and the gig economy in this sector. The former, also known as the collaborative economy, is a new economic system in which assets and services are shared between private individuals, in a peer-to-peer-based sharing. Frenken and Schor (2017: 4-5) defined the sharing economy as "consumers granting each other temporary access to under-utilised physical assets (idle capacity), possibly for money." Pioneering study of Benkler (2004), at the beginning of 2000s, recognised the economic potential of sharing activities through the Internet. This economic system builds upon the Internet by connecting consumers with unused resources with almost zero marginal costs. Although under discussion, two classic examples are Uber and Airbnb (Bond, 2015). Platforms have empowered sharing economy in their rising phase (Bond, 2015).

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[19] For instance, purely digital MP3 files.

[20] See the description of most common examples of cloud computing service in the epigraph 2.2.

[21] Blockchain is becoming a familiar technology in different sectors and industries. It allows asset digitisation and contributes with support to those persons interested in exchanging digital assets with other people. In this context, tokenisation is the act of changing the ownership of a physical asset into a digital token. Thus, a token is a transferable unit of a physical asset. Besides, there can be "digitally native" assets that are those which lack physical substance (Kim et al., 2019: 182).

A gig economy is a kind of digital labour market in which companies can hire temporary flexible positions of independent contractors and freelancers. They are short-term contracts instead of full-time employee agreement. The employment relationship becomes a work assignment (Muntaner, 2018). Hence, the labour offer is a sporadic work and freelancers work by project. Other characteristics of the gig economy are: innovation predominates over routine work; digital labour market provides job flexibility; contracts can cross borders; the work comes by messages; it reaches more and more sectors today; and it does not create working ties. Besides, labour power comes to be transformed into a commodity (Gandini, 2018).

In the fourth sector, which includes segments that produce a combination of physical and digital products, we have the broad scope of the digital economy (Bukht and Heeks, 2017). Many of these sectors were incorporated after the first generation of digital products. In general, these second and third generations of digitised products are physical objects that are enriched in their functions and usability with digital technology, which in turn result in digitised artefacts and digital innovation. Therefore, this type of digitised goods is characterised by both digital and physical materiality (Herterich and Mikusz, 2016), or in other words, ICT is becoming part of the physical product itself (Porter and Heppelmann, 2014)

However, the applications of ICT to process production are also important. It is worth to mention here Industry 4.0, Agriculture 4.0, Health 4.0, Finance 4.0, Smart Grids for energy management, and the second and third generation of e-commerce[22]. First-generation platforms in e-commerce were devoted business to customers (B2C)[23]. The second generation developed capabilities to meet rapidly changing business to business (B2B). These included new forms and safety for payment transactions, ordering, pricing, shipping, returned goods, product specifications, and functionalities to assign products to certain geographies and for real-time inventory management. B2B e-commerce solutions are substantially more complex than first-generation B2C platforms. The third generation of B2B e-commerce can be described as solutions integrated with ERP and CRM[24], based on

[22] E-commerce is a business model that includes buying and selling online transactions made through the internet, embracing also other activities as internet banking, payment gateways, auctions, and online ticketing. E-commerce is basically the use of the Internet to make business transactions.

[23] In 1995, Jeff Bezos uploaded one million book titles to Amazon webpage, making easy to look for and purchase new books contained in CD-ROMs provided by book publishers. This opened the first stage of evolution of e-commerce. See https://www.klarna.com/knowledge/articles/the-evolution-of-e-commerce-7-epic-milestones/

[24] ERP refers to a software integrated solution for planning at firm level (Enterprise Resource Planning), and CRM refers to a software solution for the systemic management of customers (Customer Relationship Management).

cloud computing technology and smart applications such as cross-referencing and catalogue extensions[25].

Today, B2C and B2B e-commerce have incorporated AI, AR, VR, and the Internet of Things, creating an immersive e-commerce experience for customers. There are also included solutions for mobile apps (called m-commerce), conversational commerce via live chat, chatbots[26], and voice assistants. All these technologies are increasing the rate of penetration of e-commerce in the society, but the pandemic has multiplied this effect. For instance, according to McKinsey (2020), e-commerce in USA has replaced physical channels in three months (May to July 2020) what was foreseen in the next ten years, reaching almost 35% of penetration.

In turn, derived in part from this description, some of the stylised facts[27] that characterise the digital economy as a whole, can be summarised in the following (OECD, 2014; Bukht and Heeks, 2017; Rayna, 2008; Tapscott, 2015):

a) Reliance on ubiquitous data, including "big data".
b) Digitation is converting and storing explicit knowledge in digital form at the core.
c) High degree of scalability and range of digital markets.
d) Discordance or unevenly distribution among countries, with highest development in central nations.
e) Digital economy grows faster than overall economies, especially in the global South.
f) Significant contributions to employment although employment statistics for the digital economy are underestimated.
g) Labour productivity is generally higher than that in the overall economy.
h) It is a knowledge intensive economy.
i) Centrality of virtualisation, converting physical and tangible goods and processes into virtual.
j) High mobility of intangibles, users and business functions.
k) Prosumption, i.e. the same agent is a producer and at the same time a consumer of information.
l) Important degree of flexibility in many cases to locate servers and other resources.
m) Network effects based on integration and internetworking of all the players (suppliers, producers, customers, competitors).

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[25] According to Reid and Sanders (2013: 113-114), in technological terms e-commerce began with automated order entry systems, evolved to electronic data interchange (EDI) in late 1970s, to electronic store fronts in mid 1990s, to net marketplaces in late 1990s, and to the development of intranets and extranets since the last decade.

[26] A chatbot is a computer program that uses artificial intelligence (AI) to simulate a conversation or chat with human users, in natural language especially over the Internet. It is also called virtual assistant.

[27] The concept of stylised facts is based on the methodological proposal of Kaldor (1961: 179) for the social sciences.

n) Business models are multi-sided in which the two sides of the market may be in different regions.
o) Business models and digital innovation favour the convergence of digital technologies.
p) Monopoly or oligopoly are usual in certain business models, operating globally and relying heavily on network effects.
q) Reducing intermediation, connecting directly business with their customers.
r) Molecularisation, with more probability of survival of "light" organisations than "heavy" ones.
s) There are low barriers to entry and fast evolving technology, and therefore an important market volatility.
t) Some digital goods are easy replicable; thus they are public goods; others are durable and experience goods.
u) Immediacy or shorter times between ordering a product, its creation, and delivery.
v) Creativity and imagination are the main source of value, which is also affected by scale economies (see next).

1.7. Digital "platformisation" of economy

Platform economy has grown at high speed in recent years, capturing an increasing share of the economy in core countries (Neittaanmäki et al., 2016: 26-27). Thus, it is very important to understand the power and value of these multi-sided enterprise models in contemporary management[28]. The concept of "platform" appeared in the early 2000s in the ITC sector (Casilli and Posadas, 2019: 293). It refers to a digital infrastructure developed in a firm that embraces digital objects (data, connections, and codes) (Nambisan et al., 2020: 161) as digital intermediaries that connect persons, information, and goods (Casilli and Posadas, 2019: 293), in a layered architecture with a governance model (Pearlson et al., 2019: 212; Van Dijck, 2020). The digital objects and the governance model are crucial for a business model that allows for a sustainable value creation process engaging the customer and generating the success of the platform.

They are commonly described as an ICT solution that can intertwine different economic or social agents from both supply and demand sides. Therefore, the digital platform is basically an instrument for IT consuming (Pearlson et al., 2019: 212). They can be classified

[28] It brings together groups of different users in two-sided networks, though there exists IT platforms that firms build primarily for their own use, and are one-sided markets (Tiwana et al., 2010).

according to different criteria. Considering the target to whom products or services would be focused, Boudreau and Lakhani (2009) distinguished three types of platform business models: integrator, product, and two-sided platform. Taking into account the focus of the platforms, they can be classified in transaction-centric digital platforms, which function as a facilitator of transactions between supply and demand[29], and data-centric digital platforms, whose focus is on data-based networking. These two ideal types can be also combined. Both are predominant but not exclusively devoted to B2B commerce (von Engelhardt, 2017: 5-6)[30].

Using the nature of the activities involved and the business model used in a digital platform as a criteria, Srnicek (2017: 63-101) classifies this digital infrastructure in the following five categories:

- Advertising platform: they gather data from users, extract value from this, and capitalise on advertising in the platform space. Typical examples are Google or Facebook.
- Cloud platform: they have digitalised services available (hardware-as-a-service and software-as-a-service) and rent out such hardware and software. An example is Salesforce.
- Industrial platforms: they build infrastructures to support industrial activities or processes, or to transform traditional manufacturing into internet-connected processes. A typical example is the Siemens platform for robots (SIMATIC Robot Integrator) that allow robot integration in a given process.
- Product platform: they utilise other platforms in order to transform a traditional goods into a digital service. A good example is Spotify for music.
- Lean platforms: they operate with a business model that require minimal physical assets but use digital assets. Paradigmatic examples are Airbnb and Uber.

These categories may exist as a pure case or in combinations of some of them within a particular platform. In turn, for noticing the high relevance of the platformisation process, some authors compared it with central concepts like the industrialisation in the First Industrial Revolution or the electrification process in the Second Industrial Revolution (Van Dijck, 2020: 2).

[29] Platform replicates the contacts in a classical marketplace.

[30] According to Evans and Gawer (2016: 9), they pointed out four types of platforms: the transaction platform, the innovation platform, the integrated platform (combination of the first two), and the investment platform. Innovation platform is very similar to data-centric platform.

As it was mentioned with other words, digital platforms are not just a technological infrastructure but also a business model in themselves[31]. Therefore, some of the platform characteristics are technological and at the same time economical ones. Next, we characterise the digital platforms making a synthesis of the contribution of many authors (Van Dijck, 2020; Parker et al., 2017; Neittaanmäki, 2016; Srnicek, 2017; Baldwin and Goodard, 2009; Tiwana et al., 2010; Poell et al., 2019) to remark these combinatorial characteristics:

i. Digital platforms differ from physical systems or platforms because the former can have fuzzy frontiers that makes recombination of digital objects less costly, and use of non-rival information.
ii. Platform architecture contains different layers: device layer, network layer, service layer, and content layer (Parker et al., 2017: 256). The platform architecture functions with the role of coordination device. They also usually present middleware, which expresses the logic of information exchange between applications (interlogical). It is a software that assists an application to interact or communicate.
iii. There is also a governance component that expresses the management strategy for the platform. This component mainly includes the rules of participation of different actors, the rewards for this, the control mechanisms[32], and the property right of the digital products that already exist and those that will be created. It also expresses the strategy for the platform.
iv. They are intermediary digital infrastructures that enable interactions among different users (customers, advertisers, service providers, developers, producers or suppliers), and even physical objects. In some cases, platforms can empower users with tools that allow them to create or co-create their own products, services, and marketplaces.
v. In this sense, a platform presents different digital resources. First, API[33]-enabled components are important, because they give a platform business the ability to configure offerings from components in a modular, "plug and play" fashion. A module is precisely an add-on software subsystem that connects to the platform for aggregating functionality. An SDK[34] is also necessary, which is a collection of

[31] "Platforms are, as a result, far more than internet companies or tech companies, since they can operate anywhere, wherever digital interaction takes place" (Srnicek, 2017: 59).
[32] From the control perspective, platforms are a very complex alliance networks called platform ecosystems, which are quite different from the classical notion of interfirm alliances. Governance requires a delicate balance between platform owner control and autonomy for independent developers (Tiwana et al., 2010).
[33] Application Programming Interface (API) is a computing interface which defines interactions between multiple software intermediaries. It delimits the kinds of calls or requests that can be made, how to make them, the data formats that should be used, the conventions to follow, etc.
[34] Software Development Kit or SDK.

software used for developing applications for a specific device or operating system. It is important to also have SLA (standard licensing agreements), code libraries, and templates.

vi. Platforms exhibit network effects, which are the main reason for their rapid growth. That is to say, with a greater number of users, the potential to create value from its users and their activities on the platform is greater. Therefore, platform businesses present rapid, exponential growth and unprecedented capital accumulation over a relatively short time. Besides, in case two identical platforms start competing, the one that could be more appealing will end up as the only competitor because of the network effect (more users attract more users). This is called the 'winner-takes-all' market' effect, because the platform with the bigger market share will continuously intensify its share and advantage.

vii. Platforms use cross-subsidisation. Free products and services are a usual strategy to accumulate more users and increase the level of activities on its network. In turn, the platform can balance out the economic gains and losses taking advantage of its multiple arms of the business.

viii. Digital platforms are evolvable systems because they can adapt to unanticipated changes in the external environment. Adaptation is at a low cost due to its modular architecture, without losing its identity or continuity of design.

ix. Digital objects are made with digital code that is reusable, making easier knowledge spillovers from the platform.

x. For developing code, platforms also present a low cost of investment in the tools necessary for such purpose, and almost zero cost of reproduction of digital objects once they are developed.

xi. Even physical products, employing a servitisation process (like we explain in 2.2), are sold by firms adding a digital layer to them, which is included in digital platforms.

xii. They are an instrument for value creation and value capture. About the former, value creation is not just an internal process but also happens externally through the users and developers, which are not an outsourcing resource for the platform but a third part involved. Therefore, the developer communities can be crucial for the success and extension of the platform. With regard to value capture, platforms are designed for user engagement showing attractive presentations of themselves and their offerings[35].

[35] This engagement favours extracting more data from its users (Parker et al., 2017: 256).

xiii. They have the potential to profit from application successes[36] while reducing the costs of failures.

xiv. They take advantage of the potential of digital technologies to reduce transaction costs, which in turn open new possibilities for incorporating new or additional market transactions. In particular, platforms ensure interoperability among different applications or modules within the integrated system, which is the base for reducing transaction costs[37].

xv. Platforms also exhibit almost zero marginal cost[38] for production or distribution of goods and/or services, brought on by the digitisation of everything. This makes potentially very cheap or nearly free digital products in the market. This almost zero marginal cost is passing through the physical products, representing the base for the new sharing economy[39].

xvi. From a performance perspective, platforms need to have a balance or trade-off among the main expected outcomes. For example, there would be an equilibrium between quality and reliability, as well as growth, speed, and agility. Quality cannot be sacrificed instead of growth, for short term results that affect platform sustainability in the long term.

xvii. Platforms have the ability to scale rapidly because developers are not limited by the processes of hiring, training, project selection, and coordination. These processes are carried out outside of the platform, allowing for much more rapid growth (Parker et al. 2016). Besides, digital platforms can show a high degree of scalability and range because they can expand their computing capacity in a modular way, in a relatively quick and flexible form. Therefore, the platform can adapt fast to additional demand (von Engelhardt, 2017).

xviii. From a strategic point of view, time is a critical factor for launching a platform, because the first mover has an advantage to first reach the critical mass and capitalise the network effect, becoming dominant and building a quasi-natural monopoly in the market.

xix. At the international level, digital platforms generate a division of labour between platform owners in developed countries and platform consumers in developing

[36] "If successful, a platform creates its own marketplace; if extremely successful, it ends up controlling something closer to an entire economy" (John Herrman, 2017).

[37] Particularly, blockchain technology diminishes transaction costs for digital platforms.

[38] Marginal cost of production or distribution is the additional cost incurred in the production or distribution of one more unit of a good or service.

[39] See sharing economy definition in epigraph 3.1.

countries (Nielsen and Kimaro, 2019: 116). When they grow up, digital platforms usually move from domestic markets to operate in the international arena.

xx. In a platform context, the innovation process also changes to a digital nature. As Parker et al. (2017: 256) expressed it, "…a relevant innovation is any digital application, including a product or service that is produced by an ecosystem partner using core platform resources."

xxi. Platforms are reshaping production, consumption, transportation, and delivery systems. For society, there are important impacts on the way we work and communicate, educate, care for health, inform and even entertain ourselves (Schwab, 2016: 7).

The following Figure 12 represents diagrammatically the main characteristics of the digital platforms synthetisised above, showing particularly the different stakeholders that participate in a digital platform, the main resources that usually are present in this structure, and the main components of this digital organisation (the architecture, the middleware, and the governance structure).

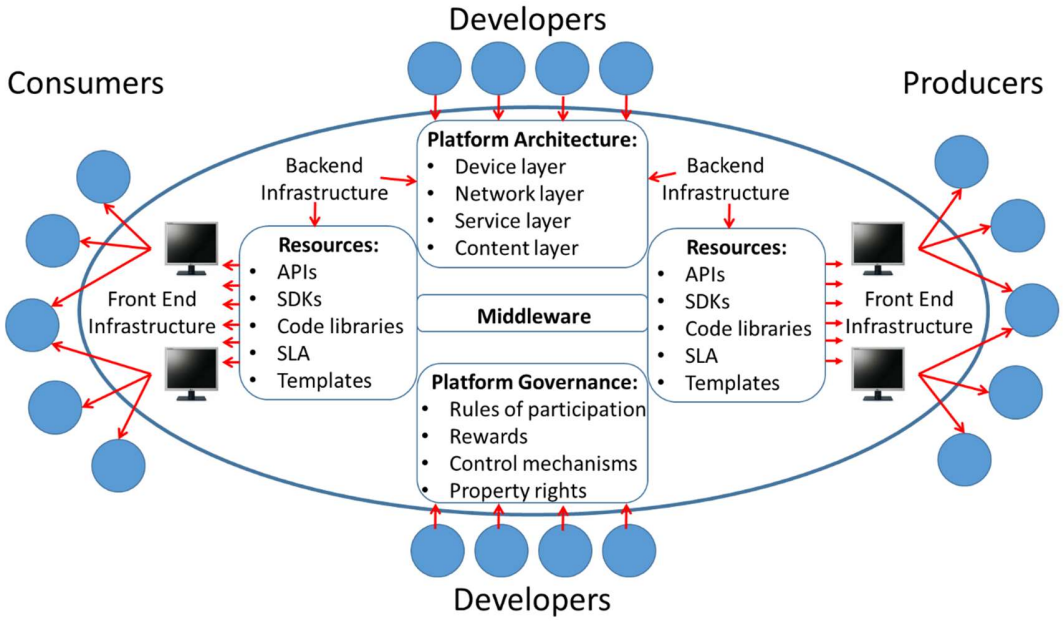

Fig. 11. Platform Structure and Actors
Note: The acronyms: APIs for Application Programming Interface; SDKs for Software Development Kits; SLA for Standard Licensing Agreements.
Source: own elaboration on the base of the previous synthesis and the work of Neittaanmäki et al. (2016: 26).
Rys. 11. Struktura platformy i aktorzy
Uwaga: Akronimy oznaczają: APIs - Application Programming Interface (interfejs programowania aplikacji); SDKs - Software Development Kits (zestawy do tworzenia oprogramowania); SLA - Standard Licensing Agreements (standardowe umowy licencyjne).
Źródło: opracowanie własne na podstawie poprzedniej syntezy oraz pracy Neittaanmäki et al. (2016: 26).

With regards to a central process in a digital platform, i.e. value creation, there are very interesting differences between traditional industrial firms and digital platform business firms. In the former, once the product is designed and launched to the market, in general the value is maintained almost constantly with the volume of operation (correlated with the size of the firm), except in the case when the firm innovates the product, in a kind of step function. Even in this case, the value creation is not necessarily correlated with the size of the firm or economies of scale.

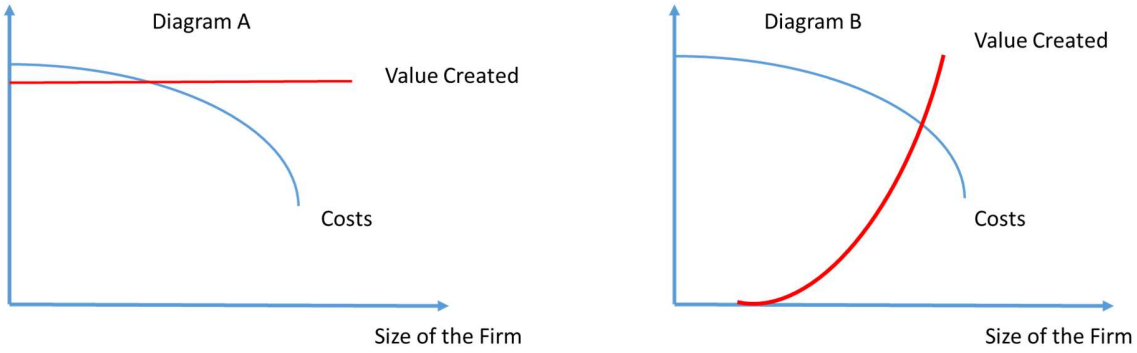

Fig. 12. Value Creation versus Size of the Firm (Economies of Scale)
Source: own elaboration.
Rys. 12. Tworzenie wartości a wielkość firmy (Ekonomie skali)
Źródło: opracowanie własne

In the latter, the value increases with the volume of production in a continuous pattern. This increase in the value created is due to the exploitation of big data, which is effectively correlated with the size of the firm (von Engelhardt, 2017; Van Dijck, 2020). Data sets can be reused, modified, refined, filtered, and even repurposed to produce new insights or value for them[40]. The digital innovation process, discussed in section 2.2., is at the base of the value adding and value capture that comes up of digital data.

Besides, these operations are performed with almost zero marginal costs, which make an important difference in profit with tangible products. In both cases (tangible and digital products), the companies can take advantage of the economies of scale, but in the second case, the profit is increasingly bigger. This description is reflected in Figure 12 above, where the industrial firms are shown in Diagram A and the digital platform businesses are presented in Diagram B.

[40] Sometimes these operations are in conflict when personal data are used without the due diligence (Yeung and Lodge, 2019: 10-11).

1.8. Impacts of the Fourth Industrial Revolution

When we talk about impacts and changes produced by the Fourth Industrial Revolution, the scale and scope of them are very wide (Schwab, 2016: 14). Industry 4.0 is characterised as a new vector for the growth and development of the knowledge economy (Bogoviz, 2019). The future seems to be a field of unavoidable changes and uncertainties, at local and global levels. However, Industry 4.0 is not an end in itself, but the tool for the transformations (Jeschke et al., 2017: 8) required to confront the great challenges humanity has in the medium term, like global warming.

The impact of Industry 4.0 on economic and societal changes is due not just by the availability of new digital technologies and their pervasiveness, "… but also by ideologies, power structures, and human aspirations and agendas. Technologies are not exogenous forces that roll over societies like tsunamis with predetermined results. Rather, our skills, organisations, institutions, and values shape how we develop technologies and how we deploy them once created, along with their final impact" (National Academies of Science, Engineering and Medicine, 2017: 54).

As in the case of previous industrial revolutions, the typical changes expected at the macro level will impact how people communicate with each other socially, and introduce economic disruption, as well as employment uncertainty associated with the 'gig economy', will produce social transformation with generational change around the world (Shields et al., 2020: 419), will transform the relationship between humans and machines (Brown, 2020: 241), and will change the landscape of labour, trade, and manufacturing with digital innovations.

At the firm level, the impacts are extended to all areas like marketing, engineering, materials sourcing, manufacturing, sales, customer support, human resources, and finance. In terms of processes, improvements in operational effectiveness accounted for greater resource efficiency, shorter time-to-market, higher-value products, and new services (Jeschke, 2017: 8). Industry 4.0 is changing the relationships with suppliers, producers, and consumers, with a digitally coordinated agile supply (Brown, 2020: 241).

In this context, in the next lines, we analyze the impacts on productivity, on the new sources of energy and its management, and on the working processes.

1.9. New sources of productivity introduced by Industry 4.0

Important improvements in productivity are at the core of every industrial revolution (Herčko et al., 2015). Productivity increases when we deploy technology (Brynjolfsson and Saunders, 2010). However, there is very little systematic empirical evidence that measures these economic and technical effects. For instance, Graetz and Michaels (2015) demonstrated with data from 17 countries the positive effects of industrial robots on economic growth and productivity. In this work, other findings were that industrial robots increased both labour productivity and value added, as well as increased wages and total factor productivity[41]. The robots also raised countries' average growth rates by about 0.37 percentage points.

On the other hand, the introduction of advanced and efficient production processes certainly will achieve productivity increases and also the exploitation of economies of scale. One question is what digital technologies are particularly involved in the positive effects on productivity. In Germany, the Fraunhofer Institute analysed in 2013 the use of Industry 4.0 and its impacts on the companies' productivity and growth potential. The main conclusion was that increases in productivity depended on the combination of five key technologies: embedded systems, smart factories, strong networks, cloud computing, and cyber security (Nagy et al., 2018: 3).

However, there are critical voices on the positive evolution of productivity. Gordon (2016) pointed to social and economic factors like a rising inequality, stagnating education, and aging population as a brake to the USA productivity growth, even though smart manufacturing was implemented. On the contrary, Rüßmann et al., (2015: 2) estimated for Germany that Industry 4.0 could drive the productivity gains of 5 to 8 percent, of total manufacturing costs over 10 years, which amounted from €90 billion to €150 billion. Therefore, the effects on productivity of the Industry 4.0 are still ambivalent.

The sources of productivity can be found in both the physical world and the digital world. In this sense, Schuh et al. (2014) suggested four main factors for productivity increase that can be considered in the physical and cyber level, and also taking into account the software and hardware as another dimension of analysis:

- ICT-Globalisation: The computing power, both storage capacity and high speed computing, is huge right now and has diminished the costs of storing data in a global cloud system, transforming data into ubiquitous object that can be accessed rapidly from any place.

[41] Total factor productivity is a wider measure of productivity than labour productivity (output per hour worked). This measure is the quotient of the outputs over the all inputs (labour, capital, energy, materials, and purchased services).

- Single source of truth: All the information from the product, along the product cycle, is available for all the partners along the value chain. Then, the visibility of the product information for all the actors is transparent, which avoids ambiguity, errors, and overlapping, making product changes easier.
- Automation: The cyber-physical systems (CPS) are the key piece for this factor. As we see in 2.2., CPS integrates computers, sensors, and actuators in a single system, facilitating the coordination at the plant level. Furthermore, the Internet of Things (IoT) improves the coordination with better communication into the industrial environment. Artificial intelligence (AI) has to also be accounted for because it produces new kinds of automation, with superior performance due to assisting or replacing humans as the main actor of productivity at work (Skilton and Hovsepian, 2018: 242). Therefore, CPS, AI, and IoT increase productivity through better coordination at the factories but also at the firm and value chain level.
- Cooperation: The cooperation has three different natures: the cooperation among workers, the cooperation among machines, and the collaboration between workers and machines. These three types enhance the decision-making process (see epigraph 5 next), as a crucial base for improving the productivity at an organizstional level.

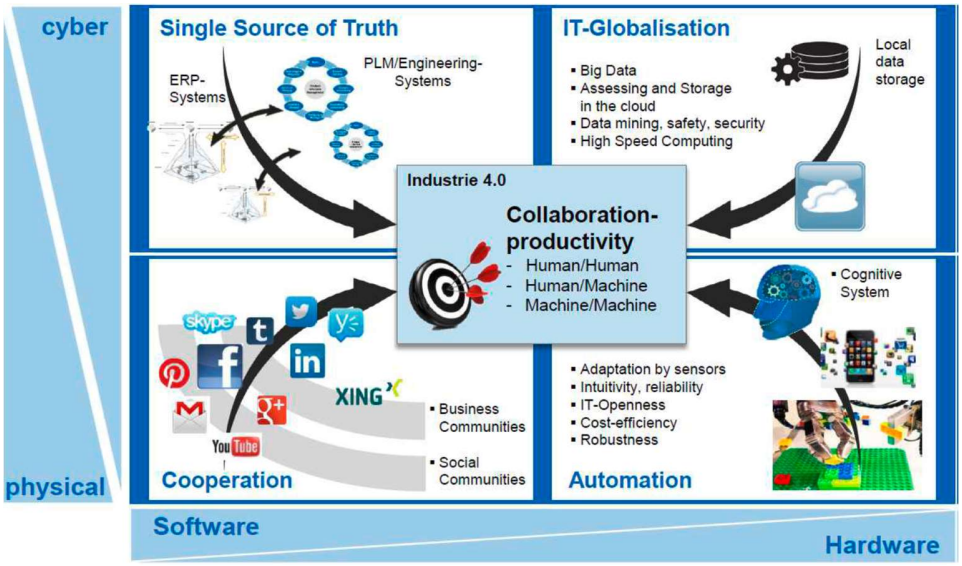

Fig. 13. Sources of Productivity in Industry 4.0
Note: PLM states for product lifecycle management.
Source: Schuh et al. (2014) and (Herčko et al., 2015).
Rys. 13. Źródła produktywności w Przemyśle 4.0
Uwaga: PLM oznacza zarządzanie cyklem życia produktu
Źródło: Schuh et al. (2014) oraz (Herčko et al., 2015)

As Figure 13 shows, the core for productivity increases is the collaboration at an organisational level, using ubiquitous data and their integration/exploitation, as the new approach, which in turn is fed by these basic four factors. Other sources of productivity are closely connected to these four factors, in a kind of concentric circle. There are radically shorter product development processes, virtual engineering of complete value chains, revolutionary short value chains, and performing better than engineered (Herčko et al., 2015: 5).

1.10. Incorporation of new approaches to energy and efficiency

At the centre of the First and Second Industrial Revolutions, steam and electricity were the transformations of one energy into another. However, with smart automation in the Fourth Industrial Revolution, the digital transformations depend on electronics and computing based mainly on energy efficiency and savings, rather than a new type of energy sources (Skilton and Hovsepian, 2018: 6). This happens even though smart plants and urban communities are highly energy-consuming systems (Riva Sanseverino et al., 2014).

The technologies Industry 4.0 involves can address and solve some of the challenges the world is facing today such as resource and energy efficiency, urban production, and demographic change (Herčko et al., 2015: 5).

Industry 4.0 impacts in the energy field are accounted for in several activities, processes, and objects. First, the different ICT technologies have positive impacts on energy management systems for production processes and also for managing energy efficiency in buildings. There are also contributions in the evaluation and measuring of energy consumption data (smart energy meter electrical signal), in the installation of energy management systems, and in energy-saving devices (Weber, 2018: 125)[42]. For example, mobile phones are managing their batteries' energy through algorithms that optimise the battery life and at the same time update GPS location tracking. At the factory level, smart sensors and smart meters at the machine and production line are truly IoT devices, which can give visibility to energy consumption. Therefore, managers can make good decisions on the basis of real-time energy data, improving saving and energy efficiency in manufacturing processes (Shrouf and Miragliotta, 2015).

[42] These contributions are explicitly recognised in the ISO 50001 standard for energy management systems. See Kals (2015), chapter 7.

Increasing energy demands, environmental concerns, and possible shortages of fossil fuels have made important impacts on the design and use of ICTs in the energy field. One line of development is the green ICT that "… is concerned with using computing resources efficiently. The need for green computing is becoming more obvious considering the amount of power needed to drive the world's computers and telecommunication parts" (Pearlson et al., 2019: 310). From this point of view, ICT technologies are big energy consumers. Morley et al. (2018) documented the growing consumption of energy in networks and data centres, and data traffic. The Internet consumes as much as 9% of global electricity if televisions, audio/visual equipment, and broadcast infrastructures are included (Morley et al., 2018: 129). Besides, Andrae and Edler (2015) calculate that ICT will consume up to 21% of global electricity consumption by 2030, considering the production and operation of the Internet and digital devices.

Green ICT as a whole, including energy-oriented ICT, embraces two main fields of application (Kals, 2015: 67-68):

- As a tool in all business domains allowing energy efficiency and sustainable energy supply. For such purpose, there are software developments called computer aided energy management (CAEM).
- As an approach, green ICT seeks to optimise the life cycle of computers of all sizes.

Last but not least, the application of the Internet to electrical energy systems deserves some comments. When ICTs and Internet are applied to energy production infrastructure, it gives rise to the Internet of Energy (IoE). Smart Grid is a typical example of IoE, where the digital platforms enable a two-way interaction of the utility with its customers, and at the same time can digitally supervise transmission lines and the charges required. The grid has intelligence because it consists of controls, computers, automation, sensors, smart meters, and equipment working together for optimising the generation, storage, and distribution of energy, in an electrical grid to meet the electric demand digitally (Bagdadee and Zhang, 2019).

IoE can reduce energy waste, meet quick changes in the demand, using the internet for the most efficient management of the grid. IoE is challenging the model of centralised electricity generation, transmission, and distribution. In contrast, modern internet and energy networks and services are transforming the electricity distribution system into a flexible and robust platform for the exchange of electrical energy. Therefore, the IoE change the paradigm from "… centralised power generation and one-directional power flow into more secure, reliable, efficient, flexible, and sustainable energy networks. Like the

internet networks, the goal of the IoE is to provide a robust system for exchange of energy between prosumers" (Kafle et al., 2016: 1).

Finally, energy efficiency, recycling processes, and circular economy strategies and tools were developed as separate topics from Industry 4.0 approaches. The consideration of a linear rationale for industrial processes was not changed nor discussed in the framework of Industry 4.0. Therefore, it is necessary to integrate the research agenda and practice of Industry 4.0 and the circular economy for solving urgent environmental problems and challenges (Lopes de Sousa Jabbour et al., 2018).

1.11. Impacts on the working processes or "Work 4.0"

During the First and Second Industrial Revolutions, the impact of industrialisation[43] on human labour was widely discussed. There were conflicting positions among those who considered the impacts extremely pessimistic, to those toxic optimists who did not have the critical capacity to perceive the problems generated by the modification of work processes. There was documented evidence of negative impacts like labour exploitation (with children work even), environmental problems, and social changes (Varghese, 2016). "Predictions that new technologies will make workers largely or almost entirely redundant are as old as technological change itself" (National Academies of Science, Engineering and Medicine, 2017: 61).

Certainly, this discussion has a prospective nature, since it is about analysing the future of work in the framework of the Fourth Industrial Revolution (BMAS, 2015: 5). The first country to raise this discussion was Germany with the introduction of the concept of Work 4.0 (Arbeit 4.0). Germany's Federal Ministry of Labour and Social Affairs launched the White Paper on the future of work for the year 2030. This pioneering initiative extended the discussion to Europe and other industrialised regions in the world. Some of the main issues dealt with and discussed in this book were the following (BMAS, 2015):

- Job losses[44].
- Labour opportunities and where they lie.
- Erosion of today's skills and creation of new ones.

[43] Industrialisation is understand here as the transformation from an agrarian society into an industrial one, with important impacts on environment, work, way of living, and the culture.

[44] "… as computers get more powerful, companies have less need for some kinds of workers" (Brynjolfsson and McAfee, 2016: 14).

- Work intensification.
- Breakdown of the boundaries between work and private life.
- Freedom and flexibility versus stability and security.

On the other side of the Atlantic Ocean, McKinsey Global Institute (2017) launched in December 2017 the famous report "Jobs Lost, Jobs Gained: Workforce Transitions in a Time of Automation." One of its main conclusions, which covers in a prospective the view up to 2030, can be summarised as follows:

> "Automation technologies including artificial intelligence and robotics will generate significant benefits for users, businesses, and economies, lifting productivity and economic growth. The extent to which these technologies displace workers will depend on the pace of their development and adoption, economic growth, and growth in demand for work. Even as it causes declines in some occupations, automation will change many more—60 percent of occupations have at least 30 percent of constituent work activities that could be automated. It will also create new occupations that do not exist today, much as technologies of the past have done" (McKinsey, 2017: 1).

Therefore, similar to discussions on the industrialisation process, the digital transformation polarises opinions on the problems and impacts on Work 4.0[45]. As Industry 4.0 evolves, the workers' and the firms' expertise in advanced manufacturing technology is crucial to achieving greater productivity, take advantage of data analytics, and improve connectivity in manufacturing operations. Industry 4.0 is driving massive changes for organisations (BMAS, 2015: 44; Schwarzmüller et al, 2018: 115; Skilton and Hovsepian, 2018: 232). In this section for Work 4.0 analysis, we will focus on four specific issues: the nature of work, the expected impacts of digitisation process on human labour, the competencies the workers require for coping with Industry 4.0, and lastly, the interesting issue of ghost workers and crowd workers.

The first question that arises adresses the nature of the work processes in Industry 4.0. Figure 14 shows what could be identified as the most important traits for Work 4.0.

[45] The studies of impacts of digitalisation on work in the existing literature are highly fragmented and most of them in the "infancy" (Schwarzmüller et al., 2018: 116; Bartocci Liboni, 2019). For the moment, there is a lack of data on the consequences of the ICTs for society in general and on the work in particular. We are "flying blind" (Skilton and Hovsepian, 2018: 21; Mitchell and Brynjolfsson, 2017: 290). This book tries to contribute with data and pieces of evidence to this debate.

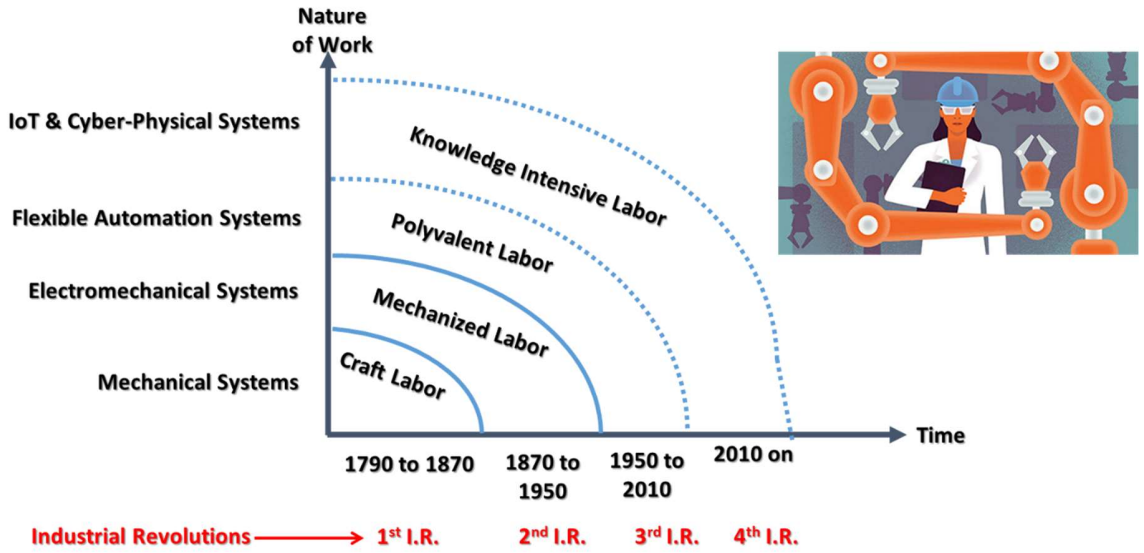

Fig. 14. Evolution of Human Labour
Source: own elaboration.
Rys. 14. Ewolucja pracy ludzkiej
Źródło: opracowanie własne.

Undoubtedly, the analytics competencies for manipulating, interpreting, displaying and transmitting data, and also literacy skills for basic communication in virtual teams are all workers' knowledge-intensive capacities (Prifti et al., 2017; Fitsilis et al., 2018; Schwarzmüller et al., 2018). This constitutes an important shift in the competencies required for working in the Fourth Industrial Revolution. Smart factories require skills for software control of virtual and cloud infrastructures, instead of the traditional management of physically controlled factories (Fitsilis et al., 2018). Furthermore, there are important arguments for tacit knowledge that are involved in common tasks and even in knowledge-based competencies, i.e., high-value human capacities, that avoid being included in automation processes (Autor, 2015). Therefore, the complete replacement of human labour by automation would not be possible.

Interactions of humans and machines are another source of changes in the nature of the work. In this sense, machines are *learning* to *think* and to operate in a more complex environment, and can replace workers in routine activities. For example, some of the most advanced abilities that nowadays robots have, are the following (Deutsche Telekom AG, 2015):

- Self-reliant interaction with the physical world: a) development of fine and gross motor skills of robots; b) identification of environment and assured spatial navigation.

- Development of ability to comprehend and use speech: a) voice recognition; b) processing of natural language; c) active use of language (both written and spoken).
- Ability to solve problems: a) answering unstructured questions; b) rule-based analysis; c) pattern recognition and classification.

This fast evolution of collaborative robots is pushing for a new division of labour between humans and robots[46], a kind of Digital Taylorism, which raise new questions about the nature of work, the job profiles, and qualifications in the workplace (Townsend et. al., 2019: 64). Robots become more powerful and capable over time (Brynjolfsson and McAfee, 2016: 57), particularly in the last ten years with the addition of the spectacular evolution of AI, particularly deep learning (Skilton and Hovsepian, 2018: 21).

A second important issue is referred as the expected impacts of digitisation processes on human work. There are important increases in remote work and the so-called click-working that impact on employment conditions, the flexibilisation of working hours, and organisational, and value chain structures. These types of impacts are usually studied at the macro level of an industry or a country, at the organisational level of the firm, or at the micro level of the workplace. We will first address the last two levels, and then will analyze the problem at sectoral level.

