The Benefits and Challenges of Digital Transformation in Industry 4.0

Heron Jader Trierveiler[1], Denilson Sell[2] and Neri dos Santos[3]

[1] Federal University of Santa Catarina

Received: 13 December 2018 Accepted: 3 January 2019 Published: 15 January 2019

Abstract

The development of digital technologies has been promoting a real transformation in the lives of people and businesses in recent years. This movement has been called Digital Transformation. It intensified in the mid-2000s when many companies began a move to adapt their business infrastructure to the new digital age, benefited from the average price reduction of technology components, increased computing performance and global connectivity. In the manufacturing industry, a similar move, albeit a little late, has been carried out by the development of Industry 4.0 or, as some prefer to call it, smart factories. This article presents a vision of the digital transformation in industry, emphasizing the benefits and key challenges, from the analysis of 9 relevant publications published between 2005 and 2014. Its content will be especially important for those who are beginning their research on this topic. but whose practical implications can already be felt in our daily lives. Throughout the text, we discuss the breadth and importance of the Internet of Things and cloud computing for Industry 4.0, the applications and the importance of identification and tracking technologies, wired and wireless sensors, big data, communication protocols and distributed intelligence, the new role of IT strategy in manufacturing organizations, the impacts of new modes of production on organizational structures and the foundations of work, and the possibilities for generating, extracting and analyzing large volumes of data from connected machines in a collaborative community.

Index terms— smart factories; manufacture; technological development; digitization; digital strategy.

In this research, we could have analyzed many environments and contexts, but we decided to focus on the manufacturing industry. To this end, we rely on the assumption that the so-called Industry 4.0 is the leading driver of digital transformation in the manufacturing industry. But, before describing in detail the procedures adopted for this, we should recall some basic principles of the literature review process.

The literature review, in the scientific methodology, underlies the questions and methods that will be adopted by the researchers. Objectively, it comprises a critical qualitative analysis on one or more themes that have already been published (RUSSEL, 2005; KLOPPER; LUBBE; RUDBEER, 2007). It is up to researchers, at this moment, to search, collect, prioritize, read with purpose, look for key issues and themes, and then describe and criticize them (KLOPPER; LUBBE; **??**UDBEER, 2007).

As for methodological rigor, in the literature review, researchers should adopt standards equal to those of research conducted on primary data sources. This could not be different, since the literature review is nothing more than a research on the published research (WHITTEMORE; **??**NAFL, 2005). The analysis of the structures, processes and relationships between the themes is also essential for a good review, and it is up to the researcher to connect the previous research to the work he is doing in his research area (KLOPPER; LUBBE; **??**UDBEER, 2007).

The present work describes the results of a systematic search in Web of Science citation database, relating Digital Transformation and Industry 4.0 1 ? What do the authors mean by Digital Transformation? What is the relationship established . After identifying the main publications that explored the relationship and even at the intersection between the two themes, we aimat answering the following questions: 1 To mitigate the risk of ignoring relevant articles that addressed the topic of interest without explicitly mention Digital Transformation or Industry 4.0, we added a few secondary keywords to the search: eeconomy; digital economy; digital maturity; digital strategy; digitization; digitalization.

In the business environment, this transformation is also happening. In fact, it is a two-way street. The transformation of the business environment affects people's daily lives to the same extent as the reverse occurs.

by the authors between Industry 4.0 and Digital Transformation?

? Is the research restricted to which economic sector (i.e. primary, secondary or tertiary) and which business area (e.g. manufacturing, technology, software)? ? What is the research locus? National, regional, company, employee or consumer? ? What technologies (e.g. blockchain, internet of things, sensors) are identified as relevant in digital transformation initiatives?

From these search criteria, we organized the selected articles into three categories: most cited, most recent published in the most relevant journals, and most referenced by the publications of the two previous categories (i.e. most cited and most recent).

This article, it should be said, is part of a broader research. Therefore, it covers the analysis of only the most referenced works by the most cited and most recent publications selected from the systematic search. These are nine articles, as detailed in the following table: For the development of this article, we were concerned also about the concepts adopted and the contexts worked by the authors in their publications. We analyzed the benefits and challenges identified by them arising from digital transformation in the manufacturing industry in different aspects, but mainly technological, organizational and marketing.

In the following sections, we detail what we have identified as most important for the purposes of our research in Digital Transformation and Industry 4.0.

1 II.

2 The Digital Transformation

Since the 2000s, immediately after the Internet bubble, many companies, both startups and corporations, have begun to adapt their business infrastructure to the new digital age. They sought primarily to benefit from the average price reduction of technology components, increased computing performance and global connectivity.

The boundaries that delimit the perimeter of industries have also shifted by the emergence of nonlinear dynamic environments and, it is no exaggeration to say, rather turbulent. New dynamic capabilities, especially those related to business interactions with their consumers, are gaining value. It is even becoming increasingly difficult to decouple products and services from their own IT infrastructures.

The development or adoption of digital platforms allows companies to operate in new spaces and niches. a) The expandable capacity of smart, connected products In addition to new supply channels, expansiveness has emerged as an important attribute of the new generation of products revolutionized by the evolution of information technology. Formerly composed primarily of mechanical and electrical parts, they are becoming complex systems that combine hardware, sensors, data storage, microprocessors, software, and a myriad of new forms of connectivity.

Increased processing capacity, miniaturization of devices, and the benefits of ubiquitous wireless connectivity have made these new products possible and are fostering a new era of competitiveness. Some may think that the Internet is largely responsible for the emergence of smart, connected products -and they are not fundamentally wrong. But it is the transformative nature of "things," that is, the expandable capacity of smart, connected products that is actually driving the transformation.

