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Trends and Challenges of Manufacturing Management in Industry 4.0

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Abstract
Today's globalization is creating and is bringing new opportunities for sustainable development. New emergent markets are rising, thus more environment friendly new innovative solutions for meet current demand are released. The global economy is facing today with many challenges and for manufacturing systems in order to be competitive on the global market it is mandatory to innovate permanently. Industry 4.0 (I4.0) with its main component smart factory i.e. factory of the future may be seen like an innovation in manufacturing field. Factory of the future (FoF) will be driven by intelligent manufacturing systems, characterized by smart machines, smart equipment, smart operators and smart products with the purpose to achieve mass customization, industrial growth and added value. The newest information and communication technologies play a key role in development of the smart factory and together with the physical devices lead to creation of so called Cyber-Physical System (CPS) which is the core of FoF. This paper contains a systematic study of the researches undertaken in the field of I4.0 and reveal the trends and the challenges of manufacturing management both those presented by literature and those resulting from direct researches of the authors, in four categories.

Keywords
trends, challenges, manufacturing management, Industry 4.0, CPS

1. Introduction

Industry 4.0 (I4.0) has become nowadays one of the most approached subject in manufacturing research field. This initiative is synonymous with digitalization of the production systems. Digitization is seen by many institutions, researchers and firms as the fourth industrial revolution [1 ... 6]. A summary of the industrial revolutions is presented below:

- 1st industrial revolution (end of 18th century) was governed by mechanization and steam power;
- the 2nd one (end of 19th century) was dominated by mass production, steel industry, combustion engine and electricity;
- the 3rd (second half of the 20th century) marked the rise of electronics and computers and production automation [7].

The 4th industrial revolution is represented by the new information and communication technologies (ICT) e.g. Cloud Computing, Big Data, Cloud Manufacturing, real-time localization, Internet of Things (IoT), Internet of Services (IoS), Internet of Data (IoD), Internet of People (IoP) and Internet of Everything (IoE) [3, 4, 8 ... 11] which comes like an evolution for the existing approaches e.g. Computer-Integrated Manufacturing (CIM) and Lean & Agile Manufacturing. Figure 1 presents a background of the industrial revolutions.

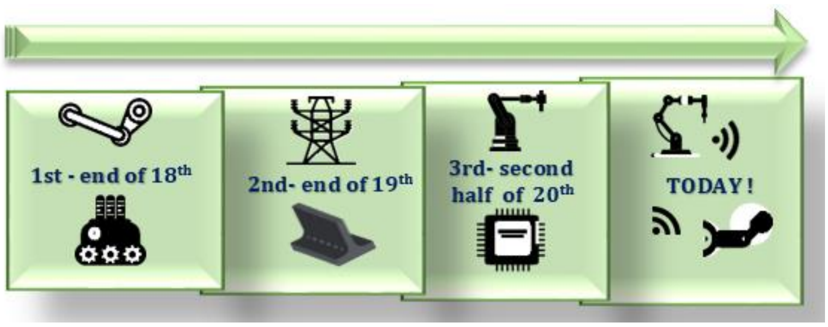

Fig. 1. Background of industrial revolutions

Even if I4.0 is considered the 4th industrial revolution by most, there are voices which strengthens the idea that this concept is an industrial evolution rather than an industrial revolution [12]. Anyway, this initiative may be seen as an innovation in industrial engineering and production systems, especially in manufacturing. This concept turns the nowadays manufacturing in an automated and digitized manufacturing [4, 13] able to made smart products [1, 3, 4, 8, 10] and gentelligent components [13]. I4.0 tends to significantly change of traditional processes involved in manufacturing systems. According to [1, 2, 4, 5, 6, 8, 10] the implementation of "Industry 4.0" yields a lot of benefits for manufacturing system e.g. novel business and pricing models, an increase of flexibility, productivity and competitiveness, cost savings, processes optimization mainly machining and maintenance, and improving customer relations, but also is rising lots of concerns regarding employment, employers' skills, investment needs, network environment and data security [2, 4, 14, 15, 16].