At the organisational level, the two main key impacts of Industry 4.0 are on the design of work[47] and the relationship-oriented leadership (Schwarzmüller et al., 2018). There are many prospective studies of the effects of advanced ICTs on organisations using international experts for consolidating feasible scenarios. Next, there is a synthesis of the main aspects that would be modified, as well as some hypotheses for that, for the next 10 years, on the base of Schwarzmüller et al. (2018), BMAS (2015), National Academies of Science, Engineering, and Medicine (2017), and Deutsche Telekom AG (2015):

- Work-life and health: Mobile computing, augmented and virtual reality move the existing boundaries between online and offline settings, between working and private life. This new situation is posing health issues, like burning out, on the agenda.
- Skill requirements in the workforce: they are based on the use of ICTs in the working processes and communications for the team's functioning. For instance,

[46] The new division of labour in the Fourth Industrial Revolution seems to be between human and digital labour, i.e. between people and computers. Computers can do all types of symbolic work, from math to logic to language (Brynjolfsson and McAfee, 2016: 33). Digital services are divided into ever smaller parts and delegated to Digital services, which in turn are divided into ever smaller parts and finally subcontracted to virtual labourers (Deutsche Telekom AG, 2015). See next ghost workers and crowd-workers.

[47] The design of work involves here both how workers deploy their tasks in organisations and the conditions for developing such tasks.

videoconferences require new skills for working in virtual teams. In general, required skills are both technological competencies and soft skills (Clavert, 2019). See next a deeper analysis.

- Performance and talent management: the use of sensors embedded in wearable devices, machines constantly producing big data, intelligent software, and smart robots making complex decisions, modify the performance measuring in the factories. Besides, software solutions can identify those workers with expertise by recording results for problem solving.
- Organisational hierarchies: Workers have access to the information in a horizontal way. Tele-presence systems for virtual meetings also challenge organisations. These impacts in the organisational leadership. Organisational forms and standardised process are the adaptation of the organisation to complex IT systems specifications, and not the adaptation of the software to processes and workers, all of which redefined hierarchies. The app developers and data experts of today generate disruptive change within corporate cultures and hierarchies. On the other hand, software with monitoring tools allows for increased control of workers and strengthens existing hierarchies.
- Focus on employment: With digitalisation, physical labour has been minimised, and hence the number of workers needed has been decreased. However, there are new tasks created even with the automation process. The net balance for employment is still under discussion.
- Leadership: leaders should learn how to establish personal ties even though impersonal technical communications are in place.

At the workspace level, the impacts that have been identified are the following (Schwarzmüller et al., 2018; BMAS, 2015; Deutsche Telekom AG, 2015): Fitsilis et al., 2018; National Academies of Science, Engineering, and Medicine, 2017):

- Employees are almost always connected to their workplace due to cloud services and mobile devices, a phenomenon that profoundly affects their work and private life.
- Regular teamwork is replaced more and more often by working in virtual teams, with communication with others team members by messaging, social media, and teleconferencing.
- Collaboration on specific projects is carried out by means of knowledge-sharing platforms and digital collaboration tools.

- The volume of collective information about people, products, processes places, scheduling, and performance at workspaces, even on a planetary scale, is amazing, changing the base for making decisions.
- The modern workspace environment is also characterised by digital networks, like those belonging to the firm's value chain. Networks inside and outside of the workspace generate jobs without a clear organisational allocation, and workers would perform tasks for products without a clear origin. Sensors also typify the digital "workplace".
- Companies will rely less on their permanent workforce and more on a highly qualified staff "hired on demand", by means of a digital work platform.
- The availability of on-demand computing power will empower many tasks at workspaces which in turn will require educated learning and skills in order to navigate, interpret, and make complex decisions at floor level. Like in Lean Production, complex tasks will "descend" to the operative line. Creative work has "autonomy of content."
- The humans' role in the production process is changing from execution to monitoring or controlling. There are some competencies very difficult to replace by machines, like entrepreneurial skills, creativity, leadership, and the control of machines.
- Data analytics is used for monitoring worker jobs all along the 8 hours, which can open conflicts between the workspace activities and private life. However, many traditional workplaces and working hours are transformed into a task based on ICT and organised individually (remote working), combining work and family, which in turn introduces new stress factors ("always on").
- The change of traditional employment relationships and processes, to an individual organisation of tasks mediated by ICTs, makes self-management very important as a core qualification for digital jobs.
- New forms of interaction between man and machine at the workspace, like workers controlling machines, machines as workers' colleagues, a merger with special interfaces between man and machine, or even machines in charge of the processes.
- New online eLearning platforms are introduced at workspace for supporting the workers' activities and enhance on-the-job learning and re-training of them.

At the industry level, there are certainly several impacts that can be accounted for (Skilton and Hovsepian, 2018; Schwarzmüller et al., 2018; Brynjolfsson and McAfee, 2016; Deutsche Telekom AG, 2015; National Academies of Science, Engineering, and Medicine, 2017):

- The globalisation of the workforce has been produced by means of digital work platforms that transform the employment relationship into a work assignment.
- Markets will be affected if technological unemployment is not solved. There are tasks for robots' installation in the discussion.
- The increase of automation and globalisation has an important impact on every industry on lower and middle-class jobs for routine work and to high-class jobs on regular decision-making work.
- Innovation processes are deeply modified within interconnected supply chains that work across even in many country borders, requiring for this problem solving and creative competences.
- Virtual value chain requires transparency for data and the co-creation with customers and suppliers (crowdsourcing and open innovation), which contributes to the opening up of previously closed corporate structures, introducing digital networks at workspace and increasing the need for data processing from different sources of the virtual and physical value chain.
- The introduction of additive manufacturing (3D printers) makes it possible to separate design from manufacturing in a new division of labour that impacts on logistic activities and centralised production in an industry.

A third important issue is related to the competencies that are required for workers, for coping with the challenges and changes driven by Industry 4.0. Undoubtedly, workers need to acquire new skills in order to move onto new jobs in Industry 4.0. However, ". . . it is difficult to map the competencies and skills expected in industries not yet created, we can reasonably assume that demand will increase for skills enabling workers to design, build and work alongside technological systems, or in areas that fill the gaps left by these technological innovations" (Schwab, 2016: 46).

The digitalisation process is mainly focused on the automation of routine work (Ansari et al., 2018: 2). Thus, there is an increased demand for workers with ICT skills, able to make automation functioning well. They must have competencies for a full application of digital devices, working with advanced human-machine interfaces, getting informational outputs from them, and even developing new programs and applications (Prifti et al., 2017; Fitsilis et al., 2018). Besides, the skills needed for Industry 4.0 are numerous and diverse (Fitsilis et al., 2018).

Technological competencies should be matched with the development of soft skills (Clavert, 2018; Ustundag and Cevikcan, 2018: 129). A constellation of these capabilities will make a difference to the challenges of AI, machine learning, augmented reality, data

analytics, cloud computing, etc. However, the "paradox" of Industry 4.0 is that it not only requires "hard" skills based on the mastery of various ICT technologies, but also numerous so-called "soft skills" and tacit knowledge, without which no advanced system can work. For instance, complementary computing systems and human centred automation are opening new spaces for combining the "talents" of a machine with the intellect and physical prowess of people at the workspace. This will bring new roles, competencies and types of work in joint human-machine problem solving teams (National Academies of Science, Engineering and Medicine, 2017: 48-49). Figure 15 shows this combination of technological and soft skills.

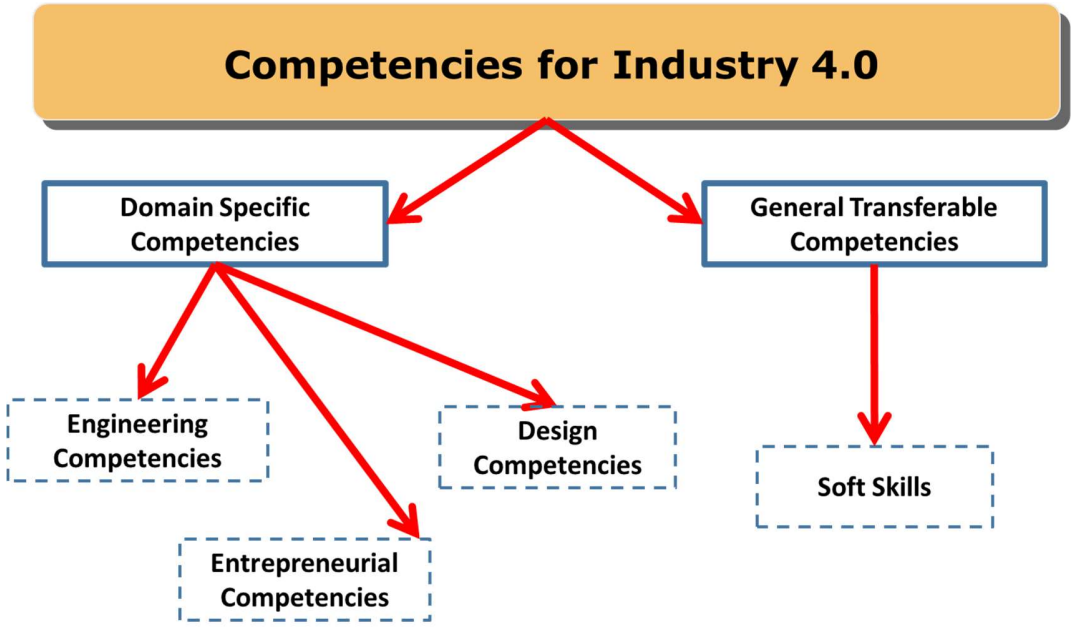

Fig. 15. Competencies for Industry 4.0
Source: own elaboration on the base of Clavert (2019).
Rys. 15. Kompetencje dla Przemysłu 4.0
Źródło: opracowanie własne na podstawie Clavert (2019).

Regarding engineering competencies, different studies arrive at similar identification of skills and knowledge necessary for qualified workers (Prifti et al., 2017; Fitsilis et al., 2018; Clavert, 2019; Gray, 2016). The identification process was on the basis of expert interviews, taking into account a future scenario. Here we particularly describe the study of Clavert (2019), carried out in the framework of the project "Universities of the Future", financed by the European Commission. The reason is that it includes Poland in the survey, so results are close to the Polish Industry 4.0 profile and needs. The engineering skills identified are: data science and advanced (big data) analytics; novel human-machine

interfaces; digital-to-physical transfer technologies, such as 3-D printing; advanced simulation and virtual plant modelling; closed-loop integrated product and process quality control/management systems; data communication and networks, and system automation; real-time inventory and logistics optimisation systems; artificial intelligence; robotics; automation; programming; information technologies; mechatronics; cyber security; augmented and virtual reality. There were also different topics or knowledge pinpointed: IoT, interfaces, communication protocols, understanding systems and the process behind the data, cloud solutions, software know-how, technical know-how, sensors and electronics, Lean manufacturing, and continuous improvement process.

Some domain-specific competencies related to entrepreneurial skills are: technology awareness, change management and strategy, novel talent management strategies, organisational structures and knowledge, the role of managers as facilitators, tech-enabled processes as forecasting, planning metrics or scheduling, business analysis, digital skills in general. Other domain-specific human capacities are necessary for mastering design and innovation as the main dynamics in organisations, including the following competencies: understanding the impact of technology, human-robot interaction and user interfaces, tech-enabled product and service design, and tech-enabled ergonomic solutions and user experience (Clavert, 2019: 36-37).

In relation to soft skills, María Clavert (2019) has analysed and defined the following: a) to think critically to make value judgments; b) to solve complex, interdisciplinary and unstructured problems; c) to have creative and entrepreneurial thinking; d) to make innovative use of knowledge and information; e) to communicate and collaborate; f) to apply global communication and global thinking. In a similar vein, Ustundag and Cevikcan (2018: 129) pointed to communication, coordination, and autonomy skills. From a more psychological perspective, other soft skills that were identified as necessary in Industry 4.0 are (Cotet et al., 2017: 5): interpersonal skills, asserting personal, respect, strength of self, empathy, will, a spirit of perfection, self-discipline, intellectual curiosity, refining, independence, and creativity.

Fourth, we will raise two interesting issues about the impact of Industry 4.0 and the digital economy on work. They are the so-called ghost workers and crowd workers. In the first case, it is about those people who perform invisible tasks such as cleaning and refining the data that feed the algorithms that train AI, starting within Microsoft (Gray, 2019). ICT technologies advance by automating routine and mechanical jobs. However, this same improvement in turn generates other new automated tasks for which it again needs human help. This recursive fact is known as the “paradox of the last mile of automation” (Gray, 2019). Millions of people around the world are working in coordination with programmers

and developers, deploying tasks like above mentioned through an API (application programming interface), driving AI, and the automation of the Internet (Moreno, 2019; Gray, 2019).

Automation in factories requires human labour for maintenance, or to program and adapt automated processes, although these workers are visible. On the other hand, ghost workers are not visible in the digital economy and it seems that they will not disappear from the automation process based on AI due to the aforementioned paradox. They are equivalent to the workers of the extractivist models, except that in this case, it is about the exploitation of data behind the curtain of artificial intelligence (Moreno, 2019).

The second special case of work is carried out by the workers of the digital platforms dedicated to the assignment of micro-tasks. These platforms give companies and other clients access to a large and flexible workforce (or "crowd workers") to carry out generally small tasks that can be carried out remotely using a computer and the Internet (Jäger et al., 2019). They are also called "virtual workers" (Deutsche Telekom AG, 2015). These are tasks that range from image identification, transcription and annotation of images, content moderation, data collection and processing, audio and video transcription, and translation (Moreno, 2019).

On the platforms, the clients post task packages that need to be completed, while workers select tasks and receive payment for each task they perform. The payment received by the workers corresponds to the price indicated by the client less the commission charged by the platforms. They consider that their workers are independent, thereby depriving them of the protections provided in labour laws and in matters of social security and union rights. The ILO report shows the results of the survey conducted on working conditions among 3,500 workers residing in 75 countries around the world and working on five English-speaking platforms dedicated to the allocation of micro-tasks (Moreno, 2019). The risk potential for wage dumping and (self-) exploitation is still unknown (Jäger et al., 2019) but expectable.

For finishing this section, it is important to highlight that ". . . the future of employment is not only a question of the availability or necessity of tasks to be performed, but how they are organised, compensated, and more generally valued by society. These are matters of a business strategy, social organisation, and political choices, and not simply driven by technologies themselves" (National Academies of Science, Engineering, and Medicine, 2017: 63).

1.12. Impacts on organisational decision-making process

The impact of Industry 4.0 on decision-making is to a great extent connected directly with information sharing (Preindl et al., 2020). Today's technology allows companies to collect huge amounts of data with relative easiness (Watson, 2014: 1248). Many companies now have more data than they can use[48]. However, the data often doesn't make sense until it is refined and analysed, looking for trends, patterns, relationships, and other useful information (Albright and Winston, 2015: xiii) that help to make decisions in an organisation[49]. Therefore, analysing data and making quantitative-based decisions are two tightly connected processes. Digitalisation means some saving of human salaries, but it also means that whenever there is an active human decision-making process, data analytics can be used (Laursen and Thorlund, 2016: 18).

Decisions in any context were, until recently, a human process involving from the most simple, mechanical, and irrelevant choices, to important and crucial ones. Although many people think that all of them are rational and thoughtful, a very high percentage of these choices are not (Zentall, 2017: 309-310; Ramachandran, 2002: 848, vol.1). Relatedly, the availability of a huge amount of data has made the development of data analytics possible, being a good support for improving the quality of human decisions. Hence, one of the major focuses in Industry 4.0 is on business analytics, i.e. the use of large data sets for helping make good decisions (Albright and Winston, 2015: xiv).

Big data is related to data infrastructure, but the use of business analytics and the application of results by decision makers and organisational processes are connected with a deriving value from big data (Watson, 2014). In other words, ". . . what the company needs is for the right people to have the right data and information at the right time" . . . i.e., to deliver ". . . the right decision support to the right people at the right time" (Laursen and Thorlund, 2016: xiv). Decision-making processes are increasingly based on the intelligent analysis of big data instead of on leaders' own experience and intuition (Schwarzmüller et al., 2018: 115).

On the other hand, artificial intelligence is beginning to make decisions in the digital area (Albright and Winston, 2015: xv). However, in a similar way as human decision-making based on heuristic search, AI does not guarantee an "optimised or correct" solution (Ertel, 2017: 261). There are also very important ethical issues in the use of AI, and not just

[48] It is estimated that our senses can perceive more than 11 million bits of information per second. However, our conscious brain only has the capacity to assimilate 50 bits / second (Zimmerman, 1989).
[49] Raw data is not suitable as an input for the decision-making process. It has to be refined and structure into sensible information to be used in decision-making.

technological ones. In an academic event organised by UNESCO, across all the challenges and diverse perspectives on AI, there was intense concern about the role of AI in the decision-making process. Do humans voluntarily give away their decision-making power to AI? (Lasry and Kobayashi, 2018: 11). From an ethical point of view, AI systems affecting human rights are and should be under greater regulatory scrutiny than those that take decisions that only affect objects (Scantamburlo et al., 2019).

Besides, as we have described, CPS usually integrates physical components with digital functionalities, including computing and communication technologies. CPS offers an advanced level of networking for data processing and feedback, and a decision-making capability supported by an intelligent data processing and computational powers that operate on the physical infrastructure (Salkin et al., 2018: 8). Therefore, the Fourth Industrial Revolution provides a big impact on the human decision-making process, even with the alternative of replacing it.

Next, we will analyze such impacts of Industry 4.0, and the main technologies that are involved, on the decision-making processes, then on the learning process (as correlated to decision-making), and finally on the relationships among people and society, altering old links and producing even trans-human modes of living.

1.13. Decision-making processes

Decision-making is a broad process that happens in many different personal and organisational contexts, every day. The classical decision theory states that the process for such decisions is completely rational. It is called the unbounded or complete rationality model, that involves decision-making strategies which have access to all available information and there are no constraints of time, knowledge about the alternatives and their consequences, or computational capacities. Particularly, neoclassical mainstream economic theory is largely based on unbounded rationality models, where economic agents are fully rational Bayesian maximisers that choose the alternative which maximises expected utility (Schilirò, 2018).

However, human judgment and decision-making processes are most of the time being made under conditions of uncertainty and/or complexity. In the former case, there is no algorithm applicable or suitable information is unavailable. In the latter, there are too many choices or too many factors in each choice, so decision-making is not a simple process. These two conditions exert a great influence on the decision-making of people and

organisations. Humans then turn to the use of heuristics, which are rules of thumb or empirical judgments used to generate adequate solutions to intractable problems. Heuristics ". . . bypass normative rules of logical inference and thus permit judgments without recourse to algorithms" (Ramachandran, 2002: 847, vol.1).

After this brief introduction to the topics, the issues would be the followings: Is it possible to transfer the human decision-making process to smart digital devices of Industry 4.0, particularly to CPS and AI components? Does this process lead to a complete transfer of the decision-making process to the machines? From the last experiences, rather than substituting workers with digital devices, ICT may also assist these workers in performing their tasks, particularly in decision-making processes (Schwarzmüller et al., 2018: 117; National Academies of Science, Engineering, and Medicine, 2017: 11). Even though data on this phenomenon is elusive, Brynjolfsson and McElheren (2016) have found that the use of organisational decisions based on big data has tripled in the USA, from 2005 to 2010, and that the "complete replacing" hypothesis is not true.

For the first issue, it is interesting to highlight that from the principles of design for Industry 4.0, from different authors, several are related to the decision-making process (Wang and Wang, 2016; Ghobakhloo, 2018; Salkin et al., 2018)[50]. Hermann et al. (2016) describes four principles, which with the exception of the first (interconnection), the last three are related to organisational decisions (information transparency, decentralised decisions, and technical assistance). For information transparency, connections of different entities (devices, sensors, machines, and people) allow the fusing of information which can be used by the entire system to optimise its performance. The digital twin of the system is an example of information transparency. For decentralised decisions, it is required that decisions were made by entities themselves as autonomously as possible, by incorporating mechanisms which allow for solving of conflicting goals among entities. Finally, for technical assistance, it is referred to the quality of human-machine interaction in changing environments. In the past, workers were operators of machines and systems, and now have become part of the process itself. Therefore, they are strategic decision makers in a flexible environment, and are integrated into CPS production contexts (Hermann et al., 2016).

[50] Wang and Wang (2016: 5-6) stated six design principles named interoperability, virtualisation, decentralisation, agility, service orientation, and integrated business processes. Salkin et al. (2018: 19) proposes an additional one (real time data management). Ghobakhloo (2018: 914) synthesised from different authors twelve principles, including those from Wang and Wang (2016). Many of these design principles are related to the management of data and the decision-making process, which therefore is central to the Industry 4.0 paradigm.

Smart machines can easily emulate humans' rationality processes in decision-making. Therefore, structured and routine decision-making are in the best position to be transferred to an AI system[51]. Smart machines show an impersonal approach to decision-making that contrast with a most of the time ". . . subjective, emotionally charged, and contextually sensitive nature of many intuitive decisions made in organisations" (Jarrahi, 2018: 6).

Against the growing fear that smart machines will soon replace humans at work, particularly in decision-making, there is some evidence that the integration of AI into organisational decision-making enables humans to be augmented in their decision-making and to make smarter decisions (Claudé and Combe, 2018: 64). According to Dear (2019), there are four contributions of AI to the human decision-making process: a) it enables by means of predictive analytics a much earlier intervention; b) it forces humans to take themselves 'out of the loop' for decision-making; c) it provides correct advice, but sometimes difficult to explain; and d) it drives unprecedented rigor into decision-making processes.

The transferability of decision-making tasks from humans to machines depends to a great extent on the nature of the process itself. From a qualitative or holistic approach, one possible classification of decision-making is shown in Table 1. Certainly, classifications characterise the process but not the actions that take place within it (Nutt and Wilson, 2010: 15). The main criteria[52] used here was if the nature of decisions was programed or non-programed[53]. As it was mentioned, routine tasks and routine decisions are the best candidates for partial or total substitution, and they are programmed decisions.

[51] Ruled-based and criteria-based decision-making processes can be changed with enough experience into procedural routines (Johnson and Busemeyer, 2005: 4).

[52] Classifications usually fails to explain how a decision maker operates (Nutt and Wilson, 2010: 15). However, the aim of the analysis here is to analyze which decisions can be partial or totally replaced by different Industry 4.0 technologies.

[53] Decisions can be classified with different criteria. For instance, in terms of major and minor decisions; or routine and strategic decisions; or policy and operating decisions; or programmed and un-programmed decisions; or in structured or unstructured decisions. Table 1 shows a combination of some of these criteria.

Table 1

Classification of Decisions according to Programmable Nature

Characteristics	Programmed Decisions	Non-Programmed Decisions
Type of problem.	Structured	Unstructured
Context	Controlled & certain	Ambiguous & uncertain
Issues to be solved	Clear issues	Novel and confusing issues
Solution relies on	Procedures, rules & criteria	Judgment, innovation & creativity
Data & information	Complete, reliable & available	Incomplete, unreliable & ambiguous
Frequency & experience	Repetitive & routine	New & unusual
Goals & objectives	Clear & specific	Vague
Deadlines for solution	Short term	Relatively long term
Organizational level	Lower & middle level	Upper level

Source: own elaboration based on Turban et al. (2013: 43), Mintzberg and Westley (2001), Malakooti (2012: 734), and Woehrle (2002: 4).

In some decision problems (Table1), the actor already has a potential solution or routine available. The routine decisions arise during the course of production or administration and are settled based on past practice. The opposite in nature to routine decisions are strategic or innovative decisions. Routine decisions are usually delegated by managerial level to workers and strategic and innovation decisions are manager's own field (Johnson and Busemeyer, 2005: 3-5). From the pioneering work of Herbert Simon in the fifties and sixties, the distinction between programmed and non-programmed decisions is a classical one. The formers are those which are repetitive and routine in nature, usually expressed in a procedural form that worked in the past. The second are decisions taken in an unstructured ambiguous and uncertain context, at any time whenever they arise because this issue or similar have not been experienced earlier.

Ansari et al. (2018) propose an interesting classification of decision-making processes related to production, showing the transferability of different decision-making tasks from human to CPS or AI powered smart systems. The transfer is based on the routinised nature of the decision-making process. Figure 16 diagrams the various options, following two critical axes for the transfer of such tasks, as they are the competence level of human resources (for decision-making) and the autonomy degree of the production system.

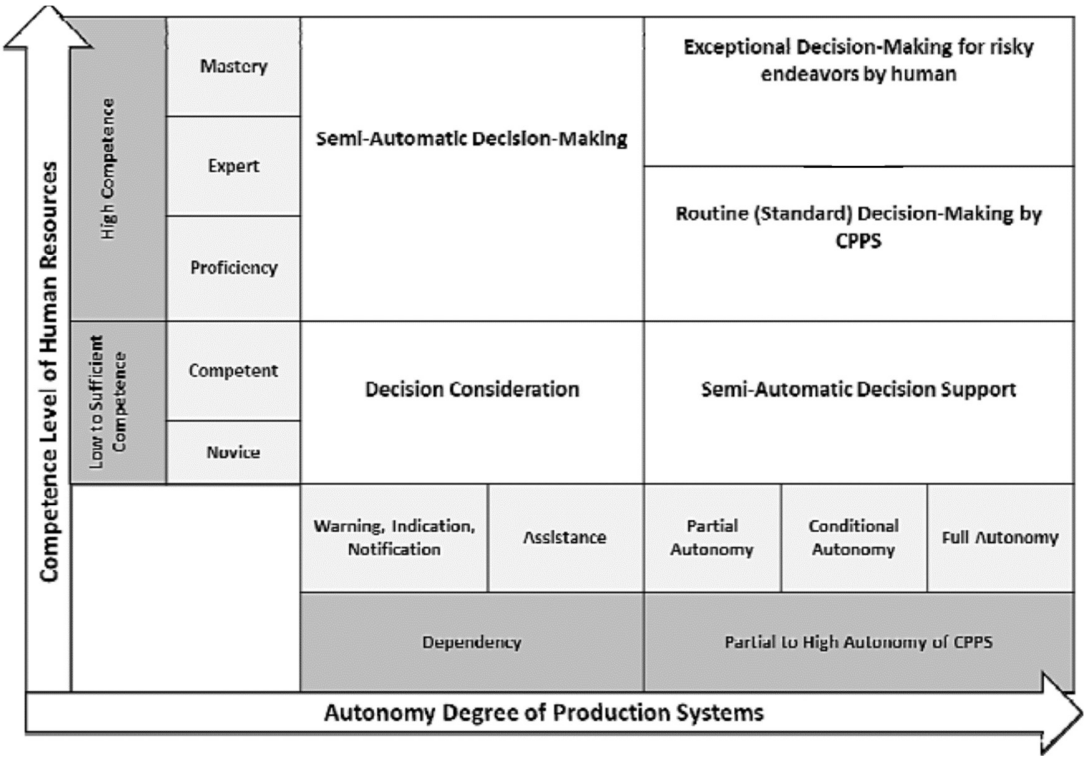

Fig. 16. Transferability of Different Decision-making Tasks
Note: CPPS states for Cyber Physical Production System.
Source: Ansari et al. (2018: 2).
Rys. 16. Możliwość przeniesienia różnych zadań decyzyjnych
Uwaga: CPPS oznacza Cyber Physical Production System.
Źródło: Ansari et al. (2018: 2)

As it can be appreciated in a production environment, AI and CPS systems are able to "cooperate" and work together with workers, in a rather partial or conditional autonomy. Algorithmic decision-making is then a decision support system for improving and expanding smarter organisational human decisions (Turban et al., 2013: 43).

Remarkably, routine and simple tasks are usually performed in elementary occupations, which may require important physical effort and the utilisation of hand-held tools[54]. According to the Skills Panorama (2020: 2) for Europe, the key skills and tasks for elementary occupations are routine, autonomy, servicing, and attending[55]. Surprisingly, this same official European publication (of CEDEFOP and European Commission)[56] figured

[54] Almost on the opposite side, a lot of knowledge intensive occupations today are transactional service jobs, i.e. people helping customers to access what they need from a value chain or from complex business systems (Kapoor, 2019: 15).
[55] The workers involved in elementary occupations are employed as: a) cleaners and helpers; b) agricultural forestry and fishery labourers; c) labourers in mining construction, manufacturing, and transport; d) food preparation assistants; e) street and related sales and service workers; and f) refuse and other elementary jobs (Skills Panorama, 2020: 2).
[56] Skills Panorama is supported by the European Commission, Directorate-General for Employment, Social Affairs, and Inclusion and powered by CEDEFOP, the European Centre for the Development of Vocational Training.

out that the number of people employed in elementary occupations has been increasing, where employment grew by 8% from 2005 to 2015. It was projected another growth of 10% from 2018 to 2030.

On the other hand, McKinsey Global Institute (2017: 87) computed that between 75 million and 375 million people around the world may need to change occupational categories and acquire new skills by the year 2030. These figures come out from the potential effects of automation, including AI and physical robotics. Interestingly, the report takes into account not only every occupation in the world workforce but also all of their constituent activities[57], about 2,000 of them that are routine activities. Therefore, the figures express the number of jobs that contain such activities that could potentially be automated by adapting technologies that exist today and technologies that might be developed in the future.

Recently, there were important advances in deep learning technologies, starting the automation of non-programmed decision-making processes, in an unstructured environment. As it was mentioned in 2.2., deep learning is a new branch of artificial intelligence based on artificial neural systems that imitate the way the human brain perceives and interacts with the world. The important advance is that these smart algorithms can learn and operate without pre-programmed details about their surroundings (Yang, 2016). So deep learning is starting to advance in non-programmed decision-making processes.

Therefore, we are cautiously optimistic about the future of the human work, where some jobs will be destroyed and new ones will be created, as in the past of technology.

1.14. Learning process at individual and group level

There is almost no discussion that the majority of the countries are living in a knowledge economy, in which knowledge plays a fundamental role and innovation is the main driving dynamic that transforms knowledge into economic and social value. In turn, learning is a central process in this economy, because it creates knowledge as a source of growth, and the base for competitiveness of firms, regions, and countries (Lundvall, 1988; Grønning and Fosstenløkken, 2015; Arciénaga et al., 2018: 4)[58]. In the digital economy,

[57] An occupation or job is conceptualised here as a bundle of activities.

[58] Learning is understood here in terms of formal education and training, by informal organisational learning (learning-by-doing, learning-by-using, learning-by-interacting), and learning based on R&D. Studies usually fall short in terms of understanding specific competencies and tools that address the context factors for learning, e.g., uncertainty,

different experts give utmost importance to continuous learning, training, and education in order to the adaptation of the workforce's competencies to future requirements derived from Industry 4.0 technologies (Bonekamp and Sure, 2015; McKinsey Global Institute, 2017: 124; Onar et al., 2018: 138).

A great deal of human learning stems from a simple process rooted in the nervous system. Humans ". . . learn new skills over the course of their life from experience and from other humans." Due to tacit knowledge, ". . . we cannot communicate to another person precisely how the resulting skill should be executed. We can at best hope to offer pointers and guidance as they learn it on their own" (Yang, 2015).

However, learning in the digital economy also makes reference to the algorithms that can "learn". Machine learning, and above all deep learning methods, have made impressive improvements in the last ten years (Kapoor, 2019; Brynjolfsson and McAfee, 2016; Kamath et al., 2019; Marr, 2020: 4). As we mentioned previously, deep learning is a field within machine learning and AI, based on algorithmic methods that permit smart systems to learn from data without human supervision and intervention (Kamath et al., 2019: 3). Deep learning enables computers to follow the human learning process, that is, to learn by example (Shah, 2020: 313).

The system architecture, based on artificial neural networks, makes it possible to "learn" complex and intricate encoded forms of the given information (Agarwal et. al., 2020: 162). This means that ". . . rather than just giving a machine a set of rules to follow, machines can now 'learn' from data. . . The more data a machine has to learn from, the smarter it becomes" (Marr, 2020: 4). Therefore, the combination of neural networks and big data is responsible for dramatic advances in AI in the last few years. Thus, deep learning can be featured by the use of big data, the types of architectures, and the algorithms that process data in hidden layers. In addition, machine learning algorithms can be classified into two broad categories: supervised and unsupervised machine learning. The first embraces the process of building a model with variables whose data can allow to identify an output, similar to the regression of independent and dependent variables in statistics. The latter encompasses a process of building a model without relying on input data, and the focus is on identifying the structure of such data (Lynn et al., 2018: 36; Joshi, 2017: 30).

The implication of machine learning from data for humans is that it makes possible data-driven predictions or decisions. In organisational terms, machine learning is an important support to automatically identify and learn the patterns and rules from big data,

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complexity, globalisation, ambiguity, and rate of learning versus the rate of technological development (Arciénaga et al., 2018: 4).

enabling decision makers to set more appropriate rules based on learning from data (Hacioglu, 2019: 344).

It is interesting to point out the differences between machine learning and human learning. In the case of traditional machine learning, this method is sensitive to continual changes in the context or environment. On the contrary, humans show a perceptual learning which allows them to circumvent such restrictions. This happens because ". . . learning in humans is selectively incremental, so it does not need a large number of known examples (training set), and simultaneously, it is not biased by already learnt but outdated facts. Learning and knowledge extraction in human beings are dynamic and the human brain adapts to the changes occurring in the environment continuously" (Kulkarni and Joshi, 2015: 236).

Other differences between machine learning and human learning can be summarised in the following list (Kulkarni and Joshi, 2015: 236; Marr, 2019: 4; Jarrahi, 2018: 6):

- Learning in human beings is selective and incremental, so they do not require large numbers of known examples. On the contrary, in machine and deep learning, the more data set the algorithm has, the smarter it becomes.
- Human learning is not biased by what a person already learnt but by outdated facts. Machine learning can be biased by the training data set.
- Learning and knowledge in human beings are dynamic and they are in a continuous adaptation to the changes in the context or environment (contextually sensitive nature). Slightly different, smart machines are built as an autonomous agent, i.e., an entity able to make decisions based on what it observes.
- Human beings are usually very subjective, emotional, and intuitive decision makers in organisations. In contrast, smart machines exhibit an impersonal style for decision-making based on data.
- Human learning is a simple process to a large extent rooted in the nervous system. Deep learning just uses an artificial neural network to mimic human brain activities ()

Despite the great advances in AI, tasks in current real-world business applications cannot yet be solved by machines alone (Dellermann, 2019: 274). Machine learning has become a resource which can augment or even replace human learning (Rudin, 2017). Focus on whether machines can beat humans was the main assumption of machine learning until recently (Bier et al., 2019). However, there is an important development of human-

centred AI, in a kind of third wave of AI evolution (Xu, 2019; Zhang et al., 2020)[59]. Machine learning, deep learning, AI, and big data analytics can power a fruitful "cooperation" in human-machine interfaces. For example, common activities can open unrestrained human-machine collaboration, robotic exoskeletons, decision support systems for smarter judgments, systematic recording and mapping of tacit knowledge, action guidelines, human qualification, and fully personalised E-learning (Oks et al., 2017: 29). Ensuing, we will develop some schemes that show the new approaches of "cooperation" between AI with human workers.

Figure 17 below shows that workers and smart systems interact with the working process, between each other, and at the same time take decisions regarding their work using both data analytics and AI. Therefore, the scheme relaxes the assumption of planning all aspects of the production process ahead of time. A deep learning algorithm can interact with the workers and the environment, and both (AI and workers) generate first and second order learning, with a human-machine interface acting in a synergic functioning. In turn, second order learning produces a reinforcement learning of AI algorithms that can dramatically improve the workers' behaviours, the transformation of better choices into action, the production of knowledge for both, and the results of different problems at the workspace. In the case of the AI designer, he/she only has to provide a performance measure for obtaining a reinforcement learning[60] of the AI system (Kochenderfer, 2015: 5).

[59] Accenture made in 2018 a survey among 6,300 corporate IT executives around the world, finding that the most important citizens' concerns were for AI, which is clearly pointing to more attention to other important nontechnical factors, rather than just the AI technology itself (Xu, 2019: 42).

[60] Reinforcement learning is a technique for training machine learning models to make a sequence of decisions, in an uncertain and complex working environment.

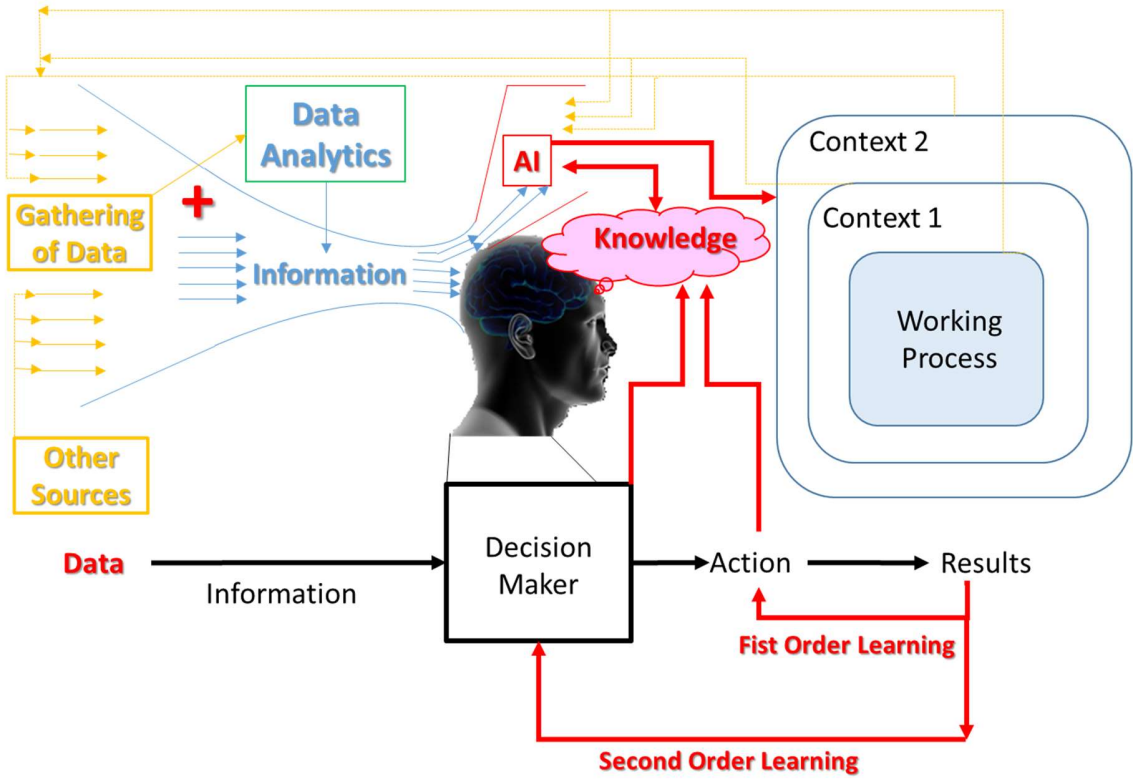

Fig. 17. Working and Learning Process in the Industry 4.0
Source: own elaboration.
Rys. 17. Proces pracy i uczenia się w Przemyśle 4.0
Źródło: opracowanie własne

First order and second order learning in this Figure are feedbacks that produce significant improvements for both the people and the smart system. Without cognitive feedbacks, improvements are usually negligible (Harvey and Fischer, 2005: 119). Depending on the type of feedback, the result of learning could be very different. In the case of first order learning, we have simple performance feedback. It relies upon step-by-step incremental learning, accumulating on previous capabilities, and at the same time modifying what has been learned before. Learning comes from observing an action and assessing its results, which in turn is the basis of standard problem-solving techniques (Senge, 1990; Gharajedaghi, 2007).

In second order learning, there are also fundamental changes in human learners' thinking as decision makers, which is expressed through a reframing of previous learning. In this case, it is questioned why the action was carried out, looking for the sense of purpose and the rationale of the decision maker. The actions are then re-interpreted and this process in turn constitutes another source of enhanced learning. Therefore, human and digital

decision makers both become producers of their own competencies (Chittenden, 2013; Senge, 1990; Gharajedaghi, 2007).

Furthermore, in periods that demand rapid changes, first order learning alone is no longer sufficient, because the requirement is for rapid learning too. The solution for this critical issue is the so-called generative learning, which encompasses the observation and questioning of the dominant rationale and the way of taking action. This reframing makes room for a suitable creativity and greater levels of comprehension, which are crucial in designing proper new strategies (Logan and Mayer, 2016). The collaboration of the human brain with artificial neural networks of deep learning is a good complement for generative learning.

1.15. Relationships among people and society (trans-human modes)

Independent of other considerations, it is appropriate that this introductory chapter includes social and trans-human impacts of Industry 4.0, for providing a systemic approach of Industry 4.0 for the rest of the chapters. Thus, this epigraph will deal briefly with political issues like privacy, technological sovereignty or state surveillance, and social impacts on the relationships among people and society, and the meaning of trans-human modes of life. Maybe a new paradox is that human technology transforms and generates trans-human environments.

For instance, in the last fifteen years, the appearance of social networks mediating into human relationships has risen new considerations for basic concepts, such as community and friendship; computer simulation has introduced new inquires on reality and its normativity; and wearable and enhancement technologies opened discussions on emergent post- or trans-humanist ideals (Mitcham and Briggle, 2009: 1182). “Today we acknowledge that AI is here to stay as a key dimension of human existence. What does this mean for the near future? Are we about to arrive at a singularity, where Human Intelligence and AI become totally integrated?” (Lasry and Kobayashi, 2018: 10).