IT, for this reason, is becoming an integral part of the products themselves. Sensors, processors, software, and connectivity between them, as well as cloud data storage and processing, have led to substantial improvements in product functions and performance (PORTER & HEPPELMANN, 2014).

In order to understand well what we are referring to when talking about smart, connected products, it is important to keep in mind that they are made up of three main elements:

? Physical components: mechanical and electrical parts of the products.

? Smart components: sensors, microprocessors, data storage, controls, software, and typically an embedded operating system and end user interface.

? Connectivity components: ports, antennas, and protocols that enable wired or wireless connections to the product. Smart components extend the capabilities and value of physical components, while connectivity extends the capabilities and value of intelligent components and allows some of them to exist outside the physical product itself. The result is a virtuous cycle of value addition (PORTER & HEPPELMANN, 2014).

This transformative impetus of products even changes the value chains, impacting the relationship that companies have with their products and consumers, as they will tend to establish continuous, open and long-term relationships, forcing them to rethink and change virtually all their internal processes.

Even competitiveness will be affected by product developments. They will demand from companies new strategic choices related to the way value is created and captured, the use and management of the huge amount of data generated, the redefinition of relationships with traditional business partners, and the role that companies would have to play to the extent that the boundaries of industries expand (PORTER & HEPPELMANN, 2015).

3 b) What to do with this huge volume of data

One element that deserves much attention from those who wish to deepen about the evolution of smart and connected products is the use and management of data. Until recently, business data was primarily generated by internal operations and through supply chain transactions -order processing, supplier interactions, sales, customer visits and so on (PORTER & HEPPELMANN, 2015).

Responsibility for maintaining and analyzing data used to be decentralized within functions, sectors and departments. Even if data were shared, this was done in a limited, sporadic way (PORTER & HEPPELMANN, 2015). Now, finally, traditional data sources are being supplanted by another -the product itself. Smart, connected products can generate data in variety and volume like never before. **??**orter and Heppelmann (2015) even claim that data now equals people, technology and capital as a core asset of the corporation. In many businesses, they have even become a decisive asset.

Data generated by products is valuable, but it is a fact that its value increases greatly when it is integrated with other data, such as service histories, inventory locations, commodity prices, and traffic patterns. Here is the importance of companies with pretensions to remain competitive in the future to create and implement data generation, capture, storage, analysis and security policies and processes (PORTER & HEPPELMANN, 2015).

4 c) IT strategy repositioning -from operational to strategic level

Until very recently -and it is no exaggeration to say that even today in many companies -IT strategy has been confined to the functional level that, in turn, should be aligned with business strategy.

In recent years, this approach has been gradually changing as a result of impacting developments in information, communication and connectivity technologies.

Perhaps this is the time to rethink even the role of IT strategy. Rather than functionally aligned but subordinated itself to business strategy, a promising path is the fusion of IT and business strategies, which Bharadwaj and Venkatraman (2013) While the IT strategy can be positioned as a functional strategy, the digital business strategy should be positioned below the business strategy, but itself treated as a business strategy for the digital age.

Gradually, as companies and industries become more digital and base their products on information, communication and connectivity, the digital business strategy will be the business strategy (BHARADWAJ & VENKATRAMAN, 2013).

5 III. Industry 4.0 -The Digital Transformation in Industry

In this increasingly intelligent and connected world, the presence of the Internet of Things and Services will be felt in every area. In some, such as energy supply, mobility and health, smart grids are already formed. In manufacturing, vertical networks, end-to-end engineering, horizontal value chain integration, and increasingly intelligent products and systems are creating the fourth stage of industrialization -Industry 4.0 (KAGERMANN; WAHLSTER; HELBIG, 2013).

The recommendation issued by the German government with the term Industry 4.0 in its title was a decisive factor for its rapid expansion. Adopted by the Ministry of Education and Research, the term has become an eponym for a project establishing the hightech strategy for 2020 (LASI ET AL., 2014).

The US, as well as the Germans, are also taking steps to combat deindustrialization through advanced manufacturing promotion programs. This term even emerged as an alternative for Americans to Industry 4.0.

The working group responsible for publishing the German report to which we refer stated that, for Industry 4.0 to be effective, action will be needed in eight key areas (KAGERMANN; WAHLSTER; HELBIG, 2013): 1) Standardization and reference architecture; 2) Administration of complex systems; 3) Broadband Structure for industry; 4) Safetyandprotection; 5) Organization and work design; 6) Training and continuing professional development; 7) Regulatory framework; 8) Resource efficiency.

Essentially, Industry 4.0 will involve the technical integration of cyberphysical systems (CPS) in manufacturing and logistics, and the use of the internet of things and services in industrial processes. This will have implications for value creation, business models, production lines and work organization. Industry 4.0 will be able to promote transformations in various areas of manufacturing and especially throughout the value chain and the way companies relate to their customers. Next, from the publication of Kagermann, Wahlster and Helbig (2013), we detail the main ones:

? Individual consumerrequirements Individual and customer-specific criteria may be included in the design, configuration, ordering, planning, manufacturing and operation phases. Last-minute changesmayalsobeincorporated.

6 ? Flexibility

Ad hoc networks based on cyberphysical systems will allow the dynamic configuration of different aspects of business processes, such as quality, time, risk, robustness, price and sustainability.

7 ? Optimized decision making

Real-time end-to-end transparency will enable engineering decisions to be anticipated and more flexible responses to disruption and global optimization across all companies in the manufacturing sphere.

8 ? Productivity and resource efficiency

Cyberphysical systems enable manufacturing processes to be optimized on a case-by-case basis throughout the value chain. In addition, rather than disrupting production, systems can be continually upgraded during production, particularly in terms of resource and energy consumption.