The main element of I4.0 is the concept of the smart factory [1, 17, 18]. The traditional factory become smart factory, more flexible and more autonomous, sustainable, with smart equipment and machines able to collect, storage, interpret and exchange mass data with another entities, with smart operators and smart products [1, 4, 8, 18] having as main aim business performance improvement.

2. Key Technologies Involved in Industry 4.0

I4.0 is closely linked by the new ITC technologies. The internet of things (IoT) represents a large-scale network of interconnected devices, machines, equipment, sensors, and actuators, robots able to communicate with each other [6, 10, 11, 19, 20, 21]. In production systems, this network is called Industrial Internet of Things (IIoT) and is part of IoT [21, 22]. The communication between "things" i.e. data exchange in production systems is achieved by so-called CPS [1, 3, 6, 9, 18, 23] designed to tightly merge the physical world and the virtual world [9], using wireless networks, radio-frequency identification (RFID), cloud technologies [10] and other emerging IT's. The CPS embed cameras, mini-computers, mechatronic components (e.g. actuators and sensors), microchips and autonomous systems [3, 10, 18] which collect information, measure characteristics of products and processes [5], communicate and safeguard men (socio-CPS) [9, 24]. In manufacturing field, this system is called Cyber-Physical Production System (CPPS) [1, 6, 10, 25]. All these technologies are moving forward to a worldwide network with interconnected entities e.g. equipment, machine-tools and devices [11], with available data anytime and anywhere [6] and change the relationships throughout the supply chain in terms of trust and satisfaction [10].

RFID is a wireless rapidly growing technology, which is increasingly used in industry and beyond due to the considerable benefits that offers in different fields as logistic, manufacturing or supply-chain management [26, 27, 28]. It is used for example in supply chains for containers, pallets or parcels tracking, to increase of delivery performance and to reduce, in the recycling field to improve the waste management efficiency, access control and payments [26, 27].

RFID system is an automatic identification system, without contact, which can identify entities and consist in three fundamental elements as reader, tag and middleware software [26, 27, 29]. The RFID tag, which contains integrated circuits, antenna and chips, is attached to a product or incorporated in products, allow data storage and has an electronic product code (EPC), unique in the world [26, 27, 29].

The role of reader is to read data stored and to write new data in tag [29] and communicates with the tag within radio frequencies [27]. The reader comes in various forms, and the configuration and complexity depends on the functions to accomplish, but the main functions is to ensure the communication with the tag [26, 27]. The antenna has the role to transmit the signal (radio frequencies) between tag and reader [29]. When the tag is found in the magnetic fields of the reader, it receives signal and can transfer data stored [29]. The role of middleware software is to convert the data stored in tag into relevant information, to solve different errors of reader and to ensure that bad or useless reads are removed [26, 27]. Depending of the power source, there are three types of tags: active, passive and semi-passive [26, 27]. The power source of a tag is a key feature since it determines the read range, the cost and the lifetime of the system [27]. The active tags have, in general, an internal battery and have the ability to start their own communication with readers [27], while the passive tags don't have own power source and absorb energy provided by the reader [26, 27]. Even if the passive tags have a shorter read range them active tags and their reading capacity depends on the material of the items in which they are embedded, the passive tags are the most often used tags due to the small size, cheap manufacturing, easy integration into products and don't require maintenance [26, 27]. The semi-passive tags have their own power source as active tags but communicate in the same manner as passive tags [26, 27]. The read range of the active and semi-passive tags can be up to 100 meters [27], since the passive tags read range varies from 0.1 meters if is using low frequency (125 kHz) up to 10 meters if is using microwave (2.4 GHz) [26, 27, 28]. The future of the tags seems to be focused in eliminating the chip and manufacturing from biodegradable materials [26, 28], but also the concerns regarding systems security is considered [27].

