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# HUMAN RESOURCES BETWEEN THE OPPORTUNITIES AND THREATS OF NEW INDUSTRIAL REVOLUTION CONTEXT: A LITERATURE REVIEW

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**Abstract:** The threat of job cuts with human input in the context of the digital technology revolution has emerged in recent years as a result of the labor crisis. The current research starts from the question of how to define the problem, which can be the natural reduction factor of labor force or indeed the new industrial revolution has changed the paradigm and caused a radical change in the typology of industrial activities and jobs. For this reason, the literature survey has set itself the objective of scattering the environment through a SWOT diagram, in which human resources are considered the main assets of an organization, and the major threat is considered the loss of jobs for the human factor. The analysis steps followed the manifestation of social, technological, economic, ecological and political (STEEP) factors within Industry 4.0 and Industry 5.0 with impact onto the human capital associated with the social factor. In this regard, the main characteristics (definitions), operating principles and basic concepts of the industrial revolutions I 4.0 and I5.0 have been reviewed in order to understand the key points of the I 4.0 and I 5.0. The researching methodology approached also critical concepts, among them the theory of the asymmetries I.4.0 and several other academics inputs which explained the transition from stage I4.0 to I5.0 and have been considered for future researching directions. The main conclusion showed a clear determination relationship between the actual environment industrial context of I4.0-I5.0 over the Human Resources which shall be demonstrated through related academic research and environmental results provided from case studies.

**Keywords:** Industry 4.0, Industry 5.0, STEEP factors, SWOT diagram, critical approach, asymmetrical theory, human resource, literature review

# 1 INTRODUCTION

The industrial revolution, recognized as a defining event between the 18th and 19th centuries, through stage Industry 1.0, gathered domestic manufacturing practices and transferred from the private to the industrial environment by grouping activities using tools and transforming them into mechanized machines, thanks to the original form of energy, steam power. As a result, transport, communications and banking sectors flourished. In addition to the increase in the volume and variety of products on the market, the standard of living of the population is changing with the creation of new types of jobs, but these changes do not necessarily represent the achievement of the comfort zone, on the contrary, they are rather bleak and sad for the poor or working class. The next chronological stage Industry 2.0 is defined by the new means of production and technologies having a new source of energy, which linked to the discovery of electricity at the beginning of the 20th century. The impact on the social factor is much stronger through the coagulation of the defining classes of capitalist society, the working class and the bourgeoisie, which are united by common economic interests, the diversification of jobs (development of the industrial sector with areas linked to machine building, chemicals, consumer goods products, clothing, cars, foodstuffs) and the polarization of social and political interests (the formation of trade unions with workers' revolt movements, political struggles to express democratic or radical, socialist or extremist ideologies). Industry 3.0, which appeared around 1970, is recognized by the advent of computers and the development of automation. I3.0, which appeared around 1970, is recognized by the debut of computers and the development of automation, the PLC (programmable logic controller) system being iconic for this time. This stage later facilitated the development of digital connections, the internet and re-generable energy. In terms of social impact, there has been a migration of manufactured industrial production. to less developed or emerging countries due additional changes in the area of occupational typologies directed towards the services industry in the industrially developed countries. Thus, changing production relations once again were fragmenting the "working" social class, but also the so-called "upper class" of capital owners, into social categories identified according to the nature of the work performed. The categories directly involved in the production process of the "blue collar" type are identified as industrial flow operators, i.e. middle management, and the second "white collar" category, those linked to innovative, research or scholastic occupations, intellectuals/scientists, and those with a social and political impact, society is no longer so much in conflict with internal political conflicts between social classes as with the global competition between capitalist and communist ideologies, the conflict has shifted to the international sphere, with the formation of economic nuclei and geographically marked markets on the one hand, in Western Europe and the countries of North America (USA and Canada) and on the other hand, the C.A.E.R. market coagulated around the former communist countries in Eastern Europe controlled by the Soviet Union. However, at the end of the 1980s, the collapse of the communist bloc and then the upheavals in the Balkans in the 1990s, with the Eastern European countries with their economies anchored in the old ideologies of centralized management and planning, came into play. Industry 4.0 raises to an extraordinary level the unprecedented progress of innovations facilitated by the previous phase, focused on CPS (cyber-phiscal system), IoT (internet of things), cloud computing, cognitive computing and the continuously developing information sources, such as Big Data (facilitated by internet access). If initially, the main aim was to increase the comfort zone for consumerist society, by obtaining production facilities, as well as inter-