? Creation of value opportunities through new services Novas formas de criação de valor e de emprego serão viabilizadas por meio, por exemplo, da agregação de serviços. ? Responses to demographic changes in the workplace Given the shortage of skilled labor and its increasing diversity in age, gender and cultural background, Industry 4.0 will create the conditions for careers to be more diverse and flexible, allowing people to work and stay productive for longer time.

9 ? Work-life balance

The more flexible organizational models of companies adopting cyberphysical systems will enable them to meet employees' growing need for a better balance between work and their personal lives, as well as continuous personal and professional development.

In the future, it will be possible for businesses to establish global networks that will incorporate their machinery, storage systems and production facilities in the form of cyber-physical systems. In manufacturing, these systems will comprise intelligent machines, storage systems and production facilities capable of autonomously share information, initiate actions and control each other. Individual consumer requirements may also be met. This means that even single units with unique and non-scalable features could be profitably manufactured. In Industry 4.0, dynamic business and engineering processes will enable last-minute changes in production and enable companies to respond flexibly to vendor disruptions and failures, for example (KAGERMANN; WAHLSTER; HELBIG, 2013).

The smart factories that are already operating employ completely new production methods. Smart products have unique identifiers, can be located at any time, and know their own stories, current condition, and alternative ways to reach the desired state (KAGERMANN; WAHLSTER; HELBIG, 2013).

10 a) Key aspectsofIndustry 4.0

In future production systems, manufacturing will be modular and efficient and products will be able to control their own manufacturing processes. This new reality, although it may seem fictional to some, is possible by the combination of Internet technologies and future technologies in the field of intelligent objects (LASI ET AL., 2014). Some aspects deserve mention to characterize what will be Industry 4.0:

1) It will be characterized by a new level of socio technical interactions between all actors -human or not -and resources involved in manufacturing (KAGERMANN; WAHLSTER; HELBIG, 2013).

2) It will allow workers to control, regulate and configure situation-based manufacturing steps supported by context-sensitive sensors. This way, they will no longer have to do so many routine tasks and can focus on more valuable creative activities.

At the same time, as we have said, flexible working conditions will enable greater compatibility between their work and personal needs (KAGERMANN; WAHLSTER; HELBIG, 2013). 3) Products and production processes will be intelligent. During the supply chain they will be able to orient themselves independently. Therefore, factories will have to learn how to deal with rapid product development, flexible production and more complex business environments (BRETTEL ET AL., 2014). 4) Communication between humans, machines and products will be fluid. Cyberphysical systems will capture and process data to self-control certain tasks and interact with humans through interfaces (BRETTEL ET AL., 2014).

Good jobs, technological innovation and worker codetermination are not mutually exclusive elements in the context of Industry 4.0. They are part of a forwardlooking approach that aims to develop solutions that are both technologically efficient and socially sustainable (KAGERMANN; WAHLSTER; HELBIG, 2013).

11 b) The Interdisciplinary Character of Industry 4.0

Industry 4.0 should be treated as a systemic approach consisting of actions needed in several key areas. It should be implemented in an interdisciplinary manner and in close cooperation with other areas (KAGERMANN; WAHLSTER; HELBIG, 2013). Its approaches and ideas lie at the interface of the disciplines of electrical engineering, business administration, computer science, business engineering, information systems, and mechanical engineering (LASI ET AL., 2014).

Some fields of research related to Industry 4.0 demonstrate its interdisciplinarity (BRETTEL ET AL., 2014): The concepts to which Industry 4.0 refers also deserve distinction, as they are varied and not always very clear. Below we list the main extracts from the publication by Lasi and his collaborators (2014):

12 ? Smart factory

The manufacturing will be equipped with sensors, actors and autonomous systems. Through the use of intelligent technologies and the application of ubiquitous computing, so-called intelligent factories will evolve to the point of becoming autonomously controlled.

13 ? Cyberphysical systems

The physical and the digital merge, and it is often no longer possible to differentiate them reasonably.

? New approaches to product and service development Open innovation and smart production are very important as product and service development will be individualized.

14 ? Adaptation to human needs

New manufacturing systems should be designed to address human needs rather than create them.

15 ? Corporate social responsibility

Sustainability and resource efficiency will be central to the design of manufacturing processes. Product success can be measured by companies' attention to these factors.

16 c) The transformations delivered and demanded by

Industry 4.0 -cloud manufacturing, manufacturing servitization, and more Not only will manufacturing and logistics processes be significantly affected by Industry 4.0, but also the organizational structures and the very nature of the work. The core roles of product development, IT, manufacturing, logistics, marketing, sales, and after sales will be redefined, and the need for coordination between them will certainly be greater.

Many new functions may emerge, especially those that will be responsible for managing huge amounts of data created, captured and managed by organizations. The classic organizational structure of manufacturing is compromised! Porter and Heppelmann (2015) even state that this will be the most substantial change in manufacturing business since the Second Industrial Revolution over a century ago.

A new technology infrastructure will also emerge from the spread of Industry 4.0. The new technology framework will consist of multiple layers, including new product hardware, embedded software, connectivity, a cloud of products running on remote servers, a suite of security tools, a portal to external information sources, and integration with corporate systems (PORTER & HEPPELMANN, 2015).

Cloud computing is perhaps one of the smart technologies that will most influence the direction of the manufacturing industry. Its main virtue is the provision of on-demand computing services with high reliability, scalability and availability in a distributed environment that provides a strategic dynamic capability for companies to scale up or down their infrastructures (BHARADWAJ & VENKATRAMAN, 2013; XU, 2012).

Cloud computing, still widespread in some manufacturing clusters, could expand significantly in the coming years. Its adoption usually occurs in two ways: i. Direct adoption of some cloud computing technologies; or ii. Cloud manufacturing.

