ROUTLEDGE FOCUS

Industry Dynamics and Industry 4.0

Drones for Remote Sensing Applications

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With great affection,
Bernardino Quattrociocchi, Sapienza, University of Rome, July 2021

Preface

The Fourth Industrial Revolution has encouraged companies to adapt to a new business paradigm based on digital interconnection and the ability to respond increasingly quickly to the needs of consumers and users. This has been further amplified in recent years, in which the spread of COVID-19 has conclusively highlighted how digital innovation and the rethinking of business models should be considered increasingly crucial factors for business survival in the present era. These are conditions that are closely related to the advent of new digital technologies, which enable the real-time integration of devices and systems for production control through technological platforms.

In this context, drones and robots play a notable role. Drones, indeed, comprise an integral part of this process; owing to their physical and technological characteristics, drones can be used in different industrial sectors (military, security, energy, transport, agriculture, etc.), and their potential can be exploited even in areas that are not accessible to humans.

Given this logic, the present Volume aims to investigate the forms and methods with which the company is now facing the new business paradigm, commonly known as Industry 4.0 (Pedrazzini, 2018) as well as the impact of new digital technologies on the evolutionary dynamics of the company and related business models. More specifically, the Volume proposes an assessment of the impact of new technologies on productivity and investment in complementary resources–such as human, organizational, and managerial capital–as well as the effects on production processes related to the introduction of the Internet of Things (IoT).

When following this approach, the focus is subsequently shifted to drone technology, which is considered by many to be one of the revolutionary technologies in the context of Industry 4.0; in addition to investigating its history and potential applications, many of which proved to be fundamental during the COVID-19 pandemic, the Volume also emphasizes the ethical and social aspects of drones, such as the degree of knowledge and public acceptance regarding them.

The Volume, which was drawn up through an academic and professional approach, is proposed as a manual for professionals, entrepreneurs, and academics with a particular interest both in digital innovation and the sector of drones.

Finally, following these brief introductory notes, our dutiful and sincere thanks go to those colleagues who, with their skills and their passion, have contributed to our professional growth.

Fabio Massimo Castaldo – Vice-President of the European Parliament, July 2021

Introduction

Technological innovation related to Industry 4.0 has revolutionized the manufacturing industry. The most interesting and challenging aspect of this revolution concerns the optimization of numerous aspects of the organizational structure of a company. Digital transformation, which has a profound impact on the entire value chain, is an essential element for determining a company's competitive advantage. This new production paradigm aims to make the organization of work and the methods of production more efficient; however, a new system configuration will be required to improve the relations between the company and its stakeholders as well as internal and external communication.

Precisely because of the substantial magnitude of the consequences of this innovative scenario–the reorganization of the structure and of the production activities of the company–the process in progress has been identified as the "Fourth Industrial Revolution," also known as "Industry 4.0" in the literature.

The transition from the Third Industrial Revolution, which encapsulates the latter half of the 20th century, to the fourth was driven by the transition from analog equipment to those based on digital technologies owing to the rapid development of information technology (IT) or information and communication technology (ICT), which is characterized by the convergence of computer science and electronics. Major societal changes followed this transition and, in many ways, still serve as harbingers of further developments. In this new dimension, technologies such as Big Data, cloud computing, advanced robotics, and artificial intelligence (AI) have resulted in the new production paradigm called "Industry 4.0" (Pedrazzini, 2018). This paradigm provides an organizational method for the production of goods and services that is based, first and foremost, on the integration of physical systems, plants, and machinery with digital technologies through an efficient connection to a network that enables the collection and analysis of information for the improvement of the production cycle. In addition, the widespread use of the IoT, wherein electronic devices in a network are embedded with software that allows it to exchange data with other connected devices, also promotes the development of the Fourth Industrial Revolution.

The term "Industry 4.0" has its genesis in the German expression "Industrie 4.0" (and the subsequent English "Industry 4.0"), which was derived from a specific research document entitled "Zukunftsprojekt Industrie 4.0" that is, "Project for the Industry of the Future 4.0." The aforementioned study was presented at the 2011 Hannover Fair as part of the German government's broader *High-Tech Strategy 2020 Action Plan* for the digitization of production processes and products themselves.

Consequently, this new paradigm based on innovation completely changes a company's approach to both production and market, forcing it to change the structural references and even to seek new professionalism and skills. The perception of value itself and corporate strategies also change with the technologies that drive the new scenario considered herein.