The technology of any kind not only exploits or expands needs but also it enlarges rights claims (Arthur, 2009). One of these rights is personal data privacy, which historically is connected with the discussions about technological sovereignty. The link between these two topics has to be with different recent episodes like the WikiLeaks case in 2009, the Snowden's revelations in 2013, and the Cambridge Analytica case in 2018[61]. All these scandals reveal the dark side of the Internet, misuse of personal data, the abuses of digital commercial platforms, and the monopoly practices of some big digital firms. Particularly the case of Cambridge Analytica illustrates how the dominant digital platforms look for modifying individual behaviour with big data analytics for changing democracy or profit and by stealth. Next, Figure 18 shows the most important facts that occurred in the development of Internet, the digital economy, and Industry 4.0, in parallel with the discussions on technological or digital sovereignty and personal data privacy rights.

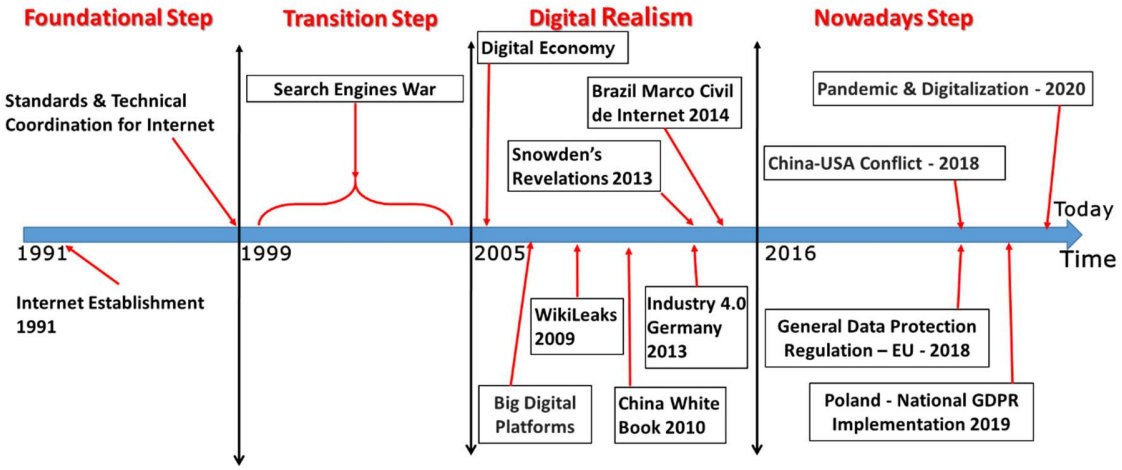

Fig. 18. Internet, Digital Economy, Industry 4.0, Digital Sovereignty and Privacy Rights
Source: elaboration on the base of Arciénaga (2020).
Rys. 18. Internet, gospodarka cyfrowa, Przemysł 4.0, suwerenność cyfrowa i prawa do prywatności
Źródło: opracowanie na podstawie Arciénaga (2020).

As it could be appreciated in the Figure above, the foundational step was led by governmental initiatives, like ARPANET in the USA and the CERN in Europe, with no commercial activities allowed (Bing, 2009: 37-40). Then, the evolution went from the "innocence age" of an idyllic Internet in the transition step[62], with just the war of search engines, to the Internet of corporations from 2005 onwards, with the launch of Google or the consolidation of Amazon, and soon other big digital platforms. The scandals initiated

[61] See a complete information of this case on The Guardian website on how this firm influence "democratic" votes in Argentina, UK, USA, and Kenya: https://www.theguardian.com/news/2018/mar/17/cambridge-analytica-facebook-influence-us-election Access on 11/07/2020.
[62] The Internet aims were focused in this transition step on the web as a cultural and educational instrument.

by WikiLeaks showed the enormous problems with the privacy of data at a personal level, which were aggravated with Snowden's revelation of espionage to German and Brazilian governments by the USA National Security Agency in 2013.

The dispute for data and the lack of respect for privacy rights led Harvard Professor Shoshana Zuboff calls the two last steps in Figure 18 the "age of surveillance capitalism"[63], a new phase in the evolution of market economy that seems today to become the dominant form of capitalism in our time (Zuboff, 2019: 4-6). The monetising model for personal data is a dominant rationale ". . . to private venture capital but it delivers little public value, disrespecting our fundamental rights" (Bria, 2019: 164). One of the main issues posed by ICT is that the use of these technologies necessarily involved to a great extent personal data as customers (producers) or as citizens, but this is quite different from behavioural manipulation (Kramer et al., 2014).

The answer to privacy rights came from the government level first, with many initiatives that opened the discussions to look for solutions. Today, ICT threatens the privacy rights of customers, producers, and citizens due to possible negative consequences as a result of digital firms' access to personal data. The debates on these topics in the European Union gave as result the General Data Protection Regulation (GDPR)[64], adopted by the EU in May 2018. The EU Data Privacy Directive established an unambiguous consent from a person for each use of his/her personal data. This debate in the USA has also embraced the economic analysis of the monopoly position of the big digital firms, which are mainly from this country. It was already mentioned that while writing this chapter, the House Judiciary Committee's Antitrust Subcommittee corroborated (October 7, 2020) the monopoly position and business abusive practices of Apple, Amazon, Google, and Facebook. Therefore, there will be structural changes in the near future that will also effect on the suitable deployment of privacy rights, due to reinvigorate antitrust enforcement[65].

However, there are other initiatives from the private sector, like those claimed by Zyskind et al. (2015), who argue that blockchain technology can be an efficient tool for decentralising privacy and for protecting personal data. The question here is, with so many

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[63] This new concentrated economic system considers human personal data as free raw material for hidden commercial practices of extraction, prediction, and sales, with the production system subordinated to a new global architecture of behavioural modification, marked by concentrations of wealth, knowledge, and power unprecedented in human history (Zuboff, 2019: 1).

[64] See the General Data Protection Regulation (GDPR) of the European Union on the official website: https://ec.europa.eu/info/law/law-topic/data-protection/data-protection-eu_en Access on 09/10/2020.

[65] See the press release of the conclusions of Judiciary Antitrust Subcommittee Investigation, where it reveals that digital economy is highly concentrated and impacted by monopoly power. Available at: https://judiciary.house.gov/news/documentsingle.aspx?DocumentID=3429, Access on 10/10/2020.

smart AI devices becoming better and better, who should control who. Providing principles, suitable technologies and safeguards to protect data to data controllers is an important base for guaranteeing information system design will respect privacy. A complete discussion about privacy rights is out of the range of this chapter, even though the main problem has been posed[66].

Data privacy also has a collective dimension. In this case the analysis goes mainly through the issue called technological sovereignty, which in today version is named also as digital sovereignty. This issue has been triggered by the Snowden and the Cambridge Analytica cases, because both showed that strategic data from countries can be manipulated for cyberespionage. The pandemic has reinforced this tendency, and therefore the technological sovereignty is high in the agenda of the European Union.

Technological sovereignty denotes citizens' capacity to have an opinion about technological infrastructure and the software used, and participate actively in how these technological components operates around them and what ends they serve (Bria, 2019: 166). This is a kind of human-centred autonomy. However, there is another version of technological sovereignty that involves the action of states and governments. In this case, the technological sovereignty implies developing, accessing, using, and distributing technology in a country, without external conditionings (Arciénaga, 2020)[67]. An assumption that is usually hold by the big digital firms and developer designers is that "… technology is frequently regarded as emerging and existing outside regulatory systems" (Yeung and Lodge, 2019: 7), which is at the base of the sovereignty problem either for citizens or states. On the other hand, ICT are indeed advancing so fast that the legal framework and regulatory systems are not suitable any more (Webb, 2020: 67). This situation means a thorough destabilisation of existing powers.

On the other hand, Edward Snowden's revelations led the European Union and German government ". . . to demand reforms to the Safe Harbor Agreement with the United States, and harmed U.S. technology companies seeking international business" (Solove and Schwartz, 2018: 455). Germany for instance has requested to ensure digital sovereignty with an autarkic European cloud computing infrastructure, Gaia-X[68], and the use of Airbus for developing AI[69]. In October 2019, the President of the European Commission Ursula

[66] Therefore, we recommend further readings of Perera et al. (2015), Liu et al. (2015); Zhang (2018), Altshuler et al. (2013), and Solove and Schwartz (2017).
[67] This last interpretation is related to the political concept of state sovereignty, which means that one state cannot interfere with the internal affairs of another state. Sovereignty is based on the assumption that all states are equal as such. Therefore, a sovereign state has complete control over its territory and limited influences on other. Global issues as human rights treatments or climate change are modifying slightly this approach (Arciénaga, 2020).
[68] See https://www.data-infrastructure.eu/GAIAX/Navigation/EN/Home/home.html, Access on 01/08/2020.
[69] See https://www.airbus.com/innovation/industry-4-0/artificial-intelligence.html, Access on 01/08/2020.

von der Leyen set technology and climate change as the top priority for the next five years, including technological sovereignty for key technologies (general purpose technologies such as quantum computing, artificial intelligence, blockchain, and critical chip technologies) (Scott, 2019).

Coronavirus has also impacted the sovereignty agenda of the European Union. Recently in March 2020, the European Commission approved the guidelines to protect critical European assets and technology in the pandemic crisis. Guidelines introduced foreign direct investment controls to regulate non-EU investment in AI, robotics, pharmaceuticals for coronavirus, and quantum computing[70].

Social relationships and culture have been deeply modified by ICTs. Social networks seem to create influential relationships (Centola, 2018: 163; Mitcham and Briggle, 2009: 1147). It is not new that technology has influenced the way humans conceive and evaluate their worlds and themselves been influenced by such evaluations (Mitcham and Briggle, 2009: 1147). For instance, smart cities are ordering and planning their activities with new approaches for better standards of living, modifying the citizenship concept. Friendships and communities are drastically impacted by social networks and gaining new meanings. Simulation and visualisation change our habits of thought and learning across the different cultures, mutating these cultures. Design software alters the vision and links between architects, engineers, and customers about buildings and public works. New robotic prosthesis, smart devices, and digital health surveillance will change forever how medical doctors and patients focus on their bodies and diseases, evolving even what is understood by human concept. Teachers and students are modifying forever the teaching-learning process, renewing the education concept. Cyberspace can deploy unresolved conflicts for some users and provide opportunities for solving important problems for others. Some people are more connected digitally than socially, emerging new virtual identities. Besides, as it was mentioned, entrepreneurs and managers will demand new business model in the digital era, changing the economic rules and laws. Is this the rise of the era of data-driven and social algorithms? (Lazer, 2015).

Another evolving front for ICT is its merging with biological science that could give rise to trans-human considerations and even philosophical discussions. Transhumanism is a philosophical school created by Nick Bolstrom and David Pearce[71] that is based on the

[70] See the official website: https://trade.ec.europa.eu/doclib/press/index.cfm?id=2124, Access on 01/08/2020.

[71] Transhumanism has some roots in the 1960s, with the Movement of Human Potential, born in California's psychedelic culture. Cryonics and trans-human libertarian joined the movement in the 1960 and 1980s respectively. In 1998, two Swedish and British philosophers, Nick Bostrom and David Pearce, founded the WTA (World Transhumanist Association), giving official birth to this movement at world level, with the big support of the Internet. In 2007, the WTA established its headquarters in Palo Alto, crossing its roots with Silicon Valley technological solutionism. Transhumanism is not a monolithic set of ideas (Manzocco, 2018: 36-38).

idea that by using technologies humans can overcome their problems, reaching happiness and eliminating suffering, and pain (and possibly death) through human enhancement (Brey and Søraker, 2009: 1389). This new doctrine has an optimistic view of technology, very close to technological solutionism, but being conscious of the potential dangers arising from the misuse of technology (Toraldo and Toraldo, 2019).

Anthropological mutation would be the result of a progressive alteration of human characteristics employing genetic and electronic manipulation. Human enhancement means that body and cognitive abilities are augmented by modern technology (Brey and Søraker, 2009: 1389). In this sense, transhumanism arguments that humans already use technological devices with their body (glasses, clothes, cochlear implants, prosthetics, navigation systems, languages translators, exoskeletons), and biological processes (repairing or modelling surgeries, vaccinations, assisted reproductive technologies, stem cells biotechnologies, synthetic biology) (Vallverdú, 2017: 199-202). At the bottom of the debate about human enhancement is the ". . . fundamental questions of what it means to be human" (Münch, 2014: 204).

There are several critics to transhumanism and human enhancement. Some come from humanist thinkers, like Jürgen Habermas[72], and others come from Francis Fukuyama, from the neoliberal school at Harvard. The opponents of transhumanism are called bio-conservatives (Torralba, 2018). The main critics are the following: a) there is a certain contempt for the human body, for which they adopted a computer functionalism view; b) the body is considered as *de facto* a contingent limitation of human potential; c) unlimited interventions of technological human improvement, provided the safety of the techniques employed; d) no worries for qualitatively new social inequality produced by technological enhancement; e) the explicit goal is to surpass the Homo sapiens' limits by means of technology, so post-human beings would no longer be humans (there is no upper limits); the promise of joy and happiness is justified on the continuous enhancement; f) high possibility of creating reproductive barriers for humans (Münch, 2014: 204-208; Agar, 2010: 19-23).

Therefore, this is a new techno-centric utopia or ideology. There are other versions of human enhancement that are much more moderate. However, they share in common an almost religious faith in technology to solve all the human problems at the individual level. The choice is always individual and there is no qualm for collective common goods.

In the bio-conservative position, there are important arguments like: a) the inviolability of emerging human life; b) the human life cannot be reduced to a mere object and must be

[72] Known German scholar of the second generation of the Frankfurt School.

preserved of the danger of certain mechanisation (present in the enhancement rationale); c) if post-human species are superior, they might enslave or even exterminate human beings; d) human nature should be valued as a gift and not as a limitation; e) humans are a "given" reality, rather than an evolutionary starting point of rupture; f) life is a dynamic reality marked by the interplay of possibilities (Torralba, 2018: 12-13; Hopkins, 2012).

By way of a concluding reflection, we would like to add that this brief travel that we make through the Fourth Industrial Revolution, in this nascent stage, is just starting. Probably, it will be a journey that has some known patterns, similar to previous industrial revolutions. However, other events of the Industry 4.0, as were illustrated, are closer to the concept of singularity[73]. As a consequence, we hope to be making our small contribution to a kind of a collective consciousness, which will be critical for building a world where we collaborate with smart robots and AI devices rather than being controlled and ruled by them.

[73] This concept is based on Kurzweil's (2005) idea that humans will generate an AI system, improved by itself, which will overcome human intelligence in all forms. At that moment, the technological singularity will occur. Even though we recognize the advancement of AI, and the possibility for a singular point similar to the steam machine, our position is far from considering that the AI system will displays and carries out an attitude of control and dominance over human nature. Therefore, the human-centred design of AI and smart systems is the road.

2. THEORETICAL BACKGROUND FOR THE ANALYSED RESEARCH VARIABLES OF WORKERS REPRESENTING OCCUPATIONS IN INDUSTRY 4.0

2.1. Introduction

In the Human Relations stream, popularised in the field of work psychology and organisation, psychosocial and organisational variables play a special role, given their impact on the functioning of the individual in the professional environment. The study of subjective variables, such as: personality determinants, positive orientation in the life of an individual, ego resilience, a sense of effectiveness, and specific parameters of human functioning in the context of professional experiences - such as demonstrating an attitude towards safety at work, perceiving the organisation, adjusting to the place of work, feeling of stress, and a sense of threat - makes it possible to understand the mechanisms and behaviours that characterise employees of specific sectors and professional branches. In this monograph, the authors try to get to know and understand better the workers of Industry 4.0, so the study of their attitudes, perceptions and individual characteristics has been taken as a fundamental research issue. Below is the theoretical background of the variables studied.

2.2. Personality factors

In the scope of interest of the authors of this monograph in the context of the study of industrial workers 4.0 there are personality factors, treated as relatively constant parameters of human functioning. In the light of psychological literature, they are significantly related to the specific response of an individual to experiencing psychological stress. The best known and best empirically verified concept of personality is undoubtedly the Great Five Costa and McCrae model (1997).

In his understanding, extraversion (versus intrusion) describes the tendency to social interaction, as well as energy and activity, and the feeling of positive emotions. Therefore, high extraversion usually means cordiality and friendliness, activity and optimism, sociability and conversation, the tendency to play, the search for stimuli and stimulation. On the other hand, low extraversion (introversion) usually means reserve in social contacts with other people, shyness, lack of optimism, or a preference to be alone. Another factor of the model: amicability describes the tendency of an individual to have a positive versus negative attitude towards other people related to altruism versus antagonism. High amicability usually also means sympathy, willingness to help, straightforwardness, straightforwardness, honesty, meekness, and gentleness, as well as modesty and affection for others. It should be noted that a low level of amicability usually means egocentricity, a competitive attitude, and sometimes even aggressiveness and dryness in contacts with other people. Another personality variable is conscientiousness, which describes a person's attitude to goal-oriented action and is connected with the level of organisation, motivation, and perseverance. High conscientiousness usually means a strong will to achieve and motivation to act and perseverance in pursuing and achieving one's own goals. On the other hand, low conscientiousness usually means a low level of definition of life goals, low meticulousness and motivation of achievements; hedonism, impulsiveness in making decisions, and spontaneity in acting.

In the Big Five model, emotional stability (versus neuroticism) describes the susceptibility to experiencing negative emotions, such as dissatisfaction, confusion, feelings of guilt, fear, anger. High emotional stability (low neuroticism) usually means emotional adaptation, the ability to cope with stress without experiencing tension, annoyance, or fear. High neuroticism, on the other hand, usually means less ability to control one's drives and deal with stress, a tendency to worry, shame and a sense of confusion in the presence of others, and even reactions characterised by fear and tension. The last factor of the model - openness to experience describes the tendency to seek and positively value new life experiences, tolerance to novelty, and cognitive curiosity. High openness to experience usually means curiosity, creativity, imagination, unconventionality, as well as independence in judgements. On the other hand, low openness to experience usually means conventionality, conservativeness, adherence to traditional values, pragmatic interests, and preferences for socially recognised ways of acting.

Over the last dozen or so years or so, interest in shortened versions for the study of personality variables has increased significantly. Currently, the 24-stage questionnaire for the measurement of six personality traits The Questionnaire Big Six Scale (24QB6; Thalmayer et al., 2011); 10-stage questionnaires for the measurement of five personality

traits are used: The 10-Item Big Five Inventory (BFI-10; Rammstedt, 2007), Ten Item Personality Inventory (TIPI; Gosling, Rentfrow, and Swann, 2003) and Mini-Markers (Saucier, 1994), which is a 40-property version of Goldberg's (1992) Goldberg's (Big Five Factor Markers) list of top 100 lexical indicators, or the Mini-IPIP 20-statement questionnaire.

The advantage of short versions of the tools is a much shorter testing time and low cost of distribution of such tools. Reise and Henson (2000) have shown that most of the features measured by the NEO-PI-R questionnaire on the 8-statement scales can be compared with comparable quality to the 4-statement scales. They used the CAT (computerised adaptive testing) procedure. In this procedure, in order to maximise measurement precision, the computer systematically selects test items for a specific test person based on information resulting from their previous answers (Weiss, 2004).

Mc Rae and Costa (2007) draw attention to the risks of using fewer items in personality measurement. They recommend that special care be taken to verify the reliability factors of the shortened scales.

As for the tool used in the own research, a 20 item IPIP-BFM questionnaire was used. Authors of Polish adaptation - Topolewska, Skimina, Strus, and others. (2014) used in their analyses the IPIP-BFM-50 questionnaire, which is used to measure personality in the commonly used Big Five model. Secondly, it is a Polish adaptation of the IPIP-BFM-50 tool, which is a version of the shortened questionnaire of Donnellan and colleagues (2006).

The IPIP-BFM-50 questionnaire is available in the Polish adaptation of Strus and Associates (2014). The study, which was an adaptation of the tool, was carried out using the paper-centre method. It involved 903 people aged 16-83 (M age = 30.97; SD age = 13.82), among whom women constituted 55%. The respondents came from all over Poland, with the majority being residents of the Mazowieckie Voivodship (73.1%). A significant part of the respondents lived in a city with more than 500,000 inhabitants (43.3%). In a city with 100,000 to 500,000 inhabitants there were 9.7% of the respondents, in a city with up to 100,000 inhabitants there were 29.7%, while in the countryside - 17.2%. Approximately 31% of the respondents had higher education and the same number were in the course of studies. Partial higher education was declared by 6.5% of the respondents, post-secondary education by 2.5%, secondary education by 21%, vocational education by 3.8%, and basic education by 3.6%. Personal characteristics were also measured using four other questionnaires. These were: NEO-PI-R Costy and McCrae questionnaire (1992), in the Polish adaptation of Siuta (2006), and IPIP-NEO-PI-R questionnaire, measuring the same personality traits as those measured by NEO-PI-R, but coming from IPIP resources. The Polish version of IPIP-NEO-PI-R was prepared by Rowiński, Strus, Cieciuch. The Polish

version of the questionnaire was prepared by Strus and colleagues (2012). The measurements with the above-mentioned questionnaires were carried out at intervals of 2 to 6 weeks after the measurement with the IPIP-BFM-50 questionnaire.

The analyses carried out on the basis of Donnellan's and co-authors' procedure (2006) made it possible to construct a Polish, 20-confirmation IPIP-BFM-20 questionnaire, which is an abbreviation of IPIP-BFM-50, used to measure the Great Pit in Goldberg's lexical model. The IPIP-BFM-20 questionnaire is characterised by good accuracy (satisfactory CFA matching indicators and correlation coefficients with other methods to measure the Great Beat) and reliability (satisfactory alpha Cronbach indicators). The questionnaire consists of 20 items and includes 5 score scales. These are: scale of Extraversion, Convenience, Summary, Emotional Stability, and Intellect.

2.3. Personality type D

The D personality type, the so-called depressive personality, which was first introduced to the literature by J. Denoletto (1998, 2001), seems to be a theoretical, although also an application opposite of positive orientation and ego resilience. Stressful personality - so-called Type D (26). It consists of two main dimensions treated as relatively constant personality traits, namely negative affectivity, and social inhibition. Negative emotionality is expressed by a tendency to experience strong negative emotions, such as: anxiety, anger, irritation, hostility (Pedersen et al., 2006). Social inhibition, in turn, is associated with a tendency to refrain from expressing negative emotions and behaviours consistent with those emotions. Refraining from revealing emotions is conscious in nature and is undertaken mainly in social situations, primarily for fear of disapproval and rejection by other people. As far as the characteristics of people with type D personalities are concerned, they are described as manifesting a tendency to worry and feel tension, blame themselves and have a low tendency to share emotions. A D-type personality is associated with such symptoms of psychological stress as: a tendency to depression, difficulties in perceiving and enjoying social support, low self-esteem, low level of life satisfaction, and a sense of exhaustion. Such people are also more often ill and experience various types of somatic problems (Ogińska-Bulik, 2009).

Both negative emotionality and social inhibition are associated with a lack of perception of social support, low readiness for support, and fear of being rejected by others (Ogińska-Bulik, 2009). Denollet points out that a D-type personality is characterised

primarily by a tendency to worry and blame, a low sense of security, a negative perception of the world, a general sense of hopelessness and unhappiness, and discomfort in social situations (Denollet, 2002). The components of a stressful personality: cognitive (generating threat/loss ratings); emotional (negative emotionality); behavioural (social inhibition) - lead to an intensification of subjective feelings of stress and vegetative and somatic changes that create a risk of health breakdown (Ogińska-Bulik, 2006). Behavioural pattern consisting of a type D personality leads not only to deterioration of an individual's immune potential, but also to a lack of self-confidence, development of a sense of helplessness, and loss of the will to live (Ogińska-Bulik, Juczyński, 2010). Currently, individuals with a stressful personality are considered to have an increased risk of developing mental disorders such as depression, post-traumatic stress syndrome, panic attacks, phobias, and medical disorders such as stroke and cardiovascular diseases (Denollet, 2000). Due to the mechanism of increased reactivity and weakened activity of the immune system, type D personality is a psychological risk and progression factor, mainly cardiovascular diseases (Ogińska-Bulik, 2005, Ogińska-Bulik, Juczyński, 2010). In literature, there are many studies proving that type D personality is associated not only with many emotional and social difficulties, but also with increased morbidity and death rates among patients with diagnosed heart disease (Denollet, Schiffer, Spek, 2010). The results also indicate that experiencing negative emotions is a predictor of such diseases as ischaemic heart disease, hypertension, cancer, peptic ulcer or psoriasis (Ogińska-Bulik, Juczyński, 2010). Type D personality testing is carried out using a questionnaire developed by Denollet. As it results from the analysis of psychometric properties, this questionnaire is a valuable research tool (Denelott, 2001). Polish research team: J. Moryś, M. Majkowicz, N. Ogińska-Bulik, A. Rynkiewicz (2006) adapted the tool.

The study included 50 patients from 4 weeks to 6 months after myocardial infarction diagnosed on the basis of typical pain, elevated concentration of myocardial necrosis indices, and characteristic changes in electrocardiographic records. Patients with a fraction of $\leq 40\%$, burdened with life-threatening diseases, diagnosed with serious mental illnesses, or with cognitive impairments preventing understanding of the questionnaires were excluded from the study. The study was conducted from November 2004 to July 2005. Type D personality was assessed on the basis of a scale of 14 statements, developed by Denollet for Belgian patients with cardiac diseases. On the basis of this scale, the tendency to experience negative emotions and tendencies to inhibit the expression of emotions in social contacts are measured. Each statement was answered on a 5-point scale from 0 to 4. Each patient was asked to choose the number from 0 to 4 that best describes him or her for each of the 14 statements. The accuracy of the self-assessment was described with values

from 0 to 4, to which the following assessments were assigned: 0 - definitely not, 1 - mostly not, 2 - I have no opinion, 3 - mostly yes, 4 - yes. Then, according to the key, the number of points within each subscale of the DS14 questionnaire was added. The sum of points ≥ 7 was considered as high values in each subscale. Patients who had high values (≥ 7) in both subscales were classified as patients with type D personality. To assess the accuracy of DS14 scale, the NEO-FFI test (examining the dimension of neuroticism and extraversion), PTS temperament scale (examining the strength of the nervous system - excitability), and STAI self-assessment scale (examining the level of anxiety as a state and as a trait) were used. Reliability was estimated by calculating Cronbach's internal compliance factor α. The accuracy was estimated using two methods:
- assessment of the so-called factorial relevance using factor analysis; Varimax rotation was used for factor analysis;
- assessment of the so-called criterion relevance, in which the relationship between the results of the DS14 questionnaire and the results of other psychometric tools with previously established relevance was estimated. For the calculation of correlation coefficients, the formula for Pearson's *r* was used. The original version of the questionnaire was translated according to the validation procedure: by two independent persons from English into Polish, and then by two independent persons whose native language is English, from Polish into English. After comparing the two versions, the final version of the questionnaire was established. The analysis showed that the scale of "negative emotionality" statistically significantly correlates with anxiety (state and trait - STAI), the balance of nervous processes (PTS), neuroticism, and openness (NEO-FFI); with a high correlation found between the "negative emotion" scale The reliability of the "negative emotion" scale is very good (α = 0.83), while the reliability of the "social inhibition" scale is quite low (α = 0.63), but acceptable for this type of tools. Factor accuracy should be considered as very good, test items "spread" in two factors according to the theoretical assumption of test D and results of the original version. The psychometric parameters of the tool are considered satisfactory.

2.4. Positive orientation

One of the concepts developed within humanistic psychology and personal resources paradigm is the theory of positive orientation (Caprara, 2009; Caprara, Steca, Alessandri, Abela, and McWhinni, 2010).

The concept of positive orientation (POS) was formulated by Gian Vittorio Caprara, an Italian psychologist from the University of "La Sapienza" in Rome. The first article by Caprara, in which the term "positive orientation" appears, was published in 2009 (previously referred to as "positive thinking"; Caprara and Steca, 2005, 2006).

Positive orientation is a fundamental tendency to notice and attach importance to the positive aspects of life, experiences, and oneself (Caprara, 2009). It is a higher-level latent variable combining three components: self-esteem, optimism, and life satisfaction. The concept of positive orientation grew out of a generalisation of empirical research results - self-esteem, life satisfaction, and optimism correlated repetitively with each other and formed a single factor in the results of factor analyses. These analyses allowed to formulate a hypothesis that there is a common hidden variable underlying them (Alessandri, Caprara, and Tisak, 2012; Caprara and Steca, 2005).

According to Caprara (2010), positive orientation is something very basic, it is an "instinct" (in the sense of innate, genetically conditioned disposition) that enables a person to live. It is rooted in a biological system that gives emotional colour to the human experience. The basic premise of the theory of positive orientation is that perceiving oneself, life, and the future in a positive way, is indicative of a basic predisposition, fulfilling an important biological function - making a person willing to cope in life despite failures, adversities of fate and the prospect of death.

Positive orientation is the basic tendency to notice and attach importance to the positive aspects of life, experiences, and oneself. It is largely responsible for adaptive functioning, as it means a natural inclination towards a positive self-assessment of oneself, high satisfaction from life and a high evaluation of the chances of achieving goals, which translates into a commitment to life's goals and a high evaluation of the quality of life (Caprara, 2009; Caprara et al., 2012). The results of studies on positive orientation indicate that its level is not related to gender or socio-economic status, but has a non-linear relationship with age - its highest level is in average adulthood.

Caprara and others. (2010) published the results of a study which aimed to confirm that a common, hidden dimension lies at the root of self-esteem, life satisfaction, and optimism. The study involved 1,331 Italians (49% of men), aged 20 to 92 (average age 48.49). The following methods were used: RSES (Rosenberg Self-Esteem Scale, Rosenberg, 1965), SWLS (Satisfaction with Life Scale, Diener et al., 1985), and LOT-R (Life Orientation Test, Scheier and Carver, 1985), to measure, respectively, self-assessment, life satisfaction, and optimism. The PANAS scale (Watson, Clark, and Tellegen, 1988) was also used to measure positive and negative affect. The perceived quality of interpersonal relationships was also assessed - subjects responded to statements relating to the quality of family,

marital/partnership relationships and relationships with friends. The respondents also answered 6 questions concerning the frequency of health problems. Confirmatory factor analysis was used for statistical analyses. The model best suited to the data turned out to be one in which positive orientation was a hidden dimension explaining the variability of self-esteem, life satisfaction, and optimism. In addition, positive orientation correlated positively significantly with, respectively, the hedonic balance (the difference between the frequency of experiencing positive and negative emotions), the perceived quality of interpersonal relationships with the spouse/partner, the perceived state of health and, to a lesser but still significant extent, the perceived quality of family relationships and the perceived quality of relationships with friends (Caprara et al., 2010).

So far, positive orientation has been measured using three separate scales measuring self-assessment, optimism, and life satisfaction; based on their results, it was necessary to calculate a factor score, which could only be obtained after factor analysis on the overall results of the three scales. The scales themselves have a relatively large number of claims in total (especially considering the fact that only one indicator of the latent variable is finally derived from them), and the procedure for calculating the factor score requires appropriate skills. Therefore, a short scale was proposed instead as an extract of three output components. Currently, researchers are using a shortened version of the tool - the P scale.

The Polish version of the P scale is made of 8 statements, all of them of diagnostic nature. The test person is asked to indicate the extent to which they agree with each of them. Answers are given on a five-point scale from 1 - I strongly disagree to 5 - I strongly agree; one claim is reversed (claim 4). The score is the sum of the points; the higher the score, the higher the level of positive orientation, the range of raw results is from 8 to 40. To develop the Polish language version, the scale has been translated by two independent translators from English and one from Italian (the scale has several language versions). The agreed Polish version has been translated back into English, which showed a satisfactory correlation with the original.

According to theoretical assumptions, positive orientation is the opposite of the depressive triad (Caprara, 2010). The indicator of the accuracy of the method which is to measure it should be a negative correlation with a sense of hopelessness, which is one of the indicators of depression. Numerous statistical results of both the Italian team and researchers from other countries confirm the Caprara positive orientation model. Statistical analyses indicate the existence of a latent variable - positive orientation, which explains the variability in self-esteem, life satisfaction, and optimism. It is largely genetic in nature. Such a positive orientation is indeed connected with personality characteristics related to the quality of life, such as, for example, hedonic balance, quality of interpersonal relations,

perceived social support, health condition, ego resilience (psychological resilience), self-confidence, and basic hope. Positive orientation is most strongly associated with self-assessment, i.e. self-assessment is most important, more important than optimism and life satisfaction.

Alessandri, Caprara, and Tisak (2012) emphasise that it is not excluded that other variables, apart from self-esteem, life satisfaction, and optimism, may also belong to positive orientation. In their own research it has been assumed that positive orientation is an important variable that constitutes a personal resource and thus enhances the potential of employees in sector 4.0 to cope with occupational stress, feelings of insecurity and determining their psychological well-being.

2.5. Ego resiliency

The term resilience was introduced into literature as early as the 1950s (Block, Block, 1980). The word resilience is derived from the Latin salire, meaning spring, spring up, and resilire, i.e., bounce back, spring back. Two terms are used in the literature, resilience and resiliency. The first one is associated with the process of successfully overcoming negative life events and phenomena, while the second one refers to a characteristic of the personality or a relatively durable resource of the individual.

The authors of the construction (Block, Block 1980), conducting research on self-control, proposed a two-dimensional model of taxonomy of personality types, including suppleness of the ego, or resistance (ego-resiliency), and control (ego control). Self-control includes tendencies to hold back (versus expressing) emotional and motivational impulses. In turn, ego-resilience means adjusting a typical way of control to the requirements of a situation, i.e. balancing this impulsivity and inhibiting it (Oleś, Drat Ruszczak, 2008). The resilience of the ego therefore refers to the individual's ability to react flexibly to the changing requirements of a situation, including stress, conflict, or uncertainty.

Researchers treat resilience as a relatively permanent disposition determining the process of flexible adaptation to constantly changing life requirements. They see it as a personality trait (ego-resiliency) important in the process of dealing with both traumatic and everyday events.

The resilience approach to ego proposed by Block was introduced to Polish literature by Z. Uchnast (1997), using the term ego resilience. The author indicates that it is a constantly developed and improved ability to deal with everyday tasks in changing and

often stressful conditions. The term therefore refers to a person capable of adapting in an adequate, consistent, and persistent way to changing living conditions, both through the appropriate tuning of one's own abilities and skills, and the appropriate use of factors in the environment. The opposite is true for people with a so-called "fragile personality", for whom a low threshold of frustration is characteristic. Such people react to new situations with rigidity and anxiety. resilience is the basic property of personality regulation processes. The ego's resilience, also known as personal resilience, is treated in terms of type rather than characteristics, indicating the existence of a specific system of character characteristics.

Luthar and others. (2000) presented a position suggesting that resilience refers to the process of dynamic and positive adaptation in the face of emerging adversities. Activating resilience therefore requires experiencing an immediate threat or traumatic situation and maintaining the ability and competence to deal with it.

resilience is seen as a dynamically changing result of interaction of forces in the context of the ecosystem, conditioned by many factors. Thus, it is not only a set of properties of a person, but the result of mutual interaction of individual and environmental characteristics. It is a dynamic property, depending on the life context, so it can be developed and shaped.

Jeanne and Jack Block (1980) have characterised resilient individuals by indicating that they are self-confident, productive, persevering, valuing their independence, having a sense of humour, able to win the favour and acceptance of others. In addition, they are people who are aware of their motives for their own actions, and the tasks they have undertaken are completed. They are characterised by cordiality and ability to have close relations with others.

Some research reviews, e.g. by Semmer (2006), have shown that a resilient individual is a person who is capable of being successful: tends to interpret the surrounding environment as generally favourable and, like an optimist, expects more positive than negative things to happen to him. Such a person is more amicable and does not tend to harm others. Furthermore, he or she sees stressful events primarily as a challenge; accepting the deterioration of the situation and treating the failures experienced as normal events that do not necessarily result from a lack of competence or indicate a hostile world. A person with a strong ego treats life as something that is influenced by it, as a result of his or her own activity, and as a person capable of influencing it. He/she is characterised by emotional stability (not lability and the tendency to experience negative emotions). Besides, he treats the encountered difficulties as an opportunity to gain new experiences and his own development.

The resilience is associated with such personality structures as emotional stability, openness to experience, optimism, a sense of coherence (especially a sense of sensibility), a sense of control or self-efficiency. It is also inseparable from experiencing positive emotions. A strong link between resilience, positive emotions, and a tendency to deal with them effectively also indicates some similarities between this construct and emotional intelligence.

In the literature on the subject, the resilience of the ego is an overriding concept. It is treated as a mechanism of self-regulation that includes both cognitive elements, characteristic of beliefs and expectations, concerning, among other things, perception of reality in terms of a challenge, as well as one's own competence, and emotions, involving positive effect and emotional and behavioural stability, expressed in the search for new experiences and undertaking diverse and effective strategies of dealing with problems. According to Block and Kremen (1996), resilience stands in opposition to both lack of control (impulsivity) and excess control (rigidity). Moreover, resilience seems to be the inverse of a stressful personality (type D), which is characterised by perceiving the world as a threat, experiencing negative emotions and coping by not expressing emotions and refraining from contact with other people (Ogińska-Bulik, 2009).

The ego is associated with the experience of positive emotions, which positively influences the assessment of stressful situations (in terms of challenges), as well as the choice of more effective and situation-specific coping strategies. It therefore means that individuals are more resistant to stressful situations. What is important, it is of particular importance for the health of an individual, especially his or her mental dimension. The relationship between resilience and positive emotions seems interesting. Positive emotions mediate the process of overcoming negative emotions. This allows people who experience unpleasant life events (e.g. as a result of a serious illness) to change the way they look at the world, gain hope and find other ways of solving their problem, and this fosters the development of a spiral of processes beneficial to health (Fredrickson, 2001).

In the field of health psychology, various tools have been developed to measure this construct. Several tools have been developed to measure the level of resilience in adults. One of the first is the Ego Resilience Scale, whose authors are Block and Kremen (1996). The Resilient Scale (RS), constructed by Wagnild and Young (1993), is very popular and is also used in youth research. More contemporary is this: The Connor-Davidson Resilience Scale (CD-RISC) (Connor, Davidson, 2003), Baruth Protective Factors Inventory - BPFI (Ahern et al., 2006), The Resilience Scale for Adults - RSA (Friborg et al., 2003), The Brief-Resilient Coping Scale - BRCS (Sinclair, Wallston, 2004). It is worth noting that the assessment of the level of resilience, treated in terms of the process, is also based on tools

used to evaluate the resources available, such as the sense of coherence, location of control, hardness, self-esteem or effectiveness. These are treated by researchers as indirect measures of resilience.

The tool used in the own research presented in this monograph is the SPP-25 Ogińska-Bulik and Juczyński (2008). The first research was conducted on a 100-person group of adults, women and men, aged 20 to 50 years, representing different levels of education. Based on the assessment of the discriminatory power, a dozen or so items were eliminated, which correlated least with the overall score (below 0.35). The results of the left-over statements were subjected to factor analysis to determine the components of the structure. After elimination of the claims of weak factor loadings (below 0.40) and comprising several factors, 25 claims were left in the final version. This version of the scale was tested on a group of 500 adults, diverse in terms of education, age, professions represented, as well as health and traumatic experiences. The results of 8 people were rejected on the basis of incomplete data. For further analysis, the results of 492 people were used, including 263 men (53.4%) and 229 women (46.6%). The age of the respondents ranged from 19-65 years (M=39.2; SD=11.9).

As far as psychometric parameters are concerned, the internal compliance, determined on the basis of Cronbach's alpha, is 0.89 for the whole scale, and the standard error of measurement for the overall result is 3.81. The reliability of the 5 subscales is similar and ranges from 0.67 to 0.75. P. The factor structure has also undergone a confirmation analysis to confirm the validity of the adopted solution. D
The values of the parameters were estimated using the method of generalised smallest squares. The obtained good fit 47 ratios (GFI=0.93; AGFI=0.91; RMSEA=0.06) confirm the assumed 5 factorial structure of the resilience structure.

The SPP-25 is a scale for measuring resilience - SPP-25 is designed for adults, both healthy and ill. It contains 25 statements on the different personality properties that make up resilience, also associated with mental resilience. The assessment is made on a 5-stage Likert scale. In addition to the overall score, the scale measures the following 5 factors: 1. perseverance and determination in action; 2. openness to new experiences and a sense of humour; 3. personal competence to cope and tolerance of negative emotions; 4. tolerance of failure and treating life as a challenge; 5. optimistic attitude to life and ability to mobilise in difficult situations. The agility, treated as a self-regulatory mechanism, is universal and should protect against the negative consequences of the experienced events, both traumatic and everyday. The scale can therefore be used to measure the personality predisposition of people exposed to stress, including those of a traumatic nature. It can therefore be used as a selection tool for certain professions where there is a high risk of exposure to stress, such

as firefighters, policemen, and paramedics. In addition, it can be used as a tool to predict responses to traumatic stress, including responses to an incurable illness of oneself or one's relatives. SPP-25 is a self-writing tool. It takes about 10 minutes to complete the scale. Research can be conducted individually or in groups. The instruction at the beginning informs about the purpose of the examination and the way of responding. The person examined responds to the statements given, surrounding the appropriate number, which means: 0 - definitely not 1 - rather not 2 - nor yes and not/difficult to say 3 - rather yes 4 - definitely yes

The results are calculated both for the whole scale and for individual factors. The higher the number of points, the higher the resilience. The overall score of SPP-25 can be expressed in the stenium scale, where scores in the range 1-4 mean low, 5-6 mean average and 7-10 mean high resilience.