The benefits of adopting cloud computing by manufacturing are varied, but are almost always related to enabling new business models (e.g. pay-as-you-go, elasticity of production, customization of solutions), support for smart business (e.g. better integrations and more efficient processes) and improved operational efficiency (e.g. moving an operating process to the cloud) (XU, 2012).

Cloud manufacturing, in turn, dictates that manufacturing processes are no longer productoriented but service-oriented. It finds inspiration in cloud computing and is seen by many as an attractive and natural solution.

In this new approach, distributed resources are encapsulated within cloud services and centrally administered. Consumers can use them according to their requirements through varied requests related to design, manufacturing process, testing, management or all other stages of the product life cycle (XU, 2012). Companies are expected to slowly modulate their business processes and have plug-and-play capabilities to connect these digital assets. This is already common in many new startups that developed connectors through APIs and web services (BHARADWAJ & VENKATRAMAN, 2013).

Cloud manufacturing is based on a variety of computing trends applied across a wide range of areas, such as pay-as-you-go computing, elasticity, virtualization, grid computing, distributed computing, content outsourcing, and web 2.0. However, to be viable, it must incorporate very characteristic technologies into the manufacturing context, such as network manufacturing, grid manufacturing (MGrid), virtual manufacturing, agile manufacturing, and the Internet of Things (XU, 2012).

To this new approach, Lee, Kao and Yang (2014) call it product service-system (PSS). They see it as a strategic innovation of organizational capabilities and processes toward selling not just more products, but integrated products and services. Continuous monetization in this approach is provided by offering a complete service solution, often delivered after sale, meeting unmet customer needs (LEE; KAO; YANG, 2014).

17 d) The 'speed problem' -from launch to product upgrade

Product launches in this new era of digital strategies will be accelerated. Speed will necessarily have to be recalibrated based on releases by pure play companies -which manufacture a single or a product line and are therefore much more dynamic. A multi-year, sequential product development plan will be essential for companies looking to remain competitive on a par with startups and other competitors.

In traditional molds, the launching speed is controlled alone and autonomously by the offering company. In recent years, however, due to increasing digitization, releases require network coordination with complementary products and services. And more: the competitive advantage will tend not to lie solely in launching new products but in ensuring their availability on a global scale.

The orchestration of the global supply chain itself is bringing competitive advantages to the companies that do it well. This is not about outsourcing low value activities. It is much more than this! We refer to collaborative work ranging from conceptual design to the recycling of today's products, but also tomorrow's, which demand the need for constant and dynamic realignment between partners and suppliers (BHARADWAJ & VENKATRAMAN, 2013).

18 IV.

The Benefits of digital Transformation in Industry 4.0 It is important to consider technological innovations in their sociocultural context, as cultural and social changes often, or almost always, drive them. The development of Industry 4.0 will strengthen the competitive position of many countries, especially the most developed ones such as the US and Germany, but will also make it possible to create solutions to many global challenges such as energy efficiency and resource use (KAGERMANN; WAHLSTER; HELBIG)., 2013).

It will enable new business models to emerge and impact the organizational structures of many industries. In addition, it has the potential to promote economic growth coupled with new forms of consumption and important progress in the environmental area.

19 a) New business models

Industry 4.0-based technology development will provide companies with new capabilities, enabling them to meet more sophisticated consumer requirements. This change will likely require the development of new business models and partnerships that address these requirements.

Kagermann, Wahlster and Helbig (2013) predict that the level of development of new business models for manufacturing on the Internet of Things and Services will approach the level of development and dynamism of the Internet itself. Even the perceived quality of products by consumers can increase, as remote maintenance and the development of new services and updates from data extraction and analysis will be feasible (BRETTEL ET AL., 2014).

20 b) The new manufacturingorganization

Over time, many units within companies may merge. IT and R&D, for example, will begin this process through closer collaboration and integration, which in many cases will culminate in a complete merger between them.

A new standalone unit should also emerge. It will be responsible for supporting corporate strategy for smart and connected products and will be composed of talented professionals who will mobilize the technology and assets needed to bring new offerings to market by working with all affected business units (PORTER & HEPPELMANN , 2015).

In some more sensitive areas, such as aircraft manufacturing, medical devices and agricultural equipment, smart and connected products will coexist with traditional ones for some time. This means that the organizational transformation described here will be evolutionary, not revolutionary, and old and new structures will need to coexist, operating in parallel (PORTER & HEPPELMANN, 2015).

21 c) Consumption reduction and progress on environmental issues

After decades of focusing on increased production, cheaper products, and increasing availability, businesses and consumers may need fewer and fewer things. This trend is already clearly seen in the so-called collaborative economy. Smart, connected products of the future will give us the autonomy to buy just what we need, share what we don't use so much, and enjoy more what we already have. Rather than discarding old products that often do not have the proper destination and may even compromise the quality of life of future generations, we will opt for products that are continually improved, updated and modernized (PORTER & HEPPELMANN, 2015).

In this new paradigm, we will be able to make much progress on environmental issues. We will substantially increase the efficiency of land, water and raw material use as well as energy efficiency and food production.

These relevant advances will contribute to the improvement of the human condition, especially in health, safety, mobility and education. But they imply, we must say, the challenge of changing the consumption trajectory of society as a whole (PORTER & HEPPELMANN, 2015).

22 d) Economic growth, better working conditions and solving human needs

The opportunities for innovation provided by smart, connected products and the expansion of data they create could drive strong economic growth. If this really happens, new industries, new services and new roles will emerge that will enable people to fulfill their aspirations. Porter and Heppelmann (2015) even predict relevant and positive impacts on employment. For them, smart, connected products will enable people to be more productive and work less routinely and repetitively. By equipping a technician with an augmented reality application and a smartphone, for example, he or she can make a complex repair even with limited training. Less skilled workers can be trained and guided much more easily by specialists.