This publication describes the forms and methods with which a company is tasked with developing a new business model that is capable of governing the transformation of said company and serving as a tool for aligning technological development and the creation of economic value. The term "business model" refers to "an architecture of products, services, and information flows" (Timmers, 1998), thus configuring an abstract, exemplary description of business activity. The perspective chosen by the present publication aims to assess the impact of new technologies on productivity and investments in complementary resources, such as human, organizational, and managerial capital, as well as the impact of IoT on production processes, which allows for an increasing amount of information to be made available throughout the value chain. From the latter perspective, companies are called to address various challenges, such as privacy and security measures for protecting the data generated by the IoT, given that its use in business processes significantly affects not only the quality and range of products, up to their extreme personalization, but also the dialogic dynamics with the market and with all the target audiences in a continuous circuit that consists of information exchanges in real time. The transition to Industry 4.0, therefore, affects every aspect of the structure of a company, beginning with the same business models and extending to the logistics systems.

Consequently, changing the production paradigm, or moving to Business 4.0, entails managing machines, products, and human resources in an integrated and intelligent manner.

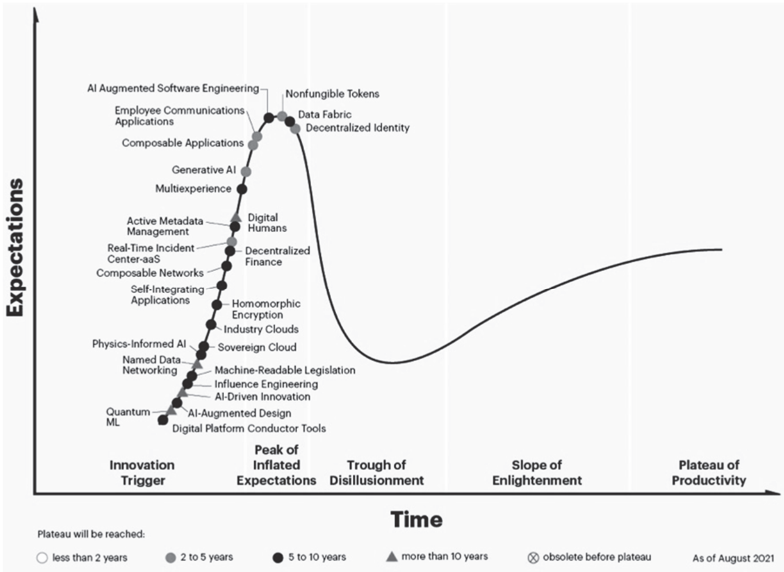
Among the various enabling technologies that characterize the ongoing innovative process in many respects, some are destined to have a decisive impact on the transformation of business processes. These technologies include the use of clouds and augmented reality vision systems, the interconnection of tools and machinery by means of the development of internet networks, Big Data analytics, and cyber security, among others.

Support for 5G technology, which allows for faster and smarter networks, is a crucial factor in grafting these technologies into business processes. These new technologies will have a profound impact on the use and enhancement of data as well as on the level of human–machine interaction, thus opening a new chapter of skills and necessitating a requalification of labor resources.

As shown in the diagram below, the Gartner Hype Cycle for Emerging Technologies 2020 identifies 30 technology skill profiles that will have a significant impact on society and business in the next 5 to 10 years. The Gartner tool employs the unique hype cycles, which distill over 1,700 technologies into a list of must-know technologies and trends. The 2020 data highlights the following five unique trends:

- composite architectures,
- algorithmic trust,
- beyond silicon,
- training AI, and
- digital me.

Fig. A. Hype Cycle for Emerging Technologies, 2021



Source: www.gartner.it – https://www.gartner.com/smarterwithgartner/3-themes-surface-in-the-2021-hype-cycle-for-emerging-technologies.

The training AI, a type of AI that is capable of dynamically changing to respond to a situation, for example, adapting over time to technologies that are capable of generating new models to solve specific problems, is one of the most interesting pieces of evidence proposed by the Gartner data. This is the case with generative AI, which can create new content (images, videos, etc.) and alter existing content. The new artifacts are similar, but not identical, to the original ones.

The fifth trend examined by Gartner, called "digital me," comprises technologies that entail the creation of digital integration systems between man and technology. Bidirectional brain-machine interfaces, for example, are wearable devices that allow bidirectional communication between a human brain and a computer or machine interface. The potential applications of these devices include authentication, access and payment, immersive analytics, and exoskeletons in the field of business relationships.

