The Fourth Industrial Revolution

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TABLE OF CONTENTS

***The illiterate of the 21st century will not be those who cannot read and write, but those who cannot learn, unlearn, and relearn*.**

Alvin Toffler,

The Third Wave

By 2048, everything we know will have changed.

Bill Gates,

Interview for Forbes 2018

PREFACIO

En el siglo XIX, la revolución industrial cambió el entorno social y dio origen a la gestión científica. Los cambios que hoy en día se observan traerán consigo una revolución tecnológica aún mayor y la necesidad de verificar los fundamentos de la disciplina de gestión, así como de identificar los elementos de un nuevo paradigma de gestión. Sobre los paradigmas que regirán nuestra realidad contemporánea, Robert Nasbitt ya escribió en 1982 en su obra Megatrends con sorprendente precisión. Este autor hablaba de tendencias como la descentralización, la creación de redes, las altas tecnologías y la sociedad de la información.

Hoy tenemos la oportunidad de observar el funcionamiento de estos paradigmas en la práctica. Muchas áreas de la vida moderna están influenciadas por nuevos cambios. La creciente complejidad de las nuevas tecnologías, el progreso de las tecnologías de la información y la comunicación, la creación de redes, la globalización, las innovaciones sociales y el aumento de las necesidades de los clientes plantean nuevos retos para la gestión y la economía.

Hoy en día utilizamos la palabra turbulencia para describir la naturaleza de nuestro entorno actual, ya que percibimos un aumento de en la intensidad y velocidad de los cambios y una creciente complejidad de los negocios (Ansoff, 1985). Si nos fijamos en las transformaciones del entorno empresarial, podemos correr el riesgo de decir que el entorno está determinado por el acceso a la información, y la propia economía se vuelve informativa, porque la productividad y la competitividad dependen del uso de la información.

Además el entorno contemporáneo presenta una dimensión global porque los procesos de gestión son globales, ya sea directamente o a través de una red de relaciones entre entidades económicas. Nuestro entorno está en red, porque en las nuevas condiciones históricas, la generación de eficiencia y competencia tiene lugar en las redes empresariales (Castells, 2007).

En relación a esto, el libro "La Cuarta Revolución Industrial" trata un tema extremadamente interesante e importante desde para una perspectiva económica que merece ser elogiado. El autor presenta los últimos desarrollos en áreas seleccionadas basándose en la literatura sobre las megatendencias de la Revolución Industrial 4.0.

Las tecnologías modernas, especialmente en el área de las TICs, tienen un impacto creciente en el funcionamiento de las empresas modernas y determinan las

direcciones de los cambios en los sistemas de gestión de muchas de ellas, así como en la vida social. Las estructuras y jerarquías de las empresas se están desdibujando y muchas de las funciones que tradicionalmente se les atribuían están desapareciendo. Cada vez más el valor de los proyectos y empresas se produce mediante el empleo de capital intelectual y no por los recursos materiales. Asimismo, estos recursos materiales pueden calificarse de perecederos y temporales, y los papeles y funciones de los agentes del mercado están cambiando.

Los procesos de virtualización cambian muchas áreas de la actividad empresarial, haciendo que las empresas busquen fuentes de ventaja competitiva en áreas como el acceso a la información, el conocimiento, las relaciones con los clientes y los socios comerciales.

El tema de la cuarta revolución industrial es abordado de manera muy amplia por el autor. El libro describe tecnologías relacionadas con la automatización y Smart Factory, Sharing Economy, cloud computing, entre otras, así como las amenazas de la revolución industrial 4.0.

En la introducción se esbozan brevemente las revoluciones industriales anteriores, destacando que nos encontramos en vísperas de la cuarta revolución industrial, que fusionará varias tecnologías y desdibujará las fronteras entre los mundos físico, digital y biológico. El autor subraya que esta fusión es uno de los pilares de la revolución industrial 4.0. También concluye acertadamente que los cambios tecnológicos dinámicos impulsarán cambios estratégicos en los gobiernos, las grandes empresas y las empresas en general. Son catalizadores del cambio que obligan a los diferentes actores del mercado a crear nuevas visiones y a remodelar sus propias estrategias y modelos de negocio.

Asimismo, uno de los objetivos de este libro es mostrar cómo las tecnologías disruptivas influyen en cambios en industrias enteras como la banca, las finanzas, la medicina y los negocios globales, así como mostrar el nacimiento de una nueva economía y el uso de nuevos modelos de negocio en los que operan empresas como Uber, Airbnb o Alibaba. Coincidimos con la acertada afirmación del autor de que muchas de las nuevas soluciones tecnológicas están actualmente en proceso de definir el potencial para su implementación, y la dinámica de los graves cambios que se producen en su alcance limita la posibilidad de "estar al día en todas las direcciones del desarrollo del mundo". La solución recomendada es seguir la información más

reciente, y el mejor ejemplo de cómo hacerlo es esta publicación y el trabajo de investigación realizado por su autor.

Tambien se exploran los temas relacionados con la innovación en el campo de los datos digitales, que no sólo afecta directamente a la economía global, sino que también tiene un profundo impacto en las empresas locales y en las vidas de los empresarios y consumidores asociados a ella. El autor describe a menudo las últimas soluciones en un campo dado, demostrando competencia en el difícil y multifacético tema de la industria 4.0.

Al analizar los últimos años, han aparecido en el mercado varias tecnologías de vanguardia. Por ejemplo, 2015 fue un año lleno de cambios tecnológicos en el área de Cloud Computing, IO, Big Data y RV. Las principales empresas de investigación, institutos y editores de medios de comunicación, en sus previsiones para 2016 y 2017, predijeron nuevos cambios de este tipo. Las novedades tecnológicas provocarán nuevos cambios revolucionarios no sólo en las actividades de las empresas, sino también en nuestra vida cotidiana.

En el contexto de la cuarta revolución industrial, algunas cuestiones merecen especial atención. Cabe mencionar aquí las cuestiones de identificación personal, el desarrollo de la biometría para la identificación y autenticación, el papel de la criptografía o el enfoque revolucionario de la protección de datos personales (es decir, la protección de datos sensibles) en relación, por ejemplo, con los grandes datos y la ciberseguridad

La ventaja de este libro es su lenguaje comprensible, que el autor utiliza al tratar temas complejos y desafiantes de innovación. El libro menciona acertadamente muchos ejemplos de soluciones modernas que encajan en la industria 4.0, como Uber, una empresa asociada al transporte de personas que carece de medios de transporte, Facebook que crea medios sociales en los que la propia empresa no crea ningún contenido, Airbnbnb que opera en la industria hotelera sin una base hotelera o Alibaba que es una cadena minorista sin sus propios almacenes.

La mayor parte del trabajo realizado por el autor tiene un carácter descriptivo o incluso informativo. En cuanto a la ciberseguridad, el autor subraya que "la defensa contra los ciberataques (...) es una cuestión no sólo de los especialistas en TI, sino también de los políticos y gestores, que deben crear, aplicar y actualizar las políticas de seguridad adecuadas". No se trata sólo de políticas de seguridad, sino sobre todo de educación y formación para cambiar la mentalidad en todas las organizaciones y responder hábilmente a los ataques de cada empleado o directivo. Esto requiere una nueva

mirada al problema y una reorganización de la estructura existente de cada empresa, desde las grandes corporaciones hasta las PYMES, lo que supone un enorme reto, especialmente para los empresarios locales.