human communication, in the years following 2011, the definition of the 4.0, the phenomenon of rejection recorded in numerous critical analysis articles is also developing, with the emergence of threats to the active population in the process of digitization with the loss of jobs through the disappearance of industrial areas replaced by industrial robots or the reduction of interest in occupations related to production, due to the lack of modernization solutions at the level of ergonomic and material comfort. The I4.0 concept was launched in 2014, by the one who is considered the father of this phrase "Kagerman, or "the 4th industrial revolution" definition given by Schwab in 2015. The approach to the analysis process started from the establishment of benchmarks, in order to identify similarities and differences between the five stages of industrial development. which shows that while in stages 1.0-3.0 the dynamic force of progress is given by innovative energy sources (from steam to electricity and then nuclear energy), in stage 4.0 a new form of innovation is given by technology and the virtual information space, and then in stage 5.0 the dynamic force of human resources is "rediscovered", by which we mean the need to develop the creative and decisive skills of the human factor in order to control and use both technology and the phenomenon of digitization.

## 2 RESEARCH PROBLEM

Looking at the evolution of means of production and technological facilities, it become obvious the discrepancy between the technical progress and lack of updating of HR managerial tools to develop the human resources becoming interested of industrial manufacturing jobs. The main feature of the production entity within the actual industrial is the SMART FACTORY demanding SMART employees. The candidates shall be attracted by using SMART persuasive managerial strategies, capable of convincing them that their future jobs are important and useful both for them and for the organization. The permanent company concern was related to training and maintaining a skilled workforce, modern technology to determine high level of quality and professional services for clients creating profit. The current research starts from the question of how to define the problem, which could be the natural reduction of labor force by ageing or indeed the new industrial revolution has changed the paradigm and caused a radical change in the typology of industrial activities and jobs. Therefore, the next table shall gather the main frames of environmental conditions in relation with human factor and changes recorded on the production relationship between human resources and technology, as a a result of innovative source of progress which generated the shift.

Upon observing the impact onto the social and human factor coming from the progress source of each industrial stage, a preliminary presumption could be drawn:
-the existence of a direct determining relationship from the main significant technical means affecting the typology of activities and the role of the human factor in this increasingly technological context.

Table 1. Human resource changes along the evolution of industrial revolution-adapted from Vanderborght, B. (2019)

| Historical milestones of the stages of the industrial revolution | Driving source generating progress | impact on social factors | Impact on human resources involved in industrial activity |
|---|---|---|---|
| **Industry 1.0-** 1765 James Watt-invention of the steam engine | The energy developed by steam, in the mechanization of production processes, being the textile industry, through the mechanical loom. | The emergence of the two social classes of capitalist society (the one owning financial capital and property and the productive one owning labor-power as a result of industrialization). | >defining behavioral standards in the workplace through Taylor-scientific management theory. >social unrest and conflict, inequalities in the workplace (wage rights and workplace risks). |
| **Industry 2.0-**the age of great inventions (Edison, Bell, Tesla, Ford). | Electricity drives the development of mining, steel, automobiles, railways | Crystallization of social classes of stage 1.0 and the beginning of the emergence of the underclass defined as "white collar" (researchers, inventors, industrial managers | >dividing production processes by operations and simplifying work at the level of moving parts to achieve productivity.<br>>modernization of means of production.<br>>strong blue collar class unrest marked by social conflicts, workers' strikes |
| **Industry 3.0** - powered by alternative energy sources | The emergence of nuclear power, logic systems and industrial computers | The new model of 3 social categories (holders of financial capital, productive "blue collar" and involved in scientific research and management "white collars") | >The advent of automated equipment makes work easier and increases productivity;<br>>increases the level of job skills and specialized qualifications of industrial operators;<br>>the influence of industrial unions increases |
| **Industry 4.0-**the driving force from energy sources to digitization technology | Emergence of industrial robots, complex databases - Big data, virtual communication networks | The social categories model is dominated by IT specialists, database decision makers and policy makers. | The Smart Factory 4.0 concept defines the communication relationship through IoT >criticism of the technological determinism danger through loss of employee jobs and replacement by cyber entities. |
| **Industry 5.0-** returning to the concern for the driving force of human creativity, customization interest in artisanal products. | Development of robots and their interconnection through sensors, simulation models and dynamic production (Digital Twin), training in virtual environment | >New technologies and the information from Big Data require a change in the institutional education model as well as the model for new specializations with digital skills, moving from the traditional learning model to the artificial intelligence-assisted "deep learning" model | >develops the human-machine production relationship, robots take over difficult, repetitive, monotonous tasks , increasing the importance of the functions occupied by human resources with a decision-making role, or robot control/training.<br>>social tensions are shifting from local to international organizations due to differences in economic development and investment in digital industrialization |