Here, the timeline proposed by Gartner highlights the continuous evolution of technologies that can be applied to business processes and the related innovative skills and professional figures that might be required by the market; in addition, it suggests ideas for planning investments in IT. In a context such as that of the ever-changing Industry 4.0, there is a need for new professional figures such as digital business analysts, cyber security experts, hardware engineers, and architects of new technological and organizational systems.

Various government projects have been promoted and implemented in Europe to transfer the concept of Industry 4.0 to the entrepreneurial fabric and encourage the adoption and development of technologies related to the Fourth Industrial Revolution: “Industrie 4.0 in Germany, “Industrie du Futur” in France, Smart Industry” in the Netherlands, and “Catapult–High-Value Manufacturing” in the United Kingdom (UK) are all investment support and incentive activities with similar characteristics and objectives. These initiatives are all characterized by arrangements of tax incentives and financing for companies that intend to evolve according to digital connection and integration models. The system adopted by Italy that starts from the 2017 Budget Law, which is named “National Industry 4.0 Plan,” ensures the financial commitment of the government in supporting tangible and intangible investments from a multi-year perspective. This regulatory system includes various incentive profiles, which primarily concern tax relief measures for plant and machinery as well as for research and development expenses. The Italian incentive system stimulates the creation of appropriate network infrastructures and the provision of public support tools to guarantee private investments and facilitate the transition toward the new production paradigm (Quattrociocchi, 2020).

As might be expected, even the boundaries of the technological world enclosed in Industry 4.0 are destined to be overcome, at least in the instrumental sphere if not in the regulatory one, by the evolution of innovation that begins to prefigure the lines of an “Industry 5.0” profile. This evolution can be seen in the introduction of collaborative robots or cobots, which can communicate with operators and improve their performance, into specific production processes with obvious benefits for the health and safety of workers as well as for the competitiveness of a company in terms of its environmental impact. In other words, such an evolution is the "Human Technology Oriented" model defined by the Japanese manufacturing world.

It is therefore essential to understand the consequences of technological innovation for the value chain of a company and for business models as well as how these consequences can generate the differences that determine a company's competitive advantage.

According to a 2018 Deloitte research (Report Italia 4.0, www.deloitte.com/it), Italian business executives are particularly aware that the implementation of new technologies is a key factor for competitive differentiation on the market, with 32% stating that they "completely agree" on this point. Consequently, Italian companies recognize the importance of adopting new 4.0 technologies to remain competitive in the future and have started investing in them.

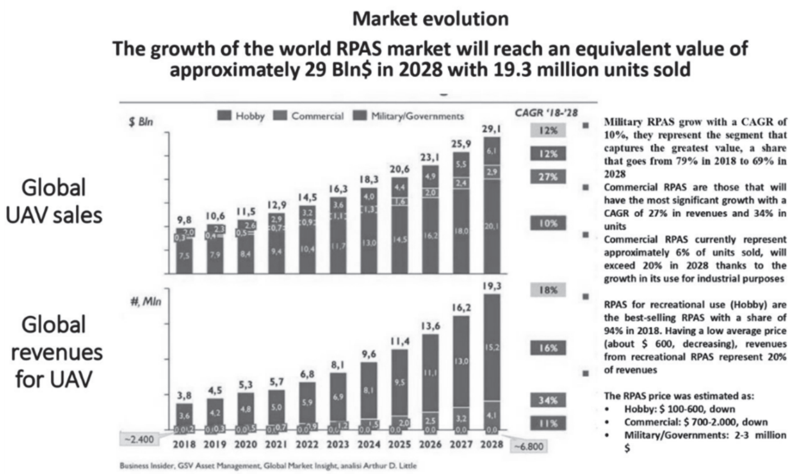
One company function that is particularly involved in undergoing changes in in terms of its production processes is **logistics**, which will be considered here. It is interesting to confirm how technological innovations with numerous applications, such as blockchain, can have a significant impact in the field of external logistics. These systems enable the certification of information and transactions carried out between the network nodes, similar to a distributed public register. Indeed, I have already adopted numerous blockchain-based projects in various sectors, from financial to healthcare services as well as mobile payments, logistics, and supply chain management.