Actualmente estamos asistiendo a un cambio en el paradigma del pensamiento en el contexto de la seguridad. La seguridad, que antes se consideraba uno de los principales factores contra la implementación de, por ejemplo, el cloud computing, ahora es uno de los principales impulsores de su despliegue. Esto ha sido el resultado de las grandes inversiones de los proveedores de cloud computing en tecnologías de seguridad de la información, pero también gracias a la adaptación de los servicios de cloud computing a las leyes y normativas aplicables. En la actualidad, el cloud computing puede ofrecer el nivel de seguridad que sólo las grandes entidades de negocio pueden permitirse debido a los altos costes y a la falta de conocimiento en esta área.

En resumen, el autor señala muy acertadamente las características comunes de la mayoría de las innovaciones que surgen en la cuarta revolución industrial, a saber, el uso del poder ubicuo de las tecnologías digitales y de la información y el desdibujamiento de las fronteras entre el mundo real y el digital, así como la interpenetración mutua de estos mundos. El autor señala que "el mundo digital está conectado con el mundo físico y biológico", y los puentes entre estos mundos son proporcionados por algunas de estas nuevas tecnologías emergentes, por ejemplo, la realidad aumentada. Otras conclusiones del autor de la publicación son, por ejemplo, la observación de que "las innovaciones reales, que surgen cada vez más a menudo, son el resultado de las interrelaciones entre diferentes tecnologías" y el hecho de que las grandes corporaciones están iniciando proyectos en muchas áreas diferentes - por ejemplo, Google desarrollando proyectos médicos o Sony involucrándose en la industria de seguros. Los rasgos característicos de los cambios que resultarán de la aplicación de estas tecnologías son el uso generalizado de las últimas tecnologías en el ámbito del consumo empresarial e individual, lo que reducirá significativamente los costes unitarios de las soluciones informáticas y provocará un rápido crecimiento de la demanda de recursos de calidad, productividad, potencia de cálculo o memoria para las soluciones técnicas en el ámbito del consumo, así como cambios en la percepción de la identidad de los objetos que constituyen el entorno técnico que rodea a las personas y que presentan identidades similares a las humanas (lo que en sí mismo puede ser peligroso).

La enorme variedad de temas y la cantidad de información que se encuentra en esta publicación merece reconocimiento. Las tecnologías modernas se están volviendo relativamente baratas, ampliamente disponibles, y su funcionalidad, especialmente el alcance de la posible integración, excede nuestras visiones anteriores de ellas. La libertad en su implementación desencadena innovaciones sin precedentes, a veces completamente inesperadas para sus inventores. La cuarta revolución industrial está cambiando la mentalidad y la forma de pensar de la gente.

PREFACE

In the 19th century the industrial revolution changed the social environment and gave birth to scientific management. The changes observed today will bring about an even greater technological revolution and the need to verify the fundamentals of management discipline as well as to identify elements of a new management paradigm. About the paradigms that will govern our contemporary reality, Robert Nasbitt wrote surprisingly accurately as early as in 1982 in his work Megatrends. He mentioned such trends as decentralisation, networking, high-technologies, and the information society. Today we have an opportunity to observe the functioning of these paradigms in practice. Many areas of modern life are influenced by new changes. Constantly increasing complexity of new technologies, progress in information and communication technologies, networking, globalisation, social innovations as well as an increase in customer requirements pose new challenges for management.

We now use the name *turbulence* to describe the nature of the environment, by which we mean an increase in the novelty of change, an increase in its intensity, an increase in the speed of change and a growing complexity in business (Ansoff, 1985). If we look at the transformations in the business environment, we may risk saying that the environment is determined by access to information - and the economy itself becomes informational, because productivity and competitiveness depend on the use of information. It has a global dimension because management processes are global, either directly or through a network of links between economic entities. It is networked, because in the new historical conditions, the generation of efficiency and competition takes place in business networks (Castells, 2007).

The book "The Fourth Industrial Revolution" deals with an extremely interesting and economically important topic, which deserves to be commended. The author presents mostly

the latest developments in selected areas, basing himself on the literature in which the megatrends of the Industrial Revolution 4.0 are indicated: i.e. analysing its physical, digital and biological aspects. Modern technologies, especially in the area of ICT, have an increasing impact on the functioning of modern companies and determine the directions of changes in the management systems of many of them, as well as in social life. Structures and hierarchies of companies are being blurred and many functions traditionally attributed to them are disappearing. More and more often we deal with projects and undertakings, and each time there are fewer and fewer repetitive activities. Values are created by intellectual capital and not by material resources. Material resources can be characterised as perishable and temporary, and the roles and functions of market players are changing. The virtualisation processes change many areas of business activities, making companies look for sources of competitive advantage in areas such as access to information, knowledge, relations with customers and business partners.

The topic of the fourth industrial revolution is grasped very extensively by the author. The book describes technologies related to automation and Smart Factory, Sharing Economy, among others, as well as the threats of the industrial revolution 4.0. The introduction briefly outlines previous industrial revolutions, stressing that we are now on the verge of the fourth industrial revolution that will merge various technologies and blur the boundaries between the physical, digital and biological worlds. The author stresses that this merger is one of the pillars of the industrial revolution 4.0. He also rightly concludes that dynamic technological changes will force strategic changes in governments, large corporations and business in general. They are catalysts of change that force different market players to create new visions and re-model their own strategies and business models.

One of the goals of this book is to show how disruptive technologies influence changes in entire industries such as banking, finance, medicine and global business, as well as to show the birth of a new economy and the use of new business models in which operate companies such as Uber, Airbnb or Alibaba. We should agree with the author's accurate statement that many of the new technological solutions are currently in the process of defining the potential for their implementation, and the dynamics of serious changes that occur in their scope limits the possibility of "being up to date with all directions of the world's development". The recommended solution is to follow the latest information, and the best example of how to do it is this publication and research work done by its author. He explores the issues related to

innovation in the field of digital data, which not only impinges directly on the global economy, but also has a profound impact on local business and the lives of entrepreneurs and consumers associated with it. The author often describes the latest solutions in a given field, showing proficiency in the difficult and multithreaded subject matter of industry 4.0. When analysing the recent years, several breakthrough technologies have appeared on the market. For example, 2015 was a year full of technological changes in the area of Cloud Computing, IoT, Big Data and VR. Leading research companies, institutes and media publishers in their forecasts for 2016 and 2017 predicted further changes of this type.

The advantage of this book is its comprehensible language, which the author uses while dealing with complex and challenging innovativeness issues. The book aptly mentions many examples of modern solutions that fit into the 4.0 industry, such as Uber, a company associated with people transportation actually lacking transport facilities, Facebook creating social media in which the company itself does not create any content, Airbnb operating in the hotel industry without a hotel base or Alibaba being a retail chain without its own warehouses.