The past decade, in the business context, has been characterized by the pursuit of domestic cost savings, cautious investments, increased profitability, growing merger and acquisition agreements, and quiet innovations among leading economic players. As a result, there has been reduced growth in the average population's jobs, wages and living standards, leading to a lower sense of economic opportunity, doubts about capitalism and reduced public support for business (PORTER & HEPPELMANN, 2014).

In this era of smart, connected products, businesses and governments will need to work together to define the rules and regulations necessary for setting standards, enabling innovation, data protection, and overcoming progress-driven efforts (PORTER & HEPPELMANN, 2014).

23 V.

The Challenges of Digital Transformation in Industry 4.0 Technical, business and legal factors will certainly determine the future of the manufacturing sector during the implementation of Industry 4.0. But also the new social structures in the workplace will be able to promote greater worker involvement and thus contribute to their consolidation. Industry 4.0 is likely to significantly transform work and workers' skills and abilities as a result of two trends: i. The clear division of labor characteristic of traditional manufacturing processes will be supplemented in the new organizational and operational structure by decision-making, coordination, control and support functions. ii. The need for organization and coordination of interactions between virtual and physical machines, plant control systems and production management (KAGERMANN; WAHLSTER; HELBIG, 2013). For this transformation to take place in line with the demographic changes that are taking place around the world, but more intensely in Europe, it will be important to increase the proportion of older people and employed women. It is already recognized from the latest research that individual productivity is not directly related to the age of people, but to the time in which they occupy a particular position and the way in which their activities are organized in the workplace. In order for workers' productivity to be preserved or even to increase over longer careers, various aspects of the work environment will need to be transformed, particularly health management and work organization, career models and lifelong learning, team structures and knowledge management (KAGERMANN; WAHLSTER; HELBIG, 2013). Some important questions immediately arise when we look at the topic:

? What will be the impact of Industry 4.0 on the work environment? ? What will be the responsibilities of business and society in a decentralized high-tech economy where cyberphysical systems will be common? ? In a future characterized by automation and realtime control systems, how can we ensure that people's jobs are good, safe and fair?

Enterprises will only be able to increase levels of innovation and productivity by widespread deployment of autonomously controlled, knowledge-based, sensorequipped manufacturing systems when they adequately answer these questions.

A new mission of innovation also presents itself on the horizon of manufacturing companies wishing to conform to Industry 4.0 principles. Work organization will need to be smarter and workers' skills expanded as they will be an essential part of the development and assimilation of technological innovations. As a result, a radical transformation of the content, processes and the work environment itself is expected, affecting flexibility, time control, health care, demographic change and even people's private lives (KAGERMANN; WAHLSTER; HELBIG, 2013).

Work organization will need to be rethought and models that combine a high degree of individual responsibility and autonomy with decentralized leadership will be important. Offering employees more freedom to make their own decisions, engage more and define their workloads while enabling more flexible work arrangements can also be tested (KAGERMANN; WAHLSTER; HELBIG, 2013).

While companies will demand from their workers the ability to manage complexity, abstract situations and solve problems, as well as greater flexibility and the accomplishment of more tasks, there is a risk that they will experience loss of control and alienation from work. This stems from the progressive dematerialization and virtualization of business and work processes. In addition, there can be a significant impact on companies' headcount as IT's presence in manufacturing increases. Some people may have their work threatened, especially the less qualified, due to the decrease of low complexity manual activities that will be performed (KAGERMANN; WAHLSTER; HELBIG, 2013).

24 a) Strengthening learning in organizations

Businesses will become highly complex, dynamic and flexible systems. Therefore, they will need to empower workers by empowering them to be controllers and decision makers. This will require broadspectrum training and work organization models that promote continuous professional learning and development (KAGERMANN; WAHLSTER; HELBIG, 2013).

An important way to make the training feasible will be by establishing partnerships between companies and educational institutions. It will be interesting that short-term training programs are complemented with work placement and more advanced courses. Some transferable skills, such as business and project management, will also be highly valued. However, some authors, such as Kagermann, Wahlster and Helbig (2013), also emphasize the importance of training that focuses on the importance of workers' health, physical activities and lifestyle, which will help to ensure a long professional career.

The aforementioned working group organized by the German government that coined the term Industry 4.0 listed some recommendations concerning qualifications, training and lifelong learning in the context of Industry 4.0 (KAGERMANN; WAHLSTER; HELBIG, 2013):

1. Promotion of project models 2. Establishment and promotion of "best practice networks" 3. Investigation of new approaches to workplace knowledge and skills acquisition and the development of digital learning techniques 4. Promotion of cross-cutting approaches to work organization 5. Promotion of specific content for Industry 4.0 and interdisciplinary cooperation 6. Modeling IT-basedtechnology systems b) Product and production architecture changes due to mass customization In Industry 4.0, mass customization will consist of a production strategy that will focus on large-scale production of custom products. This will require process flexibility, modular product design, and strengthened integration among supply chain actors along the value chain (BRETTEL ET AL., 2014).

Reconfigurable Manufacturing Systems (RMS) emerge as an important alternative to the need to produce custom products. Intelligent factories that choose them can add, remove, or rearrange machine components depending on their modular mechanical interfaces. A recent survey by the Institute for Industrial Management in Aachen, Germany, however, found that the lack of robustness and possibilities for integrating IT systems, employees' inadequate knowledge of production processes and insufficient efforts for change within companies make it difficult to implement RMS (BRETTEL ET AL., 2014).

Brettel and others (2014) also suggest some guidelines for exploring the flexibility of collaborations:

? Supply chain redesign to enable route and schedule adaptation; ? Reduction in inventory levels and lead times to achieve high agility; ? Strengthening the synchronization of organizations with information sharing to ensure the satisfaction of consumer needs. The exchange of information, emphasized on this last point, will depend on the industry-wide establishment of uniform data transfer and use patterns (BRETTEL ET AL., 2014).