2.6. Self-efficacy

Albert Bandura (1977) introduced perceived self-efficacy. A higher sense of self-efficacy increases motivation to act and is associated with better individual performance. Nowadays, it is described as a key resource, as it is related to strengthening the individual's self-efficacy, e.g. in the context of pro-healthy behaviour.

According to social and cognitive theory, our behaviour is guided by the expectations of: situation-outcome expectations, action-outcome expectations, and self-efficacy expectations. Self-efficacy refers to the action itself and falls within the scope of personal action control (Bandura 1997). It is, in a sense, an image of individual competence.

The stronger the convictions about self-efficacy, the higher the goals people set themselves and the stronger their commitment to intentional behaviour even in the face of piled-up failures. A strong sense of competence therefore affects not only intellectual achievements, but also the efforts made and the level of determination of the individual. What is very important is the fact, highlighted by psychologists, that self-efficacy affects the choice of situation, i.e. its rejection or acceptance, depending on the expected consequences. The cognitive processes that precede action allow for the proper use of available resources and the preparation of concrete action plans. When a person experiences zero self-efficacy, his/her motivation potential automatically decreases. The first empirical research on the variable "self-efficacy" assumed that it allows to predict intentions and

actions in different areas of human activity, including health behaviour. (Schwarzer, 1992, 1996).

It is worth stressing that self-efficacy is associated with such health behaviours as: preventing uncontrolled sexual behaviour, taking regular physical activity, controlling weight and food-related behaviour, preventing and stopping smoking and other addictions' (Schwarzer, Fuchs 1996). The influence of self-efficacy on blood pressure, heart rate, catecholamines in challenging or threatening situations has been empirically proven. Perceived efficacy' favours coping with stress and even has a mobilising effect on the functions of the immune system. People with a high sense of effectiveness are able to better control pain than people with a low sense of effectiveness. The sense of self-efficacy is also a subjective belief that creates a variety of personal and situational elements. Bandura (1977) distinguished three aspects of self-efficacy, i.e. size, generality, and strength. Size (level) of conviction refers to the degree of difficulty of the task and the related sense of coping with it. The overall sense of effectiveness concerns the range of possible situations, among which specific situations may require additional specific control competences. The strength of the sense of effectiveness expresses the degree of confidence and trust in one's own competence. According to Bandura, perceived effectiveness should be interpreted by referring to "specific" effectiveness.

The tool for measuring the presented variable is the Generalised Self-Efficacy Scale (GSES), which refers to the Bandura's (1977, 1997) concept of expectations and the concept of perceived self-efficacy. The scale consists of 10 statements. It was prepared in German in 1992 and translated into English the following year. The scale captures the strength of an individual's general beliefs in coping with difficult situations and obstacles (Schwarzer 1993). Its structure includes 4 possible answers to each question, from "NO" - scored 1 point, to "YES" - scored 4 points. The sum of all the scores gives an overall indicator of self-efficacy. The higher the grade, the greater the respondents' self-efficacy. The psychometric data for GSES is mainly based on the results of three German studies. The first one involved more than 2,000 subjects, adolescents and adults from Berlin and Düsseldorf, while the second one involved 269 teachers from 10 cities. The third survey involved over 3,000 students. The internal reliability assessed with Cronbach's alpha Cronbach was 0.82 to 0.93, the reliability of the established test-retest method in a group of 991 emigrants from the former GDR was 0.47 for men and 0.63 for women. The internal reliability of different language versions of the scale ranged from 0.91 (Japanese version) to 0.78 (Greek version). The accuracy of the scale was assessed by comparing the scale results with tools measuring similar properties. As expected, a positive correlation of the effectiveness indicator with self-esteem (0.52), location of internal control (0.40), and

optimism (0.49) was obtained. Negative correlation concerned general anxiety (0.54), timidity (0.58), and pessimism (0.28).

The translation of the scale was done according to the accepted principles developed for use in intercultural research (WHOQOL Translation Methodology), based on the English version. The positive formulation of the test statements was a facilitator for the translation to be consistent. The first studies were conducted on several dozen people aged 20-40 years (Juczyński 1997). The basic tests were carried out on a group of 496 people, aged 30-50 (mean age = 41.2 years), selected at random. The respondents came from small and large cities and the rural environment. All levels of education were represented. Correlation coefficients of individual claims with the overall result are high and range from 0.47 to 0.63, Cronbach's alpha coefficient is 0.85. The reliability of the scale assessed in the group 85 was 0.78. The accuracy of the scale was assessed by comparing the results of the 496-person group with the results obtained using other methods (Juczyński, 1997). Standardisation for the Polish population was also developed, which is an additional diagnostic value of the tool.

The scale constructed by Schwarzer and Jerusalem has become a popular measurement tool. This is due to the need for methods to determine the described construction, expressing the dispositional properties of an individual so important for predicting behaviour. On the basis of previous research, it can be concluded that the Polish version of SUWS has satisfactory psychometric properties.

2.7. Attitudes towards safety at work

Attitudes are an extremely important aspect of human functioning. They determine the motives for behaviour, the choices of individuals and the decision-making mechanisms. In the psychological literature, attitudes are defined as a relatively permanent disposition of an individual to take a specific position (positive or negative) towards a given object, which may be an object, event, opinion, another person. In determining an attitude, it is important to determine its sign (positive or negative), intensity (large or small), as well as strength, validity, compatibility, and connection with other attitudes (Wojciszke).

Psychological research involves a three-factorial definition of posture, i.e. the existence of a cognitive (learning), emotional-evaluating (affective), and behavioural component. The first of these - the cognitive component - is the knowledge of the individual and the resulting beliefs about the posture object. The second - the affective component contains

feelings (positive or negative) about the attitude object. The third - the behavioural component is the consequence (effect) of the cognitive and affective component.

An employee's attitude towards work safety can be defined as the total of relatively permanent dispositions to perceive and evaluate the principles of work safety, to react emotionally to them and to perform work safely (Znajmiecka-Sikora, 2019).

The cognitive component refers to knowledge about the principles and ways of performing work safely, risks in work processes, potential accident situations. necessary knowledge is provided, among others, during instructions (initial, positional), periodic training, by means of positional manuals, risk assessment cards, and other documents defining the principles of safe performance of work in the organisation, interviews with superiors and colleagues. The affective component manifests itself in the individual's emotional attitude towards observing health and safety rules, while the behavioural component manifests itself in undertaking given behaviours at work. For example, an employee's knowledge of the risks and ways of personal protection and a positive attitude may result in safe behaviour at the workplace, in accordance with the applicable procedure. (Nowak, 1973, Szczygielska, 2012, Stasiła-Sieradzka, 2012, Znajmiecka-Sikora, 2019).

When considering attitudes towards safety at work, attention should be paid above all to the working conditions, i.e. the machinery used, the technical condition of the machines and equipment, the way in which employees are organised, and the resulting lack of time pressure and the correct flow of information. The results of empirical research indicate unequivocally that with the improvement of working conditions and work organisation, the level of attitudes to safety expressed by employees increases. Another important parameter is the size of the company - working in a large company is associated with a higher level of the cognitive component of the attitude and the presentation by employees of safer behaviours at the workplace (Znajmiecka-Sikora, 2012, 2014, Stasiła-Sieradzka, Dobrowolska, 2016). The organisational factors related to attitudes towards safety and related behaviours in the workplace include an organisational climate in which the safety climate is a kind of mediator: the organisational climate has a significant impact on the safety climate, and the safety climate is related to the employees' declaration of activities in accordance with the organisation's health and safety procedures, and their participation in workplace safety activities.

Attention should be paid to the interesting conditions of dispositional attitudes towards safety at work. Among the subjective features related to the attitude, age, and education are indicated. Knowledge about safety at work and attitudes towards safety are related to the age of the employee: the older the employee, the more knowledge about safety and the

more positive attitudes towards safety. In addition, as employees get older, they become more interested in safety at work.

In most psychological research, the diagnosis of employees' attitudes to safety is made by means of observation at the workplace, interviews with employees or methods for studying the organisational climate. The Questionnaire on Attitudes to Safety used in our own research is based on concepts related to safety culture. The research related to the development of the tool involved 1,300 people (770 women and 530 men) representing 24 organisations from the area of small, medium, and large enterprises in the manufacturing and services sector. In order to estimate the reliability of KPwB, the procedures for calculating the internal compliance factor using *alpha* Cronbach were applied. The value of the coefficient for the whole scale was 0.849. The cognitive aspect of Cronbach's *alpha* Cronbach was 0.730, and the aspect was 0.750. The scale measuring the behavioural aspect has slightly weaker properties, however, the *alpha* Cronbach coefficient of 0.690 allows to consider its reliability as satisfactory. The data from the study also fulfilled the assumptions of the factor analysis.

In order to estimate the theoretical accuracy of this questionnaire, the Safety Climate Questionnaire, the Organisational Climate Questionnaire, the Risk Perception and Risk Taking Questionnaire, and the Human at Work Scale were used. The research of M. Znajmiecka - Sikora proved the connection between the safety climate and the cognitive and behavioural component and the general attitude towards safety. The organisational climate was related to the cognitive component of the attitude. The direction of the correlation was positive, which means that the high safety culture of the organisation and the supporting organisational climate are accompanied by pro-safety attitudes to safety.

The attitude to safety is also linked to the tendency to perceive and take both instrumental and stimulus risks. The direction of this relationship is negative, which means that the increase in attitudes towards safety and all three components of it is accompanied by a lower propensity to take risks. Conversely, the higher the propensity to take both stimulative and instrumental risks, the more negative the attitude towards safety.

It is worth mentioning that the sense of where control is located, i.e. the conviction that the effects of one's own work relate to internal or external factors, is linked to an attitude towards security. The direction of these correlations is negative, which means that the higher the external sense of where control is located, the lower the results in terms of attitudes towards security. Conversely, the more internal the sense of control, the more pro-security attitudes to security. The results of the statistical analyses allow the conclusion to be drawn that KPwB is a tool with sufficiently satisfactory psychometric properties, recommended for use for research and diagnostic purposes.

2.8. Workplace perception − a subjective perception of organisation

In the work psychology, the current called "human relations movement", whose main authors were E, contributed to the development of the organisational climate problem. Mayo, D. McGregor, and R. Likert (Stoner, Wankel, 1994). Classical management theories turned out to be ineffective in the organisational environment, as employees did not always behave according to expectations or predicted patterns of behaviour. There was a growing interest in the human factor in organisations, which contributed to the emergence of the "Human Relations" trend, which was primarily interested in informal relations between people and intangible stimuli influencing the psychological climate in the work environment.

The Kurt Lewin Field Theory, whose author stresses the importance of the subjective environment of an individual in determining his or her behaviour, is also connected with the development of the issue of organisational climate research (after Rosenstiel, Boegel, 1992, Hall, Lindzey, 1994). In Kurt Lewin's concept, man is presented as a closed figure, separated from the outside world by very clear boundaries. The inner (personal) area of the human being is completely surrounded by a perceptual and motoric area, responsible for information and stimuli reaching the inner area. Man and his environment are dependent on each other as they constantly influence each other. Kurt Lewin called the human living space *"the entire psychological field"* (Hall, Lindzey, 1994). Human behaviour is therefore seen as a function of his living space. Therefore, in order to interpret an individual's behaviour, it would be necessary to be aware of matters concerning the immediate human environment. The perception of human behaviour as a function of two basic factors: its personality and the psychological "field" implies valuable insights for work and organisational psychologists. The individual brings his or her views and opinions to the organisation which, together with his or her organisational role and structure, influence how he or she perceives his or her work and how efficiently he or she performs it. Thus, the efficiency of an employee is determined not only by the objective organisational situation, but also by the subjective feeling of the general atmosphere of the place where he works (Augustynowicz, Witkowski, 1997).

In scientific concepts, the organisational climate is often identified with organisational culture. For example, one of the first subject theories (D. Katza, R. Kahn, and Ch. Argyris) defined the climate as a formal but internalised system of norms and values typical of an organisation. Organisations have some common patterns of feelings and beliefs that constitute the organisational climate (Augustynowicz, Witkowski, ibid.).

The concept of L.R. James and A.P. Jones defines the organisational climate as a narrower concept than the organisational culture, which consists of properties, stimuli, and other major organisational influences. The climate is made up of workplace characteristics and processes within a working group. The psychological climate is a process based on the perception and interpretation of the immediate organisational environment (after Borucki, 1985).

R. Harrison, in turn, identified the organisational climate with the "ideology of the organisation", which presents a system of ideas controlling the nature of the organisation (after Armstrong, 2007). It is in this ideology that the expectations towards the members of the organisation, management techniques, and the way of treating co-workers are included.

D.A. Kolb defined three main types of organisational climate (after: Lipińska-Grobelny, 2007). According to the author, the supporting climate in the organisation is characterised by high, understandable but also clearly defined professional requirements for employees. Employees are personally responsible for their tasks. Teamwork is promoted in such an organisation. The leader seems to be a competent and friendly person with a friendly attitude towards his subordinates. Communication is a two-way street. The opposite of this characteristic is the description of an organisation with an autocratic climate. Employees receive unclear and unspecified tasks and are not personally involved. They are punished rather than rewarded for success. The supervisor does not enjoy acceptance or respect. Unilateral communication prevails. According to the author, the indirect type of climate oscillates between the supportive and autocratic types. Functioning in an autocratic organisation certainly brings more negative experiences and can lead to rapid professional disappointment.

In the literature on the subject, the organisational climate was also identified with 'organisational prestige', i.e. the image of an organisation among the society it contacts (Ch. Perrot, after: Augustynowicz, Witkowski, 1997). This approach refers not only to internal - organisational experiences, but also takes the perspective of people who are not participants in the organisation.

On the basis of literature analysis, Paluchowski (1998) distinguished three groups of phenomena concerning organisational climate:

- *organisational and social phenomena* that create *an organisational climate* defined as an image of clarity of objectives, structures, and procedures in the organisation, but also an image of the delimitation of responsibilities, power sharing, and powers. It is also a system of evaluation and perception of its adequacy, ways of motivating, relation between remuneration and work, personnel policy, and management style of the organisation.

- *phenomena concerning the process of communication within an organisation* which create *an informational climate* defined by the author as access to information needed at work, the existence of communication links, access to direct and senior superiors
- *individual attitudes towards organisations* that create *a psychological climate*, i.e. a picture of interpersonal relations at work, a picture of support and assistance, acceptance, rivalry and conflicts within the company, attitude to innovation and spontaneity, and openness. Paluchowski constructed his own questionnaire tool to measure the organisational climate. On the basis of factor analysis, he received seven factor scales, which form the method. These are: positive relations (direct superiors - subordinates), tolerating risks and conflicts, feeling of loneliness, good access to information, identification with the staff team, punitive competition, and general attitude towards the organisation.

Contemporary concepts of organisational climate, including R. Payne (2001, Payne et al., 1996) and V. González-Romá (1999, 2002, 2005, 2009), indicate that people working in different groups or teams can perceive the climate of the same organisation in a completely different, radical way. Researchers criticised the conceptualisation of climate as an image - a vision of the company shared by all employees. Thus, the perception of climate appears in this paradigm as a subjective variable.

Organisations are nowadays the dominant forms of functioning of social groups. Bańka (2007) characterised work organisation as a structure composed of four elements: technological system, social system (people with their attitudes, motivations, abilities and personality traits), structural system (these are all organisational positions and roles) and ecological system (external environment). Etzioni (1964, after: Sułkowski, 2004) described organisations as characterised by the division of labour, power, and information flow, which is not accidental or traditional, but deliberately planned. This agreement is intended to achieve specific goals through the presence of power centres that control the concerted efforts of the organisations and direct them towards their goals. Organisations are also characterised by the substitutability of staff, which means that those who do not fulfill their tasks can be removed from the organisation and their roles assigned to others. Katz and Khan (1979) also distinguish important elements such as the previously discussed roles, norms, and values, and the emotional climate of the organisation. Bańka (2007) defines the organisational climate as the subjective perception of the organisation's characteristics or its subsystems from the point of view of the treatment of its members. The theoretical model of M. Leiter's work organisation areas.

Work overload is a workload that occurs when the expectations of the various members of the role reference system are legitimate and not logically contradictory, but the worker

finds that he is not able to meet all the tasks he is asked to do on time and at the appropriate quality level (Katz and Kahn, 1979). The workload is the main source of occupational stress, alongside the ambiguity of the role and the conflict within the role (Kahn and Byosiere, 1992; after: Ford, Heinen, Langkamer, 2007). In turn, a sense of control at work (autonomy) is the degree to which an employee can decide when, where and how he or she can carry out his or her tasks (Thompson and Prottas, 2005). Research shows that authority and diversity, and the resources they include, create positive effects in terms of motivation, energy, new skills or attitudes that can mobilise for enhanced functioning in other areas of life such as the family (Friedman and Greenhaus, 2000; after: Grzywacz & Butler, 2005; Clark, 2001). Perceived organisational support, in turn, is the general belief of the employee that the employer values his contribution and cares about his welfare (Rhoades and Eisenberger, 2002). Such support provides resources in the form of socio-emotional support, technology, and funds, which, as research has shown, correlates with improved performance at work (Witt and Carlson, 2006). Work support describes an interpersonal transaction that involves emotional concern and instrumental assistance from superiors and/or colleagues and consists of obtaining feedback on the level of performance at work or evaluation (after: Aryee, Srinivas and Tan, 2005). Social support is understood by the authors as one of the mechanisms for dealing with stress, as support mitigates and suppresses the pejorative consequences of stress (Cohen and Wills, 1985). Studies show that the informal (e.g. collegial) context of social support may be more important for work-family integration than official support programmes from organisations and institutions. The compatibility of the employee-organisation congruence system describes the relationship between the employee's values and the culture of the organisation in which the employee works. According to Chatman (1991), a desirable situation is one where compliance represents harmony, balance, and alignment between the organisation's value model (e.g. organisation culture) and the individual value model. When there is a value match, employees are more likely to have a more positive attitude to work. Cross-cutting research has shown that compliance is associated with important determinants such as job satisfaction, commitment to work, dedication to the organisation, reduced.

The questionnaire of Maschlach and Leiter's Working Life Areas, used in the own research presented in the monograph, covers issues such as: workload, perceived support from the organisation, support from other people at work, compatibility of the employee's and organisation's value system. The Work Life Areas Questionnaire is a tool constructed by Christina Maslach and Michael Leiter at the Centre for Organisational Research & Development at the University of Arcadia, Canada, who specialise in the study of the burnout phenomenon. The questionnaire is designed for subjective evaluation of the work

environment by employees. It allows for the assessment of the employee's functioning in the work environment and the incompatibility between the requirements of the organisation and the needs, aspirations, and capabilities of employees. The questionnaire consists of 29 statements grouped into six scales. The Workload Scale refers to an individual's sense of how much work he or she is overburdened with, whether he or she considers the situation to be one he or she is overwhelmed by excess work. The Behavioural Control Scale examines the possibility of making independent decisions, choices at a given job. The Awards Satisfaction Scale, on the other hand, assesses the level of satisfaction with the awards a person receives for their work: both material awards, promotion opportunities, and social ones, such as recognition and respect from colleagues, superiors, and customers. The Support Scale of the Co-workers is about assessing the quality of the social environment in the workplace (mutual support, cooperation, and showing positive feelings). The Sense of Justice Scale refers to an employee's feeling that they are being treated fairly or not and concerns aspects of work such as clear rules, the distribution of goods and opportunities for promotion. The scale of Values makes it possible to assess whether there is a conflict of values within the organisation itself or between the employee's values and those held by the organisation. The English language version of the tools is translated into Polish. Ten English-speaking teachers who have a good command of English were asked to complete the original questionnaire. After a three-week break, the same group was asked to fill in the questionnaire in a Polish version. The results were poorly correlated. The highest correlation for individual questions was 1, the weakest - 740. The questionnaires were rejected in this version. In the next stage of adaptation, Terelak and Izwantowska (2008) conducted an interview with persons participating in the test-retest study, asking them mainly about the reasons for extremely different answers in English and Polish versions. All the answers suggested a lack of knowledge of the psychological context of work in Polish conditions. The whole adaptation process was started once again by changing the group from teachers to 5th year students from work psychology. Pearson's *r* correlation coefficients between the answers in the English and Polish versions for particular items were calculated. All questions received a statistically significant correlation value up to 0.05. The Cronbach's coefficient α=0.83 was calculated as a measure of internal test compliance. The results of research using this version of the questionnaire, in the context of professional burnout, confirmed its theoretical value and methodological usefulness in relation to the phenomenon of professional burnout (Terelak, Izwantowska, 2008) and in relation to the interaction between work and family (Grzywacz, Butler, 2005; Terelak, Łozińska, 2007). More detailed data on the theoretical basis and usefulness of the

Work Life Areas Questionnaire are presented, among others, by P.M. Leiter (2006) and L. Rhoades and R. Eisenberger (2002).

2.9. Sense of bonding

In the area of Polish psychological thought, social bonding was defined taking into account a broad psycho and sociological context (Jacher, 1987, 2005).
Jacher (1987) defined them as an essential link between groups and individuals, a constitutional element which determines the cohesion of a group. Without a social bond there is no cohesion within a group. Social bond can be understood as the organisation of a group, and can have an awareness dimension. Group awareness, collective awareness, is above all a sense of communication and solidarity. This understanding of social bond refers to the classics of sociology, August Comte and E. Durkheim. Professor Jacher also pointed out the interdependence of ties and integration: The concept of integration is linked to the concept of social bond, while disintegration is linked to the phenomenon of falling out of social bond. Modern research identifies social bond as a sense of group identity and indicates that it is much more often expressed, for example, through personal relations between an employee and employer or civil communities.

When analysing the factors determining the bond factors in the work environment, it is important to point out in particular: the sense of teamwork - especially in the case of professions in Industry 4.0, which require cooperation in the face of various difficult situations, mutual teamwork - garrisoning, team membership, group constancy, teamwork and mutual sympathy - respect for mutual work and involvement, appreciation of the involvement of other group members. An act that binds the team together at work is also a willingness to cooperate - improvement in the effective work of the team, which must act as a single organism, and recognition of the importance of cooperation for the success of team goals. Mutual trust - awareness of the dependence of one's own safety on other members and a sense of security - based on the reliability of the group's collective actions - is also an important factor in strengthening the sense of bond at work. In addition, the acceptance of the leader/supervisor as a guardian caring for the safety of all group members has a strong integrating role. The sense of bond is a phenomenon widely described in the sociological and psychological literature.

For the purposes of the monograph's own research, a shortened scale of Skarżyńska's social ties was used to measure the quality of ties. The original version of the scale contains

6 items: 3 of them confirm good quality and/or a number of contacts with people, and 3 deny them. The person examined decides the degree of compliance with a given claim on the 5-point Likert scale: from 1 - "definitely yes" to 5 - "definitely no". The overall result of the scale (after reversing the scale of negative statements) is an average rating of all items in the range 1-5. The higher the rating, the higher the number and the better the quality of social relationships. The respondents were asked to determine the degree of satisfaction with the bonds in relation to the people they work with. The reliability index obtained by the author of the tool was $\alpha = 0.68$, and the reliability index in the research of the authors of this article was $\alpha = 0.75$.

2.10. Fitting to organisation

Research over the past 50 years on the adaptation of people to their working environment has provided ample evidence that occupational stress results from a mismatch between the characteristics of the worker and the environment in which they work. Among the many levels of adaptation, adaptation to the organisation understood as the similarity or compatibility of the characteristics of employees and the organisation (a social group that operates according to certain rules and principles in order to achieve a specific goal) is particularly important. Muchinsky and Monahan (1987) introduced the terms "supplementary matching" and "complementary matching" in relation to the human-organisational relationship. A supplementary fit is a similarity in terms of the objectives, values and standards of an employee and an organisation - an "apple-and-angler" fit (Czarnota-Bojarska, 2010). Complementary matching, on the other hand, means the complementation of missing and needed elements in the characteristics of the employee and the organisation; it is the tuning of the organisation's requirements towards the employee to his or her ability to meet those requirements and the expectations of the individual towards the organisation and the ability to meet them (Merecz and Andysz, 2011) - plug and socket matching (Czarnota-Bojarska, 2010).

Satisfying the employee's needs and the conformity of the values he or she values with those recognised by the organisation leads to his or her identification with the organisation. For this reason, some researchers consider the degree to which an employee identifies with his or her organisation as a third indicator of alignment with the organisation. It is understood as a bond based on the beliefs and emotions that employees feel about their organisation, or as a process in which the objectives of employees and the organisation

converge. Fitting to the organisation is a continuous process, which starts already at the stage of the recruitment and is built through mutual interaction during the employee's employment.

The degree to which a person fits into an organisation depends on both the characteristics of the employee and the organisation. Among the individual characteristics of an employee that favour a good fit, apart from competence, are: openness to new experiences, conscientiousness, type of professional personality, intelligence, valued values, self-efficacy and control (Merecz, 2010). The characteristics of an organisation on which matching depends are: a culture based on strong values, the use of different ways of socialising new members, clear formulation of roles, requirements and responsibilities within the organisation (Cable, Parsons, 2001; Kima, Cable, Kim, 2018)

The matching to the organisation has a significant impact on the level of job satisfaction felt by employees (Westermn, Cyr, 2004). High satisfaction of employees, in turn, favours involvement in work, and thus influences its quality. On the other hand, a large discrepancy between mutual expectations and resources, inappropriate division of power and responsibilities, bad interpersonal relations, and policies inconsistent with employees' expectations lead to a loss of trust in the company and constitute a source of stress for employees (Ulutas, Kalkan, Bozkurt, 2008). The degree of adaptation to the organisation negatively correlates with the perceived stress (26), as well as health and work ability (Bocchino and Hartman, Foley, 2007, Marcz and Andysz, 2012).

Studies by J. Czarnota-Bojarska (2012) show that organisational identity mediates the relationship between complementary fitting and productivity of employees, but does not change the relationship between supplementary fitting and productivity. These results are in line with the predictions resulting from the theory of social categorisation (Turner, 1987) and the concept of human-organisation matching (Kristof, 1996). Supplementary fitting, as the basis for category formation and organisational identity, independently influences the beneficial functioning of employees. As a consequence of the categorisation process, depersonalisation appears and group goals begin to be treated as personal. Thus, organisational identity becomes more important for productivity than the satisfaction of the employee's needs by the organisation, i.e. the feeling of complementary matching. Complementary matching increases productivity mainly through organisational identity.

Psychologists' recommendations are about paying more attention in organisations to the strength and unambiguity of the group identity than to the satisfaction of the individual, personal expectations of individual employees. Considering complementary matching - relating to the mutual satisfaction of the needs of the employee and the organisation - as

more of a consequence of the sense of organisational identity than its source, it would be necessary to build the sense of identity of employees through group influences.

Questionnaire for the study of subjective human fitting - P-O organisation (Czarnota-Bojarska, 2006) examines complementary fitting (i.e. the complementarity of missing and needed elements in the characteristics of the employee and organisation) (16 questions) and supplements (i.e. similarity in terms of objectives, values, and standards of the employee and organisation) (18 questions). The respondents answer on a 6-point scale from 'I strongly disagree' to 'I strongly agree'. The reliability of the Cronbach's *alpha* Cronbach Complementary Match Scale is 0.945, while the Supplementary Match Scale is 0.969. The questionnaire showed satisfactory psychometric parameters.

2.11. Sense of dignity

The issue of 'human dignity' became the subject of researchers in the humanities and social sciences after the Second World War. Researchers often refer to the Declaration of Human Rights and especially to the fundamental rights belonging to the human individual - such as freedom, equality, and a sense of dignity (Articles 1 and 2). Z. Płużek and S. Steuden proposed a concept of self-esteem (Steuden,2006, 2011, 2016) which defines self-esteem as a multidimensional construct, consisting of components such as: self-respect based on the hierarchy of values that is held and recognised and progressive in accordance with it, confidence in oneself and one's abilities that enables one to undertake difficult and responsible life tasks, and full acceptance of oneself assuming awareness of one's strengths and weaknesses. Such an operationalised construction means that it is possible to influence many different subjects and social variables on an individual's sense of dignity (Kofta, 2006). In addition, the level of sense of dignity will change with the course of human life, depending on the specific stage of development.

According to Steuden, a sense of dignity builds on two key elements: the subjective conviction of the individual that he or she is someone of value, and the subjective conviction that other people treat the individual as a person of value and deserving of respect. The sense of dignity perceived in this way is very personal and constitutes an important element of spiritual and existential growth. For this reason, it can be strongly determined by the individual's self-esteem, but also by the assessment of the quality of relations with other people (Brudek, Steuden, 2017).

The basis for the development of the research tool was data and premises from the psychological practice conducted by the authors and the analysis of psychological literature. In 2006, the first version of the tool - KPWG - 1 was developed, consisting of 16 open questions, the aim of which was to reach the hidden theories of self-dignity, namely to capture how people evaluate people who, in their opinion, have a high level of dignity. Subsequent versions of the tool were based on a quantitative survey among different age groups of respondents.

In the own research, the Questionnaire of Feeling Dignity (KPWG-3) by Paweł Brudek, Stanisława Steudenka, and S. Steuden (2017) was used. The tool contains 36 statements from the four dimensions: Cognitive, Loss, Relevance, and Meaning. The task of the researched person is to evaluate (on a five-stage scale: 1 - "Yes"; 5 - "No") individual statements in terms of (degree of) their veracity in relation to themselves and their own life experiences.

The method has satisfactory psychometric properties. The reliability of KPWG-3 (α-Cronbach) for individual scales ranges from 0.87 to 0.91. The tool's factorial accuracy has been verified using Confirmation Factor Analysis (CFA). The matching indicators were at a satisfactory level, enabling the model to be accepted as well-matched to data (CMIN/df=2.285; RMSEA=0.056; PCLOSE=0.191; GFI=0.950; CFI=0.977; TLI=0.970) and thus confirming the four-factor (four-dimensional) structure of self-esteem.

2.12. Perception of social world

The subject of interest in social psychology is a very wide range of issues related to the social functioning of man and the mechanisms of his functioning and perception of the surrounding world. For the purposes of this monograph, the authors deal in their own research only with the issue of formulating opinions and judgments about the social world on the basis of so-called faith - that is, the belief in the game of zero-sum.

Believing in a zero-sum game is a social belief in the hidden assumption that the profit or success of one person is possible only at the cost of the loss or failure of another person (Różycka, Wojciszke, 2010). The theory of believing that life is like a zero-sum game derives from classical social exchange theories (Homans, 1955), conflict theory (Olson, 1965; Hardin, 1968), theory of differences in social orientation (Grzelak, 1978), social interdependence and game theory (Kelley, Thibault, 1978), interdependence of interests in a conflict situation (Ruble, Thomas, 1976), and experimental economics (Smith, 2000).

People convinced that life is like a zero-sum game believe that they can only gain at the expense of another person, that economic success is only possible by losing someone else, that people's interests are inherently antagonistic. This is based on the belief that the world's goods are limited and that it is impossible to meet the needs of most people.

Those who see the world as a zero-sum game are motivated to act by antagonistic goals, and other people are seen by them as selfishly directed individuals (rivals for potential limited goods), satisfying their own interests and therefore should not be trusted. This type of hidden assumption makes it impossible to see common (synergistic) interests and thus effectively prevents cooperation.

Furthermore, the belief in a zero-sum game is characterised by people who feel less satisfied with life and -see the socio-political system -as unsatisfactory and unjust. In the case of everyday functioning, such people are oriented towards protecting their own interests (from threatening rivals for resources) and refrain from entering into social exchange relationships. They are accompanied by a strong fear of the selfish intentions of others, and they behave selfishly in social interactions (e.g. in situations of social dilemmas where a decision has to be made to act for the common or own good).

Because of their fear of exploitation by others, they oppose any social changes, both at the micro (interpersonal) and macro (social) level, which, as the authors write, makes them supporters of political conservatism (after: Wojciszke, Baryła, Różycka, 2009).

What is worth emphasising is the empirical evidence that such a belief system can characterise an individual, but can also constitute a specific way of social perception in selected social, professional, and cultural groups.

The Zero-Sum Game Faith Scale (Wojciszke, Baryła, Różycka, 2009) was constructed to measure these septictive human beliefs. It consists of twelve opinions, such as: "In life, it is already the case that when someone gains something, someone else loses it. Life is like playing tennis - for one to win, the other to lose...'. The scale has satisfactory psychometric parameters - a moderately high internal consistency (ranging from 0.70 to 0.87 for various Polish trials and from 0.67 to 0.84 for various international trials) and quite high time stability (r=0.74) , and it is characterised by a very good structure reproducibility (structural equivalence) in the vast majority in 37 studied student trials from different cultures.

The Zero-Sum Game Faith Scale, together with the Interpersonal Trust Scale, the Balance Scale, the Zero-Sum Game Faith Scale, the Social Exchange Scale, and the Self-Evaluation Scale form the Social World Opinion Questionnaire. All items of the questionnaire are answered on a 7-point Likert scale, where the next points are marked: 1 - I strongly disagree, 2 - I disagree, 3 - I rather disagree, 4 - it is difficult to say, 5 - I rather agree, 6 - I agree, 7 - I definitely agree.

The Interpersonal Trust Scale consists of 7 items: 4 items are by Eisenberger, e.g. "Most people are good for others", "Most people are basically good and kind" and 3 items by Wojciszke (e.g. "Most people can selflessly help others in need", "Most people can be trusted"). In this version, the scale has a one-factor structure, where a high score indicates a high level of trust.

The scale of the Social Exchange Balance sheet by Wojciszke consists of 11 items. The scale measures the general feeling of satisfaction with the social exchange and the balance of profits and losses experienced subjectively by the respondents in relations with others, with the higher the result the greater satisfaction in the exchange relation (positive balance). Examples of items are "I am good at dealing with most people", "In total, I give more to people than I get from them". The Self-assessment Scale is a classic Rosenberg scale, consisting of 10 items (sample items: "I have a lot of good qualities", "I'm actually inclined to think that I'm doing poorly in my life", "I can do as well as most other people"). In all Polish studies, the Self-assessment, Social Exchange Balance, and Interpersonal Trust scales achieved high reliability.

The Zero-Sum Game Faith Scale, which is part of the Social World Opinion Questionnaire, has been repeatedly used in many studies by various authors, on various Polish and international samples. It obtains satisfactory statistical parameters and creates very interesting relationships with many variables. The studies carried out to date show that belief in the zero-sum game is accompanied by low self-esteem, a sense of loss in the process of social exchange, and a lack of trust in others, which significantly reduces the willingness to cooperate. People with a high level of belief in the zero-sum game show an external sense of control (and thus hold others responsible for their own failures) and are pessimistic about the world and people. The analysis of the data shows that belief in the zero-sum game is accompanied by a number of negative social and economic consequences and, conversely, that a bad social and economic situation fosters this belief.

According to Wojciszke and others. (2010) there are specific situational conditions that favour the development of a high level of belief in the zero-sum game as an externally conditioned attitude: these are mostly more collectivist cultures with a relatively high level of cynicism (as a result of the political past), as well as a rather low level of economic development and a low level of democracy in the country. In such situational and environmental contexts, members of a society are characterised by a lack of trust and willingness to cooperate.

2.13. Psychological stress and coping strategies

The term stress is commonly used to refer to external circumstances, requirements, burdens or difficult situations, or to describe unpleasant emotional experiences, tension, and discomfort (Heszen, Sęk, 2010). These two ways of understanding stress are reflected in theoretical proposals and research on the subject.

Approach I. Janis's approach is described in the literature on the subject as stimulating because it refers to external circumstances (after: Terelak, 2008). Psychological stress is defined by the author as a change in the environment, which causes a high degree of emotional tension and disturbs the typical reaction of an individual. External circumstances are called stressors. The notion of Janis is criticised primarily because of the ambiguity of concepts and the omission of individual differences related to factors that cause stress.

The reactive approach to stress, in turn, refers to specific human reactions and derives from a biological and medical paradigm. The representative of such a way of dealing with stress is H. Selye, who defined it as: *"an unspecific reaction of the body to all the demands placed on it"*. (for: Terelak, 2008, p. 29). The author has introduced additional terms "stress" or "bad stress" to denote stress that causes overload or deprivation and leads to illness. The merit of the researcher was to draw attention to the anatomical and physiological mechanisms of stress, which can be characterised by referring not only to the action of the hormonal system but also the neural system.

Modern concepts of psychological stress do not locate the sources of stress solely in the individual or his environment, but rather indicate a specific type of relationship (interaction, transaction) between the individual and his environment. The cognitive and transactional paradigm of Lazarus' stress and coping focuses precisely on human activity in a specific situational context. A transaction between a person and his environment is a certain whole, constituting, according to the author, a new quality, which is, in fact, constantly changing. It is also subject to cognitive evaluation of the subject and has a dynamic character (primary evaluation). The individual assesses those elements of the relationship with the environment that are important to him/her from the perspective of his/her own well-being. Lazarus and Folkman (1984) define stress as the relationship between a person and his/her environment, which is assessed by an individual as encumbering or exceeding resources and threatening his/her well-being. A stress transaction in the primary assessment can be considered as: harm/loss, threat or challenge. On each of these levels, characteristic emotions appear. The perception of harm - loss causes anger, regret, sadness. The threat is connected with feeling fear, fear, worry. The

challenge is accompanied by positive emotions as well as: hope, excitement, cheerfulness, and negative effects, similar to those characteristics of the threat. Secondary evaluation is another cognitive process that occurs when an individual considers a relationship to be stressful. This stage of assessment involves interpreting sources of stress and estimating own resources. If an individual assesses their own resources as sufficient to deal with stressors, there may be a change in the primary assessment from "threat" to "challenge. The secondary assessment is therefore the stage of analysis that can initiate activity aimed at changing the stress transaction. Folkman and Lazarus describe coping with stress as the changing cognitive and behavioural efforts of an individual to master specific, external, and internal requirements. These requirements are burdensome for the individual and exceed the resources available. The first coping strategy is problem orientation (instrumental, task-oriented). It consists in improving the relationship between the requirements of the environment and the capabilities of the person. The second strategy involves the self-regulation of emotions and consists in reducing unpleasant tension and relieving negative emotions. S. Hobfoll (2006) accused the concept of Lazarus and Folkman of excessive complexity and impossibility of falsification. His criticism resulted in the development of a concept that was presented by the author of the dissertation in chapter I, 1.2.6. Hobfoll's concept of burning out as a loss of resources.

There are many different theoretical approaches in the literature on the subject, which are not presented in this subsection. However, it is worth mentioning the medical concept of stress of B.S. and B.P. Dohrenwendów (1974) concerning stressful life events as predictors of the so-called diseases of civilisation, G. Caplan's approach to life crises (after: Terelak, 2008) or the concept of salutogenetic stress A. Antonovsky (1995) based on the assumption of a dichotomous division into health and illness. The formulation of the first psychological concepts of stress was also connected with the concept of frustration S. Rozenzweig (1939), which brought many elements to explain the mechanisms of human reaction in situations of "lack and thwart". The theoretical proposal of "stress - tension" put forward by M.J. Apter (1982), in turn, saw the sources of stress as a discrepancy between the preferred and current level of individual motivation. The Lazarus concept was revised by S. Folkman and Moskowitz (2000), focusing on positive and negative emotions appearing in stressful situations. The main sources of emotions were considered to be positive re-evaluation, coping focused on the problem, creating positive events, and saturating ordinary events with a positive effect. In the proposed model, emotions act as a motive for remedial behaviour and as a marker of their goal. The modified concept contains primarily clinical implications and is used in cognitive-behavioural therapies.

It is also worth mentioning the psychological stress in the work of Polish psychologists. The precursors of research in this field were T. Tomaszewski (1965) and J. Reykowski (1966). Tomaszewski drew attention to the relationship between the individual and his environment. Based on the theory of actions and situations he formulated, he defined stress as experiencing difficult situations, i.e. situations in which there are discrepancies between the needs or tasks of an individual and the possibilities of satisfying them. The author focused primarily on situations of deprivation, overload, danger, and obstruction as the main difficult situations. Reykowski defined stress as *"an objective relationship between external factors and human characteristics, so that determining whether or not stress occurred does not require an examination of human response to a given factor"* (Reykowski, 1966, p. 208). According to the author, stress means situations that constitute a threat and disturbance of human activity, leading to deprivation of needs. J. Strelau (1996) formulated an interactive concept of stress, defining it as a result of interaction between the demands placed on an individual and his actual and perceived possibilities. In turn, Terelak (2001, 2008, 2011) in his chronohabilistic concept of stress referred to the relationship between stress resistance and physical and mental performance. He referred to the anthropological paradigm, biology, philosophy, and comparative psychology. A. Biela (1990) proposed an economic approach to stress, referring to the situation of political transformation in Poland and Central and Eastern Europe. According to the author, stressful situations create conditions of shortages, in which it is not possible to secure the material existence of a family. The causes of economic stress are seen by the author in ownership transformations, restructuring activities and all activities connected with taking risks.