The Big data concept, which refer to a huge volume of complex and heterogeneous data, bring a new horizon of opportunities [22] and may be a valuable resource to gain competitive advantage. This concept has expanded the technological capabilities of storing, managing, processing, interpreting and viewing a large amount of data and is characterized by four dimensions (4V): volume (amount of data), variety (data are extracted from a variety of sources), velocity (the speed of new data generation, acquisition and analysis) and value [22, 30, 31]. The main activities related to this concept are data mining, classification and storage [10, 32]. By acquiring and analyzing large amount of data the manufacturers or sellers will be able to improve the products features and the processes involved, to predict the customers' behavior and to respond faster and better to their requests [10, 22, 30, 31].

Cloud computing (CC) is an IT concept which consists in providing of computing services e.g. software, platforms or storage [22, 33]. The cloud computing services models are: infrastructure as a service (IaaS), platform as a service (PaaS) and software as a service (SaaS) [16, 22]. IaaS provides companies IT resources as networking, servers and storage on a pay-per-use system [34] and has the strongest link with the computing infrastructure [35]. Likewise, the clients have the possibility for accessing and configuring the resources offered by cloud infrastructure as needed [36]. Such a system has some advantages as follows: isn't necessary investment in own hardware, the infrastructure scales on demand (adjusts the amount of resources allocated automatically, as needed) to support dynamic workloads and offers innovative and flexible on-demand services [34]. PaaS is primarily aimed to developers and provides a cloud-based environment with everything needed to fully support the development and delivery of applications, without being necessary to acquire and manage, hosting, software and hardware [34, 35]. The advantages of this model are linked to the faster development of applications and to the shorter time for release new web applications in the cloud [34]. Through the SaaS model, the client can use software provided by a provider on a cloud infrastructure. The cloud-based applications are hosted by a provider and run on distant computers that connect to user's computer via the internet [34, 35, 36]. In manufacturing, such a service can be represented by the applications developed by the cutting tools or machine-tools manufacturers for machining optimization. The advantages of this model are linked to the quick and easy use of innovative applications, data availability on any connected computer and minimal risk of data lose since the data is stored in cloud [34].

Cloud manufacturing (CMfg) is "*a computing and service-oriented manufacturing model*" [33] or "*a networked manufacturing model*" [21] and at the same time an emerging paradigm for the modern manufacturing industry [37, 38] with the purpose to turn the free manufacturing resources and capabilities into safe, cheap, reliable and on-demand services [33, 39]. CMfg is part of CC and integrates, in addition to cloud computing, other models e.g. design as a service (DaaS), simulation as a service (SIMaaS), management as a service (MaaS) and maintenance as a service (MaaaS) [33, 37]. Through this emerging technology the users can require various services such as design, manufacturing, testing, management or any other stage from the life cycle of a part for example, in a pay-as-you-go manner [21, 33, 37].

The cloud manufacturing architecture is composed from three layers corresponding to cloud server, local server and physical resources [38].

The main challenges of ICT's, presented in literature, in I4.0 are listed in Table 1.

An overview of the key technologies involved in I4.0 is presented in figure 2.

Table 1. Challenges for ICT in Industry 4.0

Challenge	References
IT infrastructure	[1, 19, 40]
Data collection, storage and management	[11, 16, 22, 30]
Data security	[1, 3, 4, 5, 16, 19, 22]
Data conversion in same format	[19, 22]
Bad or useless data acquisition	[30]
High speed data transfer/ 5G	[1, 40, 41]
Developing new encryption methods	[1, 4, 42]