## 3 RESEARCH METHODOLOGY

The research strategy was based on the interpretative approach, which from an ontological point of view is based on the knowledge of scientific concepts and the opinions of specialists. Concepts and theories related to Industry 4.0-5.0 are still new and yet developing, based on empirical studies, which do not work always across the board. For this reason, the research methodology is based on recent literature reviews and primary data collection from articles published in the last 7-8 years. By gathering the needed information, a further analysis has been conducted thoroughly a SWOT diagram followed by the STEEP factors observing the position of human resource within the industrial environment. During the researching stage, the collected data was structured to describe the definition and features of Industry 4.0-5.0. A critical approach of literature review revealed several concepts which explained the transition from the stage of Industry 4.0 towards Industry 5.0, integrating the social factor from society as human resource from industrial organizations. The next figure summarized the above components into an assembly view, indicating the main stream of research strategy upon literature review.

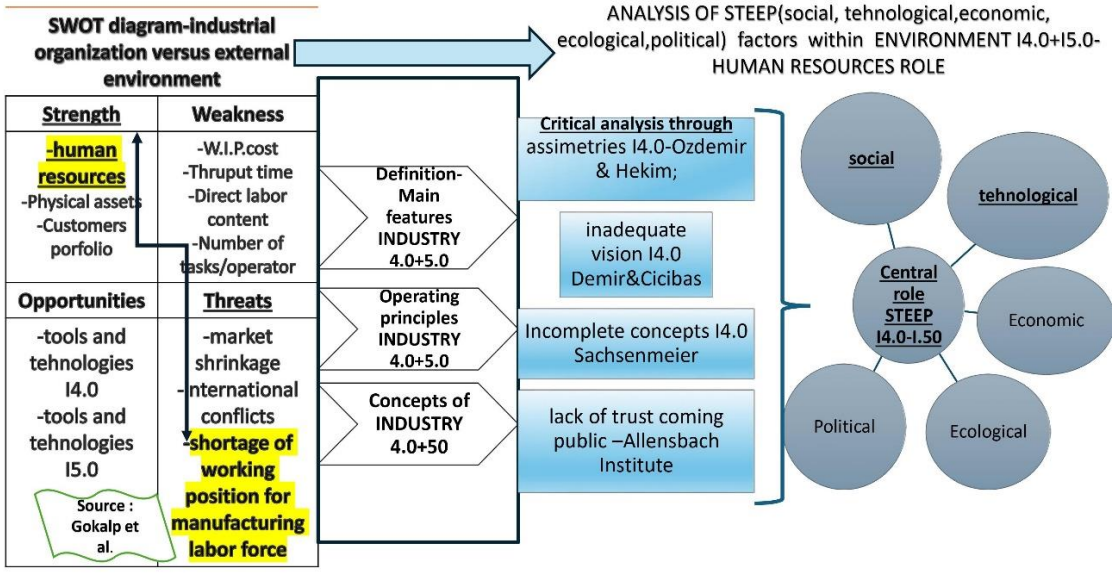


Figure 2. Researching components of Industry 4.0-5.0 versus STEEP factors

## 4 FINDINGS

The actual paper work aim to synthetize the researching results of information which followed three directions: the relevant definition, base concepts and operating principles which are going to be summarized on the following table 2 and table 3.