Lasi and others (2014) noted that developments towards Industry 4.0 will not only have technological, but also organizational, implications, shifting the business orientation from products to services. The main developments, according to them, can be summarized in five points:

? Reduced development time Development and innovation times will need to be reduced. High capacity for innovation will be a key success factor for many companies (time to market).

25 ? Individualized demand

Instead of the seller, the market will be focused on the buyer, who can define the conditions of the deal. This trend will promote increasing product individualization and, in extreme cases, individual products. This can alsobecalled batch sizeone.

26 ? Flexibility

Due to the new requirements, greater flexibility will be required in product development, especially in its production.

27 Global Journal of Management and Business Research

Volume XIX Issue XII Version I Year 2019 ( )

28 ? Descen tralization

Faster decision making processes will be required to deal with the specified conditions. This will only be feasible if the organizational hierarchies are reduced.

29 ? Resource efficiency

The growing scarcity and the consequent increase in resource prices and social changes in the context of ecological aspects demand greater concern with sustainability.

? Repositioning functional limits and new functions in business The new configurations and increased capacity of smart, connected products and the availability of large data will radically restructure traditional business functions. It tends to start with the product development area, but spread rapidly through the value chain. Functional limits will change and new functions will be created (PORTER & HEPPELMANN, 2015).

30 ? Product development

For products to become smart and connected it is necessary to rethink all their design elements. They will be complex systems that will contain software and may even have them stored in the cloud. As a result, product development teams that until then consisted mainly of mechanical engineers will mostly have software engineers. Some companies, such as GE, Airbus and Danaher, because of this transformation, have even opened offices in software engineering centers such as Boston and Silicon Valley (PORTER & HEPPELMANN, 2015).

31 ? Manufacturing

From smart and connected products will come new requirements and production opportunities. Manufacturing will overcome the barriers of physical object production because a functionally intelligent, connected product will require a cloud-based system to operate throughout its life cycle (PORTER & HEPPELMANN, 2015).

32 ? Logistics

Smart, connected products will amplify the ability and importance of tracking. It can be done continuously, regardless of where products are, without the need for a reader, providing rich information not only about your current location, but also about your location history, conditions (e.g. temperature) and the surrounding environment. Smart and connected products have the potential to significantly transform logistics processes as well (PORTER & HEPPELMANN, 2015).

33 ? Marketing and sales

The ability to stay connected to the product and track how it is being used redirects the focus of the company's customer relationship -from selling, a single transaction, to maximizing value over time. This creates important requirements and opportunities for marketing and sales (PORTER & HEPPELMANN, 2015).

34 a) New ways to segment and customize

Data extracted from smart, connected products provides a true portrayal of their use, demonstrating, for example, which features are preferred and which consumers have difficulty using. By comparing usage patterns, companies will be able to more finely segment their consumers -by industry, geographic location, organizational unit, and other attributes.

35 b) New relationships with the customers

To the extent that companies acquire the condition of continually deliver value to the consumer, the product itself will be a means for delivering value rather than the end itself. Direct and continuous dialogues with consumers will be possible through the connection manufacturers will offer through the product.

36 c) New business models

Transparency about consumer use of products will encourage companies to develop entirely new business models. Many industrial companies already offer their products as services, and this transformation tends to intensify rapidly. Consumers and the business will need to feel embedded in a win-win scenario where the goal of salespeople becomes consumer success rather than simply making the sale.

37 d) Focus on systems, not products

Interoperability with related products will be critical to the success of smart and connected products. They themselves will become components of larger systems, which will make the value proposition perceived by the consumer change. They will no longer value only the quality and functionality of the product even though they remain essential.

38 ? After sales services

In the era of smart, connected products, aftersales services will no longer be reactive, but preventive, proactive and remote. This transformation will only be possible by improving services and generating efficiency (PORTER & HEPPELMANN, 2015).

39 ? Security

Historically, it is the responsibility of IT departments of industrial companies to safeguard their data servers, business systems, computers and networks. With the advent of smart and connected devices, this reality will change radically. Responsibility for IT security will cut across all functions. Smart, connected products may even have more points of vulnerability than traditional IT systems, and the impacts from intrusions will be even more severe. Consumers will surely demand from companies security about their products and their data. Therefore, companies' ability to offer security will be a key source of value and a potential differential (PORTER & HEPPELMANN, 2015).

The Benefits and Challenges of Digital Transformation in Industry 4.0

40 ? Human resources

The requirements imposed on smart, connected product manufacturers will require new skills across the value chain, transforming the way they work and even some cultural norms (PORTER & HEPPELMANN, 2015).

41 a) New skills

The skills to design, sell and support smart, connected products have high demand but low supply. Manufacturers already developing smart, connected products are urgently required to find talented professionals as the skills required have shifted from mechanical engineering to software engineering, from selling products to selling services, and from maintenance to management of uptime products. Companies that are still undergoing restructuring processes, or have not yet begun the transformation, will face even greater difficulties. Over the next decade, manufacturers will have to streamline processes and even create new recruitment models (PORTER & HEPPELMANN, 2015).

42 b) New cultures

The need for greater coordination between roles and disciplines in smart, connected product factories will force HR professionals to rethink many aspects of organizational structure, policies and standards (PORTER & HEPPELMANN, 2015).

43 c) New compensation models

Talented professionals, already scarce today and potentially even more in the future, can be attracted and motivated by incentives such as work flexibility, concierge services, sabbaticals and free time to work on side projects of personal interest. Such policies are already common in high-tech companies that employ the kind of professionals that manufacturing companies will increasingly demand (PORTER & HEPPELMANN, 2015).