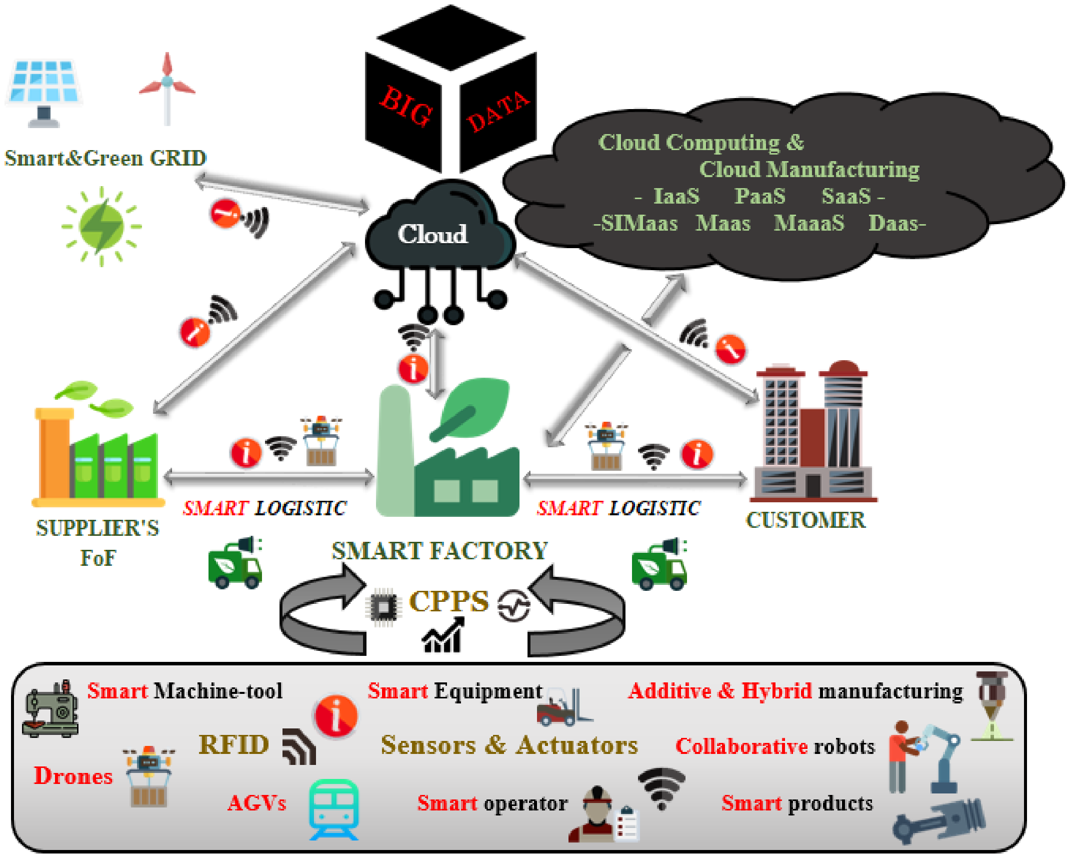

Fig. 2. Overview of the key technologies involved in I4.0

3. Trends and Challenges of Manufacturing Management in Industry 4.0

The trends and challenges are shared and discussed in four main categories closely linked by manufacturing management:

- Human resource (safety &s kills);
- Quality: maintenance and machine tool;
- Logistics & planning;
- Costs and the economic impact.

3.1. Human resource in Industry 4.0 (employees' safety & skills)

The competitiveness and success of a plant in the market, first, is provided by human resource [43], thus a safety and ergonomic environment shall to be available. Safety is found in many companies' sustainability initiatives and is seen as a competitive advantage [44], thus it can be strengthened the idea that the development of new business models in I4.0 era starts with employees' safety and well-being. The trends linked to human resource (HR) in I4.0, presented in literature, are listed in Table 2.

Table 2. Trends linked to HR in I4.0

Trend	References	Discussion
Augmented Reality	[8, 14, 45, 46]	• may be helpful in use of complex equipment or may be used for to easily solve some difficult task on working station; a cheap and fast solution for training
Collaborative robots	[47, 48]	• may take from operators the hardest and the most dangerous tasks
Mobile applications	[49]	• ensure evaluation of risks at workplaces and creation of more ergonomic workplaces
Human machine interfaces	[18, 25, 46, 50, 51]	• ensure and allow the communication between machine and users and provide access to data and information sharing; the link between cyber and physical word
Smart operator and smart technician	[14, 15, 19, 52, 53]	• new ICT require novel skills and qualifications for employees in many fields e.g. operations management, data science and supply chain management
Learning factories and modules for I4.0	[15, 25, 54]	• ensure high performance in developing new abilities and knowledge gaining regarding modern technologies