Most of the work done by the author has a descriptive or even reporting character. With regard to cyber security, the author stresses that "defence against cyber-attacks (...) is a matter not only for IT specialists, but also for politicians and managers, who should create, implement and update appropriate security policies". This is not only about security policies, but above all about education and training in order to change mentality throughout the organisations in order to respond skilfully to the attacks by each employee or managerial staff. This requires a new look at the problem and a reorganisation of the existing structure of each company, from large corporations to SMEs, which is a huge challenge especially for local entrepreneurs.

Cyber security is also extremely important against the background of the fourth industrial revolution, because it is the data itself that constitutes the "bloodstream of this revolution". The fourth industrial revolution is based on the transmission of digital data, and above all it involves data traffic to IoT, IoE, autonomous cars, smart cities, and the countries' critical infrastructures, e.g. the energy sector. This, of course, creates a huge need for the development of specific solutions (including regulatory ones), i.e. the GDPR regulation, the NIS directive or the eIDAS regulation. The cyber-security issues, or rather a deep gap in this respect, dominated in 2017 at all international conference meetings related to innovation, and with regard to the industry 4.0 undoubtedly constitutes one of the most important issues, which deserves to be analysed in depth.

We are currently witnessing a change in the paradigm of thinking in the context of security. Security, which was once considered to be one of the main factors against the implementation of e.g. cloud computing, now is one of the main drivers behind its deployment. This has been the result of huge investments of cloud providers in information security technologies, but also thanks to the adaptation of cloud services to the applicable laws and regulations. Currently, cloud computing can offer the level of security that only huge business entities can afford due to high costs and the lack of knowledge in this area.

In summary, the author very aptly points to the common features of most innovations arising in the fourth industrial revolution, namely the use of the ubiquitous power of digital and information technologies and the blurring of borders between the real and digital worlds, as well as the mutual interpenetration of these worlds. The author points out that "the digital world is connected with the physical and biological world", and the bridges between these worlds are provided by some of these newly emerging technologies, e.g. augmented reality. Further conclusions raised by the author of the publication are, for example, the observation that "real innovations, which emerge more and more often, are the result of interrelations between different technologies" and the fact that large corporations are initiating projects in many different areas - for example Google developing medical projects or Sony involving itself in the insurance industry. The characteristic features of the changes that will result from the application of these technologies are the widespread use of the latest technologies in the area of business and individual consumption, which will significantly reduce the unit costs of IT solutions and will lead to a rapidly growing demand for the quality, productivity, computing power or memory resources for technical solutions in the consumer sphere, as well as changes in the perception of identity of objects constituting the technical environment surrounding people and featuring human-like identities (which in itself can be dangerous).

The huge range of topics and the amount of information found in this publication deserves appreciation. Modern technologies are becoming relatively cheap, widely available, and their functionality, especially the scope of possible integration, exceeds our previous visions of them. Freedom in their implementation triggers unprecedented innovations, sometimes completely unexpected for their inventors. The fourth industrial revolution is changing the mentality and motivation of employees. Already today we observe that employees born after 1982 are less likely to work in formalised structures (this generation is often referred to as the YouTube generation since they are people who move freely in the information world). According to many

authors, the use of new technologies in business models will also generate other, far-reaching changes.

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Granada, May, 24th, 2019.

INTRODUCTION

The fourth industrial revolution is coming, and it will completely change the world around us. It is going to be of great importance to everyone. It will affect our way of life and work, the way we communicate, function and even think.

We can speak of an industrial revolution when new technological solutions cause great civilizational and social breakthroughs. No earlier industrial revolution can be reduced to the mere implementation of technological inventions; rather, it is a matter of the significant impact that this exerted on economic, social and cultural life.

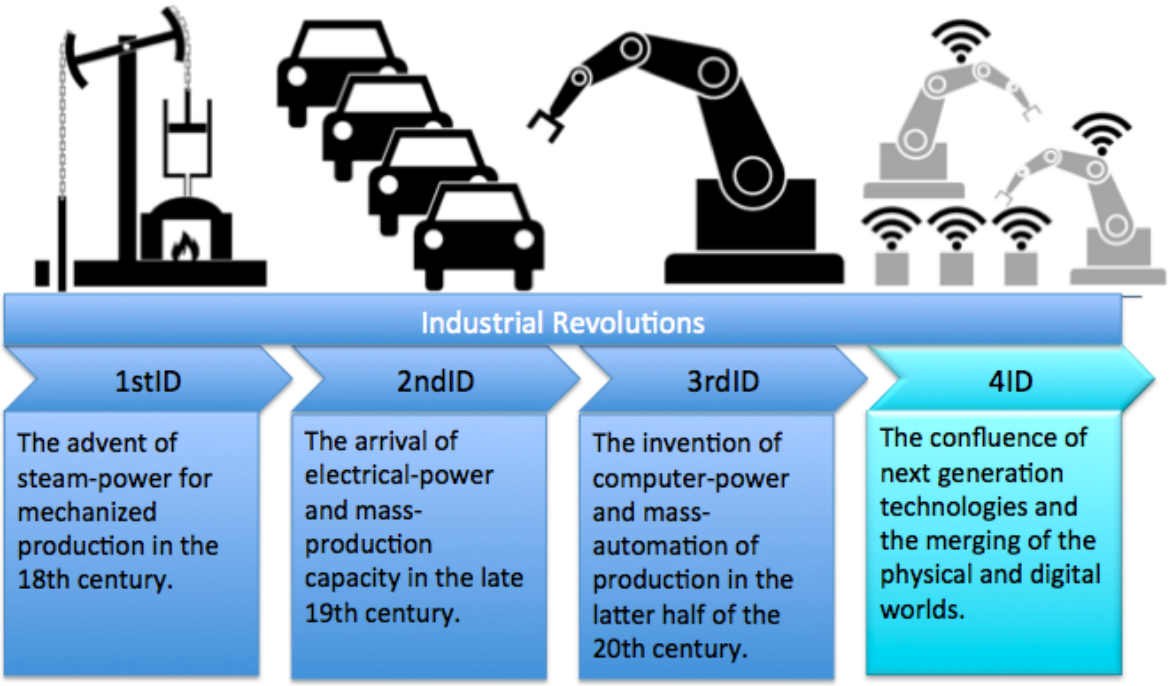
The first industrial revolution originated from the demographic explosion and was associated with the need to transform the economy based on agriculture and artisanal (manufacturing) production into an economy of scale based on production mechanisation. Indeed, it brought both a technological and an economic breakthrough that completely changed the approach to production management, resulting in a shift from manual to machine-driven work.

The second industrial revolution is, above all, the period of the full bloom of science and technology, during which many breakthrough technological solutions and inventions were created, such as the gas engine, light bulb, telephone, radio, camera, bicycle, tram or car. The main role in this was played by the development of electricity and industrial production on a massive scale which became possible thanks to the creation of conveyor belts.

The third revolution brought progress in the field of telecommunications and information and communication technologies (ICT), which contributed to the automation of industrial production and marked the start of the computer and digitisation era.

We are now on the verge of a fourth industrial revolution that will merge various technologies and blur the boundaries between the physical, digital and biological worlds.

At the same time, it will have a huge impact on governments, economies and business all over the world [301]. It will also change our approach to production, trade and services, making them fully adapted to individual expectations of each of us. The fourth industrial revolution will therefore be the era of personalised products and services that will be developed in smart factories on demand.