The pioneering research of R. Kahn and his colleagues (1964) pointed out the significant role of professional stress in weakening organisational effectiveness. Stress at work is associated with both negative attitudes and behaviours of employees, but it also brings economic costs. Terelak (2008, 2011) draws attention to the sources of organisational stress, which include the participation of an individual in a task force and its consequences, i.e. resignation from one's individuality for the benefit of the community. Among the stressful attributes of task groups present in organisations, the author has included their formal structure (hierarchy of importance of members) and informal (relationships resulting from the criterion of liking or interest), group tasks, its goals, group norms, management style, group dynamics (changes in group behaviours), interpersonal communication ("information noise", group thinking syndrome).

The general assumptions of the concept of psychological stress (Kahn, 1964; Behr, Newman, 1978; House, Jackman, 1979; Schuler, 1985) indicate that the organisational stress model should include five groups of variables. These are, above all, objective

distortions of the process of transferring the requirements of the professional role, processes of cognitive assessment of the organisational situation and of oneself, and the result of this assessment (perceived organisational stress). Further variables concern the direct reactions of the employee to perceived stress (these are emotional and behavioural reactions) and the distant consequences of stress (treated individually and organisationally). Variables modifying relationships between the categories listed should also be considered.

The postponed effects of organisational stress may lead to the breakdown of individual immunity and lead to the stage of exhaustion (Chodkiewicz, 2005). Based on Sely's GAS model, Bamber (2006) isolated chronic fatigue syndrome including the following stages: mobilisation of the body (relaxation, stimulants, pharmacological agents to improve well-being), adaptation (e.g. workaholism) and finally exhaustion (burnout, diseases). The experience of chronic organisational stress is treated as an "ignition" in the burnout problem, triggering further symptoms: exhaustion (which is the body's response to stress), cynicism and gradually decreasing self-efficacy (Maslach, Leiter, 2008, 2010, 2011).

In the presented own research, the Stress Feeling Questionnaire (KPS) of M. Plopa and R. Makarowski was used to measure the stress intensity among workers in Industry 4.0. The questionnaire is used to measure the structure of stress sensations. It contains 27 statements which the respondent refers to by selecting answers on a 5-point scale (1 - true; 2 - rather true; 3 - difficult to say; 4 - rather untrue; 5 - not true). The test provides an overall result that indicates a generalised level of stress and three results expressed in different dimensions: emotional tension, intrapsychic stress, and external stress. The higher the score on a given scale, the higher the level of stress experienced.

The scale Emotional tension describes experiencing feelings of anxiety, difficulty in relaxing, excessive nervousness. The feeling is accompanied by a lack of strength and energy to act, giving up taking action. It is often accompanied by fatigue without cause and irritability in relationships.

The result on the External Stress Scale indicates the experience of frustration, fatigue, resulting from the belief that the tasks set by the outside world (other people, society) exceed their capabilities, skills, and abilities. This can be accompanied by a sense of being exploited and treated unfairly in many social contexts (e.g. work, home, close relationships).

The dimension of intrapsychic stress describes the outcome of an individual's confrontation with himself or herself. It describes fears, worries, feelings of loss of meaning in life resulting from difficulties in overcoming everyday challenges, achieving goals, tasks and plans. Difficulties in the realisation of tasks result from the feeling of judging oneself as mentally weak, not having enough resources to cope, not being capable. The reliability

of the questionnaire is satisfactory - internal compliance coefficients for the three scales (dimensions) range from 0.70 to 0.81.

Psychological research indicates that people use different strategies to deal with stress (coping). Some are active, others prefer escape behaviour and still others focus on emotions and their discharge. The literature points to four groups of factors influencing stress management: - the psychophysical state of an individual, - gender, age, level of education, - personal circumstances - features of a stressful situation (Wrześniewski, 1996). The notion of "coping with stress" in a transactional approach is understood as "the cognitive and behavioural efforts of the subject to meet the physical external and/or internal requirements, assessed as exhausting or exceeding the resources of the individual (after: Heszen-Nejodek, 2000, p. 476). Researchers of stress and how to deal with it give many classifications of how to deal with stress. Due to the adopted research paradigm, the research methodology includes Ch. Carver and colleagues, referring to the R. S. Lazarus' theory, proposed several strategies for dealing with stress. They reflect both disposable and situational coping. They include: Active Self-Governance, Planning, Seeking Instrumental Support, Seeking Emotional Support, Avoiding Competitive Action, Turning to Religion, Positive Value and Development, Refraining from Action, Acceptance, Focusing on Emotions and their Discharge, Denial, Distraction, Discontinuation of Action, Taking Alcohol or Other Psychoactive Measures, Sense of Humour (Juczyński and Ogińska-Bulik, 2009).

The Multidimensional Stress Management Inventory (COPE) was developed by Ch. S. Carever, M.F. Scheier and J.K. Weintraub. The COPE questionnaire consists of 60 statements that form part of 15 strategies, 4 statements for each. The person examined for each of these statements represents a 4-point response (1 - I almost never do; 2 - I rarely do; 3 - I often do; 4 - I almost always do). The Cronbach's alpha-factors for the individual scales range from 0.48 to 0.94 and are the weakest for the 'Distraction' and 'Active coping' strategies and the highest for the 'Turn to religion' strategies. (Juczyński, Ogińska-Bulik, 2009). Factor analysis allowed to distinguish three factors: active coping, evasive behaviour and seeking support, and focusing on emotions that explain 77% of the variance (Juczyński and Ogińska-Bulik, 2009). The "Active coping" scale is made up of five strategies: planning, positive re-evaluation and development, active coping, avoiding competing activities, and refraining from acting. The "Evasive behaviour" scale consists of six strategies: denial, cessation, sense of humour, distraction, use of alcohol or other psychoactive substances, and acceptance. The "Seeking support and focusing on emotions" scale consists of four strategies: searching for emotional social support, focusing on emotions and their discharge, searching for instrumental social support, and turning to religion.

Mini - COPE an adaptation of N. Ogińska-Bulik and Z. Juczyński, is an abbreviated tool of the COPE questionnaire for the examination of adults, healthy and sick people. It is composed of 28 statements included in 14 strategies (2 statements in each strategy). The method is most often used to measure available coping, i.e. to assess typical ways of responding and feeling in situations of severe stress. The internal consistency of the Polish version of Mini-COPE was established on the basis of a survey of 200 people aged 25-60. Half reliability was 0.86 (Guttman index 0.87). The stability is satisfactory for most scales. The factorial charges of individual claims can be considered satisfactory in most cases. Diagnostic accuracy was assessed by correlating Mini-COPE results with the Mini-MAC scale, designed to test cancer management strategies, and predicting the severity of post-traumatic stress symptoms in the group of mothers of children treated for leukemia.

2.14. Feeling of threat

The perception of danger is defined by psychologists as experiencing or feeling a fear of the effects of potential or real danger. Collision with specific work situations generates a specific cognitive-imaginary picture, covering the entire experience in the workplace. It may include a variety of elements, but will primarily be associated with internal discomfort and fear of potentially dangerous situations in the workplace (e.g. explosion, fire, airborne explosion), as well as fears of real and current dangers in daily, routine work. In addition, the construction is defined as: "sense of danger" consists of potential actions resulting from avoiding a hazard (at the behavioural and cognitive level - e.g. continuous vigilance and attention to dangerous elements of the work environment). According to the authors of the study, such a sense of threat may be significantly related to the generation of additional levels of stress, according to the relation that the more often an employee experiences a sense of threat at work (life, health, interpersonal relations), the more he/she experiences professional stress.

The threat is related to the deterioration of the current human situation (Ratajczak, 2001). It can be treated as a temporary or permanent condition. The threat can be considered as: internal, e.g. illness; external, e.g. aggression; mixed, e.g. deprivation of the patient of the possibility of treatment. Due to the size and severity of the effects of the threat, we can talk about crises (moments of solstice, significant breakthroughs or states of collapse), catastrophes (momentous events with dramatic effects), cataclysms and major disasters (floods, tsunamis, droughts, earthquakes, ethnic struggles, destroying social upheaval), and

disasters (e.g. famine, harvest, unemployment; Badura-Madej, 1996). Some emergency situations are hereditary, such as the permanent marginalisation of social groups (Hobfoll, Canetti-Nisim, and Johnson 2006). Ratajczak (2004) distinguished six most general types of threats: economic, technological, health, social, ecological, and psychological (related to threats affecting the plane of human identity).

Slovic, Fischhoff, and Liechtenstein (1985) distinguish three basic factors influencing the perception of danger. These include the level of knowledge about the threat, the level of anxiety caused by the threat, and the awareness of the number of people affected by the threat.

Ratajczak (2004) indicates that events considered by humans to be dangerous usually have a high level of stimulation. Such a situation provokes individuals to take remedial actions, which may be active or passive. Active strategies are based on undertaking a specific fight against the threat, they induce to defend and protect the resources at the disposal of the individual and force to evacuation behaviour, i.e. escape from the threat (due to risk and stress).

It is worth stressing that contemporary threats related to the working environment are changing rapidly. The list of potential "stressors" that cause the experience of threatening the life and health of employees is deepening and broadening.

What is important from the perspective of the subject matter of the monograph, Mamcarz (2012) indicates that technological development may also be a source of danger. The growing number of cars with increasing engine power, artificial intelligence, the development of chemical and nuclear weapons, connecting all machines to information systems, etc., are, on the one hand, facilitating the improvement of the quality of life, and on the other hand, they contribute to reducing the importance of the subject towards the essence of the object. The machine-human relationship can never replace the human relationship in the process of developing a healthy personality. Therefore, according to researchers, it is difficult to identify those technologies that actually directly destroy human health, as it is only the current generations that are the test subjects for companies producing 'innovative' objects (Cervera, 1999; Bulska, 2008).

Another specific group of risks that are growing more and more acutely occurs in the workplace. The appearance of improper two-way relations between the superior and the subordinate, mobbing, aggression, pathology of systemic solutions of the organisation, including its relations with the environment, all lead to "poisoning" of the work environment and contribute to the formation of various psychosomatic disorders. Entering a new period of civilisational development, questions arise about the meaning of cultural changes, the consequences of these changes, and their impact on people. All these variables

have been recognised in the monograph as important in the case of the working environment, which is Industry 4.0.

According to Mamcarz (2012), in an emergency situation, a person creates a picture of the situation and its consequences, even though they do not really exist. Therefore, a distinction is made between two types of feeling of threat, where the content of the mental image is based on other stimuli: the so-called current - there is a threat signal in the environment (available to the senses) and the potential - there is no threat signal in the environment. The inspiration for this division was provided by the author of the tool - relations of people working in a dangerous environment. "...A firefighter entering a burning building was afraid that a gas cylinder would explode and die. However, he based his fears only on mental images, because neither the cooker nor the gas cylinder was in the perception field. Nor did he see any other manifestations that the gas that was being extracted could explode. This fear of a particular danger arose only in the mind, but has entailed other psychophysiological processes. However, it is more often the case that an employee finds himself in an environment with many dangerous factors. On the basis of the perceived stimuli, thoughts are created about what can happen in a particular situation. The resulting ideas are characterised by a high level of detail and reality. The system of responding to the danger depends on individual predispositions and mechanisms for dealing with mental content. Of course, all these creations have a defensive function of existence and are most desirable...". (Mamcarz et al., 2012, p. 21).

A team of Polish researchers (Mamcarz, 2012) stated that the sense of threat is a phenomenon associated with various dimensions of human mental space. The sense of threat is connected with many cognitive mechanisms and shapes the functioning of a person in a situation of threat both imagined and real. However, there is a lack of connotation of the sense of threat with the deepest existential internal structures, which can be explained by the fact that the sense of threat is only a cognitive phenomenon, which due to its warning function does not involve the highest processes responsible for values, attitudes, morals, and beliefs. The sense of threat is most often explained by the co-occurrence of a sense of professional stress, internal tension, physical disorders and retrospective images of traumatic events.

In own research in the area of Industry 4.0, the sense of threat was assessed by means of the Feeling Threat Questionnaire in Mamcarz's work. The questionnaire measures the sense of threat understood as experiencing fear of the effects of current/potential dangers

in the workplace. It contains 54 statements. Respondents respond to them using the Likert scale, where 1 means 'never' and 5 means 'very often'. The scale is used to examine 3 dimensions of the hazard (the reliability indicators obtained by the author of the tool are given in brackets): internal discomfort related to the fear of potential hazards ($\alpha = 0.94$, fear of current hazards ($\alpha = 0.90$, avoidance efforts ($\alpha = 0.70$). The reliability index for the whole scale, which is the sum of these 3 dimensions, was $\alpha = 0.76$.

3. PRESENTATION OF OWN RESEARCH

Employees of the Industry 4.0 sector constitute an interesting and at the same time poorly understood occupational group in terms of perception of phenomena and psychological mechanisms. The effectiveness of their daily work is based on professionalism and cooperation, as well as effective coping with difficult and threatening situations. Special attention should also be paid to the specificity of their work, namely the progressive automation and robotisation of the organisational environment. In their daily work, the employees under examination have direct contact with both organic and inorganic teams, which may significantly affect their perception of relations and sense of bonding in the workplace. Due to the lack of empirical data that would show the psychological aspects of working in the area of Industry 4.0 in Poland, in the aviation, space and manufacturing sectors, own research has an exploratory character, which has been repeatedly stressed in this monograph. The extensive questionnaire research presented below was to verify the relationships between various psychological and organisational variables in the work environment related to the latest industrial technologies, including various types of robots. In connection with the subject of the research, they were carried out in three research groups in Poland, Slovakia, and Germany.

In relation to the purpose of the research, the following research questions have been formulated:

1. What are the differences in the personality traits of Polish, Slovakian, and German employees? of industrial plants?
2. What is the level of regulation of emotions and the sense of effectiveness of the respondents and are there differences (if any) between employees representing three different nationalities?
3. What is the level of matching Industry 4.0 workers to their jobs?
4. Do workers at Polish, Slovakian, and German airports differ in their attitude to safety at work?
5. How do the professional groups surveyed perceive the social environment?
6. What is the level of perceived dignity in the workplace among workers in Sector 4.0?

7. What is the level of perceived stress and feelings of insecurity among respondents and do respondents differ as to the variables studied?
8. How is the sense of bonding in the workplace expressed by the employees surveyed and does this variable differentiate the respondents?
9. Are there any, and what are the potential relationships between the perception of the organisation's relationship and climate and the sense of threat and stress of industrial workers?
10. Which of the variables under examination (components of the workplace climate and the quality of the bonds in the workplace) allow to predict the level of feeling of threat and stress in the examined occupational group?
11. Is the knowledge of the social world and moral judgments of the respondents in any way related to the level of their sense of threat?
12. What is the level of personal resources of the research: i.e. positive orientation, ego resiliency and D-type personality?
13. Is there, and what is the relationship between positive orientation, ego resiliency and depressive personality, and the level of perceived threat?
14. Is there, and what is the relationship between positive orientation, ego resiliency and depressive personality, and the level of stress experienced?
15. What are the relationships between the age of the respondents, their personal circumstances and workplace evaluation, and the level of self-efficacy?
16. Is there a correlation between positive orientation, the resiliency of an ego with a depressive personality, and the level of effectiveness of the employees surveyed?
17. What are the relationships between the age of the workers and the level of effectiveness felt?
18. What are the relationships between personal circumstances and the sense of bond and self-esteem?

3.1. Research group

472 people were examined, representing organisations belonging to Industry 4.0, including the automotive, aerospace, and manufacturing companies, whose distinguishing feature is a relatively high level of automation, understood as the application of new 4.0 technologies in the work process. The respondents were employees working on the

positions of 3D printer, employees working with cooperating robots - cobots, employees operating modern technologies.

The test sample came from 3 countries. **Group 1: from Polish** industrial plants (group 1 n = 248 respectively), **the second came from Slovak** (group 2; n = 78), and **the third from German** (n = 146) industrial plants.

The average age of the respondents was 30.16 years (SD = 12.15). Their total length of service was 18.75 years on average (SD = 12.08), and the length of service on a given position was 10.38 on average (SD = 9.68). Average ages and job tenure for each of the three countries are presented in Table 1.

Table 1

Age and length of service of respondents

	M	*Me*	*SD*
Age	30,16	24,00	12,15
General seniority	18,75	19,00	12,08
Seniority in the job	10,38	7,00	9,68

Annotations: *M* - mean, *Me* - median, *SD* - standard deviation

All respondents were informed of the objectives of the study and agreed to participate in the study. The study was of a questionnaire character. It was conducted in the workplace of the respondents in accordance with the Helsinki Convention on Human Rights. The majority of the group of respondents were men (over 90% of respondents). Due to the significant gender inequality of the respondents, no differences were tested in statistical analysis.

3.2. Presentation of research variables

The following research methods were used to measure selected psychological variables, presented in order of their description in the previous theoretic section. The order of presentation of the examined variables is random and does not determine their significance or rank in the presented own research:

- structure of personality: the IPIP BFM-20 test, Polish adaptation: E. Topolewska, E. Skimina, W. Strus, J. Cieciuch, T. Rowiński
- type of depressive personality: DS-14 questionnaire (measuring negative emotionality and social inhibition)
- positive orientation: the P. scale, adaptation: M. Łaguna, P. Oleś, D. Filipiuk
- ego resilience: the SPP-25, N. Ogińska-Bulik, Z. Juczyński
- sense of effectiveness: the GSES questionnaire, R. Schwarzer, M. Jerusalem, Z. Juczyński
- attitude towards safety at work: Attitudes towards Safety questionnaire KPwB, M. Znajmiecka-Sikora
- evaluation of working life areas: Professional Life Areas questionnaire by Izwantowska and Terelak
- sense of bonding at work: Scale of Ties at Work developed on the basis of Skarżyńska's scale of social ties
- fitting in with the job: the P-O, J. Czarnota-Bojarska
- sense of self-esteem: Sense of Self-Dignity questionnaire (KPWG), S. Steuden, P. Brudek
- knowledge and judgments about the social world: the Opinion on the Social World questionnaire, J. Różycka, B. Wojciszke
- sense of stress: Sense of Stress Questionnaire (KPS), Plop and Makarowski
- sense of danger: Sense of Threat at Work questionnaire (KPZ), by Mamcarz KPZ
- styles of dealing with stress: the Mini-COPE, Ch. Carver, Polish adaptation: Z. Juczyński, N. Ogińska-Bulik.

3.2.1. IPIP-BFM-20

The IPIP-BFM-20 is a shortened version of the IPIP-BFM-50, which is used to measure the Great Drink in the lexical Goldberg model. The IPIP-BFM-20 questionnaire is characterised by good accuracy (satisfactory CFA matching indicators and correlation coefficients with other methods to measure the Big Drink) and reliability (satisfactory alpha Cronbach indicators). The results of the analyses conducted so far prove that the Polish version of IPIP-BFM-20 (adaptation: E. Topolewska, E. Skimina, W. Strus, J. Cieciuch, T. Rowiński, 2014) is at least as good a tool for Big Five measurements as its English-speaking counterpart. The IPIP-BFM-20 questionnaire includes 20 items, 4 each on the scale. The respondent answers on a 5-point scale from 1 (completely misdescribes me) to 5

(completely aptly describes me). IPIP-BFM-20 measures five personality traits in the lexical tradition. The questionnaire includes the following items: 1, 16, 31, 46 (extraversion); 2, 17, 22, 37 (amicability); 8, 23, 28, 43 (conscientiousness); 9, 14, 19, 39 (emotional stability) and 5, 10, 30, 50 (intellect). Sample statements of the questionnaire: "I am the soul of the company", "I don't really care about other people", "I leave my things where they fall", "I usually get relaxed".

3.2.2. D-14 scale

The D-14 scale for measuring personality type D, whose authors are Ogińska-Bulik, Juczyński is a self-description tool. It contains 14 statements, 7 of which concern the tendency to experience various negative emotions (anxiety, anger, worry, irritation, depression) and 7 - the tendency to refrain from expressing these emotions, mainly in social situations. The subjects are asked to assess their personality on a 5-point scale from 0 (no) to 4 (yes). Stress personality - so-called Type D (26). It consists of two main dimensions treated as relatively constant personality traits (Denolett, 1996, 1998), namely negative affectivity and social inhibition. Negative emotionality is expressed by a tendency to experience strong negative emotions, such as: anxiety, anger, irritation, hostility. Social inhibition, in turn, is associated with a tendency to refrain from expressing negative emotions and behaviours consistent with those emotions. Refraining from revealing emotions is deliberate in nature and is undertaken mainly in social situations, primarily for fear of disapproval and rejection by other people. As far as the characteristics of people with a D-type personality are concerned, they are described as manifesting a tendency to worry and feel tension, blame themselves, and have a low tendency to share emotions. A D-type personality is associated with such symptoms of psychological stress as: a tendency to depression, difficulties in perceiving and enjoying social support, low self-esteem, low level of life satisfaction, and a sense of exhaustion. Such people are also more often ill and experience various types of somatic problems.

Examples of statements used in the method: "I often worry about details", "I often talk to strangers", "I often feel unhappy".

3.2.3. Positivity Scale

To measure the level of positive orientation the **Positivity Scale** by Caprara and colleagues was used. The scale consists of eight statements. The tool was adapted to Polish conditions by M. Łaguna, P. Oleś, and D. Filipiuk. The person examined is asked to indicate to what extent he or she agrees with each of the statements. Answers are given on a scale of five from 1 - I strongly disagree to 5 - I strongly agree; one statement is reversed (statement 4). The score is the sum of the points; the higher the score, the higher the level of positive orientation, the range of raw results is from 8 to 40. The psychometric development of the tool proves its satisfactory accuracy and reliability.

According to G.V. Caprara, the author of the original version of the tool (Caprara, 2009, 2010, 2013), positive orientation is the opposite of depression and is the basic tendency to perceive, evaluate and construct life, the future, and oneself positively. It is a kind of innate, conditioned disposition that enables a person to live a life full of hope and self-confidence (Sobol-Kwapińska, 2014). It is worth noting that in statistical analyses, positive orientation is presented as a latent variable, explaining the (co-)volatility within self-assessment, life satisfaction, and optimism. Furthermore, it explains more variants of dependent variables (positive and negative affective states, quality of interpersonal relationships, and health status) than self-esteem, life satisfaction, and optimism treated separately. Other psychological variables, similar to positive orientation (treated as the inverse of the depressive triad), are primarily personal health potentials (emotional response styles) and personal resources. By referring the psychological conceptualisations of positive orientation to philosophy, it can be described as "life wisdom" providing a person with a happy life.

Examples of the P-scale statements: 'I am satisfied with life', 'Sometimes the future seems unclear to me', 'I generally have confidence in myself'.

3.2.4. SPP-25 Scale

The SPP-25 Scale (Polish adaptation: N. Ogińska-Bulik, Z. Juczyński) is designed for adults, both healthy and ill. It contains 25 statements concerning various personality properties that make up resiliency, also associated with mental resiliency. The assessment is made on a 5-stage Likert scale. In addition to the overall score, the scale measures the following 5 factors: perseverance and determination in action; openness to new experiences and a sense of humour; personal competence to cope and tolerance of negative emotions;

tolerance of failure and treating life as a challenge; optimistic attitude to life and the ability to mobilise in difficult situations. Ego-resiliency consists of resistance (ego-resiliency) and control (ego-control). ego control includes tendencies to hold back (versus expressing) emotional and motivational impulses. In turn, ego-resiliency means adjusting a typical way of control to the requirements of a situation, i.e. balancing this impulsivity and inhibiting it. Ego resiliency therefore refers to an individual's ability to respond flexibly to the changing demands of a situation, including stress, conflict, or uncertainty.

Example of a tool statement: "I make an effort to deal with the problem, no matter how difficult it is,' 'I can see the amusing side of what is happening to me', 'I can adapt to any situation, even the most difficult one'.

3.2.5. Generalised self-efficacy scale (GSES)

The Generalised Self-Efficacy Scale (GSES) in the Polish adaptation (R. Schwarzer, M. Jerusalem, Z. Juczyński) refers to Bandura's (1977, 1997) concept of expectations and the concept of perceived own effectiveness. The scale consists of 10 statements. It was prepared in German in 1992 and translated into English the following year. Each question can be answered with 4 answers, ranging from 'NO' - 1 point, to 'YES' - 4 points. The sum of all the marks gives an overall indicator of self-efficacy. The higher the grade, the greater the self-efficacy. The scale constructed by Schwarzer and Jerusalem has become a popular measurement tool. This is due to the need for methods to determine the described construction, which expresses important dispositional properties for predicting the behaviour of an individual. On the basis of previous research, it can be concluded that the Polish version of SUWS does not differ from the original version and has good psychometric properties. Higher self-efficacy increases motivation to act and is associated with better performance of an individual (Juczyński, 2000). The stronger the self-efficacy beliefs are, the higher the goals set by people and the stronger their involvement in the intended behaviour, even in the face of piled-up failures.

Examples of the GSES scale statements: 'I can always solve difficult problems if I try hard enough', 'Even when someone opposes me, I can find a way to achieve what I want', 'I can easily stick to my goals and achieve them'.

3.2.6. Questionnaire of attitudes towards safety

The Questionnaire Attitudes towards Safety - KPwB, M. Znajmiecka - Sikora questionnaire is a tool for diagnosing employees' attitudes towards work safety. According to the adopted theoretical concept, attitudes towards safety are understood as all relatively permanent instructions to perceive and evaluate the principles of work safety, to react emotionally to them and to perform work safely (Znajmiecka-Sikora, 2019). The tool consists of 54 test items and a response scale in format: ZT (definitely yes), T (yes), TP (hard to say), N (no), ZN (definitely not). The results of analyses conducted with the participation of 1,300 people indicate that the reliability of the entire tool is satisfactory (Cronbach alpha 0.849). Theoretical accuracy is also at a good level. The results of factor analysis indicate uniformity of scales, which together explain 45.72% variance of the results. The results of the conducted statistical analyses allow us to conclude that KPwB is a tool with sufficiently satisfactory psychometric properties. An employee's attitude towards work safety can be defined as a general, relatively permanent disposition to perceive and evaluate the principles of work safety, to react emotionally to them, and to perform work safely. The cognitive component refers to the knowledge of the principles and ways of performing work safely, the dangers occurring in work processes, potential accident situations.

Sample statements from the questionnaire: "When I notice that someone does not comply with general health and safety rules (e.g. in public places, at work, at school), I immediately intervene - I draw the person's attention, and if this does not work, I take appropriate steps (e.g. report to security, supervisor, etc.)", "If I do not have sufficient knowledge, experience or competence - I give up tasks that may be dangerous and risky", "I can assess and distinguish when someone is behaving risky and may endanger their own life or health and that of others".

3.2.7. Questionnaire of areas of professional life

To assess the climate of the workplace and precisely selected areas of professional life, the 29 item **Questionnaire of Areas of Professional Life of Izwantowska and Terelak** was used, which also makes it possible to assess the following areas on a 5-point Likert scale: workload, sense of control at work, perception of social support, assessment of organisational support, compliance of the employee's value with the values of the organisation. The tool is the result of the adaptation of the tool Areas of Professional Life

of Ch. Maslach and M. Leiter (2009). The Areas of Working Life questionnaire covers issues such as: workload, perceived support from the organisation, support from other people at work, compatibility of the employee's and organisation's value system. The questionnaire consists of 29 statements grouped in six scales: The Workload Scale (refers to an individual's sense of how much work he or she is overwhelmed by excess work), the Behavioural Control Scale (examines the possibility of making independent decisions, making choices at a given job), the Awards Satisfaction Scale (refers to an assessment of the degree of satisfaction with the awards a person receives for his or her work: material awards, promotion opportunities, as well as social awards such as recognition and respect from colleagues, superiors, and customers), Collaborator Support Scale (refers to the assessment of the quality of the social environment in the workplace, mutual support, cooperation and showing positive feelings), Sense of Justice Scale (refers to the feeling of an employee that he or she is treated fairly or not, and concerns aspects of the work such as clear rules, distribution of goods, and opportunities for promotion), Value Scale (allows to assess whether there is a conflict of values within the organisation itself or between the employee's values and those held by the organisation).

Sample statements used in the questionnaire are: "I don't have enough time for the work I have to do", "I have an influence on the way I do my work", "Colleagues trust each other".

3.2.8. Scale of social ties

The quality of bonds in the workplace was measured by the Scale of **Social Ties** developed **by K. Skarżyńska** (2004), which is used to measure the condition of social ties. It consists of 6 items, 3 of which confirm the good quality of bonds and 3 of which contradict it. The overall result of the scale, after reversing negative statements, is an average rating of all items and it is between 1 and 5. The higher the rating, the higher the quality of bonds and interpersonal relations. The alpha Cronbach scale's reliability ratios were 0.68. Six items from the original version of the scale were used in our own research. The respondents determined the degree of satisfaction with the bonds in relation to their professional environment and the people with whom they cooperate on the 5-point Likert scale.

Examples of tool items are: "I have a lot of people around me at work", "At work I usually stay alone with my problems", "I can count on the help of colleagues who are my friends in important matters".

3.2.9. Human – organisation matching scale

To measure the matching to work in an organisation aspects, the Czarnota-Bojarska's **questionnaire for study the human-organisation subjective matching** was used. The questionnaire consists of 47 items describing 3 factors: complementary fit - the compatibility of values, goals and standards of the individual, and the organisation (16 statements, e.g. "As much as I can give"); complementary fit - the compatibility between the employee's capabilities and the requirements of the organisation and between the employee's needs and the resources of the organisation (18 statements, e.g. "I fit my organisation"); organisational identity - identification with the social group that the organisation forms (13 statements, e.g. "I think the organisation is important to me"). When answering questions, respondents use a 6-point response scale from "I strongly disagree" to "I strongly agree". The result on each scale is the average of the values assigned to each term. The higher the score on each scale, the better the match in the range. The questionnaire is characterised by high reliability (Cronbach's α for individual scales is: complementary match - 0.969; complementary match - 0.945; compliance of the organisation's expectations towards the employee and its capabilities, and the individual's expectations towards the organisation and the organisation's ability to meet them - 0.911). The degree of a human being's fit to the organisation depends on both the characteristics of the employee and the organisation. Among the individual characteristics of an employee that favour a good fit, apart from competence, are: openness to new experiences, conscientiousness, type of professional personality, intelligence, valued values, self-efficacy, and control (Czarnota-Bojarska, 2012).

Examples of tool items: "I think that the organisation is important to me", "It gives me pleasure when someone praises the company", "I think of myself as a member of the organisation".

3.2.10. KPWG-3 feeling of dignity questionnaire

The KPWG-3 Feeling of Dignity Questionnaire (Steuden, Brudek) is a tool to measure subjectively perceived and felt sense of dignity. According to Steuden (2011), self-dignity is the subjective belief that an individual is someone of value and that they deserve respect, and the belief that other people treat them as a person who deserves respect. The structure of self-dignity consists of three elements: self-esteem, self-confidence, and full acceptance of oneself. The final version of the tool, i.e. KPWG-3, consists of 36 statements assessed

by the respondents on a scale of 5 steps: "yes", "rather yes", "and yes and no", "rather no", "rather no". In order to develop the psychometric tool, 402 people were tested. The results of the research indicate that the sense of dignity is a construct consisting of the following dimensions: Cognitive, Loss, Real, and Experiences. The sum of points obtained within the scales is the raw result (the reversed Loss scale). Both reliability and fitting indicators are very high, which suggests that the tool has the appropriate psychometric parameters, required in scientific research.
Examples of tool items: "Self-esteem is manifested by self-worth and self-respect", "Questions about self-esteem appear in me when it is violated by others", "Self-esteem is a very important feature".

3.2.11. Questionnaire of opinions on the social world

The Questionnaire of Opinions on the Social World of Różycka and Wojciszke is a set of methods consisting of scales: Faith in the Zero-Sum Game, Interpersonal Trust Scale, Social Exchange Balance Scale, and Self-assessment Scale. To all items of the questionnaire, the participants respond on the 7-point Likert scale, where subsequent points mark: 1 - I strongly disagree, 2 - I disagree, 3 - I rather disagree, 4 - it is difficult to say, 5 - I rather agree, 6 - I agree, 7 - I definitely agree. The Interpersonal Trust Scale consists of 7 items: 4 items are by Eisenberger (Eisenberger et al., 2004) and 3 items by Wojciszke. In this version, the scale has a one-factor structure, where a high score indicates a high level of trust. The scale of the Social Exchange Balance sheet by Wojciszke consists of 11 items. The scale measures the general feeling of satisfaction with the social exchange and the balance of profits and losses experienced subjectively by the respondents in relations with others, with the higher the score the greater satisfaction in the exchange relation (positive balance). The Self Assessment Scale is a classic Rosenberg scale (Rosenberg, 1995), consisting of 10 items. In all Polish studies, the Self-assessment, Social Exchange Balance, and Interpersonal Trust scales obtained high reliability - 0.72 to 0.90 for various Polish samples.

Sample statements from the questionnaire are: "People are generally good by nature", "Most people can be trusted", "When someone does a lot for the good of others, they gain from it too".

3.2.12. Feeling of stress questionnaire

A tool was used to measure perceived stress: Plopa and Makarowski Stress Feeling Questionnaire. The tool consists of 27 items, rated on a 5-point Likert scale. The individual questions of the questionnaire form scales: emotional tension, which concerns experiencing high anxiety, uncertainty, strong fatigue, and exhaustion of resources. The next scale measures the level of external stress, defined as experiencing stress in situations that exceed the capabilities of the individual (e.g. inadequate tasks, work area), but also the feeling of being unfairly assessed and accounted for by others. It is characteristic for this dimension to experience feelings of helplessness and loneliness. The third dimension studied is the level of intrapsychological stress, which is expressed by the lack of ability to cope with the emotional states experienced. This scale expresses pessimism, negative perception of oneself and the outside world.

Examples of statements used in the KPS tool are: "I feel anxiety that more and more things annoy me", "I think I am being fairly judged", "I have my plans, but I am afraid I will not implement them, because my psyche is too weak".

3.2.13. Feeling of threat questionnaire

The study used the Feeling Threatened Questionnaire in Mamcarz's work. The tool is used to measure the sense of threat understood as experiencing concerns about the effects of current/potential hazards in the workplace. It consists of 54 statements evaluated on a 5-stage Likert scale. It measures three indicators: internal discomfort, concerns about current hazards, and efforts to avoid hazards. Risk perception is defined by psychologists as experiencing or recognising concerns about the effects of potential or actual hazards (Mamcarz, 2016). Collision with specific work situations generates a specific cognitive-imaginary picture, covering the entire experience in the workplace. It may include a variety of elements, but it will primarily be associated with internal discomfort and fear of potentially dangerous situations in the workplace (e.g. explosion, fire, an explosion in the airspace), as well as fears of real and current dangers occurring in daily, routine work. In addition, the construction is defined as: "Sense of danger" consists of potential actions resulting from avoiding a hazard (at the behavioural and cognitive level - e.g. continuous vigilance and attention to dangerous elements of the work environment).

Examples of KPZ tools: "I'm worried about what's going to happen at work", "When I'm at work I think something bad might happen", "When I'm at work I feel the danger around me".

3.2.14. Stress management inventory

The Stress Management Inventory (Mini-COPE) by Z. Juczyński and N. Ogińska-Bulik was used to measure stress management styles. It was developed on the basis of Charles S. Carver, Michael F. Scheier, and Jagdish K. Weintraub conceptualisation. Mini - COPE is a tool for examining adults, both healthy and sick. It is composed of 28 statements that form 14 strategies (2 statements in each strategy). The method is most often used to measure available coping. The experience of chronic organisational stress is treated in the field of occupational stress and burnout as a kind of "ignition" triggering further symptoms: exhaustion (which is the body's response to stress), cynicism and gradually decreasing self-efficacy. What can be crucial in the context of dealing with stress effectively are individual strategies applied in the face of experiencing difficult situations and emotions. In spite of many scientific disputes concerning the issue of coping with stress in the psychology of work and organisation, Ch. Carver's approach is very popular, which defines coping as a result of both the individual's properties and situations. Thus, coping styles include both a constant disposition to solve difficult situations and a tendency to use active and evasive strategies, focused on both problems and emotions. The way of coping with stress is determined by the properties of the situation experienced, the individual's perception of it and the properties of the individual, among which the resources available are important. The internal compliance of the Polish version of Mini-COPE has been established on the basis of a survey of 200 people aged 25-60. Half reliability was 0.86 (Guttman index 0.87). The stability is satisfactory for most scales. The factorial charges of individual claims can be considered satisfactory in most cases. Diagnostic accuracy was assessed by correlating Mini-COPE results with the Mini-MAC scale, designed to test cancer management strategies, and predicting the severity of post-traumatic stress symptoms in the group of mothers of children treated for leukemia.

Examples of inventory statements: "I focus on work or other activities so that I don't think about it", "My efforts are focused on doing something about the situation", "I say to myself "it is not true".

3.3. Presentation and discussion of results

Below are the results of the respondents in the scope of the variables under investigation. The results of our own research will be presented in the order of research questions posed in the previous methodological part. First of all, descriptive statistics will be presented as a characteristic of the research group. Attention should be paid to the complexity of the variables under study. Many times the research results include the presentation of several components of one variable. Due to the complexity of the psychological constructs under investigation, some analyses of the results required a broader statistical analysis.

3.3.1. Personality of employees in Sector 4.0

The analysis of the personality structure of employees used the IPIP BFM-20 test, which allows to examine the personality in the Big Five approach, i.e. by determining the severity of the five main personality factors: extravagance, amicability, conscientiousness, emotional stability, and intellect/openness. The average results obtained by all subjects are shown in Table 2.

Table 2

Personality – descriptive statistics

	M	*SD*	*Min*	*Max*	Bevel
Extroversion	12,69	2,55	5	20	0,18
Ability to compromise	13,39	2,51	4	20	0,30
Conscientiousness	12,96	2,28	4	20	0,47
Emotional stability	12,39	2,03	4	20	0,47
Intellect/Openness	12,89	2,15	7	20	0,50

Annotations: *M* - average, *SD* - standard deviation, *Min* - minimum value, *Max* - maximum value.

Most of the subjects obtained results close to average - from one standard deviation below average to one standard deviation above average. The majority of the respondents were within this range, respectively 69% for extraversion, 68% for amicability, 77% for conscientiousness, 74% for emotional stability, and 76% for intellect/openness. People with results lower than average (by more than one standard deviation below average) and higher

than average (by more than one standard deviation above average) were in the minority. Detailed figures for each group are presented in Table 3.

Table 3

Personality – results obtained

	E		U		S		SE		I/O	
	n	*%*	*n*	*%*	*n*	*%*	*n*	*%*	*n*	*%*
Below average	75	16	48	10	46	10	66	14	62	13
Average	325	69	320	68	362	77	349	74	358	76
Above average	72	15	104	22	64	14	57	12	52	11

Annotations: n - number, % - percentage of results, E - extraversion, U - amicability, S - conscientiousness, SE - emotional stability, I/O - intellect/openness.

Statistically significant, small differences in the personality traits of employees were observed between the individual groups - the results of the single-factor ANOVA analysis are presented in Table 4.

Table 4

Personality – differences between groups

	F	*df1*	*df2*	*p*
Extroversion	6,73	2	183,10	0,002
Ability to compromise	8,66	2	187,55	< 0,001
Conscientiousness	11,84	2	167,29	< 0,001
Emotional stability	14,41	2	171,75	< 0,001
Intellect/Openness	10,97	2	194,75	< 0,001

The differences between the groups in terms of personality traits are shown in Figure 1. As can be seen, the highest results in terms of all personality traits were obtained by respondents from group 2, whereas the results obtained by employees from groups 1 and 3 were similar.