Regarding safety, lots of plants are using traditional handling equipment e.g. gantry cranes, forklifts, lift pallet and a lot concerns regarding safety for operators that serve them are rising. In FoF, these equipment will become smart, will be able to recognize if the operator wears safety equipment and will communicate with the operator via Human-Equipment Interfaces (HEI). Will can be use only by the licensed operators and will provide real-time data (in second or milli-seconds) about operator ID, use time, load, route, energy consumption or battery status and faults to local server. Data acquired will provide reports to safety responsible about equipment condition, damages and proper use in order to establish preventive actions (e.g. maintenance schedule, teaching) for safety and security. A possible model for these smart equipment is presented in Figure 3.

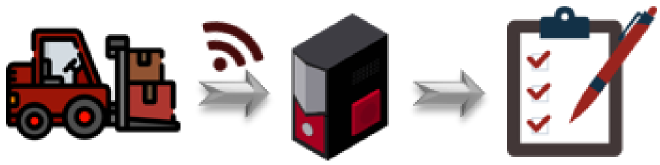

Fig. 3. Real-time data transfer from equipment to local server

The mobile applications are increasingly used in safe and ergonomic workstations. Such a smart solution is described in [49] and is used for fast evaluation of risk at workplaces.

In the future smart factories, the augmented reality (AR) and collaborative robots (Cobots) also will play a significant role in safety. The AR technology supported by smart mobile tools e.g. glasses and tablets [14, 45, 46] and smart gloves may be helpful for operators mainly in use of complex equipment, and the cobots, which cooperate with the operators (human-robot collaboration) [47, 48], may take from these the hardest and the most dangerous tasks.

Regarding skills of the employees, I4.0 brings new challenges for companies. The employees will meet more sophisticated process and will have more responsibilities at workplaces, thus novel technical skill and job profiles are required [14, 15]. Among many requirements, the employees shall to have for example knowledge of communication and security standards and methods [53], knowledge of use smart devices [14, 25] and knowledge to carry out some of the process failures or errors without maintenance crew [15].

The emerging technologies have high impact in education and training [25,53], thus companies shall focus on new qualification strategies for staff and shall develop new strategies to attract young people

[43] since skills and qualifications of the workforce will lead to meet the challenges in I4.0. The main challenges linked to HR in I4.0, presented in literature and identified by the authors, are listed in Table 3.

Table 3. Challenges linked to HR in I4.0

Challenge	References
Computation of safety distance between robots and workers	[48]
Retrofitting the traditional equipment	Authors hypothesis
Training of the operators and technicians regarding modern technologies	[14, 15, 25, 53, 55]
New skilled and young workforce	[5, 15, 43, 55]

3.2. Quality: maintenance and machine tool in Industry 4.0

The processes involved in manufacturing smart factory become more complex, automated, dynamic [56] and more sophisticated and this fact leads to new challenges for quality and quality management. To face these challenges, new techniques e.g. data mining must be implemented for quality improvement [57]. The trends linked to quality in I4.0, presented in literature and identified by the authors, are listed in Table 4.

Table 4. Trends linked to quality in I4.0

Trend	References	Discussion
Smart machine tool or machine tool 4.0	[3, 42, 51, 58]	• machine tool will be equipped with lots of sensor measuring different features, will have an intelligent system for cutting monitoring and will hold an intelligent predictive maintenance based on robust analysis algorithms
Machine learning	[4, 6, 20, 51, 42, 59]	• the machines will have capabilities for self-optimization and autonomous decision-making to improve process
Machine to machine communication	[18, 40, 51]	• allow communication between machines; cooperative manufacturing by real-time data transfer
Remote maintenance using Augmented Reality	[45, 46, 60]	• it helps to reduce reaction time at failures and to reduce maintenance tasks errors
Wireless measuring tools	Authors hypothesis	• ensure and allow the communication between equipment and users and provide access to data; the link between cyber and physical word