Different industrial revolutions, Source: Wamnda Research Lab

Every year, the number of people using new digital technologies is increasing: smartphones, tablets, 3D printers, drones, wearables, robots, cars connected to the Internet, intelligent homes, etc. They make it easier for us to communicate, work and learn, while at the same time changing our habits.

Dynamic technological changes force strategic changes in the governments of states, large corporations and widely understood business. They are catalysts for the changes that are forcing different market actors to create new visions and to rethink their own business strategies and models. The old ones simply become worthless. At present, at least a dozen of such "catalysts of change" can be identified [55, p. 1311]:

- Internet of Things (IoT) and Internet of Everything (IoE);
- development of robots and artificial intelligence;
- Smart Factories;
- 3D or even 4D printing[1] technologies;
- development of nanotechnologies;
- development of biotechnology;
- development of autonomous driving technology;

[1] 4D printing is a process of additive manufacturing of objects which, under the influence of appropriate factors, e.g. time and environmental conditions, change their morphological characteristics [342, p. 119].

- blockchain technologies[2];
- creation of digital currencies (so-called cryptocurrencies) based on blockchain technology;
- development of bio-computers;
- Smart Cities;
- development of highly advanced medical technologies;
- medical sciences benefiting from digitisation and mobile technologies;
- development of new forms of transport (e.g. Hyperloop);
- new standards in banking (Bank 3.0 and ultimately Bank 4.0);
- development of fintech companies[3];
- innovations related to the development of the Internet (e.g. the development of 5G networks);
- development of virtual and augmented reality (VR/AR) and holographic technologies;
- development of alternative energy production technologies;
- sharing economy;
- Space exploration.

It is highly likely that the dynamics, scale and strength of change that we will see in the upcoming years will transform modern societies much more than all previous industrial revolutions have done. **Imagine billions of people and devices around the world connected together by a global network, generating huge amounts of data, analysed on the fly, stored and interchanged**. This creates unbelievable opportunities for future development. All this will be additionally supported by the latest technological solutions in the area of artificial intelligence, robotics, cybernetics, cloud computing, Big Data, 3D and 4D printing, biotechnology, nanotechnology, energy storage, bio-computers or those created for the needs of space exploration. It is possible that the rare elements and other resources that we

[2] Blockchain technology is used to record, store and transfer information about transactions concluded on the Internet, which are arranged in the form of successive blocks of data. One block contains information about a certain number of transactions, and after its filing with information, another block of data is created, followed by yet another one, all arranged in a sort of chain. Every 10 minutes on average, a new block of data comes into the chain, enabling information about different transactions to be transferred. The blockchain technology can be applied i.a. for commercial transactions, transfer of ownership, trading of shares, stocks, electricity, purchases or sales of currencies, including cryptocurrencies.

[3] Fintechs are financial companies operating exclusively on the Internet, e.g. companies intermediating in online payments.

will find in space will significantly change the face of the Earth's economy. In other words, we are going to see unimaginable changes.

We are currently witnessing a slow blurring of the boundaries between the physical and the digital spheres. According to Ray Kurzweil, Google's chief futurist, within about two decades our brains will be capable of connecting directly to the virtual cloud. This will be done with the help of special nano-robots, which will be implanted into the superficial layer of the cerebral cortex, responsible for collecting and processing information [179, pp. 24-29]. A direct brain-computer connection (i.e. interface) could ultimately enable people to benefit from the digital world and from many technological IT solutions on an unprecedented scale. We would have excellent memory, the ability to perform ultra-fast and accurate arithmetic calculations and high data throughput. This would provide us with a unique hybrid system that would dramatically exceed the capacity of the brain itself [34, p. 54][365]. According to Stephen Hawking, over time such technology may even be necessary, even if only to keep up with the progress in the development of artificial intelligence [359]. On the other hand, according to Kurzweil, this is not so much justified as desirable and inevitable in the further development of the world [176]. In the future, the combination of biology and the digital world will allow people to have virtually instant access to all the information resources that will be stored in the cloud. As soon as this happens, the learning process will be replaced by the "loading of skills" process. Connecting our brains directly to the Internet will provide us with an unlimited access to knowledge, and practically effortlessly.

According to Kurzweil, around the year 2045 the artificial intelligence will be more than a billion times more powerful than the human intelligence. By that time, the first nanomachines would have been created, which would have been able to repair our immune system by themselves, and since then there would be only a small step towards achieving human immortality. Many scientists are quite serious about it. Transhumanists are convinced that the combination of genetics, nanotechnology and robotics will allow for the direction of further human evolution and, consequently, will lead to the creation of a new superhuman species which will be characterised by an ideal physical structure and above-average mental abilities. Given that such a superhuman would have access to spare organs whenever he needed them, this would probably mean that he would be practically immortal.

According to another concept considered by scientists, we could achieve the independence from our biological body by creating a digital equivalent of our consciousness, and by transferring it later to a computer (the so-called mind uploading) [2, s. 431-436].

Extending human life can in turn lead to overpopulation of the planet and the shrinkage of its natural resources. This is yet another problem that humanity will probably have to face. How will we solve it? We do not yet know. According to Stephen Hawking, the famous astrophysicist, who is undoubtedly one of the most eminent scientists of our time, the only chance to save humanity is to search for forms of extra-terrestrial life and to colonise the cosmos. Similarly, Elon Musk, a visionary and one of the most eminent entrepreneurs, believes that by 2060 a million dollar colony of people will have been built on Mars [81]. Moreover, the International Space Station has become a confirmation that a sustainable life in space is possible. NASA is constantly working on the Moon Camp project and a variety of technologies to ensure that human lives are sustained even in the most hostile and difficult environments.

The fourth industrial revolution also poses huge challenges for the business world. Even today, global markets are beginning to resemble a mass online game in which all players compete with each other for everything. This is due to the increasing ease of access to various technologies, which are simply becoming very cheap. Increasingly, we are dealing with the so-called convergence[4] of entire sectors, products or even business models. We can also talk about the growing cooperence of enterprises, i.e. their simultaneous competition and cooperation, modular technologies resembling Lego blocks or hyper-connected objects [267]. With the digital age, consumers have begun to demand open, innovative solutions, which often require the combination of many different, matching innovative technologies. A new digital reality is now emerging before our eyes, which requires contemporary leaders to be able to observe weak market and technological signals [247]. At the same time, the changes taking place in today's world are so dynamic that companies often find themselves in states of imbalance threatening their existence. Managers and business leaders should also be aware that their biggest opponent does not necessarily have to be a competitor from their sectors. It can come completely from outside. A proof of this are the examples of such giants from the digital technology industry as Apple or Google, which unexpectedly became interested in the automotive industry or even the medical industry (Google). A similar case may arise for

[4] Convergence is a coming together of two or more distinct entities or phenomena.

technologies that will completely disrupt specific sectors in the future. They can also come from outside the industry.