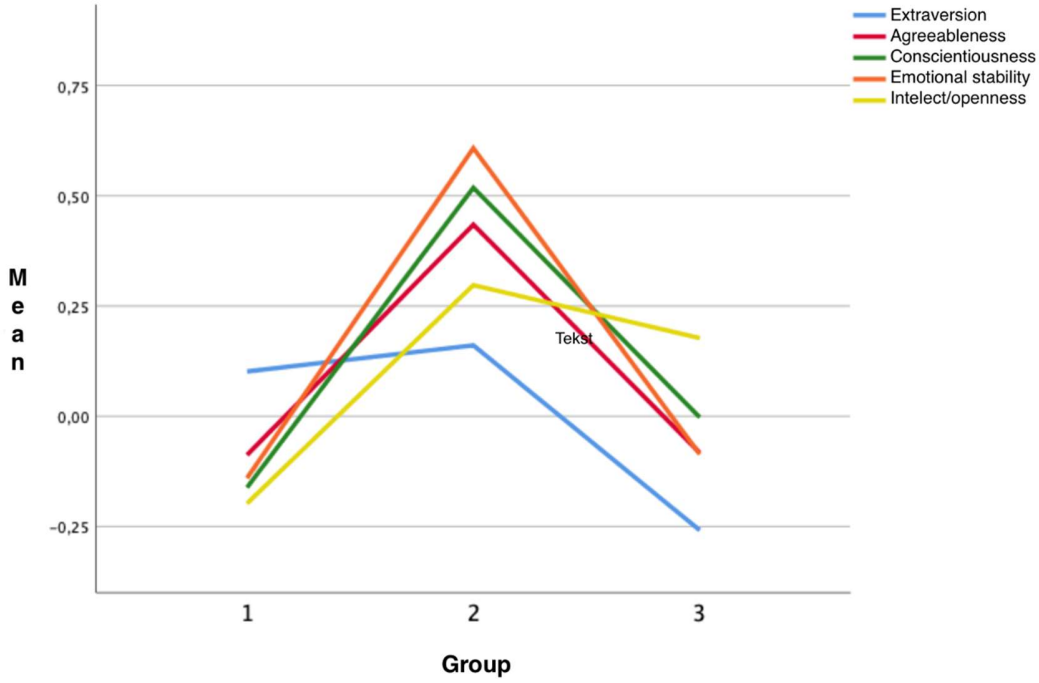

Fig. 1. Differences in personality traits between groups 1, 2 and 3 (1 - Poles, 2 - Slovaks, 3 - Germans)
Rys. 1. Różnice w cechach osobowości pomiędzy grupami 1, 2 i 3 (1 - Polacy, 2 - Słowacy, 3 - Niemcy)

The obtained results show small intergroup differences in terms of measuring personality traits such as: extraversion, amicability, conscientiousness, emotional stability, and intellect - openness to experience. The data indicates that the vast majority of employees in Industry 4.0 are characterised by an average intensity of individual traits. The group of Polish and Slovak industrial workers seems to be the most similar to each other in terms of the level of individual personality traits.

3.3.2. Regulating emotions and self-efficacy

The DS questionnaire was used to measure the level of regulation of emotions and sense of self-efficacy. - 14 and GSES, which allows for examining, respectively, the characteristics of the so-called depressive personality (negative emotionality and social inhibition) and self-efficacy, understood as the certainty of one's own competence and effectiveness in carrying out everyday tasks. The average results obtained by all the respondents are presented in Table 5.

Table 5

Regulation of emotions and self-efficacy – descriptive statistics

	M	*SD*	*Min*	*Max*	Bevel
Self-efficacy	29,63	4,40	15	40	-0,41
Negative emotionality	18,06	5,40	2	28	-0,46
Social restraint	18,00	4,89	5	28	-0,25

Annotations: *M* - average, *SD* - standard deviation, *Min* - minimum value, *Max* - maximum value.

Again, most of the surveyed employees achieved results close to average - between one below average standard deviation and one above average standard deviation. This range included the majority of respondents, respectively 70% for self-efficacy, 67% for negative emotionality and 63% for social inhibition. In the minority were people with results lower than average (by more than one standard deviation below average) and higher than average (by more than one standard deviation above average). Detailed figures for each group are presented in Table 6.

Table 6

Regulation of emotions and self-efficacy – results obtained

	Self-efficacy		Negative emotionality		Social restraint	
	n	*%*	*n*	*%*	*n*	*%*
Below average	87	18	72	15	83	18
Average	331	70	316	67	297	63
Above average	54	12	84	18	92	19

Annotations: n - number, % - percentage of results.

Statistically significant, small differences were observed between the individual groups in terms of workers' characteristics - the results of the single-factor ANOVA analysis are presented in Table 7.

Table 7

Regulation of emotions and self-efficacy – differences between groups

	F	*df1*	*df2*	*p*
Self-efficacy	12,61	2	178,66	< 0,001
Negative emotionality	40,77	2	183,28	< 0,001
Social restraint	42,54	2	190,44	< 0,001

The differences between the surveyed employees in terms of regulation of emotions and self-efficacy are presented in Figure 2. As can be seen, the results, in terms of all characteristics, were similar within each group, with the lowest results in terms of self-efficacy, negative emotionality, and social inhibition for group 3.

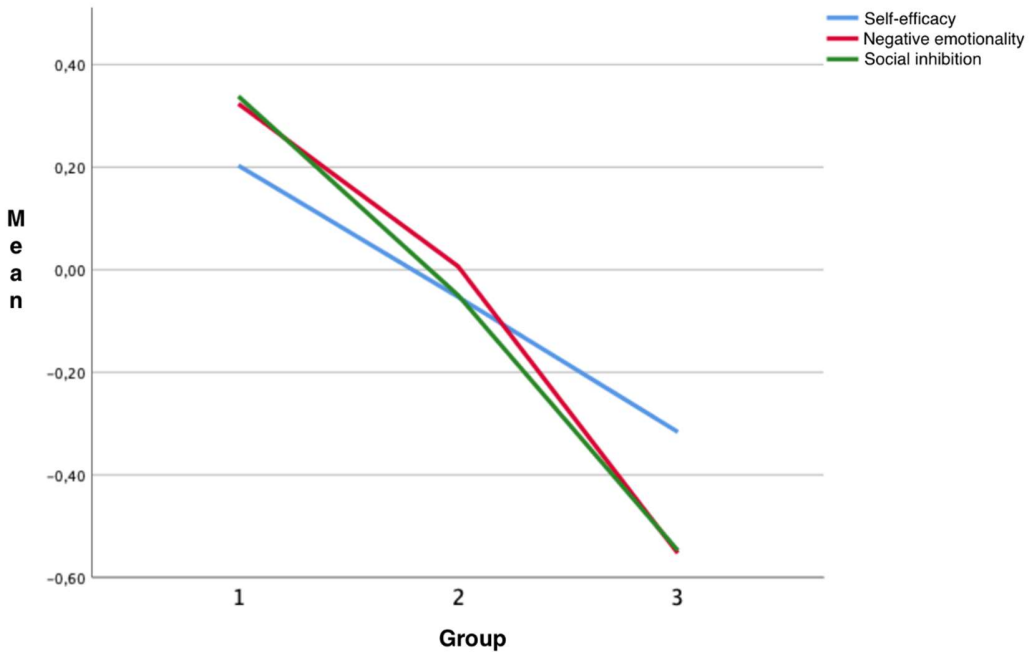

Fig. 2. Differences in the regulation of emotions and self-efficacy between groups
Rys. 2. Różnice w regulacji emocji i poczuciu własnej skuteczności między grupami

Employees of Polish, Slovakian, and German industrial plants in the 4.0 sector seem to be similar to each other in terms of perceived level of reflexivity and level of depressive personality, i.e. people with average performance in the areas studied predominate among the respondents. The subtle differences concern the German group, whose level of self-

efficacy was found to be the lowest of the groups surveyed. An interesting result, in turn, was that of the intensity of the depressive personality trait. It was the lowest in this group of the surveyed employees - which would indicate satisfactory psychological well-being parameters among the respondents from group 3 - German.

3.3.3. Relationship with professional work and functioning in organisation

As part of the statistical analysis, tests allowing for the study of relationships and dependencies in areas related to the functioning of respondents in industrial plants 4.0 were used.

The following was evaluated first:

1) the respondents' attitudes towards safety at work
2) areas of working life related to the sense of workload, sense of control, reward quality assessment, community, sense of justice, and values in the workplace
3) bonds in the workplace - their perception and feeling by the respondents
4) the degree of alignment with the organisation, understood as complementary and interdependent alignment and identification and satisfaction with work in the organisation.

The average results obtained by all the respondents are presented in Table 8.

Table 8

Professional relations and functioning in the organisation – descriptive statistics

		M	*SD*	*Min*	*Max*	Bevel
Attitudes towards safety at work	Cognitive component	18,58	5,23	7	30	0,11
	The affective component	17,92	3,60	8	26	-0,01
	Behavioural component	18,12	4,00	6	29	-0,19
	General attitude	54,62	11,49	22	82	0,10
Evaluation of areas of working life	Workload	20,51	4,88	7	30	-0,03
	Control	10,69	2,78	3	15	-0,49
	Awards	13,52	2,78	4	20	-0,43

cont. table 8

	Community	19,02	3,71	5	25	-0,80
	A sense of justice	20,09	3,95	8	26	-0,62
	Values	18,09	3,88	5	25	-0,42
Evaluation of ties in the workplace	Evaluation of ties	18,21	4,67	5	25	-0,10
Fitting to the organisation	Complementary fitting	3,35	0,82	1	5	-0,60
	Supplementary fitting	3,11	0,56	1	5	-0,44
	Identification with the organisation	3,33	0,85	0	5	-0,67
	Satisfaction with work	3,33	0,89	0	5	-0,66

Annotations: *M* - average, *SD* - standard deviation, *Min* - minimum value, *Max* - maximum value.

In the case of results concerning attitudes towards safety at work, most of the respondents obtained results close to the average. This range included most of the respondents, 64% each for the cognitive and affective component, 69% each for the behavioural component, and 65% each for the general attitude towards safety. People with results lower than average (more than one standard deviation below average) and higher than average (more than one standard deviation above average) were in the minority. Detailed figures for each group are presented in Table 9.

Table 9

Attitudes towards safety – results obtained

	Cognitive component		The affective component		Behavioural component		General The attitude	
	n	*%*	*n*	*%*	*n*	*%*	*n*	*%*
Below average	72	15	78	17	74	16	70	15
Average	302	64	303	64	326	69	308	65
Above average	98	21	91	19	72	15	94	20

Annotations: n - number, % - percentage of results.

With regard to the assessment of areas of professional life, most of the respondents obtained results close to the average. The minority included people with results lower than average (by more than one standard deviation below average) and higher than average (by more than one standard deviation above average). Detailed figures for each group are presented in Table 10.

Table 10

Assessment of working life areas – results obtained

	Workload		Control		Awards		A sense of justice		Community		Values	
	n	*%*	*n*	*%*	*n*	*%*	*n*	*%*	*n*	*%*	*n*	*%*
Below average	77	16	77	16	56	12	89	19	88	19	86	18
Average	307	65	320	68	371	79	323	68	305	64	272	58
Above average	88	19	75	16	45	9	60	13	79	17	114	24

Annotations: n - number, % - percentage of results.

Similarly, with regard to assessing the quality of bonds in the workplace, the majority, 300 people (64%) rated them as average. 66 people (14%) rated the bonds as below average and 23% (n = 106) as above average. This result indicates satisfactory - "optimal" - interpersonal relations in the work environment among all respondents.

Concerning the sense and assessment of being fit for work, most of the respondents obtained results close to average. The minority included people with results below the average (more than one standard deviation below the average) and higher than the average (more than one standard deviation above the average). Detailed figures for each group are presented in Table 11.

Table 11

Fitting to work – results obtained

	Complementary fitting		Supplementary fitting		Identification		Satisfaction	
	n	*%*	*n*	*%*	*n*	*%*	*n*	*%*
Below average	91	19	77	16	88	19	92	19
Average	301	64	326	69	308	65	306	65
Above average	80	17	69	15	76	16	74	16

Annotations: n - number, % - percentage of results.

Statistically significant, small differences were observed between individual groups in the scope of the examined variables concerning relations with work and matching to the organisation - the results of the single-factor ANOVA analysis are presented in Table 12.

Table 12
Work relationships and functioning in organisation – differences between groups

		F	*df1*	*df2*	*p*
Attitudes towards safety at work	Cognitive component	205,57	2	209,92	< 0,001
	The affective component	58,94	2	208,95	< 0,001
	Behavioural component	119,42	2	192,17	< 0,001
	General attitude	176,74	2	210,16	< 0,001
Evaluation of areas of working life	Workload	5,36	2	210,12	0,005
	Control	8,22	2	203,64	< 0,001
	Awards	18,82	2	185,53	< 0,001
	Community	22,20	2	193,79	< 0,001
	A sense of justice	114,81	2	180,03	< 0,001
	Values	78,97	2	191,16	< 0,001
Evaluation of ties in the workplace	Evaluation of ties	17,18	2	229,53	< 0,001
Fitting to the organisation	Complementary fitting	128,22	2	182,97	< 0,001
	Supplementary fitting	92,38	2	184,27	< 0,001
	Identification with the organisation	111,81	2	180,62	< 0,001
	Satisfaction with work	42,67	2	189,96	< 0,001

The differences between the groups in terms of attitudes towards safety are presented in Figure 3. The highest scores in each of the components of cognitive, affective, and behavioural attitudes were achieved by group 1 (Polish employees) - similarly, their attitudes towards safety were the highest, while lower scores were achieved by people from two consecutive groups, who were also characterised by a less open and optimistic attitude towards safety. The obtained results show a slightly higher readiness to show care and attention to safety at work among Polish employees. Generally, the orientation towards compliance with safety rules and regulations, and showing an attitude of commitment and

openness to the rules introduced in the organisation is extremely important in the case of the industry under consideration - Industry 4.0. Working with the latest technologies, in the area of full automation, brings various risks with it, including accidents or threats to the life and health of personnel. What should be of particular importance to the management is precisely building appropriate attitudes to safety at work. In this context, average results in terms of attitudes towards safety show the need for further development and strengthening of concern for safety in the industrial plants under investigation.

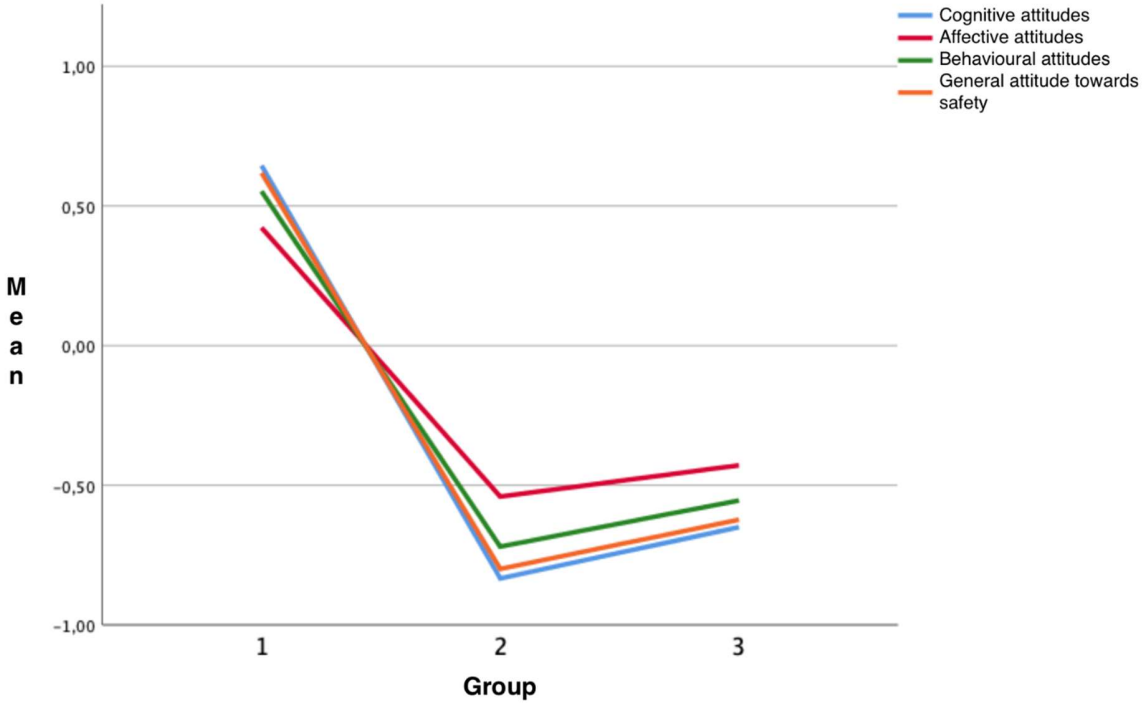

Fig. 3. Differences in attitudes towards safety between groups
Rys. 3. Różnice w postawach wobec bezpieczeństwa między grupami

The differences between the groups in terms of evaluation of areas of working life, i.e. the perception of the organisation and evaluation of its functioning, are presented in Figure 4. Groups 1 - Polish and 2 - Slovak rated the level of workload as the highest, which in turn was significantly rated lower by Group 3 - German. The group of Polish employees - compared to the other two - also rated the level of control, rewards, community, values, and fairness at the workplace higher. The results show that Polish and Slovak Industry 4.0 employees feel significantly more burdened with their workload, compared to German respondents.

It is very clear from decades of empirical research in the field of work and organisational psychology that work overload is precisely an important predictor of professional burnout (Maslach and Leiter, 2008, 2010, 2011). The long-term psychophysical workload, in the absence of other reinforcements or compensation, results in a significant weakening of work commitment. Such an assessment of the organisation's performance may also indicate difficulties with work organisation, a delegation of tasks and responsibilities, or simply staffing problems.

Group 2 – Slovakian evaluated the sense of justice at a similar level as Group 3, as well as respect for values and the quality of awards in the organisation. These areas are significantly related to employee satisfaction. The aspect of fairness concerns the perception of the organisation as fairly accounting for the effects of work and managing the team of employees. The evaluation of the workplace in the context of values is connected with the conviction that an individual - an employee is matched to the values held by the organisation and does not experience dissonance between the values held and principles promoted in the company.

Employees of Slovak companies rated the level of control in the workplace slightly lower than the German group, i.e. they rated the organisation as less controllable, while they rated the community in which they work higher, i.e. it can be concluded that their satisfaction with the level of cooperation with the community in the organisation is higher than among respondents in group 3.

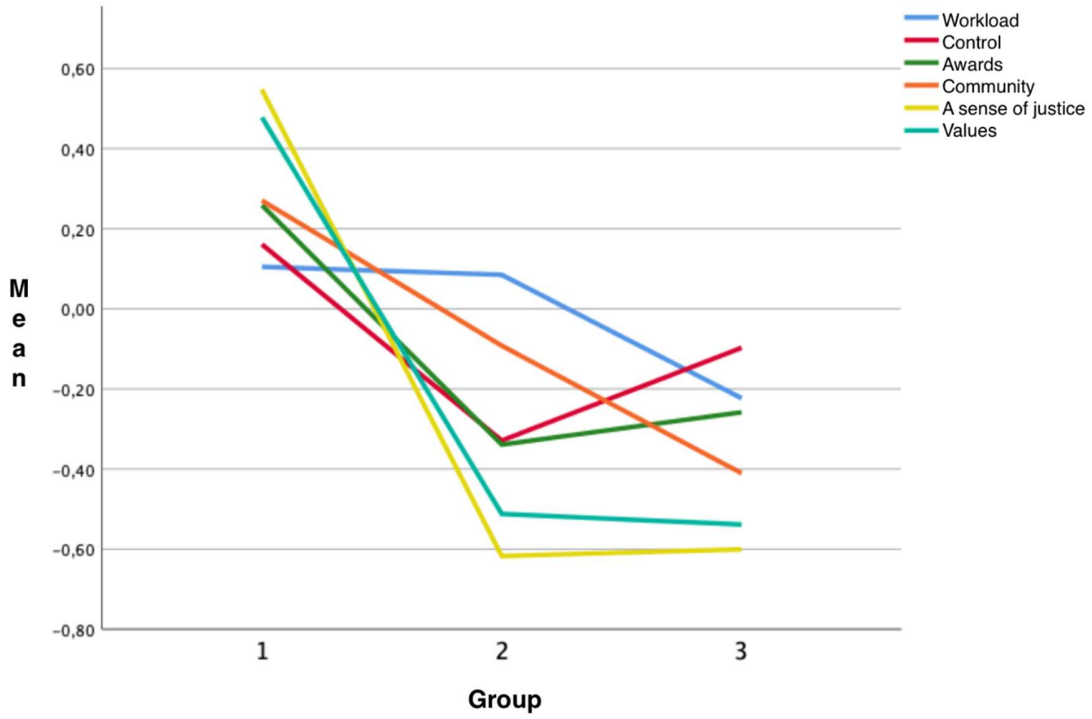

Fig. 4. Differences in the assessment of areas of working life between the 3 studied groups
Rys. 4. Różnice w ocenie obszarów życia zawodowego pomiędzy 3 badanymi grupami

The differences between the groups in the evaluation of bonds at work are shown in Figure 5. The Polish group rated the quality of bonds at work by far the highest, compared to groups 2 and 3, which rated this aspect of work lower. It shows stronger interpersonal relations, which were significantly more positively evaluated by Polish employees. The quality of bonds is an important parameter for building cooperation in employee teams. Especially in an automated work environment, the importance of bonds and interpersonal relations for organisational commitment and job satisfaction should be emphasised.

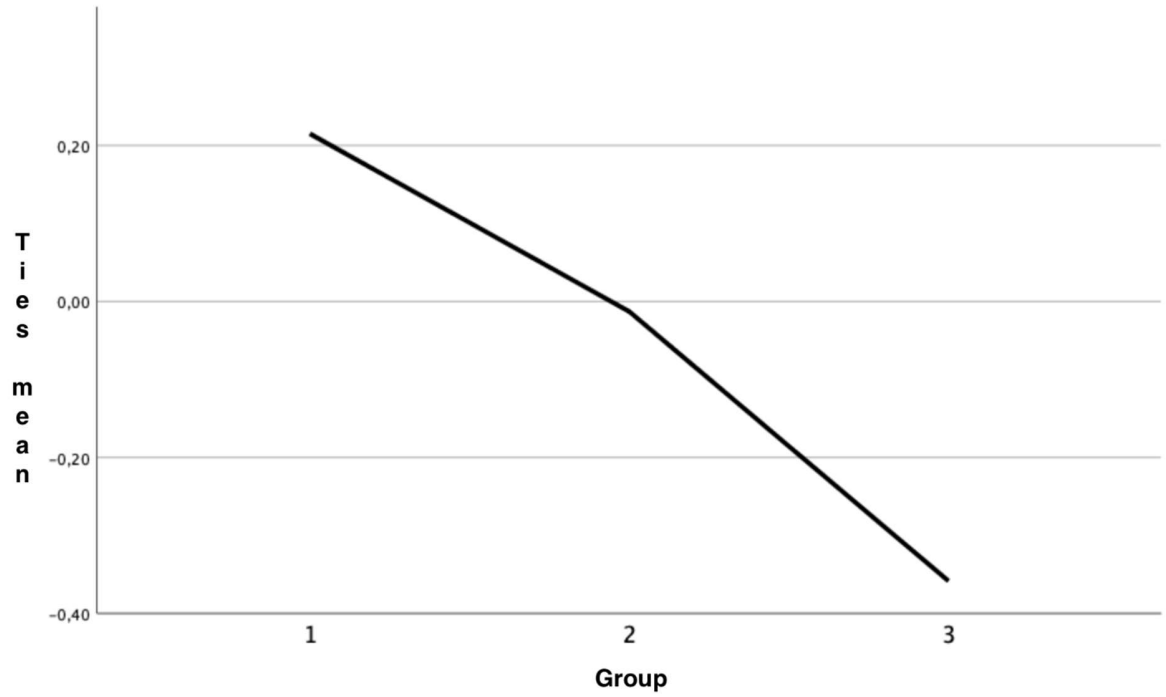

Fig. 5. Differences in the assessment of the quality of the bonds in the workplace between the study groups
Rys. 5. Różnice w ocenie jakości więzi w miejscu pracy pomiędzy badanymi grupami

The differences between industrial workers in terms of their fit for work are shown in Figure 6. Group 1 workers declared the highest level of being fit to work in the organisation in each of the three aspects: complementary and interdependent fit, as well as identification with the workplace and job satisfaction.

At the same time, the matching of Group 2 and 3 employees was similar in terms of complementary and interdependent matching and identification with the workplace. Slovak and German workers therefore seem to be similar in these aspects. However, employment in Slovak industrial plants declared higher job satisfaction than employees of German organisations.

An interesting issue seems to be a greater sense of matching to work among Polish respondents. It would be appropriate to discuss issues related to the process of recruitment and assessment of employees' competences and their formal fit for work, as well as to consider whether this declarative assessment of the Polish respondents shows more of their tendency for a slightly stronger self-presentation, or perhaps a real - more adequate fit for their professional work and organisation,

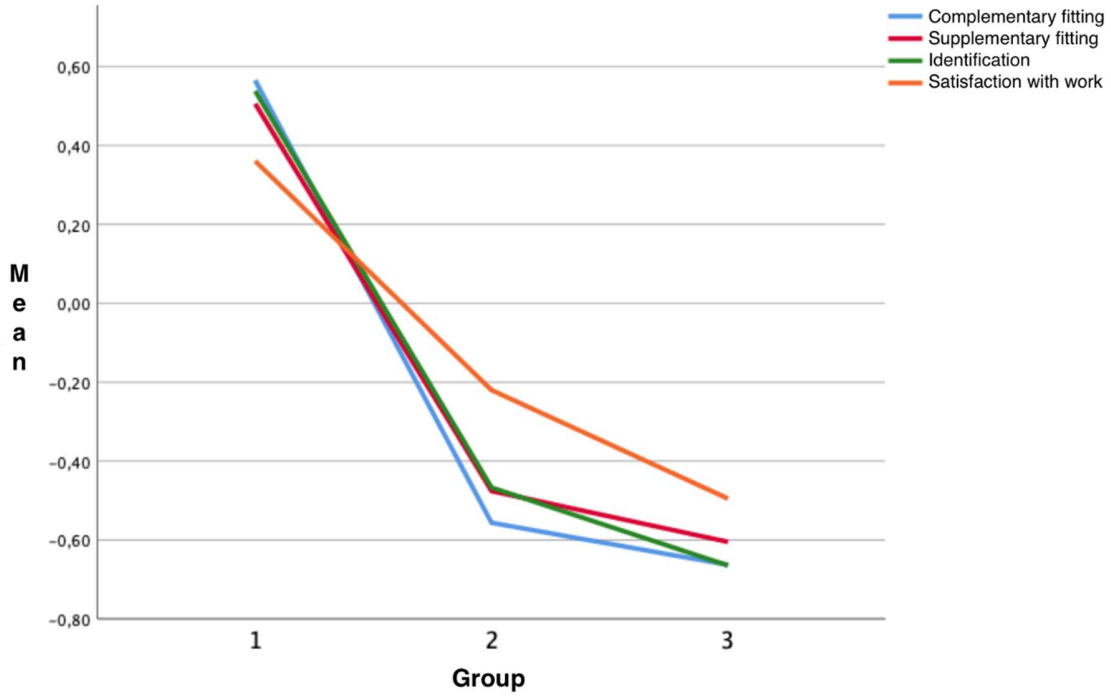

Fig. 6. Differences in matching to work between employees of the three groups under study
Rys. 6. Różnice w dopasowaniu do pracy pomiędzy pracownikami trzech badanych grup

3.3.4. Perception of the social world and self-esteem among tested employees

The analysis of the results used statistical tests to examine the opinions of respondents about the surrounding social world and assess their sense of dignity. Average results obtained by all respondents are presented in Table 13.

Table 13
Perception of the social world and sense of dignity – descriptive statistics

		M	*SD*	*Min*	*Max*	Bevel
Opinions on the social world	Believing in a zero-sum game	4,02	0,66	2	6	-0,88
	Balance of social exchange	4,53	0,95	1	7	-0,36
	Trust	4,18	0,52	3	6	1,45

cont. table 13

	Self-assessment	4,29	0,70	2	7	0,90
Self-esteem	The cognitive dimension	26,55	7,06	12	59	0,24
	Loss dimension	24,81	7,63	10	45	0,61
	The relational dimension	16,00	4,89	7	35	0,22
	Dimension of experience	19,60	4,90	8	40	0,49

Annotations: *M* - average, *SD* - standard deviation, *Min* - minimum value, *Max* - maximum value.

As far as opinions about the social world are concerned, most of the respondents obtained results close to the average. In the minority were people with results lower than average (more than one standard deviation below average) and higher than average (more than one standard deviation above average). Detailed figures for each group are presented in Table 14.

Table 14

Opinions on the social world – results obtained

	Believing in a zero-sum game		Balance of social exchange		Trust		Self-assessment	
	n	*%*	*n*	*%*	*n*	*%*	*n*	*%*
Below average	59	13	79	17	33	7	28	6
Average	369	78	316	67	381	81	370	78
Above average	44	9	77	16	58	12	74	16

Annotations: n - number, % - percentage of results.

As far as self-esteem is concerned, most of the respondents obtained results close to the average. The minority included people with results below the average (more than one standard deviation below the average) and higher than the average (more than one standard deviation above the average). Detailed figures for each group are presented in Table 15.

Table 15

Self-esteem – results obtained

	The cognitive dimension		Loss dimension		The relational dimension		Dimension of experience	
	n	*%*	*n*	*%*	*n*	*%*	*n*	*%*
Below average	75	16	76	16	93	20	69	15
Average	313	66	330	70	290	61	342	72
Above average	84	18	66	14	89	19	61	13

Annotations: n - number, % - percentage of results

Statistically significant, small differences in the sense of self-esteem in terms of so-called loss and experience were observed between the examined groups - the results of the single-factor ANOVA analysis are presented in Table 16. At the same time, the employees did not differ from each other in terms of their sense of dignity in cognitive and relational aspects.

Table 16

Perception of the social world and one's own dignity – differences between groups

		F	*df1*	*df2*	*p*
Opinions on the social world	Believing in a zero-sum game	35,00	2	166,71	< 0,001
	Balance of social exchange	48,51	2	176,26	< 0,001
	Trust	22,76	2	158,44	< 0,001
	Self-assessment	32,63	2	163,78	< 0,001
Self-esteem	The cognitive dimension	2,95	2	181,18	0,055
	Loss dimension	67,31	2	186,10	< 0,001
	The relational dimension	0,32	2	179,58	0,725
	Dimension of experience	26,80	2	183,04	< 0,001

The differences between the groups' views on the social world are shown in Figure 7. In terms of belief in the zero-sum game, as well as trust, the highest results were obtained by the respondents from group 1 - Poles, with the lowest results in terms of trust for group 3, and in terms of belief in the zero-sum game - for group 2.

Believing in a zero-sum game is a kind of human conviction that people's interests are generally antagonistic and that the profit or success of one person is only possible if the other party fails or loses (Różycka, Wojciszke, 2014). People who are convinced that life is like a zero-sum game are sure that they can only gain at the expense of another person. In the case of the presented own research, Polish workers show a higher level of beliefs about social life as unfair and connected with a zero-sum game compared to other respondents. The result of the higher level of interpersonal trust in the group of Polish employees is surprising. The analysis of the results suggests that these results are in some contradiction. Based on correlational and experimental research by Różycka and Wojciszke, it seems reasonable to say that Polish employees estimated the level of social trust in a different way - perhaps when assessing it, they took into account the closest social environment (this is indicated by the scale's features). In turn, when making declarations about social life and wider social relations, they were much more sceptical compared to other respondents. In addition, these results are interestingly linked to subsequent ANOVA analysis results.

The highest level of belief in the balance of social exchange and the level of self-esteem was characteristic of the respondents from group 2 - i.e. the Slovakian one, and the lowest - group 1 - Poles employed in Industry 4.0. The Balance of Social Exchange scale measures the level of satisfaction from a social exchange between people. The Poles turned out to be much less satisfied with the positive experience of exchanging goods and interests with others compared to the Slovaks surveyed. The result concerning self-assessment (a scale modelled on Rosenberg's global self-assessment) shows Polish employees as evaluating themselves in a more negative and strict way.

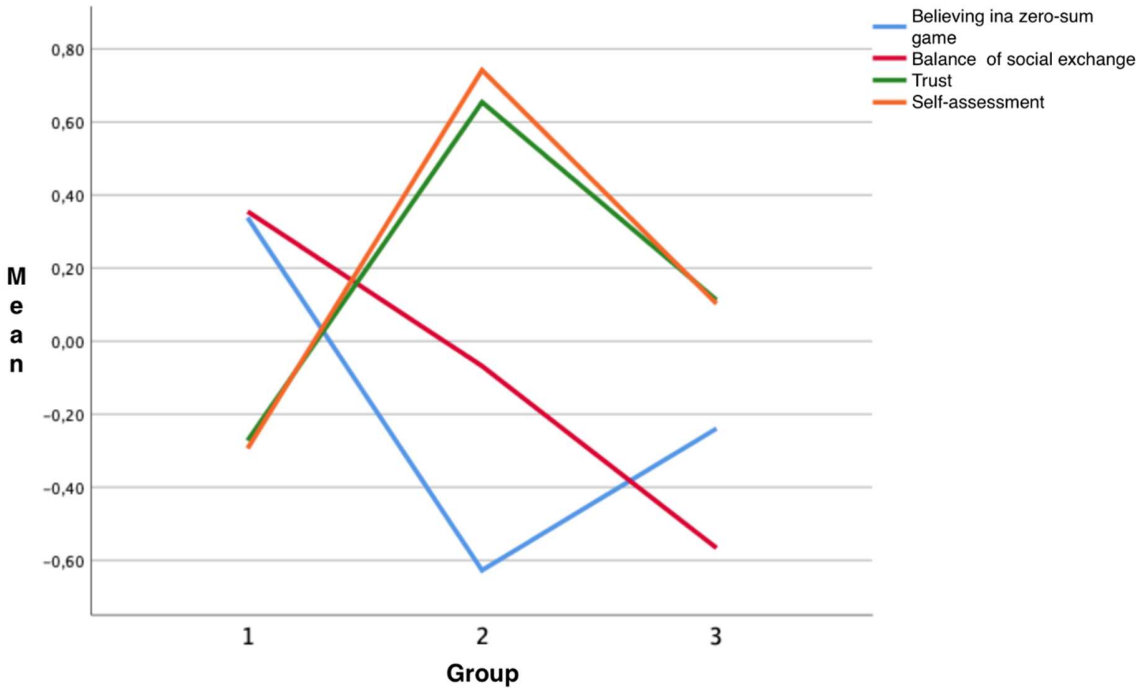

Fig. 7. Differences of opinion on the social world between groups
Rys. 7. Różnice w opiniach na temat świata społecznego pomiędzy grupami

The differences between the groups in terms of a feeling of dignity are shown in Figure 8. Employees, regardless of their place of work, similarly perceived their dignity on a cognitive and relational level. Group 1 employees - Polish employees scored lower on the dimensions of loss of self-esteem and experience of self-esteem than group 2 and 3 employees. The dimension of loss of self-esteem is defined by experiences and difficult situations in which people lose their self-esteem or are threatened with the loss of it. Those surveyed from Polish industrial plants experienced the situation of loss of self-esteem to a lesser extent. The scale of experiencing self-dignity measures the level of reflection related to the feeling of dignity in various life situations. In this aspect, Polish workers achieved lower results than Slovak and German workers.

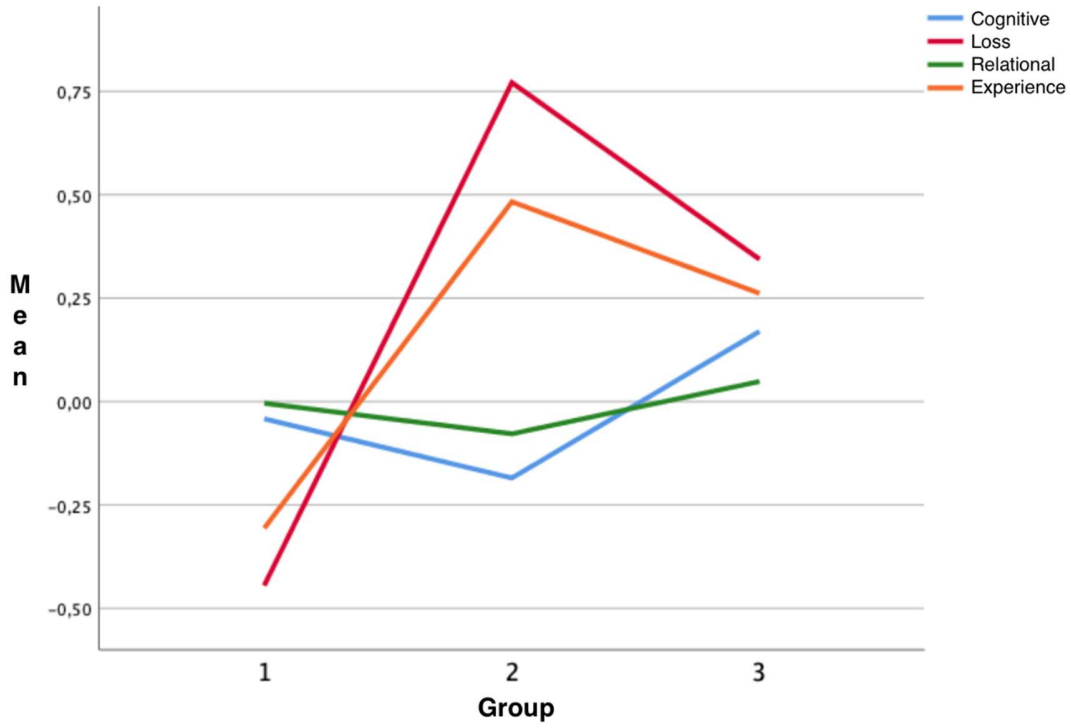

Fig. 8. Differences in the sense of dignity between groups
Rys. 8. Różnice w poczuciu godności między grupami

The test results presented are not free of many significant limitations. One of them is, of course, the correlative nature of the tests carried out in various industrial plants. However, by studying the psychological variables that determine the way of cognitive functioning, attitudes, and beliefs of employees at the level of international research, it would be difficult to carry out measurements in an experimental way. The presented international differences seem to be very interesting research results in the scope of selected variables, but they require further empirical research. It would not be right to draw conclusions that are far too generalising about the way of social perception and the social beliefs of respondents, if only because of the inequality of the groups studied. Nevertheless, these results are consistent in various respects with the results of social psychology research.

3.3.5. Stress and feeling of threat

Afterwards, analyses were carried out on the level of perceived stress and feelings of danger among workers in the surveyed industrial plants. The average results obtained by all the respondents are presented in Table 17.

Table 17

Stress and feelings of threat – descriptive statistics

		M	*SD*	*Min*	*Max*	Bevel
Stress	Overall stress level	69,24	20,43	36	155	0,84
	Emotional	21,87	6,74	11	52	1,04
	External	13,59	3,82	6	27	0,40
	Intrapsychic	104,70	28,09	53	216	0,92
Feeling of threat	Potential risks	56,11	10,94	24	97	0,17
	Current risks	18,60	4,80	7	67	2,32
	Avoidance of danger	18,97	3,70	9	31	-0,06
	General feeling of threat	18,55	4,33	7	30	-0,09

Annotations: *M* - average, *SD* - standard deviation, *Min* - minimum value, *Max* - maximum value.

With regard to stress, most of the respondents achieved close to average results. The minority included people with results below average (more than one standard deviation below average) and higher than average (more than one standard deviation above average). Detailed figures for each group are presented in Table 18.

Table 18

Stress – results obtained

	Overall stress level		Emotional		External		Intrapsychic	
	n	*%*	*n*	*%*	*n*	*%*	*n*	*%*
Below average	66	14	49	10	84	18	80	17
Average	351	74	367	78	310	66	319	68
Above average	55	12	56	12	78	16	73	15

Annotations: n - number, % - percentage of results.

About the sense of threat, most of the respondents obtained results close to the average. The minority included people with results below the average (more than one standard deviation below the average) and higher than the average (more than one standard deviation above the average). Detailed figures for each group are presented in Table 19.

Table 19

Sense of threat – results obtained

	Potential risks		Current risks		Avoidance of danger		General feeling of threat	
	n	*%*	*n*	*%*	*n*	*%*	*n*	*%*
Below average	79	17	71	15	60	13	65	14
Average	328	69	330	70	331	70	341	72
Above average	65	14	71	15	81	17	66	14

Annotations: n - number, % - percentage of results.

Statistically significant, small differences in stress and risk perception were observed between the individual groups - the results of the single-factor ANOVA analysis are presented in Table 20.

Table 20

Stress and feeling of threat – differences between groups

		F	*df1*	*df2*	*p*
Stress	Overall stress level	20,79	2	168,64	< 0,001
	Emotional	18,37	2	165,93	< 0,001
	External	16,46	2	175,01	< 0,001
	Intrapsychic	12,22	2	180,08	< 0,001
Feeling threatened	Potential risks	25,71	2	189,79	< 0,001
	Current risks	10,96	2	182,75	< 0,001
	Avoidance of danger	11,01	2	204,67	< 0,001
	General feeling of threat	14,70	2	189,97	< 0,001

The differences between respondents in terms of perceived stress levels are shown in Figure 9. The highest levels of stress and its components were declared by employees of group 3 - i.e. German, and the lowest by employees of group 2 - Slovak.