Among the various applications of 4.0 technologies, it seemed interesting to conduct an in-depth exploration of a product that offers unique insights regarding the services that can potentially be linked to it: **the drone**. This object is characterized by wide diffusion, particularly in areas that strictly concern the delivery phase of goods, especially in some parts of the world, as already implemented by the giant Amazon.

In any case, drones certainly constitute one of the most noteworthy technological innovations in recent years, particularly with respect to possible applications in multiple fields and so much so that the intervention of the technologies related to it now extend far beyond its use for hobby purposes–an initially preferential field of application–and move toward the diffusion of the drone at a general level.

The data on the trend of the sector evince some curious projections. As per the most recent analyses and as highlighted in the following figure, which was presented by the consulting firm Arthur D. Little at the Dronitaly in Milan (the most important Italian exhibition in the sector, with data from the latest publications from the firm, namely, from April 4 and 5, 2019), the global growth of the remote piloted systems market will reach significant figures by 2028, equal to a value of 25 billion US dollars and corresponding to approximately 19.3 million units sold.

Fig. B. Remotely Piloted Aircraft Systems' (RPASs) Market Evolution

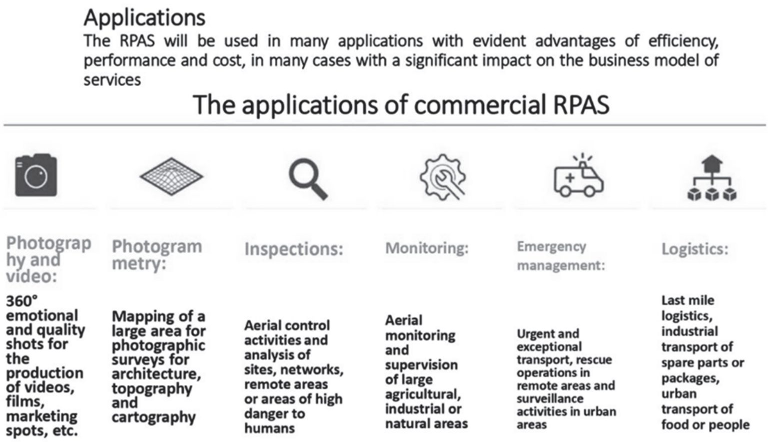


Source: Arthur D. Little (2019).

Crucially, the services sector linked to the use of drones will benefit from the rapid expansion of the market given the opening of new spaces and areas of application favored by continuous technological innovation, which will specifically involve cameras, sensory applications, and three-dimensional mapping. The global payload market will hit 7 billion dollars in 2022.

Of the applications that are being paid increasing attention is drone delivery, which has already been announced by the major players in the sector and, as in the case of DHL, has been launched in limited areas. The following figure illustrates how the commercial applications of remotely piloted aircraft systems (RPASs) will become more prevalent in various fields, with a clear impact on the business models of numerous services.

Fig. C. Main Fields of the Future Applications of RPAS Services



Source: Arthur D. Little (2019).

According to a recent study conducted and published by Single European Sky ATM Research/Air Traffic Management (SESAR), concerning an air traffic management system for the single European sky, approximately 7.4 million drones will be operating in the European skies by 2035. This will generate a demand of products and services worth of 10 billion euros. Growing technological innovation, new regulatory parameters, and cost containment, particularly registration and management costs are all factors that can influence market growth.

According to the same SESAR study, value-added services are expected to have the greatest economic impact in Europe in the coming years, accounting for approximately 70% of the total value along the unmanned aerial vehicle (UAV) value chain.

In terms of drone production, in all its forms and structures, Europe is one of the most important markets, with 235 active companies, 13% of which are in Italy, while the United States (US) and China dominate the market. France (Parrot), Germany (AirRobot, Ascending Technologies, and Microdrones), and Holland (Aerialtronics) are the primary civil RPAS manufacturing countries.

Finally, to complete the current publication, an in-depth investigation on the communication of innovation and innovation is proposed. In particular, methods are outlined for how communication can intervene and convey the value that is generated by technological innovation in relation to production processes to the target audiences of a company. Notably, however, the same corporate communication, business communication, is affected by new methods of transmitting information, which, in these circumstances, are also determined by digital transformation.

1. New business models in the Fourth Industrial Revolution

SUMMARY: 1. Introduction. – 2. Strategic innovation as a factor in new business models. – 2.1. The Fourth Industrial Revolution: Industry 4.0. – 3. The impact of new technologies on production. – 3.1. The impact of new technologies on internal logistics. – 3.2. The impact of new technologies on external logistics and after-sales services. – 4. The impact of Industry 4.0 on business models.