In the future, most products, processes, business models and even strategies will benefit from the development of artificial intelligence. This will completely change the conditions for market play in many areas of life. Today we have a foretaste of this. Managers will no longer be interested in purely operational issues, but will focus more on strategic thinking and planning, as well as the so-called disruptive thinking, i.e. a specific form of strategic thinking that allows for changing business contexts and trends in entire sectors. Such thinking leads to the creation of completely new markets and entire networks of values currently unknown to us, which will "disrupt" the functioning of existing businesses, leading to the total crowding out of many of them from the market [35][53]. Unfortunately, modern business leaders, strategists, managers and politicians in their vast majority, do not understand these mechanisms and processes. This is because they got used to the old world order, dominated by simple models and short-term thinking. They seem not to notice that newer and newer technologies are "disrupting" the functioning of subsequent sectors at an exponential rate. To cope with the challenge of the Industrial Revolution 4.0, business leaders will need to reformulate many of their old assumptions with respect to how resources should be organised, what works in companies and what does not, and what are the measures of their successes. This, in turn, will lead to the questioning of many of the rules and formulas which have so far been accepted and used. Business leaders should be aware that the digital economy is not only about people and businesses, but also - and perhaps most of all - about algorithm competition. This is evidenced by the business models of such companies as Facebook, Uber, Airbnb, Alibaba, Spotify or Netflix, which run their business practically only thanks to new advanced technologies, being practically completely devoid of physical resources. In the context of these completely new businesses, very significant are Marc Andreessen's words that *software slowly consumes the entire world* [7]. All the above mentioned companies are almost entirely driven by algorithms.

In widely understood business, quick adaptation to the prevailing trends often even determines the survival of companies on the market. No company should underestimate this. Otherwise, the consequences could be devastating. This happened, for example, to Kodak which completely neglected to follow technological innovations and therefore went out of business, even though it employed more than 60,000 people. By comparison, Instagram with

only 13 employees was bought by Facebook for $1 billion, precisely because it is a company that based its business model on new technologies and innovations. Peter Drucker, a well-known management classic, once said that only those companies that will become innovation leaders in their fields will survive the 21st century [82]. Apple, Google and Tesla are undoubtedly such leaders in their sectors. All those companies that not only want to survive, but also want to secure a significant improvement in their business lives should be ready for a real revolution.

In this book you will find many valuable insights and examples about the latest digital technologies that are rapidly transforming our world. Before you start reading, you should be aware of one important issue concerning the fourth industrial revolution and many breakthrough technologies and inventions that underpin it. Many of these new technological developments are currently in the process of defining their possible applications, and almost every day significant changes are taking place in relation to them. Therefore, whatever is written about them today, tomorrow may be outdated. We live in the times of dynamic development and constant discoveries, so it is better to assume that the current state of things will not last long. However, reading this book will allow you to form a general view on the changes we are already experiencing and those that seem most likely to occur in the future. But in order to keep up with world developments, it is necessary to keep a close eye on the latest information.

1 AUTOMATION AND SMART FACTORY

The fourth industrial revolution (*Industrie 4.0*) stems from the third industrial revolution, which began in the 1960s and was called digital or technological. It covers everything that serves to digitise, automate and integrate the world of people and machines[5]. This includes network operated machines, intelligent robots and the latest developments in materials engineering and bioelectronics.

The term "industrial revolution 4.0" was used for the first time by the German government, which presented its strategy for computerisation of manufacturing processes at the Hanover trade fair in 2011 [144]. The idea was to combine the most modern virtual technologies with real production, thus creating the so-called intelligent factory (a.k.a. Smart Factory). The aim of the smart factory concept was to streamline the entire production process so that it was as short as possible and with minimal human intervention. This, of course, involves numerous technological challenges that need to be met in order to make this idea a reality. They include, but are not limited to:

- robotisation and automation of processes,
- automation of the internal transport of materials within the plant (autonomous vehicles/wheeled robots are used),
- creation of systems coordinating the processes of communication with customers,
- use of cloud computing structures and network drives to collect and process data,
- creation of analytical and calculative systems, which will process large data structures (the so-called big data),
- ensuring communication between machines and products,
- application of innovative materials (e.g. nanomaterials, intelligent materials resulting from the process of a complex material engineering),
- design of modern, autonomous systems for production and processing of materials on production lines, enabling full visualisation and monitoring of production processes,

[5] the so-called Industry 4.0 concept (*Industrie 4.0*).

- rapid prototyping and the use of 3D printing technologies (so-called additive manufacturing), e.g. to replenish spare parts in a warehouse.

In fact, with the passage of time, consumers will be able to order in such an intelligent factory fully personalised products at their discretion. This would be a realisation of the idea of adapting products to the needs of customers in mass production (a.k.a. mass customisation) [174]. Even today, in some factories, automated production lines communicate directly with each other and independently coordinate the entire production process. In the future, production processes will be carried out simultaneously in many parts of the world in a fully automated manner and on a massive scale. In Western European countries, the concept of intelligent manufacturing can also help to solve the problem of rapidly growing labour costs and prevent the negative effects of demographic decline [144, p. 5].

While the third industrial revolution ensured the production of as many products as possible at the lowest possible unit cost, the industrial revolution 4.0 will mainly deal with the increasing importance of the individual characteristics of products while still maintaining their low unit costs. It will also mean greater integration of customers with manufacturers.

The case of CCC

CCC is one of the largest footwear companies operating in Central and Eastern Europe. It is both a manufacturer and a distributor. The company operates in its own stores and in shops which function on a franchise basis. In total, they form an extensive network of more than 700 shops located in 15 European countries[6]. The offer of the company includes the assortment in lower price ranges. CCC warehouse covers a surface area of about 23 thousand square meters and there is room for 5 million pairs of shoes. CCC is at the same time one of the few Polish companies that have noticed the potential resulting from the industrial revolution 4.0. The company introduced a lot of technological improvements in its management, which significantly increased its profitability[7]:

- thanks to automation, the company employs only eight people to operate the entire warehouse, i.e. about 2.8 thousand square meters per employee. The majority of

[6] The name of the CCC company is an acronym for the marketing slogan *Cena Czyni Cuda*, meaning Price Makes Miracles.
[7] Within 5 years, i.e. from 2011 to 2015, the company had tripled its revenues.

routine warehouse activities are performed by 24 automatic feeders controlled by computers instead of people. Within 24 hours CCC machines in Polkowice logistic centre can handle up to half a million orders,

- digital scanners read the codes of every package and their readings go straight to the computers, thanks to which the whole documentation and accounting of the company is kept tidy on an ongoing basis,
- CCC spent PLN 120 million on its automated warehouse. Without a computerised warehouse CCC would never have achieved the scale of activity it can proudly boast of today. In 2011, when CCC began building its modern warehouse, its revenue exceeded only over PLN 1 billion annually. In 2016, its revenues already exceeded PLN 3 billion.