44 d) Will every industrial enterprise become a software company?

Jeff Immelt, while serving as CEO of General Electric, once prophesied that every industrial company will in the future become a software company. It is a widely accepted fact that changing the nature of work along the value chain will imply a historical transformation of the manufacturing enterprise (PORTER & HEPPELMANN, 2015). **??**orter and Heppelmann (2015), in this sense, elaborated an overview of the organizational lessons that other industries can take from the software industry.

45 ? Shorter development cycles

The software industry has shifted from periodic major product releases to smaller and incremental releases of updates and enhancements. As a result, companies can bring new products to market and respond to consumer needs faster. Best practices in software development are: agile development processes, daily collaboration between developers and marketers, weekly deliveries, ongoing course corrections, and ongoing customer satisfaction testing.

? Product-as-a-service business models

In the software market, service-based business models are already relatively consolidated. Consumers buy software as a subscription and pay only for what they need when they need it rather than buying systems that tend to become idle. This implies the classification of the product as an operating expense rather than an investment, greatly simplifying financial and accounting postings.

46 ? Focus on customer success

Software-as-a-service models have led to the creation of customer sucess teams within software companies.

47 ? Products as part of broader systems

Most software is released as part of a business tool suite whose value is leveraged by its integrations. The most successful software companies often offer APIs and other tools for easy integration of their products with other software.

? Data analysis as a competitive advantage Many software companies, especially in ecommerce, have long understood the power of data analysis to create value for consumers.

48 e) Changes in competitive market forces

In any industry, regardless of field, five forces drive competitiveness: buyers' bargaining power, the nature and intensity of rivalry between competitors, the barrier to new entrants, the barrier to substitute products and services, and the power of bargaining from suppliers.

The composition and relationships between these forces determine how competition in industry takes place and the average profitability of competitors. New technologies, consumer wants and needs and other factors have the ability to change the structure of the industry and hence the five competitive forces. The emergence of smart and connected products will certainly affect the structure of many industries. Something similar occurred in the 2000s during the spread of the Internet. Porter and Heppelmann (2014) state that the effects could be even greater in the manufacturing sector. Ahead, let's look atthestatementoftheseauthors:

49 i. Bargaining power of buyers

Smart, connected products offer new opportunities for differentiation, exempting companies from competing on price. As they understand how consumers use products, increases their ability to segment consumers, customize solutions, set appropriate prices for the best value capture, and add value through service delivery. This reduces the

50 Global Journal of Management and Business Research

Volume XIX Issue XII Version I Year 2019 ( ) bargaining power of buyers. However, product-as-aservice and product-sharing business models reduce barriers to consumer migration to a new manufacturer, in some cases increasing their bargaining power.

51 ii. Rivalry between competitors

Smart, connected products can transform competition by opening new opportunities for differentiation and value addition through service delivery. It will be possible to offer products to more specific market segments and customize products for individual consumers.

52 iii. Barrier for entry of new competitors

When we talk about a smart and connected world, high fixed costs appear as the biggest obstacle for new competitors to enter. They come from the increased complexity of products, embedded technologies, and the multiple layers of new IT infrastructures. The collection of data by companies already in the market, which are better able to use them to improve their products and services and to redefine after-sales services, is also a major obstacle for new entrants. However, some processes characteristic of the intelligent and connected world have the ability to lower these barriers. When established companies hesitate to adapt to this new paradigm while protecting their still heavily hardware-based businesses, legacy parts and cost-effective services, the doors for new competitors open.

53 iv. Threat of substitutes

Superior performance, customization, and the inherent value of smart, connected products alleviate replacement threats and expand the industry's possibilities for growth and profitability. Smart, connected products can even pose a threat to traditional ones because they have the potential to extend their capabilities by incorporating the key attributes of equivalent conventional products.

54 v. Bargaining power of suppliers

The smart and connectivity components of new products deliver more value than physical components, making them commoditized or even replaced with software. This reduces the bargaining power of many traditional suppliers. But new vendors, it should be said, will emerge to develop sensors, software, connections, embedded operating systems, data storage and analysis, and other elements of the vast technological framework. These suppliers can gain high bargaining power by capturing a larger share of the value of the product, which will reduce the margins of manufacturers.

The effect of smart, connected products on the industry structure will vary, as it will depend on the specific characteristics of each sector, but some trends seem clear. First, increasing barriers to entry, combined with the advantages of pioneering the accumulation and analysis of product use data, suggest that many industries can consolidate.

New entrants are also likely to emerge, as companies not committed to legacy products and entrenched ways of competing and without a historic set of profits to preserve will seize opportunities to leverage the full potential of smart, connected products to create value. Some of these strategies will be less productivethat is, the system that connects products will be the main advantage, not the products themselves (PORTER & HEPPELMANN, 2014).

Smart and connected products will also affect the internal structure of companies, particularly in the areas of product development, services, marketing, human resources and security, and may even influence their strategic choices. Ahead, we detail some elements of this transformation from the perspective of Porter and Heppelmann (2014).

55 vi. Product development

Smart, connected products must meet a number of attributes for them to be understood as such. The main ones are hardware standardization through software-based customization, the ability to customize, the ability to receive updates during use, and enabling predictive, extended, or remote services. Manufacturing processes, of course, will need to accept later and even aftermarket changes quickly and efficiently. Companies will need to synchronize different hardware and software development dynamics, especially in terms of development time. In short, theywillneedtobe more agile.

56 vii. After sale services

Smart, connected products enable significant improvements in predictive maintenance and value delivery through service delivery. New organizational structures that support service delivery and delivery processes will be needed for manufacturers to benefit from product data that can reveal existing and future problems and enable real-time repairs, sometimes even remotely.