1. Introduction

The Fourth Industrial Revolution, also known as Industry 4.0, is concerned with the incorporation of new technologies into the industrial environment. Industry 4.0 reduces the importance of economies of scale; the strategic positioning of a company within the value chain, rather than its size or production volume, becomes increasingly important. In this sense, the digital transition alters business practices through the use of advanced technological solutions, which influence the entire production and distribution chain. This is a novel approach that considers the entire industrial cycle, with AI playing a central role in promoting integration into industrial plants.

Companies around the world are witnessing new technologies disrupt their industries, which translates into business model innovation. Companies such as Amazon, Uber, Tesla, Google, Alibaba, and UPS, among many others, have used AI to innovate their business models and improve their competitive advantages.

The concept of business model innovation has been brought to the forefront in the debate over how companies can maintain their market position; in this debate, identifying the drivers behind this maintenance process constitutes the main starting point. One factor that causes a company to innovate its business model is the influence of the external environment, particularly when this environment is of a technological nature. In this regard, there are two lines of research in the literature: one focuses on the external factors that can drive companies to engage in business model innovation; the other examines how the introduction of new technologies can involve companies innovating their business models. Unfortunately, few studies have been conducted to date on the direct impact that emerging technologies have on the evolution of business models. Only recently have some studies started meticulously exploring AI technology in the context of business model innovation (Lee, J., et al., 2019; Reim, W. et al., 2020).

Thus, to provide a holistic perspective on the methods of value creation, the present study aims to analyze the potential consequences related to the application of enabling technologies on business models. Here, a business model is understood as a set of interdependent activities that encompass the boundaries of a company.

2. Strategic innovation as a factor in new business models

The (first) financial and then economic crisis that has recently hit Italian companies (and others) and from which many are yet to emerge has accelerated a competitive evolution that was already underway. Even before the advent of the crisis, businesses were confronted with considerable strategic challenges posed by the emergence of trends that, albeit different in nature, have an impact on the evolution of enterprises. In particular, these trends can be recognized in the process of the globalization of production and outlet markets, which, by reducing the life cycle of products, increases the intensity of international competition, with a consequent margin erosion. In addition, companies must consider sociocultural aspects, such as changes in the behaviors of the average consumer who is increasingly attentive to intangible aspects such as creativity, design, and sustainability (Golinelli, 2011). Finally, the process of technological transformation, more commonly known as the advent of the Fourth Industrial Revolution, is the most influential trend; as previously highlighted, it significantly reduces the positive effects of economies of scale, allowing for the reconfiguration of products, processes, and, more generally, of value chains.

Although the digital transformation of the productive and economic system, which is now profound and irreversible, favors the creation of new development paths for companies, it also highlights the need to evolve organizational and technological structures toward new business models that are increasingly digital and interconnected.

2.1. The Fourth Industrial Revolution: Industry 4.0

The characteristics of the Fourth Industrial Revolution can be found in the ability to optimize the use of material resources through a more effective exploitation of digital technologies, which enable the creation of "smart" products and intra- and inter-company processes.

This process takes place through the realization of the following.

- *Cyber-physical systems* (CPSs) are product systems (a completed product, machine, or manufacturing plant) that include both a physical and a virtual component. The physical component consists of a material device equipped with sensors, memories, connectivity, computational capacity, and actuators that allow a CPS to perceive the real world in which it moves and to interact with and control or be controlled by other material devices, both physically and virtually. The virtual component, conversely, comprises a *digital twin* of the material device (Negri, 2017). This digital copy enables, during the design phase of the material device, it to simulate its behavior to prevent errors, to support its realization by reflecting user requests and determining the optimal operating conditions, and to explore alternatives while limiting costs and risks. However, during the use phase, the digital copy enables a monitoring of its correctness and efficiency throughout its life cycle, anticipating its actual performance and identifying reusable parts upon disposal.
- *Cyber-physical production systems* (CPPSs) are production systems that comprise several CPSs as well as archiving systems in addition to those already provided to an individual CPS, which are capable of sharing data to self-monitor, self-learn, self-manage, and self-adapt. Therefore, the emphasis shifts from a single machine or manufacturing plant to the overall intra- and inter-company production flow. CPPSs are constitute the basis of

the creation of an intelligent factory and its interconnection with the other actors of its *value (eco) system* as well as the *digital thread*.