The case of Raben Group

Raben Group is the largest logistics and shipping company operating on the Polish market. Even though the company operates in ten European countries and has its headquarters in the Netherlands[8], almost 50 percent of all its orders are placed in Poland. The business model of Raben Group is entirely based on new technologies and automation of processes:

- it handles an average of about 70 thousand shipments per day, i.e. almost 2.9 thousand per hour,
- consignments are of different sizes. The company handles both small ones, which are sent to customers from e-shops, as well as large containers,
- technology is a key element in creating the company's value. It consists of appropriate programs (algorithms), which control practically the entire process of accepting and handling orders in the field of shipments. These systems also enable customers to check the locations of their shipments while they are in transit, and they are responsible for all logistics (i.e. setting optimal delivery routes based on satellite navigation), forecasting the demand for transport services depending on the location and delivery dates, and estimating the time and cost of such deliveries,
- managers of this company receive information about the capacity of the entire logistics network 1-2 days in advance. As a result, they can see, for example, that bottlenecks

[8] Raben Group operates in the Netherlands, Poland, Germany, the Czech Republic, Estonia, Slovakia, Ukraine, Lithuania, Latvia and Hungary.

may arise in a specific area of such a network and can try to prevent this by directing more drivers to such areas. There are benefits for both clients who do not wait too long for their shipments and the company itself, which manages its business more easily and has lower costs.

It is worth considering what the Industry 4.0 means for consumers. First of all, they receive individualised, tailor-made products, customised to their preferences and needs, but at the same time they get them faster and at a lower cost than before. For example, you can already order a customised car today, but it usually takes a long time and is still too expensive to process. In the future, thanks to the changes that the fourth industrial revolution will bring, everyone will be able to afford a car with an individually designed interior, and will not pay for it more than today for a new car in a saloon. What's more, such a car will be delivered to a customer even within a few days, and not within a few weeks or even months, as it is often the case today.

The case of Peugeot and Django 3D configurator

Peugeot launched its new Django scooter in late 2014. Its style resembles the S57 model, the first scooter with the lion's logo manufactured in the 1950s. At the same time, Peugeot made the Django 3D configurator available to its customers, creating unique possibilities for virtual customisation of the scooter from A to Z, starting from its body colour, through rear-view mirrors to seats and finishings. More than 110,000 combinations can be achieved in this way.

The fourth industrial revolution is a very broad concept. It is not just about automating manufacturing processes, it is about creating entire mobility ecosystems using the latest cyber technologies, the Internet of Things, Big Data solutions and cloud computing. Mobility ecosystems form virtual value chains. In the future, the interconnection of automation, sourcing, collecting, analysing, processing and exchanging of mobility data and manufacturing techniques can become an incredible source of value.

Klaus Schwab[9] points out that in the future managers will devote much less time to the day-to-day operational issues (this will become the domain of computers), but will focus on strategic thinking and the so-called disruptive thinking[10].

Disruptive innovations are defined as innovations that create completely new markets and value networks and ultimately 'disrupt' existing markets and value networks, driving many leading companies and their products out of the market.

Today's business leaders, strategists, managers and politicians are rather accustomed to the Newtonian world order and are therefore guided by short-term thinking and are also most likely to use simple and proven models [267]. Many of them do not see how rapidly digital technologies are revolutionising the functioning of subsequent sectors, and also that the digital economy is increasingly becoming just a competition between algorithms. The latter is evidenced by companies such as Uber, Facebook, Airbnb and Alibaba, whose operations are actually conducted only thanks to the power of new technologies and the economies of scale. All of this is also important in view of the fact that many physical resources are no longer needed to run "digital" businesses [111]. Here are some examples:

- **Uber** - manages the world's largest taxi network, and neither owns any of them nor employs a single taxi driver;
- **Facebook** - created the world's largest network of social and advertising media and at the same time does not produce any content at all;
- **Airbnb** is the largest company in the hotel industry, although it does not have a single hotel;
- **Alibaba** - is one of the largest retail and b2b networks in the world, yet does not have its own warehouses.

[9] Klaus Martin Schwab is a German engineer and economist, founder and president of the World Economic Forum. Schwab is also the author of the book *Industrial Revolution 4.0*.

[10] Disruptive thinking is otherwise creative destruction - a form of strategic thinking that focuses on catalysts for changing business contexts (trends) of entire sectors (industries); disruptive thinking means a 'breakthrough thinking'.

All four above examples only confirm the validity of the thesis of Marc Andreessen, an American entrepreneur and co-founder of Mosaic and Netscape Navigator, that software and algorithms will slowly "eat" the whole world.

The Industrial Revolution 4.0 is driven by digital technologies, networks, platforms and algorithms and results in blurring differences between the worlds of things, numbers and the nature.

The industrial revolution 4.0 is unprecedented in the speed and scope of changes, which are disrupting almost all possible sectors and wherever possible. The scope and depth of these changes **transform the entire production and management system, both at the micro and macro levels**. The consequences of billions of interconnected, high-power computing devices with artificial intelligence and access to knowledge are virtually limitless. This, in turn, starts to affect our lives, work and social relations, leading to changes that our civilisation has never experienced before in such a short space of time, including the shifting of the global economic centre of the world from the West to the East.

Importantly, most of the fundamental technologies and models needed to accelerate the digital revolution are already in place today. That's why creating more and more innovative technological solutions boils down only to "connecting the dots", as would have called it Steve Jobs, who was an indisputable master of resource reorganisation[11]. In the future, economic growth will not so much depend on the emergence of new resources as on the reorganisation of existing ones. When it comes to the available resources and technologies that are revolutionising the world right before our very eyes, they can be seen as catalysts for the great industrial revolution 4.0 that we are just entering. Here are some examples:

- widely available computers,
- universal access to the Internet everywhere in the world,
- Web-connected objects (i.e. Internet of Things),
- equipment mobility,

[11] In Steve Jobs' era, every new Apple innovation was the result of a combination of different existing technologies.

- exponentially increasing computing power and computer memories, which at the same time are becoming cheaper and cheaper[12],
- development of artificial intelligence (including deep learning)[13],
- algorithmisation of products,
- cloud-based solutions,
- cryptographic profile of individual things (based on blockchain technology),
- intelligent sensors[14],
- renewable energy sources,
- 3D and 4D printing,
- social networks,
- innovative business models (e.g. freeconomics or sharing economy).

At this point in time, we do not know how all this will develop, but it is clear that managers' approach to the industrial revolution 4.0 should be integrated and holistic, involving all stakeholders globally, from the public and business sectors to science and civil society. The main changes will concern: customers' expectations, creation of new "intelligent" products, open, collaborative innovations and organisational forms. These changes are, above all, great opportunities for the business world and for all of us to improve the comfort of our lives. They will certainly create new business winners, but they will also contribute to the creation of new, previously unknown threats. The opportunities and dangers will be multiplied by advances in artificial intelligence, robotisation, the Internet of Things, autonomous driving technology, 3D printing, nano- and bio-technologies, material engineering, energy storage and bio- and quantum computers.

All of these technologies need to be closely followed, although some of them more than the others. Undoubtedly, the development of artificial intelligence and algorithms, which will become serious new market "competitors", will play a key role in the industrial revolution 4.0.

[12] Between 1995 and 2015, the annual data storage cost fell from about $10,000 per 1 GB to only 3 cents.
[13] Machine self-learning.
[14] One of the important elements of the so-called 4.0 industry is the wireless transmission and receipt of data gathered from remote sensors.