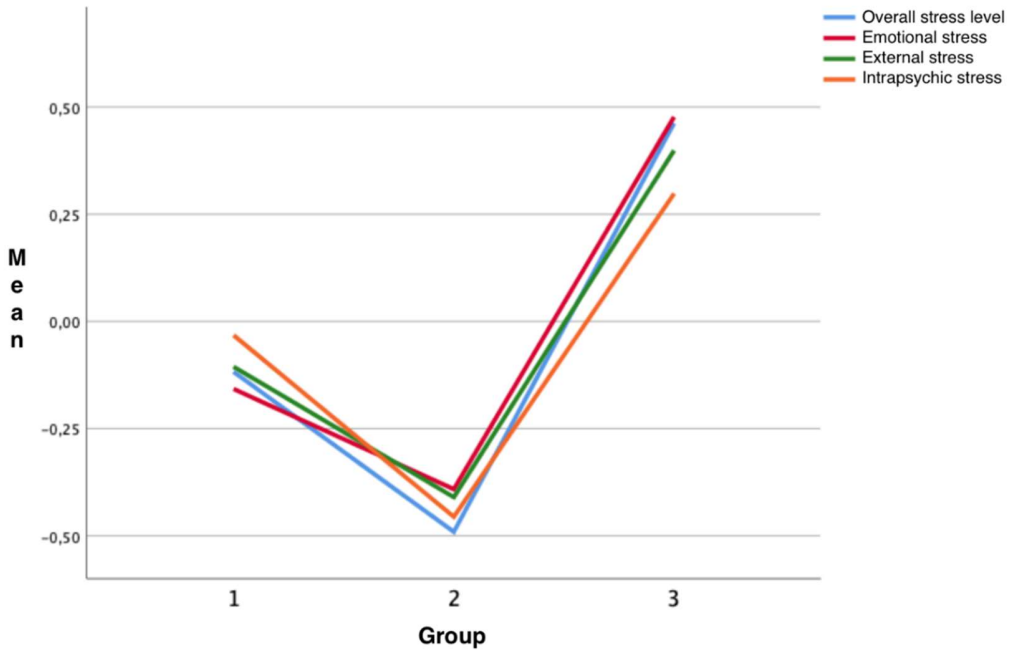

Fig. 9. Differences in the sense of stress between groups
Rys. 9. Różnice w poczuciu stresu między grupami

As for the differences between those surveyed in terms of feelings of threat, the results are presented in Figure 10. The highest overall level of feeling of threat was declared by group 1 - Poles employed in industrial plants and the lowest by German workers.

Group 1 also declared the highest level of concern regarding potential and current risks. Despite the fact that earlier analyses proved that Poles employed in the area of Industry 4.0 show stronger attitudes related to concern for safety at work, they also experience a stronger sense of threat at work. In connection with this fact, another research question arises, concerning the captured process, namely the relationship between the experience of a threat and the attitude towards safety.

It should be noted that the lowest level of fear of potential risks was declared by group 2 - the Slovak Republic, while current risks and fears were the weakest in group 3. In this respect, the German group experiences the lowest sense of risk at work, while at the same

time there is a high level of general stress, which therefore seems to be generated by factors other than situations threatening the life and health of workers.

Polish workers in group 1 were the least focused on avoiding the threat, while Slovak workers in group 2 were the most focused. Employees of Slovak industrial plants are strongly committed to avoiding risks.

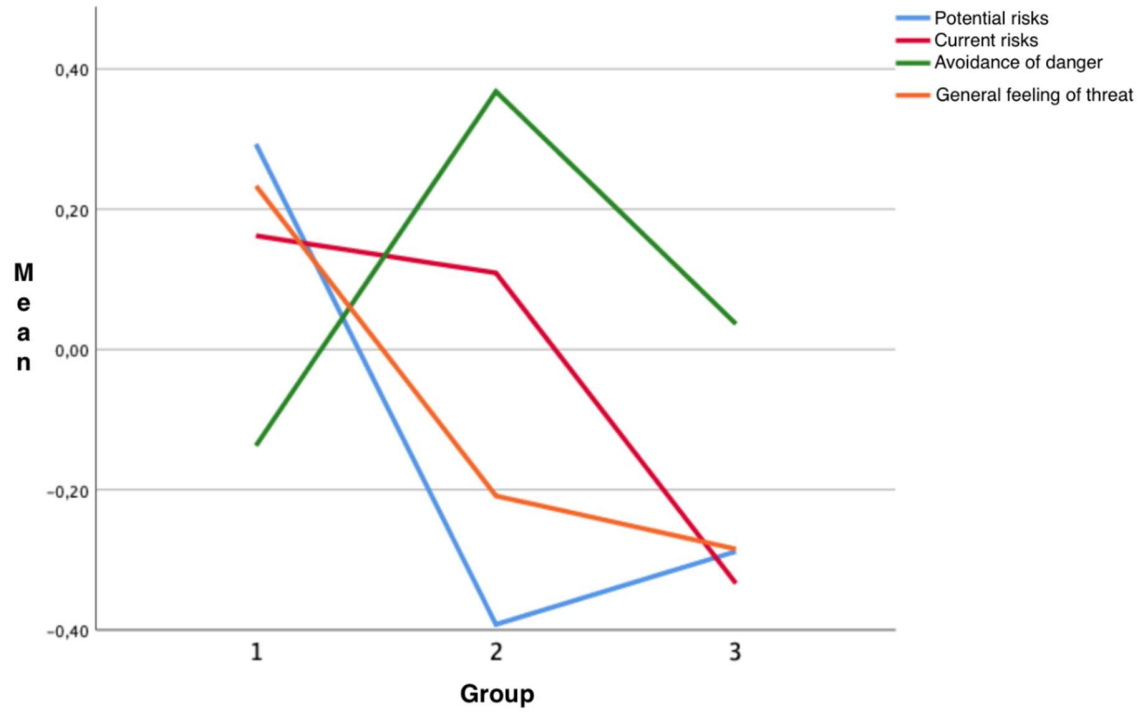

Fig. 10. Differences in the sense of threat between workers of different nationalities
Rys. 10. Różnice w poczuciu zagrożenia między pracownikami różnych narodowości

3.3.6. Dealing with stress and level of personal resources in tested employee groups

During the analysis, tests were used to measure stress management styles, ego resiliency, and positive orientation among respondents. The average results obtained by all respondents are presented in Table 21.

Table 21

Stress management – descriptive statistics

		M	*SD*	*Min*	*Max*	Bevel
Stress management styles	Active coping	9,32	3,64	1	18	0,12
	Helplessness	6,28	3,27	0	17	0,46
	Seeking support	5,43	2,53	0	12	0,32
	Evasive behaviour	7,44	3,25	0	18	0,33
	Acceptance	2,94	1,51	0	6	0,05
	A sense of humour	2,48	1,40	0	6	0,23
	A turn towards religion	2,25	1,55	0	6	0,17
Speed	Perseverance and determination	13,78	3,23	0	20	-0,98
	Openness to new experiences	14,21	3,20	0	20	-1,11
	Competence in dealing with negative emotions.	13,69	3,18	0	20	-0,84
	Tolerance of failure	14,01	3,37	0	20	-0,99
	Optimistic attitude to life	13,66	3,32	0	20	-0,72
Positive orientation	Positive orientation	29,00	4,38	10	40	-0,70

Annotations: *M* - average, *SD* - standard deviation, *Min* - minimum value, *Max* - maximum value.

With regard to coping with stress, most of the respondents achieved close to average results. The minority included people with results below average (more than one standard deviation below average) and higher than average (more than one standard deviation above average). Detailed figures for each group are presented in Table 22.

Table 22

Dealing with stress – results obtained

	ARS		B		PW		ZU		A		PH		ZKR	
	n	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%
Below average	80	17	96	20	58	12	86	18	87	18	115	24	86	18
Average	309	65	297	63	310	66	306	65	312	66	257	55	286	61
Above average	83	18	79	17	104	22	80	17	73	16	100	21	100	21

Annotations: n - number, % - percentage of results
ARS - active coping, B - helplessness, PW - seeking support, ZU - evasive behaviour, A - acceptance, PH - sense of humour, ZKR - turn to religion

Concerning the measurement of ego resiliency, most of the subjects obtained results close to the average. In the minority were people with results lower than average (by more than one standard deviation below average) and higher than average (by more than one standard deviation above average). Detailed figures for each group are presented in Table 23.

Table 23

Ego's resiliency – results obtained

	WD		OND		KRS		TN		ONŻ	
	n	%	*n*	%	*n*	%	*n*	%	*n*	%
Below average	75	16	83	18	80	17	69	15	84	18
Average	357	76	338	73	306	65	352	74	297	63
Above average	40	8	51	11	86	18	51	11	91	19

Annotations: n - number, % - percentage of results
WD - perseverance and determination, OND - optimistic about new experiences, KRS - competence in dealing with negative emotions, TN - tolerance to failure, ONŻ - optimistic attitude to life

As far as positive orientation is concerned, the majority of respondents received average results, as high as 73% (n = 343). In the minority were employees with below average (16%, n = 75) or above average results (11%, n = 54).

Statistically significant, but small differences were observed between the individual groups in most styles of dealing with stress - except for helplessness and sense of humour, where no differences were observed between the groups. There were also differences in the dimensions of ego resiliency and positive orientation. The results of the single-factor ANOVA analysis are presented in Table 24.

Table 24

Dealing with stress – differences between groups

		F	*df1*	*df2*	*p*
Stress management styles	Active coping	65,58	2	200,37	< 0,001
	Helplessness	1,17	2	181,66	0,311
	Seeking support	51,05	2	190,45	< 0,001
	Evasive behaviour	14,10	2	199,46	< 0,001
	Acceptance	52,06	2	199,20	< 0,001
	A sense of humour	1,56	2	195,78	0,213
	A turn towards religion	5,63	2	174,40	0,004
Resiliency of the ego	Perseverance and determination	15,96	2	180,82	< 0,001
	Openness to new experiences	6,69	2	187,00	0,002
	Competence in dealing with negative emotions.	10,73	2	189,76	< 0,001
	Tolerance of failure	8,14	2	184,01	< 0,001
	Optimistic attitude to life	22,97	2	201,22	< 0,001
Positive orientation	Positive orientation	4,51	2	178,72	0,012

Differences between groups in terms of stress management styles are shown in Figure 11. Acceptance, seeking support, and active coping as stress management styles were the strongest in groups 2 and 3 and the weakest in group 1. German and Slovak workers were more likely to use support strategies and task-based approaches to dealing with stress compared to Polish respondents. Group 1, on the other hand, was more likely to use religion-focused styles in dealing with stress than others. Such coping strategy was the least frequently used by group 2 - Slovakian. This is due to the predominance of Roman

Catholics in Poland. For many of the respondents, referring to their religion is the most effective strategy for dealing with stress in comparison with more secularised Slovak society.

Group 3 - the German group used evasive behaviour more often than the others in situations of severe stress. In psychology, avoidance strategies are described as less effective in the long term compared to a more monitoring approach to solving stressful situations. Avoidance merely postpones the moment of confronting the source of stress without minimising this experience.

The described differences between the test subjects are shown in the figure below.

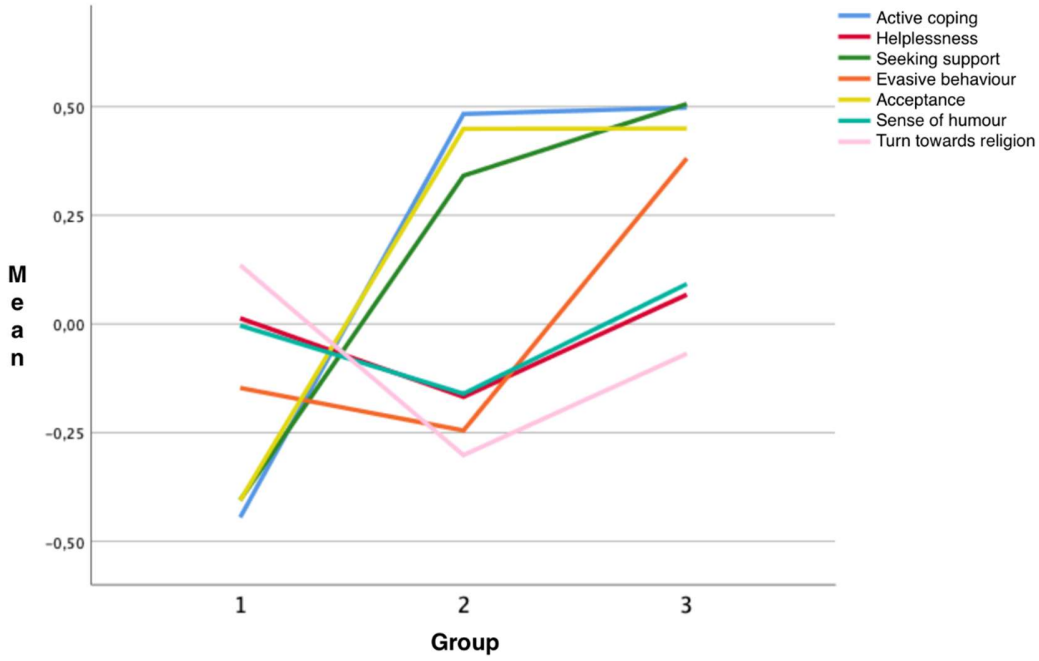

Fig. 11. Differences in styles of coping with stress between the workers surveyed
Rys. 11. Różnice w stylach radzenia sobie ze stresem między badanymi pracownikami

The differences between the studied groups in terms of the resiliency of the ego are presented in Figure 12. The subjects from groups 1 and 2 were characterised by a similar level of ego resiliency in terms of all its components, higher than group 3. Polish and Slovak workers were characterised by a higher level of perseverance and determination, openness to experience, personal competence to cope with difficulties, tolerance to failure and an optimistic approach to life in comparison to those surveyed from German industrial plants.

According to the authors of the conceptualisation of this psychological construct (Block, Block, 1980, 1996), the ego's resiliency is a resource that defines the specific

resistance of an individual. Individuals characterised by ego resiliency are able to adapt in an adequate, consistent and persistent way to changing living conditions, both through the appropriate tuning of their own abilities and skills, and the appropriate use of factors in their environment. The opposite is true for people with a so-called "fragile personality", for whom a low threshold of frustration is characteristic. Such people react to new situations with rigidity and anxiety. This resiliency is related to the experience of positive emotions, which positively influences the assessment of stressful situations (in terms of a challenge), as well as the choice of more effective and situation-specific coping strategies. Furthermore, it is important for the health of the individual, especially his or her mental dimension. In the long term, the resiliency of the ego is therefore a determinant of an individual's mental well-being.

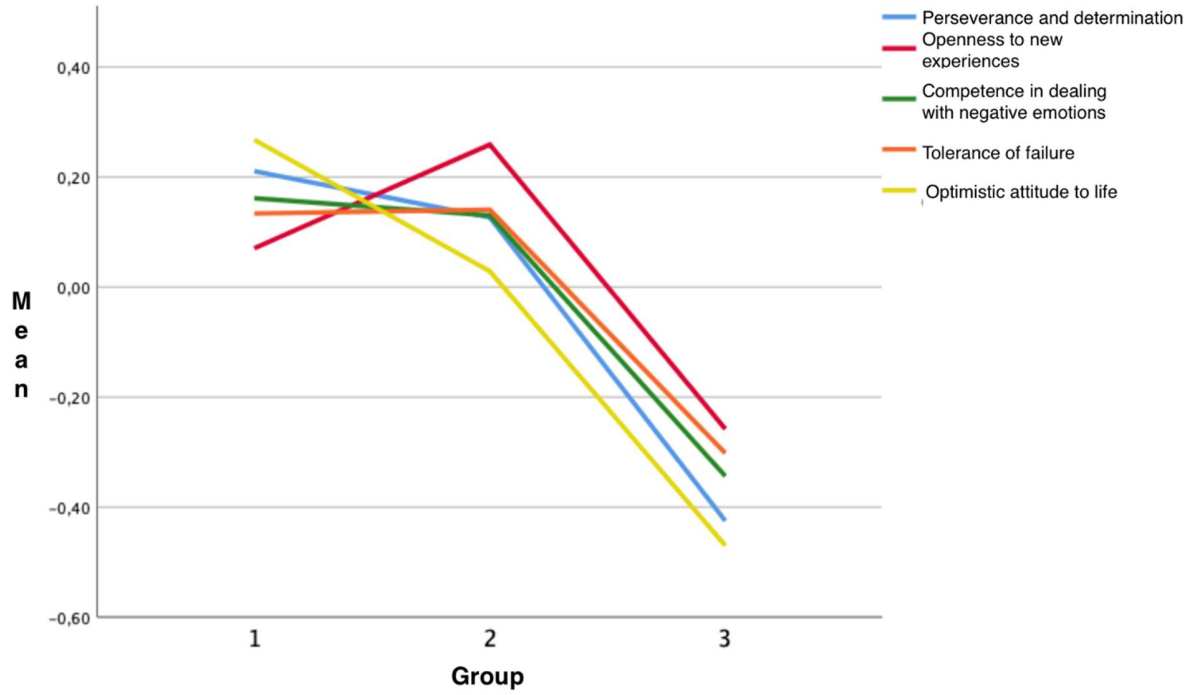

Fig. 12. Differences in ego resiliency between study groups
Rys. 12. Różnice w odporności ego między grupami badawczymi

Further differences between the groups in terms of resources: positive orientation is shown in Figure 13. The highest level of positive orientation was characteristic of employees from group 2, while employees from group 3 were characterised by the lowest level of positive orientation. The obtained result refers to the differences in the level of ego resiliency of the respondents. Also in the case of the resource of positive orientation, the

German respondents obtained slightly lower results. The highest level of positive orientation was shown by employees of Slovak companies. This feature is a predictor of specific life hope, optimism, and conviction of possessed resources to cope with difficult situations. In the context of experienced professional stress, it is precisely these personal resources - i.e. ego resiliency and positive orientation that should be strengthened in the group where employees declared their lowest level - i.e. in the German group.

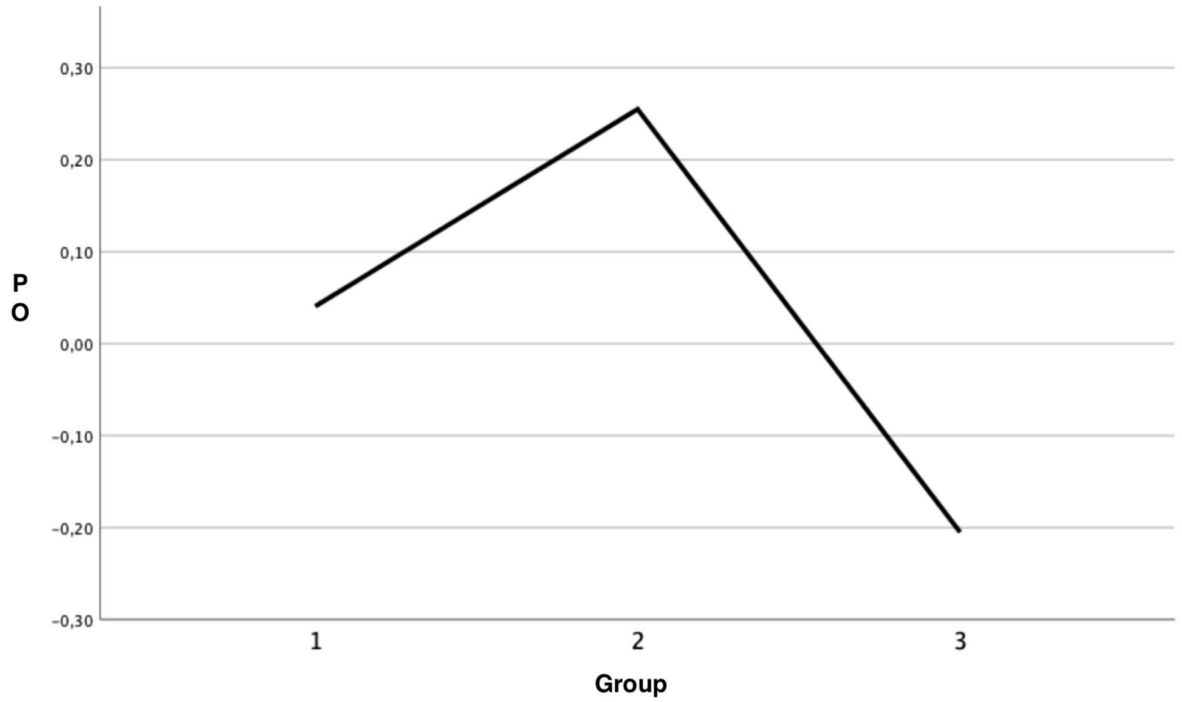

Fig. 13. Differences in positive orientation between study groups
Rys. 13. Różnice w orientacji pozytywnej między grupami badawczymi

3.3.7. Relationship between age, seniority, and attitudes towards safety among industrial workers 4.0[74]

The relationship between age, seniority, and attitude to safety was checked using Pearson's linear correlation coefficient *r.* The results of the analysis are presented in Table 25.

[74] Due to numerous data gaps, only 224 results for correlation with age and 97 and 58 results for correlation with length of service in general and length of service in the current position were included in the analyses taking into account the links between demographic variables.

Table 25

Relationships between age and seniority and attitudes towards security − Pearson's *r* correlation analysis

		1	2	3	4	5	6	7
1	Age	—						
2	Seniority	0,84***	—					
3	Seniority in the current position	0,63***	0,66***	—				
4	Cognitive component	0,11	-0,02	-0,26*	—			
5	The affective component	-0,02	-0,19	-0,27*	0,65***	—		
6	Behavioural component	0,11	-0,01	-0,30*	0,76***	0,68***	—	
7	General attitude	0,08	-0,08	-0,31*	0,92	0,84	0,91	—

* $p < 0,05$; ** $p < 0,01$; *** $p < 0,001$

There was a statistically significant, but weak and negative correlation between seniority at the current position and the following components of the attitude towards safety: cognitive ($r = -0.26$; $p = 0.045$), affective ($r = -0.27$; $p = 0.042$), behavioural ($r = -0.30$; $p = 0.024$) and general attitude towards safety ($r = -0.31$; $p = 0.019$). This means that people with higher seniority in their current position have a lower performance in terms of the components of the attitude towards safety and have a lower intensity of this attitude.

This result seems extremely interesting and raises further research questions. It suggests that the higher the level of experience in a given position, the weaker the openness of employees in Industry 4.0 and the conviction as to how to observe safety rules. The attitude of employees to taking care of safety at work is less positive, or even less important for employees. This may mean that with increasing experience of knowledge of the workplace, technology, equipment, and human resources, the feeling of threat resulting from ignorance of working conditions decreases.

The other relationships (except for the interrelationship between the steels of the safety attitude measurement tool) were statistically insignificant.

3.3.8. Relationship between age, seniority, and sense of threat

The relationship between age, length of service, and sense of threat was checked using Pearson's linear correlation coefficient *r*. The results of the analysis are presented in Table 26.

Table 26

Relationships between age and length of service and sense of threat - Pearson's *r* correlation analysis

		1	2	3	4	5	6	7
1	Age	—						
2	Seniority	0,84***	—					
3	Seniority in the current position	0,63***	0,66***	—				
4	Potential risks	-0,02	0,15	0,40**	—			
5	Current risks	0,16*	0,12	0,30*	0,74***	—		
6	Avoidance of danger	0,14*	0,06	0,26*	0,52***	0,50***	—	
7	General feeling of threat	0,05	0,14	0,39**	0,98***	0,85***	0,63***	—

* $p < 0,05$; ** $p < 0,01$; *** $p < 0,001$

A statistically significant, weak, and positive correlation was observed between the age of subjects and the current sense of threat ($r = 0.16$; $p = 0.016$), and risk avoidance ($r = 0.14$; $p = 0.031$). This means that older people have more often declared a higher level of concern about current risks in the workplace and have also been more likely to avoid risky situations. Perhaps older workers - more experienced in their jobs and lives - have a higher awareness of potential risks and are more concerned about their own safety.

There was also a statistically significant, moderate, and positive correlation between seniority in the current position and concerns about potential risk ($r = 0.40$; $p = 0.002$), as well as current risk ($r = 0.30$; $p = 0.023$) and overall risk ($r = 0.39$; $p = 0.002$). Also, statistically significant was the weak positive relationship between seniority in the current position and risk avoidance ($r = 0.26$; $p = 0.049$). This means that people with higher seniority in their current position were more likely to declare a higher level of fear of potential current risks and a stronger propensity to avoid risks, and a higher level of feeling of risk in general. Despite this, previous results suggest that experience in the workplace

does not reinforce attitudes towards safety, despite experiencing real and current risks in the workplace.

The results obtained, despite their correlative nature, are extremely important from the perspective of the management of the companies. Particularly in the areas of the latest technologies and Industry 4.0, concern for creating an attitude of care for work safety becomes very important.

The other correlations (except for the interrelations between the steels of the tool for measuring the sense of threat) were statistically insignificant.

3.3.9. Relationship between age, seniority, and the sense of stress among tested employees

The relationships between age, seniority, and stress were checked using Pearson's linear correlation coefficient *r*. The results of the analysis are presented in Table 27.

Table 27

Relationships between age and length of service and feeling of stress - Pearson's *r* correlation analysis

		1	2	3	4	5	6	7
1	Age	—						
2	Seniority	0,84***	—					
3	Seniority in the current position	0,63***	0,66***	—				
4	Overall stress level	-0,30***	0,14	0,04	—			
5	Emotional	-0,28***	0,17	0,03	0,86***	—		
6	External	-0,26***	0,11	0,00	0,83***	0,58***	—	
7	Intrapsychic	-0,23***	0,10	0,08	0,86***	0,58***	0,61***	—

* $p < 0,05$; ** $p < 0,01$; *** $p < 0,001$

A statistically significant, weak and negative correlation was observed between the age of the subjects and stress components: emotional stress ($r = -0.28$; $p < 0.001$), external stress ($r = -0.26$; $p < 0.001$) and intrapsychic stress ($r = -0.23$; $p < 0.001$). There was also a weak and negative correlation between general sense of stress and age ($r = -0.30$; $p < 0.001$). This means that older people were more likely to declare lower levels of a general

feeling of stress and lower levels of its subcomponents: emotional, external, and intrapsychological stress. Life experience and the resulting so-called "life wisdom" seem to be an important remedy for the experience of stress, including in the workplace. These results are consistent with data from psychological literature (Ogińska-Bulik, Juczyński, 2011, 2014, Maslach, Leiter, 2008. 2012). The more stressful we are as people, the more resistant we become to stressful situations.

The other correlations (except for the interrelations between the steels of the tool for measuring the sense of threat) were statistically insignificant.

3.3.10. Relationship between age, length of service, and evaluation of areas of professional life

The relationship between age, lengh of service, and the assessment of areas of professional life was checked using Pearson's linear correlation coefficient *r.* The results of the analysis are presented in Table 28.

Table 28

Relationship between age, length of service, and assessment of areas of professional life - Pearson's *r* correlation analysis

		1	2	3	4	5	6	7	8	9
1	Age	—								
2	Seniority	0,84***	—							
3	Seniority in the current position	0,63***	0,66***	—						
4	Workload	0,13	-0,05	0,05	—					
5	Control	0,04	0,10	-0,02	0,08	—				
6	Awards	0,02	0,04	-0,15	0,11	0,37***	—			
7	Community	0,11	0,00	0,17	0,26***	0,43***	0,49***	—		

cont. table 28

8	A sense of justice	0,13	0,09	0,02	0,31***	0,33***	0,45***	0,49***	—	
9	Values	0,11	0,14	0,24	0,26***	0,38***	0,48***	0,55***	0,69***	—

* $p < 0,05$; ** $p < 0,01$; *** $p < 0,001$

The relationships (except for the interrelationship between the steels of the tool for measuring the sense of threat) were statistically insignificant.

The results obtained suggest that demographic variables such as age or length of service are irrelevant for the perception of important areas of organisational life, such as the burden of work, the way in which control is exercised, rewarding the effects of work, feeling of justice in the workplace, and matching the values of the organisation. Industry 4.0 employees do not perceive them differently due to demographic conditions.

3.3.11. Relationship between age, seniority, and subjective evaluation of bonds among tested employees

The relationship between age, seniority, and bond evaluation was checked using Pearson's linear correlation coefficient *r.* The results of the analysis are presented in Table 29.

Table 29

Relationships between age and seniority and evaluation of ties - Pearson's *r* correlation analysis

		1	2	3	4
1	Age	—			
2	Seniority	0,84***	—		
3	Seniority in the current position	0,63***	0,66***	—	
4	Evaluation of ties	0,24***	0,03	0,12	—

* $p < 0,05$; ** $p < 0,01$; *** $p < 0,001$

There was a statistically significant, weak, and positive correlation between the age of the subjects and subjective evaluation of bonds ($r = 0.24$; $p < 0.001$). This means that older people assessed the bonds in the workplace in a more positive way more often. This result requires further verification. Perhaps, as age increases, respondents pay more attention to the quality of cooperation and relationships in the workplace, which are important determinants of job satisfaction.

The other correlations (except for the interrelations between the steels of the tool for measuring the sense o threat) were statistically insignificant.

3.3.12. Relationship between age, seniority, and fitting for work in an organisation

The relationship between age, seniority, and work matching in the organisation was checked using Pearson's linear correlation coefficient *r*. The results of the analysis are presented in Table 30.

Table 30

Relationships between age and length of service and fitting for work - Pearson's *r* correlation analysis

		1	2	3	4	5	6	7
1	Age	—						
2	Seniority	0,84***	—					
3	Seniority in the current position	0,63***	0,66***	—				
4	Complementary fitting	0,21**	0,18	0,14	—			
5	Supplementary fitting	0,14*	0,06	0,06	0,87***	—		
6	Identification with the organisation	0,24***	0,24*	0,23	0,91***	0,83***	—	
7	Satisfaction with work	0,21**	0,14	0,23	0,74***	0,68***	0,81***	—

* $p < 0,05$; ** $p < 0,01$; *** $p < 0,001$

A statistically significant, weak and positive correlation was observed between the age of subjects and complementary fitting (r = 0.21; p = 0.002), identification with the organisation (r = 0.24; p < 0.001), supplementary fitting (r = 0.14; p = 0.037) and job satisfaction (r = 0.21; p = 0.001). This means that older people were more likely to perceive and assess themselves as a better fit for the organisation, both complementary and supplementary, declaring a higher level of identification with the organisation and being more satisfied with their work. Complementary fit is defined in the psychology of work and organisation as similarity in terms of objectives and values of the employee and organisation (Muchinsky, Monahan, 1987, Czarnota-Bojarska, 2012, 2014). It is often referred to as an adaptation to organisational culture. In turn, complementary matching is referred to as complementing each other in the characteristics of the employee and organisation. It therefore defines the scope of what an employee can contribute to the organisation, but also gain from cooperation.

There was also a statistically significant and positive correlation between overall seniority and identification with the organisation (r = 0.24; p = 0.019). This means that people with higher overall seniority declared a higher level of identification with the organisation in which they currently worked more often.

The other correlations (except for the interrelations between the steels of the tool for measuring the sense of threat) were statistically insignificant.

3.3.13. Personal predictors of general attitude of employees towards security

In order to check the relationships between the variables, a correlation analysis was carried out, calculating Pearson's linear correlation coefficients. The results of the analysis were presented in Table 31.

Table 31

Relationships between employees' personality traits and general attitudes towards security – Pearson's *r* correlation analysis

		1	2	3	4	5	6
1	Extroversion	—					
2	Ability to compromise	0,39***	—				
3	Conscientiousness	0,15**	0,37***	—			
4	Emotional stability	0,18***	0,10*	0,24***	—		
5	Intellect/Openness	0,26***	0,37***	0,13**	0,24***	—	
6	General attitude towards security	-0,02	-0,18***	-0,16***	-0,06	-0,16***	—

* $p < 0,05$; ** $p < 0,01$; *** $p < 0,001$

There was a statistically significant, weak, and negative relationship between general attitude towards safety and amicability ($r = -0.18$; $p < 0.001$), conscientiousness ($r = -0.16$; $p < 0.001$), and intellect/openness ($r = -0.16$; $p < 0.001$). This means that subjects with a higher level of agreeableness, conscientiousness, and intellect/openness were characterised by a weaker, i.e. less positive overall attitude towards safety. This is an interesting result, especially in the context of its practical application to build a culture of safety in the organisation.

A regression analysis was then carried out in order to determine which of the variables allow predicting the general attitude towards safety. The results of the analysis are presented in Table 32.

Table 32

Personal predictors of the general attitude towards security – regression analysis

	Predictors				Model assessment	
	β	*SE*	*t*	*p*	*R2*	*F*
Extroversion	0,08	0,22	1,60	0,110	0,05	5,78***
Ability to compromise	-0,13	0,25	-2,33	0,020		
Conscientiousness	-0,11	0,25	-2,25	0,025		
Emotional stability	-0,01	0,27	-0,11	0,914		
Intellect/Openness	-0,12	0,27	-2,32	0,021		

Note: The table shows the values of standardised regression directional coefficients and corrected values of the determination factor.
* $p < 0,05$; ** $p < 0,01$; *** $p < 0,001$

Regression analysis showed that personality variables allow to predict a 5% variance in the general attitude towards safety: $R2 = 0.05$; F (5, 466) = 5.78; $p < 0.001$. In this model, the important predictors of the attitude towards safety were amicability (β = - 0.13; $SE = 0.25$; $t = - 2.33$; $p = 0.020$), conscientiousness (β = - 0.11; $SE = 0.25$; $t = - 2.25$; $p = 0,025$), and intellect/value (β = - 0,12; $SE = 0,27$; $t = - 2,32$; $p = 0,021$), the high level of which allowed for a more negative, cautious, and reluctant attitude towards safety.

This is a very surprising result, as it shows that people who are more predisposed to collaborative behaviours, to abide by the rules, to keep to the agreed arrangements, and to have a strong sense of internal control present a more reluctant attitude towards safety at work. This result requires further confirmation. Perhaps the high rates of conscientiousness and amicability are in themselves a guarantee of compliance with the accepted principles and conditions of cooperation.

3.3.14. Personal predispositions for a sense of stress among industrial workers 4.0

In order to check the relationships between the variables, a correlation analysis was carried out, calculating Pearson's linear correlation coefficients. The results of the analysis are presented in Table 33.

Table 33

Relationships between personality traits and general sense of stress among respondents - Pearson's *r* correlation analysis

	1	2	3	4	5	6
1 Extroversion	—					
2 Ability to compromise	0,39***	—				
3 Conscientiousness	0,15**	0,37***	—			
4 Emotional stability	0,18***	0,10*	0,24***	—		
5 Intellect/Openness	0,26***	0,37***	0,13**	0,24***	—	
6 General sense of stress	-0,12**	-0,11*	-0,23***	-0,29***	-0,04	—

* $p < 0,05$; ** $p < 0,01$; *** $p < 0,001$

There was a statistically significant, weak, and negative relationship between general sense of stress and extraversion ($r = -0.12$; $p = 0.008$), amicability ($r = -0.11$; $p = 0.022$), conscientiousness ($r = -0.23$; $p < 0.001$), and intellect/openness ($r = -0.29$; $p < 0.001$). This means that subjects with higher levels of extraversion, amicability, conscientiousness, and intellect/openness declared lower levels of stress. These results are consistent with previous research results in the area of relationships between personality traits and psychological stress (Lazarus, Folkman, 1980, 1990, Ogińska-Bulik, 2010, 2014).

A regression analysis was then carried out to determine which of the variables allow predicting overall stress levels. The results are presented in Table 34.

Table 34

Personal predictors of general feeling of stress among respondents – regression analysis

	Predictors				Model assessment	
	β	*SE*	*t*	*p*	*R2*	*F*
Extroversion	-0,06	0,21	-1,31	0,191	0,11	12,21***
Ability to compromise	-0,02	0,23	-0,43	0,671		

cont. table 34

Conscientiousness	-0,16	0,23	-3,28	0,001
Emotional stability	-0,25	0,25	-5,43	< 0,001
Intellect/Openness	0,07	0,25	1,39	0,165

Note: The table shows the values of standardised regression directional coefficients and corrected values of the determination factor.
* $p < 0,05$; ** $p < 0,01$; *** $p < 0,001$

The regression analysis showed that personality variables allow to predict the variance in terms of a general sense of stress of 11%: $R2 = 0.11$; F (5, 466) = 12.21; $p < 0.001$. In this model, conscientiousness (β = - 0.16; SE = 0.23; t = - 3.28; p = 0.001), and emotional stability (β = - 0.25; SE = 0.25; t = - 5.43; p < 0.001) were important predictors of stressfulness (β = - 0.16; SE = 0.23; t = - 3.28; p = 0.001), and its high level allowed them to predict a lower sense of stress. These results show that people who are particularly conscientious, orderly, well-organised, goal-oriented and have a high level of emotional stability – are calm and confident - are better able to cope with difficult situations because they experience a lower sense of stress. Structure: "emotional stability" understood by psychologists as a low level of neuroticism is identified in psychology with greater potential for health and psychological well-being.

3.3.15. Personal predictors of a sense of threat among industrial workers 4.0

In order to check the relationships between the variables, a correlation analysis was carried out, calculating Pearson's linear correlation coefficients. The results of the analysis are presented in Table 35.

Table 35

Relationships between personality traits and the general sense of threat among employees – Pearson's *r* correlation analysis

	1	2	3	4	5	6
1 Extroversion	—					
2 Ability to compromise	0,39***	—				

cont. table 35

3	Conscientiousness	0,15**	0,37***	—			
4	Emotional stability	0,18***	0,10*	0,24***	—		
5	Intellect/Openness	0,26***	0,37***	0,13**	0,24***	—	
6	General feeling of threat	-0,03	-0,14**	-0,17***	-0,17***	-0,11*	—

* $p < 0,05$; ** $p < 0,01$; *** $p < 0,001$

There was a statistically significant, weak, and negative relationship between general sense of threat and amicability (r = - 0.14; p = 0.002), emotional stability (r = - 0.17; $p < 0.001$), conscientiousness (r = - 0.23; p < 0.001), and intellect/openness (r = - *0*.11; p = 0.014). This means that respondents with a higher level of agreeableness, emotional stability, conscientiousness, and intellect/openness declared a lower level of sense of threat.

A regression analysis was then carried out in order to determine which of the variables allow predicting the overall level of risk. The results of the analysis are presented in Table 36.

Table 36

Personal predictors of general feeling of threat – regression analysis

	Predictors				Model assessment	
	β	*SE*	*t*	*p*	*R2*	*F*
Extroversion	0,05	0,55	1,10	0,271	0,05	5,78***
Ability to compromise	-0,09	0,61	-1,71	0,089		
Conscientiousness	-0,11	0,61	-2,22	0,027		
Emotional stability	-0,13	0,66	-2,75	0,006		
Intellect/Openness	-0,05	0,65	-0,95	0,340		

Note: The table shows the values of standardised regression directional coefficients and corrected values of the determination factor.

* $p < 0,05$; ** $p < 0,01$; *** $p < 0,001$

Regression analysis shows that personality variables allow for a 5% variance in the overall sense of threat: *R2* = 0.05; *F* (5, 466) = 5.78; *p* < 0.001. In this model, conscientiousness (β = - 0.11; SE = 0.61; t = - 2.22; p = 0.027) and emotional stability (β = - 0.13; SE = 0.66; t = - 2.75; p = 0.006) were important predictors of the sense of threat, and its high level allowed to predict a lower sense of threat.

As with the experience of psychological stress, the key personality traits that minimise the feeling of threat at work are high emotional stability and conscientiousness. In this context, it is worth noting the competence profile of employees of industrial plants 4.0. In the case of personal activities aimed at minimising the feeling of stress and threat, it is important to be aware of what type of personality will deal more effectively with a stressful and difficult work environment. Individuals with a high level of conscientiousness and emotional stability will perform better under less certain and less predictable working conditions.

3.3.16. Stress management styles and feeling of stress among industrial workers 4.0

In order to check the relationships between the variables, a correlation analysis was carried out, calculating Pearson's linear correlation coefficients. The results of the analysis are presented in Table 37.

Table 37

Relationships between stress management styles and general feeling of stress − Pearson's *r* correlation analysis

		1	2	3	4	5	6	7	8
1	Active coping	—							
2	Helplessness	0,14**	—						
3	Seeking support	0,61***	0,17***	—					
4	Evasive behaviour	0,44***	0,51***	0,40***	—				

cont. table 37

5	Acceptance	0,52***	0,15***	0,44***	0,31***	—			
6	A sense of humour	0,19***	0,40***	0,18***	0,28***	0,20***	—		
7	A turn towards religion	0,09	0,36***	0,13**	0,27***	0,07	0,27***	—	
8	General sense of stress	0,04	0,36***	0,05	0,38***	0,12**	0,16***	0,19***	—

* $p < 0,05$; ** $p < 0,01$; *** $p < 0,001$

There was a statistically significant, moderate, and positive relationship between general feeling of stress and helplessness ($r = 0.36$; $p < 0.001$) and evasive behaviour ($r = 0.38$; $p < 0.001$). At the same time, statistically significant were the weak, positive relations between sense of stress and acceptance ($r = 0.12$; $p = 0.007$), sense of humour ($r = 0.16$; $p < 0.001$), and a turn towards religion ($r = 0.19$; $p < 0.001$). This means that respondents who are more likely to use these stress management strategies experienced higher levels of stress.

A regression analysis was then carried out to determine which of the variables allow predicting overall stress levels. The results are presented in Table 38.