57 viii. Marketing

Smart, connected products demand new marketing practices, as it will be common for companies to establish different forms of customer relationships. New insights are gained as companies accumulate and analyze data on product usage, allowing offerings to be better positioned and communicating product value to consumers more effectively. Market segmentation can also become more sophisticated through the use of data-based analytical tools, allowing you to design products and service packages that deliver the most value for each segment and pricing to match the values delivered and captured.

58 ix. Human resources

Smart, connected products require recruiting people with a new skill set, many of whom are in high x. Security Smart, connected products require robust security management processes to protect data that travels between systems and products against unauthorized use, and to ensure the safe integration of products with enterprise systems.

59 VI.

60 Conclusion

This article is the result of part of a broader research on Digital Transformation and Industry 4.0. The evidence presented here was gathered from the literature review on these two themes, where we restricted the scope of the analysis to the works most referenced by the most cited and most recent publications published in relevant journals.

Although the number of articles analyzed is limited, relevant issues were based in our discussion. The breadth and importance of IoT and cloud computing for Industry 4.0 was enhanced by the work of Atzori, Iera and Morabito (2010) and Xu (2012). We detail some applications and the importance of identification and tracking technologies, wired and wireless sensors, actuator networks, communication protocols, and distributed intelligence for intelligent objects.

We also evaluated the new role of IT strategy in manufacturing organizations. To this end, we rely on the work of Bharadwaj and Venkrataman (2013), who suggest that IT strategy is no longer addressed at the functional level, aligned but essentially subordinate to business strategy. Instead, a fusion of IT and business strategies would lead to digital business strategy.

At a broader level, we also explore transformations in industries and markets, pointing to the potentials and developments already perceived towards Industry 4.0. For this, the publications of Kagermann, Wahlster and Helbig (2013), Brettel, Friederichsen, Keller and Rosenberg (2014), Lasi, Fettke Kemper, Feld and Hoffmann (2014) and **??**eppelmann (2014, 2015) were valuable. From the first, we know the efforts made by Germany, the precursor country of this movement, and understand how initiatives such as this can be delivered by various actors in similar directions with positive consequences for the market and society as a whole. **??**eppelmann (2014, 2015), in turn, made us look deeper into organizations, especially when they described the impacts of new modes of production on organizational structures and the foundations of work. From their point of view, we can praise the challenge that organizations will face to preserve and even improve the quality of life of their employees in both the workplace and their personal lives.

We talked about how big data generation, extraction and analysis will be made possible by big data technologies and connected machines in a collaborative community. Most importantly, we report from the work of Lee, Kao and Yang (2014) how transforming the manufacturing service into a big data environment with intelligent predictive computing tools can promote transparency and increased productivity.

Finally, it is up to us to say that all the themes discussed here deserve further study, both theoretically and practically. Therefore, the major contribution of this article may be the gathering in a single document of several topics about Digital Transformation and Industry 4.0 that may pave the way for several other more specific researches on the various topics addressed. [1]

1

#	Authors	Title	Year	Publication
		Industry 4.0	2014	Business & Information Systems Engineering
6	LEE, Jay; KAO, Hung-An; YANG, Shanhu	Service Innovation and Smart Analytics for Industry 4.0 and Big Data Environment	2014	Procedia CIRP
7	PORTER, Michael E; HEPPELMANN, James E	How Smart, Connected Products Are Transforming Companies	2015	Harvard Business Review
8	PORTER, Michael E; HEPPELMANN, James E	How Smart, Connected Products Are Transforming Competition	2014	Harvard Business Review
9	XU, Xun	From cloud computing to cloud manufacturing	2012	Robotics and Computer-Integrated Manufacturing

Fonte: elaborado pelos autores.

Figure 1: Table 1 :

Figure 2:

[Brettel] , Malte Brettel .

[Friederichsen] , Niklas Friederichsen .

[Kagermann et al.] , Kagermann , ; Henning , Wolfgang Wahlster .

[Lee et al.] , Jay ; Lee , Kao , Hung-An .

[Porter] , Michael E Porter .

[Porter] , Michael E Porter .

[Perspective. International Journal of Information and Communication Engineering ()] , *Perspective. International Journal of Information and Communication Engineering* 2014. (1) .

[Bharadwaj and Venkatraman ()] 'Digital Business Strategy: Toward a Next Generation of Insights'. Anandhi ; Bharadwaj , N Venkatraman . *MIS Quarterly* 2013. (2) p. .

[Heppelmann ()] 'How Smart, Connected Products Are Transforming Companies'. James E Heppelmann . *Harvard Business Review* 2015. p. 26.

[Heppelmann ()] 'How Smart, Connected Products Are Transforming Competition'. James E Heppelmann . *Harvard Business Review* 2014. p. 34.

[Keller] *How Virtualization, Decentralization and Network Building Change the Manufacturing Landscape: An*, Michael ; Keller . Industry 4.0.

[Lasi et al. ()] Lasi , ; Heiner , Fettke , ; Peter , Hans-Georg Kemper , ; . *Industry 4.0. Business & Information Systems Engineering*, 2014. p. .

[Helbig ()] *Recommendations for implementing the strategic initiative*, Johannes Helbig . INDUSTRIE 4.0. 2013. Germany. National Academy of Science and Engineering

[Yang ()] *Service Innovation and Smart Analytics for Industry 4.0 and Big Data Environment. Procedia CIRP, v*, Shanhu Yang . 2014. 16 p. .

[Atzori et al. ()] *The Internet of Things: A survey. Computer Networks, v. 54, n. 15*, Luigi ; Atzori , Iera , ; Antonio , Giacomo Morabito . 2010. p. .

[Klopper et al. ()] *The matrix method of literature review. Alternation, v. 14, n. 1*, R Klopper , S Lubbe , H Rugbeer . 2007.