Today, business leaders and managers are confronted with increasingly difficult business issues. However, they have much less time to solve them than in the past. Therefore, more than in the past they rely on machines supporting them. They can find such help in advanced software, which collects key data for their company, then processes and analyses them properly. This is achieved through complex computing structures and network drives that enable managers to manage data from virtually anywhere in the world at any time. These data are stored and handled by secure servers in the "cloud", where they are further processed with the help of appropriate analytical and calculative systems. Finally, such data can be virtualised, which makes it significantly easier for managers and strategists to make strategic decisions, so that they can look at many complex issues in the company in a real way, from different perspectives, using facts rather than opinions or assumptions. In addition, analytical processes are carried out in real time, which also affects the speed of decision making.

The fourth industrial revolution poses a huge challenge to human resource management. It will undoubtedly force changes in vocational education, in the labour market and in management models. Robots are becoming a new type of resource, and HR teams need to learn how to manage them and integrate them into corporate processes. In the *Industrie 4.0* era, there will be a need for multidisciplinary engineers who know the basics of technology and can think abstractly. Modern managers will not shy away from the mobility or social media presence. They will be very familiar with production process support systems (e.g. enterprise resource planning or ERP) and will use business intelligence or big data analyses in the self-service model. Today, if we have sufficient computing power, data is interpreted practically in real time, so that we can respond more broadly to needs, problems or crisis situations. In the past, it was necessary to use the services of external companies which consumed time and money and the results of their researches usually showed the reality from a perspective of the past 2-3 months.

Modern information management based on cloud computing and big data solutions will increase the competitiveness of companies. Every employee connected with the machine park will be able to check the status of individual machines and devices working within the local network without even interrupting the entire production process. This will allow for last-minute changes in many processes and the elimination of external disturbances such as delivery delays or sudden drops or increases in demand for resources and products. *Industrie*

4.0 implementations will also enable production in shorter cycles, allowing for flexibility in mass production. Production processes will therefore become much more efficient. In addition, there will be an increased possibility of monitoring and saving materials, raw materials and energy. With the fourth industrial revolution, people may soon lose their monopoly on creativity and innovations. In the foreseeable future, the technological revolution will be a constantly evolving mix of innovations, tools and business paradigms.

The case of Google

Google acquired Nest Labs in early 2014, gaining access to millions of households. Nest Labs is a manufacturer of intelligent thermostats and fire detectors integrated into the Internet.

Illustration 1.1 *Intelligent (connected to the Internet) Nest thermostat*

As a result of this investment, Google collects a number of relevant data on households, such as how many people live in them, what hours they spend in their homes and in each room, what temperatures they have in each room, and many more. Intelligent sensors connected to the network send collected data to servers, and Google later becomes the owner of such data. There are also many critics of this business model. According to some experts,

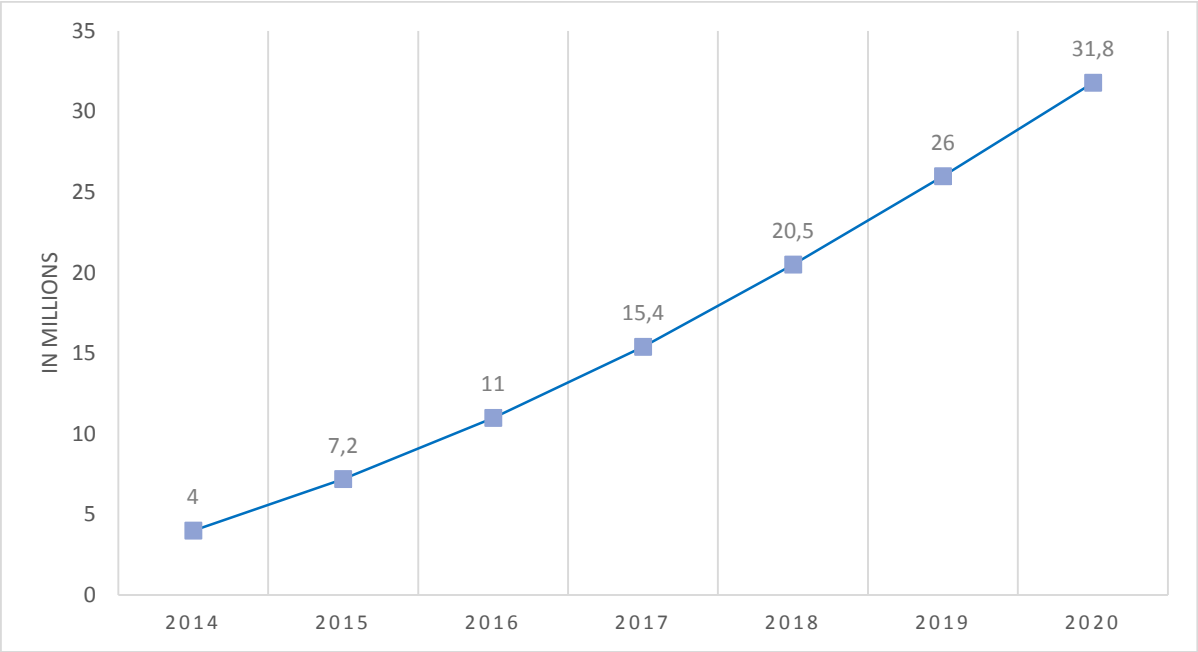
Google is beginning to resemble a police state that is very deeply involved in people's privacy. Some of them go even further in their judgments, and even claim that the GDR[15] population was not as much under surveillance in its worst period as the Mountain View giant is currently doing with its users. It is undisputable that there is a risk that data collected by Google on its servers or by third parties may in future be used by unauthorised persons for the purposes for which the data were not collected.

The case of automotive sector

There has been an extremely dynamic development in recent years in the field of vehicles connected to the Internet. New cars are increasingly equipped with vehicle-to-internet (V2I) and vehicle-to-vehicle (V2V) communication systems and other wireless communication devices that enable them to interchange information about their location and potential danger on the road. The Americans expect vehicle-to-vehicle communications to be operational at the latest by 2019, and the first cars to be equipped with such a system will soon be available for sale by Toyota. In the United States, this type of solution is being developed, among others, by General Motors. Given the growing popularity of V2V technology, it is expected that in the future such vehicles will be able to avoid accidents. The V2I and V2V systems also support the development of autonomous driving technology[16]. The connectivity and communication they provide will allow vehicles to be warned of each other's risks, and thus avoid accidents and minimise congestion. However, all of this will work only when most cars travelling on the roads will be equipped with such systems [73, p. 9].