The fusion of the physical world with the virtual one within the CPSs and CPPSs that characterize the Fourth Industrial Revolution is made possible by the advent of enabling technologies, such as the following:

1. **advanced manufacturing solutions** or advanced production systems; these technologies include automatic material handling systems and advanced robotics with collaborative robots;
2. **additive manufacturing** or additive manufacturing systems, such as the 3D printer;
3. **augmented reality,** which consists of vision systems that support operators in carrying out daily activities;
4. **simulation** between interconnected machines to optimize processes;
5. **horizontal and vertical integration,** which comprises the integration and exchange of information, horizontally and vertically, between all the players in a production process;
6. **industrial internet,** which involves internal communication between the elements of production within the company as well as external communication owing to the use of internet networks;
7. **cloud robotics,** which consists of the implementation of all cloud technologies such as the "online storage" of information as well as the use of "cloud computing" and external data analysis services;
8. **cyber security,** which involves overseeing the security of information and company systems that must not be altered in any way from the outside because of the new interconnections; and
9. **Big Data analytics** or techniques for managing large amounts of data through open systems that allow forecasts or predictions (Pedrazzini, 2018).

The application of these technologies inevitably affects the entire business system; these effects are unquestionably related to the use of data–and thus to the real value assumed by the same in light of the high interpretative capacity that is dictated by the aforementioned technologies–in the context of man–machine interaction and production logics.

3. The impact of new technologies on production

The typical solutions of the new production paradigm, as seen earlier, do not actually constitute an element of absolute novelty in the field of production systems; Industry 4.0 is founded not on new technologies but on their evolution and combination. There are numerous technologies that can be used in this area; while not new, these technologies can now be applied with reasonable purchase costs and sustainable integration efforts. However, the new data acquisition and analysis technologies are fundamentally altering the operation of manufacturing machines. For example, the most advanced machine tools can continuously monitor a process, suggesting better setups and generally ensuring a better performance compared to previous tools. This technological innovation in, for example, the manufacturing sector, which is strongly linked to ICT, is rapidly increasing the performance of production processes while reducing costs.

Until recently, equipping a machine with sensors that were not designed with this evolution in mind was extremely difficult owing to the costs of the technology as well as the complexity associated with adapting the technology itself. At present, however, there are extremely affordable devices that guarantee high-quality performance because these devices can be easily configured and used for a specific function.

Production systems will be able to automatically adapt to their operating conditions owing to the use of digital technologies and collected data. This can be accomplished by integrating the machine equipped with self-learning methods. In this regard, the integration of the new machines with those already in place in the company will be critical as this is a fundamental aspect to consider in order to fully understand if and how a reconfiguration process for production can be activated (Mercuri, 2020).

The integration process plays a decisive role in the interaction between man and machine. This interaction accounts for the possibility of incorporating advanced machines that are capable of integrating with one another and interacting with humans, such as robots, into production processes. The latter, called cobots, can share the same space as the operators and physically interact with humans without the need for physical safety devices like cages and photocells, which are standard in any industrial plant. Cobots are useful for situations in which the processing is so delicate that a simple machine cannot handle it and is so repetitive that the operator becomes alienated. Furthermore, the collaborative interaction between man and machine enables the development of new services to improve the working conditions of the employees involved in such interactions.

Redesigning systems and interfaces that are capable of adapting to the abilities of the person interacting with them is one of the possibilities offered by the redesign of work environments with an eye toward Industry 4.0. The goal is to reduce the likelihood of errors and, potentially, the number of major and injuries in the workplace. Among the various human–machine interfaces, "chatbot" technology plays a notable role. Chatbots are programs that can hold a conversation in natural language. Currently, chatbots are commonly used as "personal assistants" that can simplify interactions regarding external services, such as in retail, food, fashion, or healthcare. It should be noted that chatbot technology entails more than merely understanding natural language–in effect, a chatbot is an AI that is capable of learning from interactions with humans and proposing new solutions that are appropriate to the industrial context in which it operates.

There are numerous examples of how the use of cobots in manufacturing is becoming increasingly widespread; for example, Volkswagen has incorporated an industrial robotic arm from the Danish manufacturer Universal Robots into the engine production of its Salzgitter plant in Germany since 2013.