### *4.1 Definition, operating principles, concepts I4.0*

A brief introspection about the meaning of each operating principle could be considered for a future analysis related to the impact upon the main asset of society which is human resource. The actual concern is gravitating around the perspective of monitoring the phenomenon of

digitization by people and raising the level of responsibility in front of domination coming from technical innovations. The real advantages shall be used for human capital benefit and vulnerabilities coming from the mental comfort of digital facilities to be diminished and controlled. They are unfolded briefly onto the next tables and by future research shall be become topics of observations versus case studies.

Table 2. Definition and operating principles -I4.0

| **1** | **Definition I4.0** | **Revolution of digital tehnologies-Mass customization** |
|---|---|---|
| **2** | **Operating principles-I4.0** | **Description** |
| 2a | Interoperability principle | works on the basis of IoT and IoP (Internet of people) between man and machine to make consumer objects or production equipment; |
| 2b | virtualization principle | involves creating a real operating model in a virtual environment and simulating the operation using CPS (cyber physical system) |
| 2c | principle of decentralisation | developing the working environment and increasing the operational independence of CPS systems |
| 2d | real time capability principle | Execution, information storage, logging and process control functions can be done in real time, allowing quick decisions in case of errors reported by the CPS |
| 2e | service orientation principle | The solution is made possible by the direct connection between equipment/objects and the population through the IoS-Internet of Service system. |
| 2f | Modularity principle | the development of smart factory modules capable of organizational flexibility |

Table 3. Concepts of Industry 4.0

| # | **Concepts I4.0** | **Description** |
|---|---|---|
| 1 | Smart factory | production process equipped with artificial intelligence -AI, sensors, robots with autonomous work systems |
| 2 | Smart development systems | The possible relationship between customer and manufacturer will be strengthened through virtual communication and smart product development using open innovations and product memory (obtained by inserting RDFI sensors). |
| 3 | Organizing systems | decentralization of production units, the segmentation of the classic pyramidal organizational hierarchy into a more flattened form in which decision-makers exchange information and can make current decisions in real time, assuming responsibility and control in the system. |
| 4 | Smart product | The product is embedded with sensors and microchips that allow communication via IoT between objects and the human factor as beneficiary |

| | | |
|---|---|---|
| 5 | IOT (internet of things) | combination of robot-like work equipment, coordinated by virtual space |
| 6 | CPS (cyber-phisical system) | integrate IT programming module, communication link between work agents, production & logistics processes, monitor and control the process, providing feedback loops when deficiencies occur or as permanent checkpoints. |
| 7 | Smart city | The smart city is defined as an entity containing 6 factors:<br>1. smart economy/2. smart mobility/3. smart working environment/4. smart population/5. smart lifestyle/6. smart governance |
| 8 | AR (augmented reality) | integrates the real environment with the virtual environment and enables new tools, combined with human skills, to perform production tasks |
| 9 | Virtual simulation | effective method to support managerial decisions that radically reduces production costs |
| 10 | Autonomous robots | allow difficult tasks to be carried out, detect problems and independently adjust their tasks to balance the production process |

The information was collected from several sources, cited from Roblek et al. (2016),adding the most recent ones from Zizic, Mladineo, Gjdelum, Celent (2022),gathering the technologies concepts under the figure 3.