The machine tool plays a key role in product quality. In I4.0, the nowadays machine tool will become “Machine Tool 4.0” (MT 4.0), more autonomous and smarter [51], e.g. by using RFID labels and readers the machine-tool will be able to detect and recognize each part from the flow (i.e. machine-part communication). The MT4.0 will be equipped with sensors that measure and collect data about vibrations, forces, temperatures in cutting zone [38, 51], remaining useful-life of components, and real volume and pressure of coolant, to reach the maximum overall equipment effectiveness (OEE), to avoid burns and cracks on the products surfaces and tools cracking or chipping. MT 4.0 equipped with sensing technology for different parameters contributes significantly to product quality improvement [38, 51]. It is widely known that the vibrations of the main machine-tools parts e.g. spindle and screw ball represent a huge problem especially on those that perform final machining operation i.e. finishing hard turning and grinding, hence a complex system based on robust analysis algorithms [42] is required to allow identification of the correlation between cutting parameters, vibrations occurred, spare parts status and surface quality in order to optimize the process according to existing conditions and to prevent failures. MT 4.0 will hold an Intelligent Predictive Maintenance (IPM) system [32, 58] which will ensure prognostics and health management [51] and which will allow to detect and prevent possible failures caused for example by spare parts with low useful-life (Maintenance 4.0). If preventive maintenance it's scheduled very often lead to high costs and if it's performed few times can lead to failures, stops and scraps which involve high repair cost failure cost [59] and loss of production capacity, thus robust analysis algorithms and data mining tools & techniques may provide information to IPM system in order to schedule the equipment maintenance right on time. All functions will be integrated in Cyber-Physical Machine Tools (CPMT) [51].

In maintenance, another bright trend is remote maintenance using an application, a tablet and Augmented Reality (AR). This kind of system is described in [60] and may be a cheap and fast solution in Maintenance 4.0.

Another benefit which I4.0 can bring in Quality 4.0 is an increase in communication and business relations among supplier, manufacturer and customer. In I4.0 the plants will exchange real-time data about measured features with the support of wireless measuring tool and will be able to respond very fast in case of any deviation. Data about measurements is send fast to quality responsible and it can quickly assess the situation and decide if it's necessary to quickly inform the customer. It will be a fast communication between supplier and customer to avoid losses. The system will work in all the supply chain i.e. from raw material supplier to manufacturer, from manufacturer to manufacturer customer's and so on and will bring an increase of raw material and products quality. A possible model for this system is presented in Figure 4.

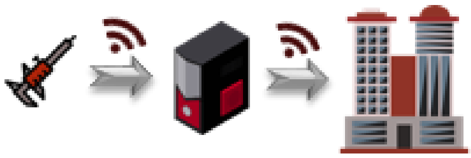

Fig. 4. Real time quality data transfer

The challenges linked to quality in I4.0, presented in literature, are listed in Table 5.

Table 5. Challenges linked to quality in I4.0

Challenge	References
Implementation of sensing technologies and machine tool retrofitting/upgrading	[51, 58]
Development of intelligent predictive maintenance	[51, 58]
Development of robust analysis algorithms	[58]
Machines control	[22, 55]
Improving tracking algorithms for AR	[60]

3.3. Logistics & planning in Industry 4.0

Logistic 4.0 (L4.0) is focusing on high transparency and visibility, small batch size or batch size one, use of self-driving & green trucks and use of drones for delivering lightweight goods [3, 5, 6, 61]. The traditional supply chain will become digital supply chain and will embed many elements e.g. smart warehousing, prescriptive supply chain analytics, autonomous and B2C (business-to-client) logistics and digital supply chain enablers [62]. It will be a significant impact of these trends in costs and pollution reduction, in customer relations and in gaining competitive advantage. The trends linked to logistics and planning in I4.0, presented in literature, are listed in Table 6.

The implementation of the newest ICT in logistic field will bring a growth of traceability and transparency by using real-time localization of products in the entire supply chain [65,66,67], will aid to avoid the "bullwhip effect" [29,68], will help to decrease the incorrect deliveries (especially in inbound logistic) and documentation efforts [73], will afford companies to react faster to unexpected and risky situations throughout the supply chain [29,61], will help to reduce work-in-progress (WiP) and will abolish loss of products. Smart systems as intelligent routing systems and end-to-end route optimization systems will allow high efficiency of inbound and outbound logistic [66]. All these benefits lead to an increase of delivery performance.