Table 38

Stress management styles as predictors of general feeling of stress – regression analysis

	Predictors				Model assessment	
	β	*SE*	*t*	*p*	*R2*	*F*
Active coping	-0,15	0,17	-2,56	0,011	0,20	17,69***
Helplessness	0,19	0,17	3,70	< 0,001		
Seeking support	-0,07	0,23	-1,34	0,181		
Evasive behaviour	0,34	0,18	6,32	< 0,001		
Acceptance	0,10	0,36	1,97	0,049		
A sense of humour	0,00	0,36	-0,10	0,919		
A turn towards religion	0,04	0,32	0,94	0,350		

Note: The table shows the values of standardised regression directional coefficients and corrected values of the determination factor.

* $p < 0,05$; ** $p < 0,01$; *** $p < 0,001$

The regression analysis showed that coping styles allow predicting a 20% variance in the general sense of stress: $R2 = 0.20$; $F\ (7, 464) = 17.69$; $p < 0.001$. In this model, helplessness ($\beta = 0.19$; $SE = 0.17$; $t = 3.70$; $p < 0.001$), evasive behaviour ($\beta = 0.34$; $SE = 0.18$; $t = 6.32$; $p < 0.001$), and acceptance ($\beta = 0.10$; $SE = 0.36$; $t = 1.97$; $p = 0.049$) were important predictors of the sense of stress. These results show that using evasive coping strategies as well as demonstrating helplessness or acceptance may generate higher psychological costs among the surveyed employees (Carver, 1999, Ogińska-Bulik, Juczyński, 2014).

This is because both demonstrating helplessness, avoiding the source of stress and accepting emotionally charged stimuli are linked to a lack of active action and monitoring of the causes of stress. Thus, a kind of passivity resulting from these strategies generates additional emotional burdens, and additionally does not resolve the causes of a difficult situation.

3.3.17. Styles of dealing with stress and feeling of threat among industrial workers

In order to check the relationships between the variables, a correlation analysis was carried out, calculating Pearson's linear correlation coefficients. The results of the analysis are presented in Table 39.

Table 39

Relationships between stress management styles and general sense of threat - Pearson's *r* correlation analysis

		1	2	3	4	5	6	7	8
1	Active coping	—							
2	Helplessness	0,14**	—						
3	Seeking support	0,61***	0,17***	—					
4	Evasive behaviour	0,44***	0,51***	0,40***	—				
5	Acceptance	0,52***	0,15***	0,44***	0,31***	—			

cont. table 39

6	A sense of humour	0,19***	0,40***	0,18***	0,28***	0,20***	—		
7	A turn towards religion	0,09	0,36***	0,13**	0,27***	0,07	0,27***	—	
8	General feeling of threat	-0,04	0,34***	-0,05	0,14**	-0,06	0,11*	0,24***	—

* $p < 0,05$; ** $p < 0,01$; *** $p < 0,001$

There was a statistically significant, weak or moderate, and positive relationship between general sense of threat and helplessness ($r = 0.34$; $p < 0.001$), evasive behaviour ($r = 0.14$; $p = 0.002$), sense of humour ($r = 0.11$; $p = 0.015$), and a turn towards religion ($r = 0.24$; $p < 0.001$). This means that respondents using these stress management strategies felt a higher level of sense of threat more often.

A regression analysis was then carried out in order to determine which of the variables allow predicting the overall level of feeling of threat. The results of the analysis are presented in Table 40.

Table 40
Stress management styles as predictors of general feeling of threat – regression analysis

	Predictors				Model assessment	
	β	*SE*	*t*	*p*	*R2*	*F*
Active coping	0,00	0,46	0,02	0,983	0,16	12,21***
Helplessness	0,32	0,46	6,01	< 0,001		
Seeking support	-0,09	0,62	-1,56	0,119		
Evasive behaviour	0,01	0,48	0,11	0,909		
Acceptance	-0,08	0.95	-1,62	0,106		
A sense of humour	-0,03	0,96	-0,55	0,583		
A turn towards religion	0,15	0,84	3,23	0,001		

Note: The table shows the values of standardised regression directional coefficients and corrected values of the determination factor.
* $p < 0,05$; ** $p < 0,01$; *** $p < 0,001$

The regression analysis showed that stress management styles allow for a 16% variance in the overall sense of threat: $R2 = 0.16$; F (7, 464) = 12.21; $p < 0.001$. In this model, helplessness (β = 0.32; SE = 0.46; t = 6.01; p < 0.001) and a turn towards religion (β = 0.15; SE = 0.84; t = 3.23; p = 0.001) were important predictors of the sense of threat, whose high level allowed to predict a higher sense of threat.

As mentioned earlier, strategies aimed at withdrawing from an active resolution of a stressful situation (so-called Monitoring) generate higher emotional costs among the surveyed employees. Showing helplessness and turning to religion is an activity which minimises control and influence of an individual on stressful stimuli. As the results of statistical analysis indicate, the use of these strategies contributes to the feeling of a higher level of threat by employees of industrial plants.

3.3.18. Opinions about social world and feelings of danger at the workplace

In order to check the relationships between the variables, a correlation analysis was carried out, calculating Pearson's linear correlation coefficients. The results of the analysis are presented in Table 41.

Table 41

Relationship between opinions about the social world and general sense of threat – Pearson's *r* correlation analysis

		1	2	3	4	5
1	General feeling of threat	-				
2	Believing in a zero-sum game	0,15**	-			
3	Balance of social exchange	-0,04	0,11*	-		
4	Trust	-0,18***	-0,56***	0,21***	-	
5	Self-assessment	-0,22***	-0,49***	0,11*	0,66***	-

* $p < 0,05$; ** $p < 0,01$; *** $p < 0,001$

The analysis of the results showed that there is a statistically significant, weak, positive relationship between belief in a zero-sum game, and a general sense of threat ($r = 0.15$; $p = 0.002$). The belief that in life and society, the interests and profits of one group exclude the welfare of other people is linked to employees feeling a higher level of general risk.

Moreover, beliefs related to social trust were also statistically significant, weakly, and negatively connected with the general feeling of threat to the subjects ($r = - 0.18$; $p < 0.001$). People who declared a higher level of social trust (in other people, environment, etc.) were characterised by a lower general sense of threat.

The level of general self-assessment of the respondents was statistically significant, poorly, and negatively related to the general sense of threat ($r = - 0.22$; $p < 0.001$). Persons with lower self-esteem were characterised by a higher general sense of threat. This result is confirmed by numerous empirical studies conducted in the area of self-assessment. High and stable self-esteem guarantees greater comfort of life by minimising the sense of anxiety, stress, and danger (Rosenberg, 1989, Łaguna, Lachowicz-Tabczek, Dzwonkowska, 2007).

It was then checked whether the specific views on the social environment allow for the anticipation of a sense of danger in life and work. The results of the analysis are presented in Table 42.

Table 42
Opinions on the social world as predictors of the sense of threat – regression analysis

	Predictors				*Model*	
	β	*SE*	*t*	*p*	*R2*	*F*
Believing in a zero-sum game	0,03	2,46	0,58	0,561	0,05	6,56***
Balance of social exchange	-0,01	1,42	-0,17	0,866		
Trust	-0,05	3,57	-0,76	0,445		
Self-assessment	-0,17	2,43	-2,85	0,005		

Note: The table shows the values of standardised regression directional coefficients and corrected values of the determination factor.
* $p < 0,05$; ** $p < 0,01$; *** $p < 0,001$

The regression analysis indicated that opinions about the social world formulated by the respondents allow to predict a 5% variance in the general sense of threat: $R2 = 0,05$; $F(4, 471) = 6.56$; $p < 0.001$. In relation to the general sense of threat, only self-assessment was its statistically significant predictor: $\beta = -0.17$; $SE = 2.43$; $t = -2.85$; $p = 0.005$.

In order to strengthen comfort and psychophysical well-being, care should therefore be taken to strengthen and stabilise self-assessment, as a key element in preventing the feeling of danger.

3.3.19. Age, quality of bonds, personality traits of the respondents, and a sense of self-efficacy

In order to check the relationships between the variables, a correlation analysis was carried out, calculating Pearson's linear correlation coefficients. The results of the analysis are presented in Table 43.

Table 43
Relationships between age, quality of relationship and personality traits, and self-efficacy of industrial workers

		1	2	3	4	5	6	7
1	Age	-						
2	A sense of bonding	0,24***	-					
3	Self-efficacy	0,18**	0,23*	-				
4	Extroversion	0,13*	0,10*	0,15***	-			
5	Ability to compromise	0,16*	0,08	0,10*	0,39***	-		
6	Conscientiousness	0,19**	0,05	0,06	0,15**	0,37***	-	
7	Emotional stability	0,23***	0,04	0,11*	0,18***	0,10*	0,24***	-
8	Intellect/Openness	0,07	0,00	0,13**	0,26***	0,37***	0,13**	0,24***

* $p < 0,05$; ** $p < 0,01$; *** $p < 0,001$

The analysis showed a statistically significant, weak, and positive relationship between age and sense of bonding ($r = 0.24$; $p < 0.001$), sense of self-efficacy ($r = 0.18$; $p = 0.008$), extraversion ($r = 0.13$; $p = 0.048$), amicability ($r = 0.16$; $p = 0.015$), and emotional stability ($r = 0.23$; $p < 0.001$). The older respondents felt higher satisfaction with the quality of bonds in the workplace and also presented a higher level of self-efficacy, while also being more extravagant, amicable, and emotionally stable.

In addition, the quality of bonds was also poorly and positively linked to extraversion ($r = 0.10$; $p = 0.032$). Those who assessed the quality of interpersonal ties more positively had higher results in terms of extraversion. Thus, these results confirm that extroverts feel higher satisfaction with their interpersonal ties.

Self-efficacy, in turn, was statistically significant, weakly, and positively related to extraversion (r = 0.15; $p < 0.001$), amicability (r = 0.10; p = 0.023), emotional stability (r = 0.11; p = 0.021), and intellect/openness (r = 0.13; p = 0.006). Individuals with a higher level of self-efficacy were more extrovert, amicable, and emotionally stable, while having a higher level of intellect/openness.

A regression analysis was then carried out in order to determine which of the variables allow to predict a sense of self-efficacy. The results of the analysis are presented in Table 44.

Table 44

Age, sense of bond and personality traits as predictors of self-efficacy – regression analysis

	Predictors				*Model*	
	β	*SE*	*t*	*p*	*R2*	*F*
Age	0,11	0,03	1,60	0,112	0,12	5,31***
A sense of bonding	0,05	0,09	0,80	0,425		
Extroversion	0,04	0,12	0,64	0,523		
Ability to compromise	0,05	0,13	0,70	0,483		
Conscientiousness	0,09	0,13	1,24	0,215		
Emotional stability	0,05	0,14	0,68	0,494		
Conscientiousness	0,23***	0,15	3,46	< 0,001		

Note: the table shows the values of standardised regression directional coefficients corrected for the coefficient of determination.

* $p < 0,05$; ** $p < 0,01$; *** $p < 0,001$

The model explained the 12% variation in self-efficacy and was well suited to the data: $R2$ = 0.12; F (7, 216]) = 5.31; $p < 0.001$. In the obtained model, however, only conscientiousness was the significant predictor of self-efficacy: β = 0.23; SE = 0.15; t = 3.46; p < 0.001; other variables were statistically insignificant. From the

perspective of potential development activities in the organisation, it is worth remembering that people with a higher level of conscientiousness will also feel a higher level of self-efficacy. This may be related to the actual results of work that generate higher self-efficacy.

3.3.20. Positive orientation, ego resiliency, and depressive personality as predictors of a sense of threat among respondent employees

In order to check the relationships between the variables, a correlation analysis was carried out, calculating Pearson's linear correlation coefficients. The results of the analysis are presented in Table 45.

Table 45

Relationship between positive orientation, ego resiliency and depressive personality, and sense of threat – Pearson's *r* correlation analysis

		1	2	3	4	5	6	7	8	9
1	P1	—								
2	P2	0,77***	—							
3	P3	0,76***	0,78***	—						
4	P4	0,75***	0,79***	0,79***	—					
5	P5	0,77***	0,72***	0,78***	0,79***	—				
6	OP	0,36***	0,36***	0,31***	0,35***	0,36***	—			
7	OD1	0,31***	0,30***	0,28***	0,26***	0,31***	0,28***	—		

cont. table 45

8	OD2	0,31***	0,30***	0,29***	0,28***	0,33***	0,24***	0,78***	—	
9	PZ	-0,11*	-0,18***	-0,10*	-0,11*	-0,09	-0,29***	0,19***	0,10*	—

Note: Dimensions of ego resiliency: P1 - Perseverance and determination in action, P2 - Openness to new experiences and a sense of humour, P3 - Personal competence to cope and tolerance of negative emotions, P4 - Tolerance of failure and treating life as a challenge, P5 - Optimistic attitude to life and ability to mobilise in difficult situations. OP - Positive orientation. Dimensions of a depressive personality: OD1 - Negative emotionality, DS2 - Social inhibition. PZ - General feeling of threat.
* $p < 0,05$; ** $p < 0,01$; *** $p < 0,001$

The analysis showed a statistically significant, weak, and negative relationship between the general sense of threat and the dimensions of ego resiliency: persistence and determination (r = -0.11; p = 0.014), openness to new experiences (r = -0.18; $p < 0.001$), personal competence to deal with and tolerance to negative emotions (r = -0.10; p = 0.029), and tolerance to failure (r = - 0.11; p = 0.013). The respondents with high scores in these components of ego resiliency declared a lower general sense of danger.

In addition, the sense of threat was also poorly and negatively related to positive orientation (r = - 0.29; $p < 0.001$). Individuals with a higher level of positive orientation had a lower level of risk perception.

The sense of threat was also statistically significant, weakly, and positively related to the dimensions of depressive personality: negative emotionality (r = 0.19; $p < 0.001$), and social inhibition (r = 0.10; p = 0.024). People with higher levels of negative emotionality and social inhibition declared a higher level of danger.

A regression analysis was then carried out in order to determine which of the examined variables allow to predict the feeling of threat. The results of the analysis are presented in Table 46.

Table 46
Positive orientation, ego resiliency and depressive personality as predictors of a sense of threat – regression analysis

	Predictors				*Model*	
	β	*SE*	*t*	*p*	*R2*	*F*
Perseverance and determination	0,06	0,70	0,73	0,463	0,11	8,09***
Openness to new experiences	-0,22	0,72	-2,71	0,007		
Personal competence to deal with	0,04	0,75	0,44	0,657		
Tolerance of failure	0,02	0,72	0,19	0,849		
Optimistic attitude to life	0,11	0,70	1,28	0,201		
Positive orientation	-0,26	0,31	-5,41	< 0,001		
Negative emotionality	0,21	0,37	3,00	0,003		
Social restraint	0,12	0,40	1,76	0,079		

Note: the table shows the values of standardised regression directional coefficients corrected for the coefficient of determination.
* $p < 0,05$; ** $p < 0,01$; *** $p < 0,001$

The obtained model explained 11% of the variability in the sense of threat and was well matched to the data: $R2 = 0.11$; $F(8, 463) = 8.09$; $p < 0.001$. The important predictors of the sense of threat were openness to new experiences ($\beta = -0.22$; $SE = 0.72$; $t = -2.71$; $p = 0.007$), positive orientation ($\beta = -0.26$; $SE = 0.31$; $t = -5.41$; $p < 0.001$), and negative emotionality ($\beta = 0.21$; $SE = 0.37$; $t = 3.00$; $p = 0.003$). The low level of openness to new experiences and positive orientation and the high level of negative emotionality encouraged a sense of threat.

3.3.21. Positive orientation, ego resiliency, and depressive personality as predictors of a sense of stress among industrial workers 4.0

In order to check the relationships between the variables, a correlation analysis was carried out, calculating Pearson's linear correlation coefficients. The results of the analysis are presented in Table 47.

Table 47

Relationship between positive orientation, ego resiliency, depressive personality and sense of threat – Pearson's *r* correlation analysis

		1	2	3	4	5	6	7	8	9
1	P1	—								
2	P2	0,77***	—							
3	P3	0,76***	0,78***	—						
4	P4	0,75***	0,79***	0,79***	—					
5	P5	0,77***	0,72***	0,78***	0,79***	—				
6	OP	0,36***	0,36***	0,31***	0,35***	0,36***	—			
7	OD1	0,31***	0,30***	0,28***	0,26***	0,31***	0,28***	—		

cont. table 47

8	OD2	0,31***	0,30***	0,29***	0,28***	0,33***	0,24***	0,78***	—	
9	PS	-0,40***	-0,37***	-0,37***	-0,40***	-0,37***	-0,42***	0,31***	0,23***	—

Note: Resistance dimensions: P1 - Perseverance and determination in action, P2 - Openness to new experiences and a sense of humour, P3 - Personal competence to cope and tolerance of negative emotions, P4 - Tolerance of failure and treating life as a challenge, P5 - Optimistic attitude to life and the ability to mobilise in difficult situations. OP - Positive orientation. Dimensions of a depressive personality: OD1 - Negative emotionality, DS2 - Social inhibition. PS - General feeling of stress.
* $p < 0,05$; ** $p < 0,01$; *** $p < 0,001$

The analysis showed that there is a statistically significant, moderate, and negative relationship between the general sense of stress and the dimensions of ego resiliency: perseverance and determination (r = - 0.40; $p < 0.001$), openness to new experiences (r = - 0.37; p < 0.001), personal competence to cope and tolerance to negative emotions (r = - *0*.37; $p < 0.001$), tolerance to failure (r = - 0.40; p < 0.001), and an optimistic attitude to life (r = - *0*.37; p < 0.*001*). Those with high scores in these resiliency components declared a lower sense of stress.

In addition, the sense of stress was also associated with a moderate and negative relationship with positive orientation (r = - 0.42; $p < 0.001$). Persons with a higher level of positive orientation had lower stress-related results.

The sense of stress was also statistically significant, poorly, and positively related to the dimensions of depressive personality: negative emotionality (r = 0.31; $p < 0.001$), and social inhibition (r = 0.23; p < 0.001). People with higher levels of negative emotionality and social inhibition declared higher levels of stress.

A regression analysis was then carried out to determine which of the variables allow for predicting a sense of stress. The results are presented in Table 48.

Table 48

Positive orientation, resiliency and depressive personality as predictors of stress – regression analysis

Predictor	Predictors				*Model*	
	β	*SE*	*t*	*p*	*R2*	*F*
Persistence and determination	-0,13	0,25	-1,79	0,074	0,27	22,73 ***
Openness to new experiences	0,00	0,25	0,07	0,947		
Personal competence to deal with	-0,05	0,26	-0,61	0,543		
Tolerance of failure	-0,14	0,25	-1,83	0,069		
Optimistic attitude to life	0,01	0,25	0,09	0,928		
Positive orientation	-0,27	0,11	-6,16	< 0,001		
Negative emotionality	0,22	0,13	3,50	< 0,001		
Social restraint	0,10	0,14	1,51	0,132		

Note: the table shows the values of standardised regression directional coefficients corrected for the coefficient of determination.
* $p < 0,05$; ** $p < 0,01$; *** $p < 0,001$

The model obtained explained the 27% variation in the sense of stress and was well suited to the data: $R2 = 0.27$; $F(8, 463) = 22.73$; $p < 0.001$. The significant predictors of stress were positive orientation ($\beta = -0.27$; SE = 0.11; $t = -6.16$; $p < 0.001$) and negative emotionality ($\beta = 0.22$; SE = 0.13; $t = 3.50$; $p < 0.001$). A low level of positive orientation and a high level of negative emotionality favoured the feeling of higher psychological stress.

The presented studies mostly confirmed the results of empirical research in the field of personal resources, such as: positive orientation, ego resiliency, personality type D and their relation to psychological stress. The examined occupational group is specific. They are employees who have contact with the latest technologies and full automation in their work, while at the same time having very high responsibility for the work on which the efficiency and safety of airport operations depends. Therefore, the problem of the feeling of threat and

stress at work seems to be important for application reasons, but also because of the verification of the theoretical assumptions presented earlier, resulting from the research of other, often very different groups of respondents.

3.3.22. Positive orientation, ego resiliency, and depressive personality as predictors of the self-efficacy of industrial workers 4.0

In order to check the relationships between the variables, a correlation analysis was carried out, calculating Pearson's linear correlation coefficients. The results of the analysis are presented in Table 49.

Table 49

Relationship between positive orientation, resiliency and depressive personality, and self-efficacy – Pearson's *r* correlation analysis

		1	2	3	4	5	6	7	8	9
1	P1	—								
2	P2	0,77***	—							
3	P3	0,76***	0,78***	—						
4	P4	0,75***	0,79***	0,79***	—					
5	P5	0,77***	0,72***	0,78***	0,79***	—				
6	OP	0,36***	0,36***	0,31***	0,35***	0,36***	—			

cont. table 49

7	OD1	0,31***	0,30***	0,28***	0,26***	0,31***	0,28***	—		
8	OD2	0,31***	0,30***	0,29***	0,28***	0,33***	0,24***	0,78***	—	
9	PS	0,36***	0,39***	0,40***	0,39***	0,39***	0,25***	-0,36***	-0,38***	—

Note: Resistance dimensions: P1 - Perseverance and determination in action, P2 - Openness to new experiences and a sense of humour, P3 - Personal competence to cope and tolerance of negative emotions, P4 - Tolerance of failure and treating life as a challenge, P5 - Optimistic attitude to life and ability to mobilise in difficult situations. OP - Positive orientation. Dimensions of a depressive personality: OD1 - Negative emotionality, DS2 - Social inhibition. PS - Sense of self-effectiveness.
* $p < 0,05$; ** $p < 0,01$; *** $p < 0,001$

The analysis showed that there is a statistically significant, moderate, and positive relationship between the general sense of self-efficacy and the dimensions of resiliency: perseverance and determination ($r = 0.36$; $p < 0.001$), openness to new experiences ($r = 0.39$; $p < 0.001$), personal competence to cope and tolerance to negative emotions ($r = 0.40$; $p < 0.001$), tolerance to failure ($r = 0.39$; $p < 0.001$), and optimistic attitude to life ($r = 0.39$; $p < 0.001$). The subjects with high scores in these components of ego resiliency declared higher self-efficacy.

Additionally, the sense of self-efficacy was poorly and positively related to positive orientation ($r = 0.25$; $p < 0.001$). Individuals with a higher level of positive orientation had higher self-efficacy scores.

Self-efficacy was also statistically significant, poorly, and negatively related to the dimensions of depressive personality: negative emotionality ($r = - 0.36$; $p < 0.001$), and social inhibition ($r = - 0.38$; $p < 0.001$). Individuals with higher levels of negative emotionality and social inhibition declared lower levels of self-efficacy.

A regression analysis was then carried out in order to determine which of the variables allow to predict a sense of self-efficacy. The results of the analysis are presented in Table 50.

Table 50

Positive orientation, resiliency and depressive personality as predictors of self-efficacy – regression analysis

	Predictors				*Model*	
	β	*SE*	*t*	*p*	*R2*	*F*
Perseverance and determination	-0,03	0,10	-0,43	0,666	0,24	20,04 ***
Openness to new experiences	0,09	0,10	1,14	0,253		
Personal competence to deal with	0,13	0,11	1,61	0,108		
Tolerance of failure	0,10	0,10	1,27	0,205		
Optimistic attitude to life	0,06	0,10	0,74	0,457		
Positive orientation	0,06	0,04	1,45	0,147		
Negative emotionality	0,10	0,05	1,48	0,140		
Social restraint	-0,19	0,06	-2,96	0,003		

Note: the table shows the values of standardised regression directional coefficients corrected for the coefficient of determination.
* $p < 0,05$; ** $p < 0,01$; *** $p < 0,001$

The model explained the 24% variation in the sense of self-efficiency and was well suited to the data: $R2 = 0.24$; F (8, 463) = 20.04; $p < 0.001$. In this important predictor of self-efficacy was social inhibition (β = 0.19; SE = 0.06; t = 2.96; p = 0.003). Lower level of social inhibition encouraged a higher sense of self-efficacy.

According to research, employees who are full of optimism, hope and self-confidence, positively oriented towards social contacts are less often and significantly less afraid of real, but also potential threats in their environment, and thanks to this internal strength, they less often avoid difficult and dangerous situations. Similarly, they feel the negative consequences of emotional tension and experienced stressors less often. Features such as: perseverance and determination to act, openness to new experiences and a sense of humour, personal competence to cope and tolerance of negative emotions, tolerance to failure and treating life as a challenge, as well as an optimistic attitude to life and the ability to mobilise

in difficult situations significantly reduce the psychological stress and sense of threat. These results have been confirmed by numerous dependencies, previously proven in the literature.

This leads to the conclusion that to minimise the effects resulting from experiencing a state of 'danger' to the psyche of employees, it would be necessary to strengthen and develop their competences, which are part of the so-called mental resiliency. It is therefore recommended to develop people's determination to act, deal with emerging problems, tolerate frustration and failure. Social relations should be strengthened through greater openness to new experiences and learning a positive, hopeful attitude towards the future.

The presented research provided interesting results in the form of mutual relations between the examined psychological variables. Thanks to that, the specificity of social and psychological functioning of employees professionally connected with the area of technology 4.0 was learned in detail.

A higher level of emotional balance (lower level of neuroticism), conscientiousness, and amicability of employees in the sector is significantly associated with lower feelings of threat. Such a personality profile therefore seems to be particularly recommended in an industry where occupational risks are directly linked to health risks. Similar relationships have been shown in regards with the relationship between the level of extraversion and a generalised sense of stress.

Despite various controversies about the relationship between personal circumstances and the psychological costs of work experienced, research findings can be referred to which show that emotional balance, low psychoticism, and the internal location of control involve the choice of more assertive strategies and the handling of stress. Extroverts often choose intuitive strategies for dealing with stress and can thus harm others because they often act reflexively without analysing the consequences of their actions.

The feeling of insecurity among the group under examination is indeed linked to the following styles of dealing with stress: helplessness, seeking support, evasive behaviour, sense of humour, and a turn towards religion. Respondents from Industry 4.0. were active in these coping styles while experiencing a higher sense of threat. According to the authors of the diagnostic tool, these activities are not proactive in nature, on the contrary, they are an expression of avoidance strategies and those related to seeking support and focusing on emotions. Dealing with emotions can be effective, but rather in the short term. On the other hand, the lack of or "holding back" the expression of emotions is described as unconstructive coping.

Studies have also found links between the level of perceived stress and coping styles based on: helplessness, evasive behaviour, sense of humour, and a turn towards religion. What seems to be crucial in the context of these relationships is the intensification of

emotional and cognitive costs, in the forms of perceived stress and risk resulting from unconstructive activities, generating additional psychological losses. The sense of humour in the conceptualisation of Scheier and Carver (1989) is treated as a substitute action, enabling distraction from the stressor and the source of danger, but not necessarily relieving the level of arousal permanently. According to the authors, any strategy that does not have the character of an active, confrontational "dealing with" with the source of stress in the long term proves less effective in the context of coping with stress. The "turn to religion" factor seems to be controversial, which in the light of Costa and McCrae's research is described as an important strategy for dealing with psychological tension. It is described as a strategy for seeking emotional support, which can, however, have a significant impact on positive over-valuation and development, and also express an active form of coping. It turns out that it is precisely evasive behaviour, i.e. avoiding a source of stress, withdrawing from confrontation and monitoring the source of stress, as well as presenting an attitude of helplessness that contributes to deepening the stress experience.

Similarly, feeling threatened intensifies the feeling of stress. These results are not surprising in the context of years of research experience in the field of health psychology. It is well known that the application of more active counter-measures involves a higher sense of self-esteem and effectiveness, and the internal location of control. According to Schwarzer and Taubert (2002) as well as Aspinwall and Taylor (1997), only proactive coping, linked to the challenges and by pooling resources facilitates effective stress management. According to the research, this activity makes it possible to deal with future events, identify potential stressors, initiate their assessment, make efforts and receive feedback on the activity undertaken. Some authors believe that it is proactive coping that is the resource of a creative lifestyle.

In the context of strengthening personal resources of workers in the sector and constructing preventive measures to minimise the risk of experiencing chronic occupational stress and burn-out, it would therefore be appropriate to focus on skills relating to monitoring stressors and strengthening proactive attitudes to difficult and threatening situations. Any training in soft skills related to strengthening mental resiliency by developing attention and awareness of one's own emotional states and willingness to confront unpleasant and difficult cognitive content would therefore be recommended, as well as training and support in behavioural and cognitive techniques, the regular use of which helps to develop greater agility and a sense of control in the face of difficult situations.

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RESEARCH AND ANALYSIS OF WORKING CONDITIONS IN INDUSTRIAL OCCUPATIONS

Abstract

The results of the Industry 4.0 study presented in this monograph highlight the importance of personal resources in reducing psychological emotional costs, such as stress and threat to employees of organisations in the digital transition process. Research on such deep, but also sensitive psychological variables in such a specific sector of the economy has many limitations. Certainly, the variables presented cannot be researched in any form other than a questionnaire. Quantitative surveys addressed to a large number of respondents have their weaknesses in the form of averaging their statements by the respondents, a greater tendency to self-presentation by being the so-called 'good respondent' or less attentive to answering questions in a large number of applied research methods. Due to the inequality of the surveyed employees of Polish, Slovak and German companies, it is not possible to generalize the presented research results. The comparison of working conditions, safety standards and the scope of tasks and responsibilities was for the authors of the monograph an assumption of a similar character of work in the three studied countries. However, special attention should be paid to the cultural aspect of international research. What seems to have a significant impact on the psychological variables studied is certainly the national and organisational culture.

The results obtained provide valuable, yet simple and clear application guidelines that can be used for the development of employees, both from Polish and foreign companies representing Industry 4.0.

An important limitation of the survey was its questionnaire character. Such methods provide limited data. However, in the case of reaching a larger group of employees in such a difficult and rather "closed" sector, the authors of the study did not find a more effective research method. The authors' scientific interests relate to attitudes, behaviour and relations between employees and the professional environment in the broadly understood context of work 4.0, and therefore especially in the sectors of the latest technologies, automation and Industry 4.0. Further directions of research have already

begun to concern the adaptation of research tools to this very specific sector, through particular focus on the nature of work in the environment of the latest technologies and the challenges associated with them.

This book tries to combine in a systemic way all the different facets of the same issue: Industry 4.0. The contribution of this monography is mainly conceptual to others. As a first topics, there is a review of the diverse origins in the increasing rate of evolution for these disruptive digital technologies. The rate of evolution is very high in terms of the appearance of new software, algorithms, and devices. For a wider framework of analysis, a brief history until arriving at the Industry 4.0 is included, as well as a non-technical description of ICT technologies. It is observed that the heart of this Fourth Industrial Revolution is a harmonious and flexible combination of several ICT.

Then, the discussion is centred on the pervasive character of Industry 4.0, analysing in specific its possible effect on the economic and social levels. The digital economy is described, including the particular form of digital "platformisation" of the economy. The pandemic that is embracing all over the world, is pushing virtual and digitalised forms in the forefront for almost every country, accelerating the structural change based on digital platforms. The analysis considered the digital economic change for customers, suppliers, producers and value chains, with projections for a national economy as a whole, and brief comments for the international trade and global economy.

On the other hand, the study also focused on the traditional impacts of industrial revolutions, as the new sources of productivity introduced by Industry 4.0, the incorporation of new sources of energy and efficiency, and finally the impacts on the working processes, the so called "Work 4.0". The core for productivity increases is the collaboration at organisational level, using ubiquitous data and its integration/exploitation as the new approach, which in turn is fed by these four basic factors. Other sources of productivity that are closely connected to these four factors, in a kind of concentric circle. They are radically shorter product development processes, virtual engineering of complete value chains, revolutionary short value chains, and better performing than engineered (Herčko et al., 2015: 5).

When ICTs and Internet are applied to energy production infrastructure, it gives rise to the Internet of Energy (IoE). ICT technologies can bring some solutions to energy management but at the same time they are big energy consumers. It is calculated that Internet will consume up to 21% of global electricity consumption by 2030.

Similar to discussions on the industrialisation process, the digital transformation polarizes opinions on the problems and impacts on Work 4.0. For the moment, there is a lack of data on the consequences of the ICTs for society in general and on the work in particular. We are "blindly flying". The focus of the analysis was put on four specific issues: the changing nature of work, the expected impacts of the digitisation process on

human labour, the competences the workers require for coping with Industry 4.0, and last, the interesting issues of ghost workers and crowdworkers

Finally, we explore the meanings of changes in the organisational decision making process. Decisions in any context were until recently a human process involving from the most simple, mechanical, and irrelevant choices, to important and crucial ones. AI, big data analytics, and smart devices will affect not just the productivity issues with better decisions, but also the learning process at the individual and group level, the addresses and models for organisational change, the working process, and the relationships among people and society. A brief discussion on trans-human modes of life closes the book.

BADANIA I ANALIZY WARUNKÓW PRACY ZAWODÓW PRZEMYSŁOWYCH

Streszczenie

Przedstawione w niniejszej monografii wyniki badań nad Przemysłem 4.0 podkreślają znaczenie zasobów osobistych w redukcji psychologicznych kosztów emocjonalnych, takich jak stres i zagrożenie dla pracowników organizacji w procesie transformacji cyfrowej. Badania nad tak głębokimi, ale i wrażliwymi zmiennymi psychologicznymi w tak specyficznym sektorze gospodarki mają wiele ograniczeń. Z pewnością przedstawione zmienne nie mogą być badane w innej formie niż kwestionariuszowa. Badania ilościowe skierowane do dużej liczby respondentów mają swoje słabe strony w postaci uśredniania wypowiedzi przez respondentów, większej skłonności do autoprezentacji poprzez bycie tzw. „dobrym respondentem" czy mniejszej uważności w udzielaniu odpowiedzi na pytania w dużej liczbie stosowanych metod badawczych. Ze względu na nierówność badanych pracowników firm polskich, słowackich i niemieckich nie jest możliwe uogólnienie prezentowanych wyników badań. Porównanie warunków pracy, standardów bezpieczeństwa oraz zakresu zadań i odpowiedzialności było dla autorów monografii założeniem o podobnym charakterze pracy w trzech badanych krajach. Należy jednak zwrócić szczególną uwagę na kulturowy aspekt badań międzynarodowych. To, co wydaje się mieć istotny wpływ na badane zmienne psychologiczne, to z pewnością kultura narodowa i organizacyjna.

Uzyskane wyniki stanowią cenne, a zarazem proste i czytelne wskazówki aplikacyjne, które mogą być wykorzystane w rozwoju pracowników, zarówno z polskich jak i zagranicznych firm reprezentujących Przemysł 4.0.

Istotnym ograniczeniem badania był jego ankietowy charakter. Takie metody dostarczają ograniczonych danych. Jednak w przypadku dotarcia do większej grupy pracowników w tak trudnym i dość „zamkniętym" sektorze, autorzy badania nie znaleźli bardziej efektywnej metody badawczej. Zainteresowania naukowe autorów dotyczą postaw, zachowań i relacji między pracownikami a otoczeniem zawodowym w szeroko rozumianym kontekście pracy 4.0, a więc szczególnie w sektorach najnowszych technologii, automatyzacji i Przemysłu 4.0. Dalsze kierunki badań zaczęły już dotyczyć

adaptacji narzędzi badawczych do tego bardzo specyficznego sektora, poprzez szczególną koncentrację na charakterze pracy w środowisku najnowszych technologii i wyzwaniach z nimi związanych.

Książka ta stara się w sposób systemowy połączyć wszystkie różne oblicza tego samego zagadnienia: Przemysłu 4.0. Wkład tej monografii jest głównie koncepcyjny w stosunku do innych. Pierwszym tematem jest przegląd różnych źródeł w rosnącym tempie ewolucji tych przełomowych technologii cyfrowych. Tempo ewolucji jest bardzo wysokie, jeśli chodzi o pojawianie się nowego oprogramowania, algorytmów i urządzeń. Dla szerszych ram analizy, krótka historia aż do osiągnięcia Przemysłu 4.0 jest włączona, jak również nietechniczny opis technologii ICT. Zauważa się, że sercem czwartej rewolucji przemysłowej jest harmonijne i elastyczne połączenie kilku technologii ICT.

Następnie omówiono wszechobecny charakter Przemysłu 4.0, analizując w szczególności jego możliwy wpływ na płaszczyznę ekonomiczną i społeczną. Opisana zostaje gospodarka cyfrowa, w tym szczególna forma cyfrowej „platformizacji" gospodarki. Pandemia, która ogarnia cały świat, wysuwa formy wirtualne i zdigitalizowane na pierwszy plan w niemal każdym kraju, przyspieszając zmiany strukturalne oparte na platformach cyfrowych. W analizie uwzględniono cyfrową zmianę gospodarczą dla klientów, dostawców, producentów i łańcuchów wartości, z prognozami dla gospodarki narodowej jako całości, a także krótkie komentarze dla handlu międzynarodowego i gospodarki globalnej.

Z drugiej strony, badanie skupiło się również na tradycyjnych skutkach rewolucji przemysłowych, takich jak nowe źródła produktywności wprowadzone przez Przemysł 4.0, włączenie nowych źródeł energii i wydajności, i wreszcie wpływ na procesy pracy, tak zwana "Praca 4.0". Kluczem do wzrostu produktywności jest współpraca na poziomie organizacyjnym, wykorzystująca wszechobecne dane i ich integrację/eksploatację jako nowe podejście, które z kolei jest zasilane przez te cztery podstawowe czynniki. Istnieją inne źródła produktywności, które są ściśle powiązane z tymi czterema czynnikami, na zasadzie swoistego koncentrycznego koła. Są to radykalnie krótsze procesy rozwoju produktu, wirtualna inżynieria kompletnych łańcuchów wartości, rewolucyjnie krótkie łańcuchy wartości oraz lepsze działanie niż inżynieria (Herčko i in., 2015: 5).

Zastosowanie ICT i Internetu w infrastrukturze produkcji energii daje początek Internetowi Energii (IoE). Technologie ICT mogą przynieść pewne rozwiązania w zakresie zarządzania energią, ale jednocześnie są one dużymi konsumentami energii. Oblicza się, że do 2030 r. Internet będzie zużywał do 21% światowego zużycia energii elektrycznej.

Podobnie jak w przypadku dyskusji na temat procesu industrializacji, transformacja cyfrowa polaryzuje opinie na temat problemów i wpływu na Pracę 4.0. Na razie brakuje

danych na temat konsekwencji ICT dla społeczeństwa w ogóle, a dla pracy w szczególności. „Lecimy na oślep". Analiza skupiła się na czterech konkretnych zagadnieniach: zmieniającej się naturze pracy, spodziewanym wpływie procesu cyfryzacji na pracę ludzką, kompetencjach pracowników potrzebnych do radzenia sobie z Przemysłem 4.0 i wreszcie interesujących kwestiach pracowników-widmo i crowdworkerów.

Wreszcie, badamy znaczenie zmian w organizacyjnym procesie podejmowania decyzji. Decyzje w każdym kontekście były do niedawna procesem ludzkim, obejmującym zarówno wybory najprostsze, mechaniczne i nieistotne, jak i te ważne i kluczowe. AI, analityka big data i inteligentne urządzenia będą miały wpływ nie tylko na kwestie produktywności dzięki lepszym decyzjom, ale także na proces uczenia się na poziomie indywidualnym i grupowym, adresy i modele zmian organizacyjnych, proces pracy oraz relacje między ludźmi i społeczeństwem. Książkę zamyka krótka dyskusja na temat transludzkich trybów życia.

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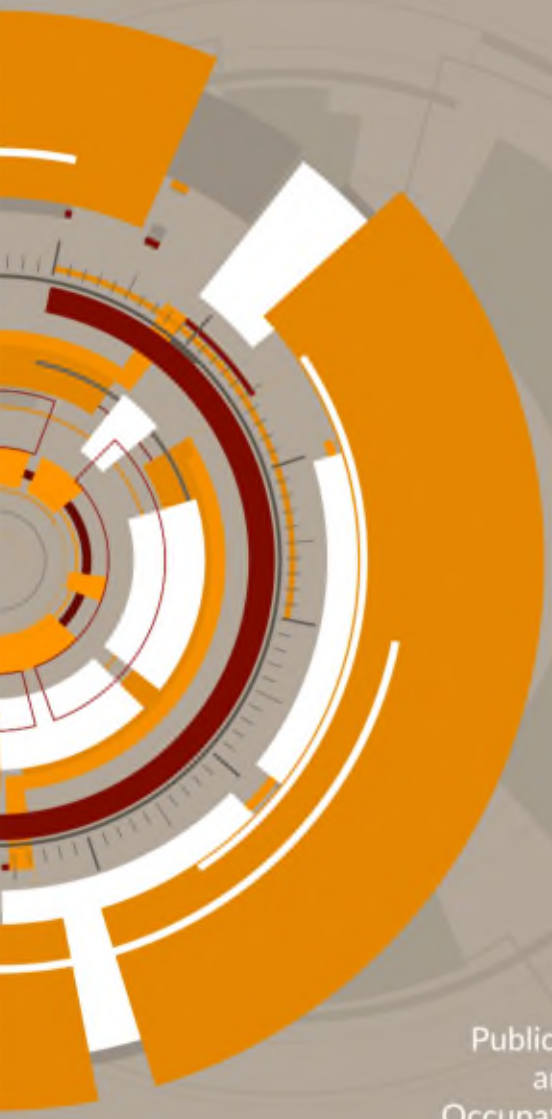

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