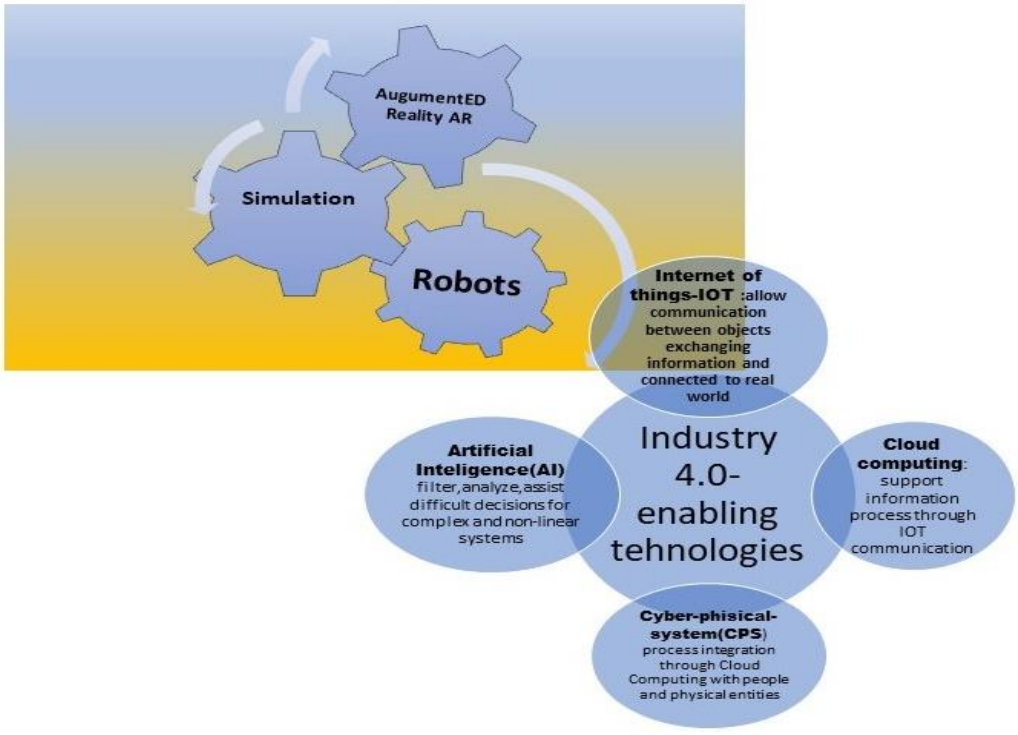


Figure 3. Technologies concepts I4.0

Research into the vulnerabilities of the new work systems contained in the Industrial Revolution 4.0 addressed the elements presented in Fridol Mekkunnel's master's thesis, based in turn on a series of previous studies by scientists from 2017-2018,summarizing the following:

- Imperfect security of cyber systems increases the likelihood of information leakage and exposure of companies to digital piracy.
- The financial investment effort, dedicated to change and flexible digital solutions, is extremely high.In this case, small family-owned organizations are unlikely to cope financially with such radical changes and risk losing their market position.
- The employment rate of the working population is in danger of declining or requires major changes in the development of new skills, often difficult to train, especially for those without upper-middle education and in some cases for the older population.
- The precarious protection of private personal data, which includes both customers and manufacturers, due to interconnection through the open communication process subject to virtual corruption.

Next paragraph continues the discussion with the similar directions of information related to Industry 5.0 in order to observe the corrective turn-up or improvement of the weaknesses of the Industry 4.0.

## *4.2 Definition, operating principles and concepts I5.0*

A similar insight as applied to the previous chapter shall be continued for the stage of Industry 5.0 based on the same criteria of followed definition , principles and concepts found on the literature review. The technological concepts defined in Phase I 4.0 are optimized onto the next stage Industry 5.0 and in addition to the technologies themselves, new tools are developed in which the role of the human factor is imperative, acting as a decision-maker but also as a trainer to "teach "the equipment exemplified by Coboti or Digital-Twin entities.

Table 4. Definition and operating principles -I5.0

| | | |
|---|---|---|
| **1** | **<u>Definition</u>** (Rada, 2015) | **the system of man-machine collaboration, tools, computers, work not only for us but also with us Mass personalization** |
| **2** | **<u>Operating principles-I5.0</u>** | **<u>Description</u>** |
| 2a | Interoperability principle | the collaboration of equipment, tools, and computers in a system |
| 2b | the principle of information accuracy | obtaining a virtual version of real objects and machines thanks to computer systems with sensor operation, allowing virtual training of CPS, or human supervision of processes performed by robots |
| 2c | the principle of technical support for the human factor | computer systems and AI support with technical facilities, human personnel to exercise their decision-making, control and executive roles |
| 2d | complementary decision principle | the computer system itself can complete specific tasks in the operational process, thanks to its artificial intelligence and the accuracy of the |