Table 6. Trends linked to logistics and planning in I4.0

Trend	References	Discussion
Batch size one	[1, 3, 5]	• allow customized product at reasonable price, making profit
Self-driving & green trucks	[5, 47]	• eco-friendly and cheap logistic
Drones for delivering lightweight goods	[6, 61]	• effortless way, fast and eco delivery for lightweight goods
AGVs'	[1, 3, 63, 64]	• will be "*interconnected via wireless communication [94]*" and will be used in internal logistic
Radio-frequency identification (RFID) of products or carry unit	[26 ... 29, 64 ... 67, 69]	• RFID bring a growth of traceability, transparency and visibility in the entire supply chain
Intelligent routing systems and end-to-end route optimization	[66]	• high efficiency of external logistic by continuous optimization depending on traffic conditions
PI(π)-container	[69, 70]	• a new paradigm that may be the smart load unit
Future demand predicts	[29, 54, 66]	• customer future demand can be predicted using big data analyse and data mining techniques
Agile ERP	[71, 72]	• best production planning in time and space

Inbound logistic (IL) and outbound logistic (OL) will take a step forward i.e. smart equipment and RFID tracking will push the traditional IL and OL to smart IL and smart OL. The material and products flow in smart factories will be high transparency i.e. loss of components and product may be fully avoided.

Based on big data analyse the production planning will be improved and future demand may be predicted with certain accuracy [22, 29, 66]. Agile ERP will be able to achieve the best planning in time and space, very fast, in accordance with future demand, using linear programming algorithms [71], predictive analysis aided by data mining, and decision support systems [72].

Last but not least, a new trend in logistic field is so called π-container in the Physical Internet (PI) [69, 70]. PI is a new paradigm which tends to radically change the logistic systems in terms of moving, handling, storage and supplied [69]. The π-container may be the smart load unit [69] in L4.0.

The challenges linked to logistics in I4.0, presented in literature and identified by the authors, are listed in Table 7.

Table7. Challenges linked to logistics in I4.0

Challenge	References
Transition to eco-friendly/ green delivery transport type	[5, 61]
Adoption of modern technologies	[61, 65, 66]
Integration of all the supply chain stakeholders in L4.0	Authors hypothesis
Design of PI(π)-container	[69, 70]

3.4. Costs and the economic impact in Industry 4.0

All the trends launched by digitalization in HR, quality, logistic and not only, entail a new costs map in manufacturing. While it is expected an increase of cost for ICT, human resource development and equipment retrofitting as well it is foreseen a massive cost reduction specially process costs e.g. machining (tools, energy, labor), assembly, packing and maintenance. The trends linked to organizations costs and economic impact in I4.0, presented in literature and identified by the authors, are listed in Table 8.

Table 8. Trends liked to organizations costs and economic impact in I4.0

Trend	References	Discussion
Additive & Hybrid manufacturing	[47, 74, 75, 76]	• batch size one is achieved very fast and cheap and they permit personalized products
Cloud manufacturing	[21, 33, 37, 38, 39, 76]	• turn the free manufacturing resources into cheap services and allow an easy way to order and to produce parts
Virtual procedures, instructions and maps for maintenance	[45, 46]	• can reduce costs by avoiding the presence of external technicians
Real-time process optimization	[1, 51]	• self-optimizing of cutting parameters can reduce cycle time, reduce energy consumption and increase tool life.
More products recycled and faster	[1, 5, 61]	• once with the transition to smart products, the smart factories will be able to recycle more and faster; these issues will lead to high cost savings and conservation of natural resources
Smart products	[1, 3, 75]	• the smart products will know their own history, from manufacture to recycle, and the information stored by these products in the entire lifecycle will help to identify certain components for reuse
Own energy sources (electricity)	Authors hypothesis	• own energy source means low energy cost, revenues by selling extra-energy and reducing the dependence on external suppliers

Additive manufacturing (AM) is a vital component of I4.0, a key technology for manufacture customized products [74, 75, 76]. Using AM in FoF, batch size one can be achieved very cheap. Today, AM represents a good opportunity and a low-cost solution to repair/reshape parts or tools e.g. dies, moulds [74, 75] or made special turning knifes. Even if the constraints regarding surface quality, tolerances, hardness and mechanical properties hinder widespread use, AM has not yet shown its true value and the outlook looks favourable. Current researches in AM will bring soon changes in traditional manufacturing.