| | | |
|---|---|---|
| | | information coming from the virtual environment |
| 2e | the principle of social reward (entertainment dividend) | work is a means of earning an income, but at the same time provides individual satisfaction due to the significance of work and recognised performance |
| 2f | the principle of social sustainability through social justice, environmental sustainability and economic sustainability | Robots through the connections created with AI will increase the connection of social segments by empathy and understanding of the needs of community members through communication and solving them through new ways of working offered by digital technologies. |
| 2g | Human centricity principle (EU,2019) | places the human resource at the center of the production process, requires the use of advanced technologies for the benefit of the operator |
| 2h | Sustainability principle (EU,2019) | focuses on re-cycling, re-use and circularity of resources, waste reduction and environmental impact |
| 2i | Resilience principle (EU,2019) | implies the flexibility and adaptation of production capacities in times of crisis |

The concept of I5.0 technologies was taken from the thesis of R.Savoretti and T.M.Kitamura (2022) and refers to 6 elements: Edge computing, digital twin, Internet of everything, Artificial intelligence, 6G beyond, Cobot and two types of updated processes, taken from the I3.0 stage such as Big data analytics, Block chain.

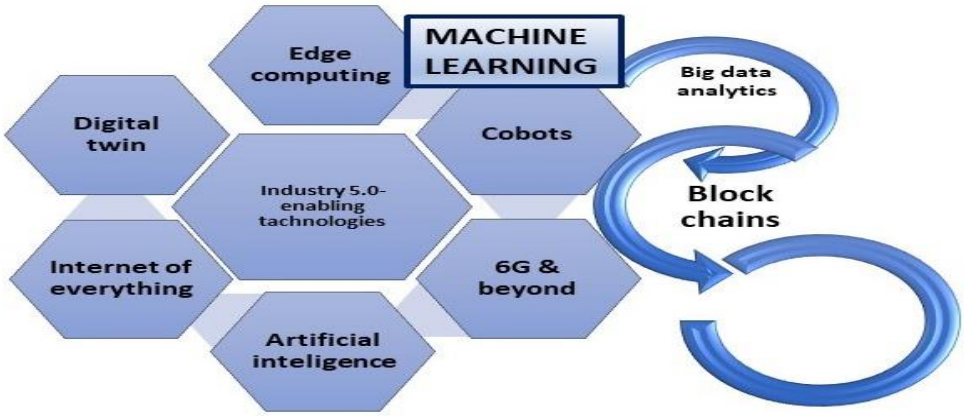


Figure 4. Technologies concepts I5.0

The major concern is related to the progress of the business model as the vital core for the development of human society. Starting from this level, the vulnerabilities of the new I4.0 systems can be identified, which are already recognized in the scientific literature, basis of this research study. The analysis continues with the STEEP factors (social, technological, economic, environmental, political) aiming to develop strategies for organizations and human resources. Ozdemir, Vural (2017),Peter Kopacek(2019),Daniel Paschek et al (2019),Saeid Nahavandi (2019) and recent innovation programs launched by the European Commission (2021) emphasize the shift between stages I4.0 and I5.0, passing from the

technological determinism I4.0 to the human factor, as the main center of creative effervescence. The literature review proposes the influence of STEEP environmental factors from the perspective of both development stages I4.0-I5.0. Temporally the global society lives in both, the difference being determined by the overall vision of political and economic decision-makers, which can be defining each country or geographical region.

## *4.3 Critical analysis*

Ecosystems require control and cannot be left to dominate by itself (Guston 2015). Thus, the 4 asymmetries model (Ozdemir and Hekim, 2018) is proposed for critical research, which addresses the following vulnerable points identified in the Industry4.0:

Table 5 Asymmetries I4.0 concepts (Ozdemir&Hekim,2018)

| Asymmetries model | Description |
|---|---|
| Asymmetry 1: Extreme integration of ecosystem connections without backup strategies | Vulnerability, the risk in certain situations of integration network blocking ( Internet viruses) |
| Asymmetry 2: Filter bubbles versus open systems | data through virtual channels, determined by one's own values, prejudices or beliefs, narrows the search area, risks an objective appreciation at the level of society and human power in science and technology in today's environment. |
| Asymmetry 3: Speeding up versus slowing down innovation processes | Due to expectations, the authors of inventions/innovations tend to force the birth of some project results, which may be ephemeral successes later overtaken by others, just to accelerate the process of amortization of the initial investment. Mirroring, the innovation process may be slowed down to allow ideas to be tested and coagulated into successful long-term results. |
| Asymmetry 4: Technology versus Society Outcome | Less of social responsibility policies leads to a technicist vision, with 2 ideological trends, one linked to technological determinism, whereby society is seen as progressing by replacing human labor force with robots, and the 2nd trend, skeptical-catastrophic, whereby human society will be swallowed up by AI domination. |

A critical approach to the critical issues related to the technology-focused Industry 4.0 concept is the "inadequate vision" proposed by Demir and Cicibas in 2017, which highlights the lack of environmental considerations, including all aspects involving the protection and safety of human society.

From the same work was extracted the idea of "incomplete concepts" that characterize the industrial revolution in stage I4.0, launched by Sachsenmeier (2016), being limited in scope, representing in fact working agendas of business, political, even academic interest groups. So, in April 2016, research conducted by the German Allensbach Institute showed that public opinion has changed direction from indifference to lack of confidence (Sachsenmeier, 2016) in regards to the digital technologies to support the human

resources. As for the challenges identified in stage 4.0, they still remain, partly solved by recognising these problems and outlining proposed development programs at European Commission level through the Directorate-General for Research and Innovation. This theme starts from the control of information and managerial decisions in production-related firms, aggregated at company level, to implement in a SMART way, the concepts of circular and sustainable economy. If I4.0 introduces the concept of "Smart Factory", I5.0 defines the culture of the organization as "agile management culture". This vision refers to the flexibility to adapt the structure of staff, technologies, strategies and decision-makers in order to achieve the profit of the organization new "agile" business model will obviously need a representative cultural model that sums up and cohabits all the components of the system for both the human factor, which operates in organizations, in all working and management positions, the "smart" means of production and the human-human, human-machine, machine-machine relationship. According to the definition given by Ryann K.Ellis in 2018,agile culture means speed of reaction, responsibility and flexibility throughout the system of production and social relations. The prospects of the new industrial wave 5.0 are linked to balancing the direction given by technological determinism 4.0 with the humanization of the business model and the integration of components in a circular and sustainable economy system. From the perspective of the European legislative policies, directions of work have been established to achieve this goal, however there is inertia at the national political level still clinging to the bureaucratic and conformist culture.

## 5 CONCLUSIONS

The primary conclusion generated after comparison analysis of I4.0-I5.0 features dynamics of the transformation of the roles played by the STEEP factors in stage 4.0 and 5.0.The central role played by the technological factor in Industry 4.0 is transferred to human resources equivalent to the social factor in Industry 5.0.The role of the political factor also changes, from observer of the IT phenomenon and digital technologies, to facilitator of economic, social and environmental programs. The environmental factor neglected in stage I4.0 gains attention in the new industrial stage 5.0, through the understanding of the vital function having as objective, the long-term existence of society, besides the principles of functioning the circular economy. The following figures illustrate the position of each factor STEEP with the focus for the one with central role. There are important points of view in this regard. Ostergaard, in his 2017 work, points out that robots are entities that support the artisanal work of human personnel, adding value through accuracy of execution, speed and precision. In the studies of Romero (2016)and Saniuk(2022),reference is made to the limitations of industrial robots, capable of replacing the work of human personnel in a timely manner.