MT4.0 which includes self-optimizing, sensing technologies and intelligent maintenance radically change the way to manufacture products. The maintenance cost will decrease by using remote maintenance right on time, and the energy cost and tools cost will decrease by self-optimizing of cutting parameters without increasing cycle time. The machine-tool will know when to decrease an increase the cutting parameters (feed rate & cutting speed), and coolant volume and pressure, to gain the best use of resources (maximum tool life and minimum energy consumption). Already some cutting tools manufacturers e.g. Walter Tools, Sandvik Coromant developed solutions for real-time optimizing of cutting parameters and may be integrated in production systems such as SaaS.

The renewable energies have become the main energy source in many countries and play an important role in global economy. The cost of equipment e.g. wind mill and solar panel have fallen in recent years while the reliability has increased and thus, in manufacturing FoF the trend may be in designing and creating of own sources of renewable energies, in the context of smart grid. The impact will be both, decrease of energy cost and increase of revenues by selling the extra-energy. Regarding the human resource, the automation of processes means lower operators, thus is expected a decrease of labour cost along with some increase of cost for training, if isn't performed in-house.

Even if large cost savings are expected, there are many concerns about how much will cost the digitalization. The introduction of newer ICT, development of a new IT infrastructure, the equipment and machine-tools upgrade and human resource development may require substantial investment [5]. FoF also will change the way of how and how much companies are recycling. Manufacturers which will produce smart products will be able to recycle more and faster [1, 5, 61] and this means that new business model focused on recycling and sustainable development, with high impact in costs saving and conservation of natural resources shall to be established between suppliers and customers. As well, the information stored by smart products on their entire lifecycle, their own history from manufacturing to recycling, will be used to identify certain components for reuse [1, 3]. The challenges linked to organizations costs and economic impact in I4.0, presented in literature and identified by the authors, are listed in Table 9.

Table 9. The challenges linked to organizations costs and economic impact in I4.0

Challenge	References
Funding and how much will cost	[3, 5, 6]
Transition of small and medium enterprise to I4.0	[2, 5]
Development of smart products	[1, 16, 17]
High quality additive manufacturing	[74]
Crossing from classical manufacturing to unconventional and additive	Authors hypothesis

4. Conclusions

Industry 4.0 is expected to change the way of how the products are made. ICT are coming to support the factories transition from traditional manufacturing to smart manufacturing integrating devices, equipment, machines and people to create Factory of the Future. New business models and strategies will emerge and more environmental friendly products and processes will arise, focused towards on value creation and sustainable development. The manufacturing processes will integrate the newest IC technologies to create smart manufacturing and sustainable factories, thus new trends and challenges for global environment are arising.

This paper brings a better view and a better understand of I4.0, reveal the trends and the challenges of manufacturing management and give an outlook for further researches. It can be strengthened the idea that I4.0 is a complex process that require a lot of specialists from different fields, time and funds for it implementations and for integration of all the functions.

The mapped benefits and ideas of I4.0 has to be shifted from vision to reality [2] i.e. it is necessary not only to develop strategies and to have ideas about future but also must to accelerate the implementation process of Industry 4.0, to have results and to quantify real benefits. The concerns of digitalization are focused mainly on SMeS due to lack of resources [2, 5] and therefore for the successful integration of all stakeholders from supply chains are necessary large investments supported not only by corporations, but also by governments [23]. However, probably, the most valuable resource for the future success of Industry 4.0 is the human resource and should be treated with priority.

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