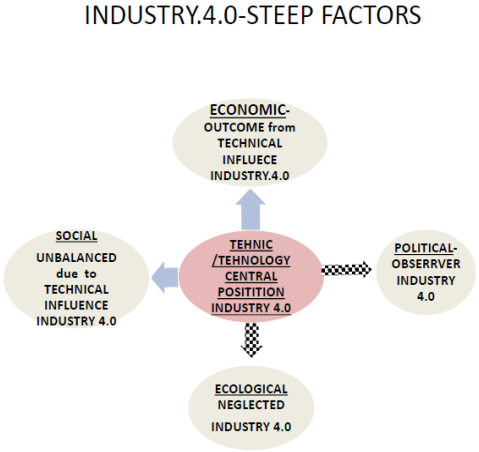


Figure 5. Industry 4.0-STEEP factors impact

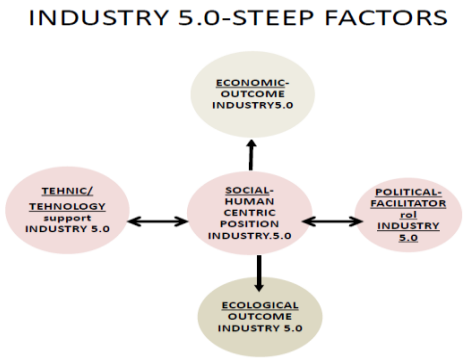


Figure 6. Industry 5.0-STEEP factors impact

The second conclusion is related to the need and understanding of the necessary changes to the proposed organizational model, as a solution for manufacturing industry, to identify the influence of I4.0 and I5.0 technological factors on the vital human resources related to organizational performance. The identification of the I4.0 and 5.0 concepts in table 6 is based on the proposed references, taken from the article by A.R.Santhi and P.Muthiswarmy "Industry 5.0 or Industry 4.S?Introduction to Industry 4.0 and a peek into the prospective Industry 5.0 technologies", published in 2023.There are certain debates around the dividing line between the concepts defined temporally at stage I4.0 and I5.0,that's why certain of them are found in both innovative phases. By adopting a positive approach, future research on the role of the human factor can detect concepts appropriate to the profile of the organization, in order to evolve and use technological progress. In the wake of business experiences, political turmoil with serious economic implications in the current post-Pandemic Covid 19 time, organizations are on alert to save their existence by adapting and controlling innovative technologies with the help of human resources, to finally find the business model that responds to the competitive advantage sought.

Table 6 Comparison I4.0-I5.0-tehnologies concepts

| # | Technology I4.0 | Technology I5.0 |
|---|---|---|
| | Mass customization | Mass personalization |
| | Autonomy of working system, high automatization | Individualized man-machine interaction |
| | Artificial inteligence | Cognitive computerization |
| | IOT(internet of things) | IOE(internet of everything) |
| | Cloud computing | Edge,Fog computing |
| | Simulation | Digital Twin |

| # | Technology I4.0 | Technology I5.0 |
|---|---|---|
| | Big data | Big data +block chain |
| | LAN, Internet | Ultra low latency speed Internet |
| | Virtual reality | Extended reality (AR,MR,Holograf),Metaverse |
| | Automatization with Industrial Robot | Intelligent Automatization with Colaborative robots |

## 6 DIRECTION OF FUTURE RESEARCH

The discovery of existing theories of I4.0 asymmetries (Ozdemir et al., 2018) and similar results obtained from STEEP factor impact analysis aim to re-evaluate and increase the driving force of the human factor, using innovative I.4.0+I.5.0 technologies. Due to the rapid technological advancement,there is now an accumulation of technologies coming from both stages.The I5.0 principles,defined by the European Commission are centred on human capital,so that society can be the beneficiary of technologies common to both industrial revolutions.At the same time society needs training and education to understand them,and the workforce needs to adapt them to the activity profile of the participating industrial organisations in the current economic context. There are important points of view in this regard.

The research direction related to the human factor and the identification of the profile of specialist and manager for the new stage of the industrial revolution 5.0,in which the society is broaden, but the workforce must reach the understanding and efficient exploitation of the technologies of the stage I4.0,which are partially implemented in manufacturing industrial fields.

Complementing this, industrial manufacturing organizations in labor shortage are looking for appropriate business models to gain competitive advantage and perform. The efficiency of business performance will come about implicitly through re-training and improving digital skills for pre-millennial generations and adapting human resource management to motivate and reward people.

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