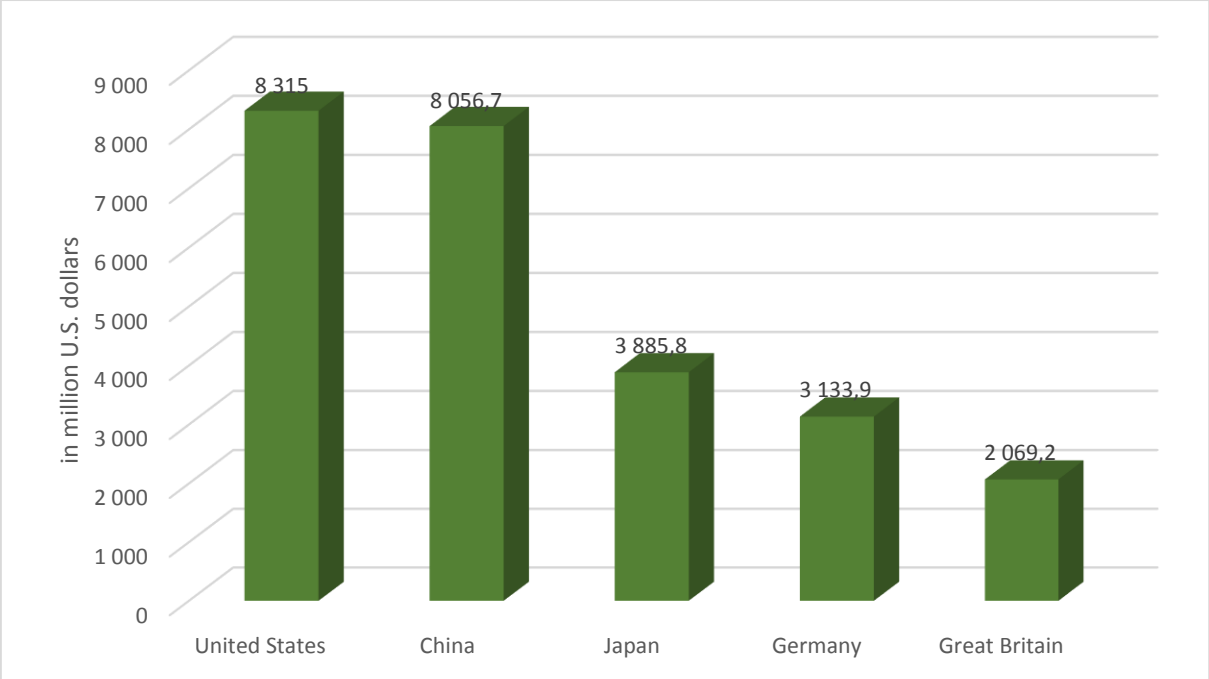
[15] The German Democratic Republic.
[16] The fully autonomous car is controlled by a processor entirely responsible for its operation, which distinguishes it completely from even the most advanced driver assistance systems.

Chart 1.1 *Number of cars connected to the Internet*



Source: Own elaboration (based on BI Intelligence data).

Chart 1.2 *Connected car revenue forecast in selected countries worldwide in 2016 (in million U.S. dollars)*



Source: Own elaboration (based on Statista Digital Market Outlook data).

Thanks to new technologies, previously unknown mobility ecosystems are created, which form virtual value chains. In the future, the sourcing, collection and analysis of mobility data can become an incredible source of value. The winners will be, above all, those who:

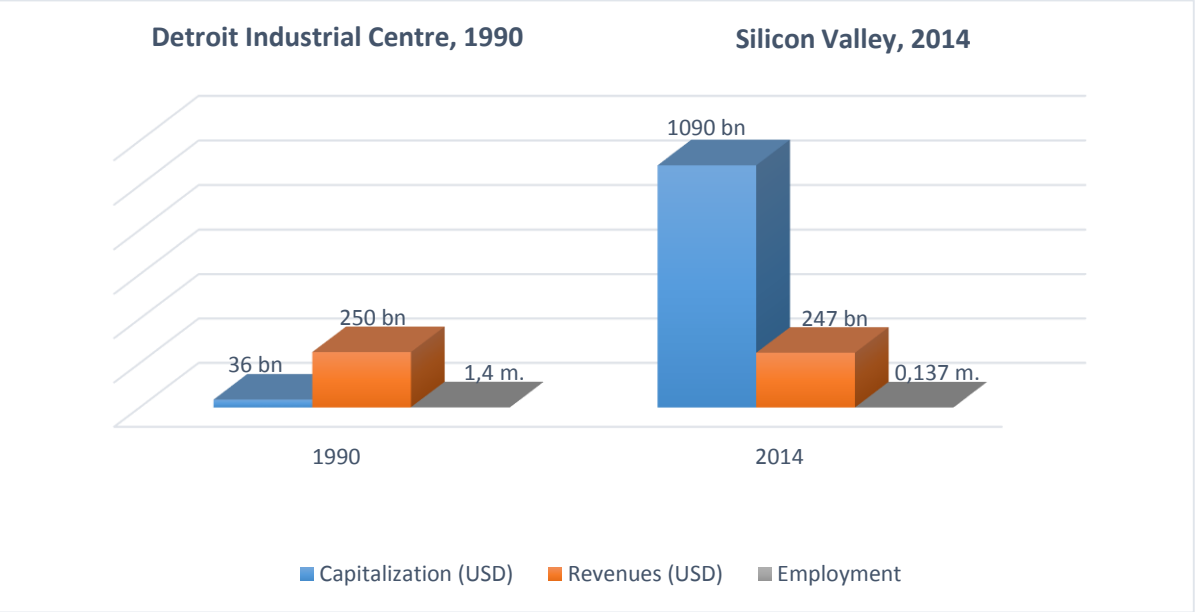
- provide a complete, seamless mobility service,
- manage the mobile operating system,
- create and manage services that will be offered during while travelling.

According to Christoph von Tschirschnitz, CEO of BMW for Central and Southern Europe, the last enumerated aspect is also the most important reason why companies such as Google and Apple are interested in manufacturing cars. Their added value is not the potential profit they can make from the sale of such cars, but only the subsequent use of such vehicles as platforms for developing their digital and mobile businesses. After all, when autonomous driving becomes legal and pervasive, when travelling in autonomous cars (which will be a place to spend free time) passengers will spend a lot of time shopping, booking their holidays and doing many other things. In this way, these companies will be able to learn more about their customers' preferences.

The future mobile ecosystem will also require companies to develop a comprehensive IT system to manage vehicle traffic and its entire network. Today, in many cities, drivers are facing huge traffic jams. But in the future car use will become "intelligent". After entering a destination address into the appropriate navigation system, the computer will select the least congested route and the autonomous car will take you to the indicated place in the shortest possible time. The technology to build such autonomous cars is almost within reach. Car manufacturers are now adding more features to new car models to enable increasingly automated driving. For example, BMW has introduced a stop-and-go function in its cars, which already allows fully autonomous driving in traffic jams. If this option is used, the vehicle is fully controlled by a computer. In this case, one can freely make teleconferences or do any other things. Connectivity and the level of communication with the world are slowly becoming one of the most important functions of a vehicle. According to calculations carried out by the BMW Group, drivers spend on average 10 to 15 minutes a day looking for a suitable parking space. The concept of smart Internet will create the possibility of shortening the time of such searches in the future [357].

The fourth industrial revolution is changing our whole lives. It influences how we live, how we make our products and services, and it also transforms the places we live in. Klaus Schwab, in his book The Fourth Industrial Revolution, gives a clear example of how the technological revolution we are witnessing influences the economy. At the beginning of the 1990s, when the centre of industry was located in Detroit, the three largest industrial companies were worth together about 36 billion dollars and employed 1.4 million people. Today, the direction of changes in the economy is determined by technology companies from Silicon Valley, and by analogy, the three largest of them are worth USD 1.09 trillion (30 times more), and employ only 137 thousand people, which is more than ten times fewer[17].

Chart 1.3 *The capitalisation of industrial sector - comparison of the 3 largest companies in 1990 and 2014*



Source: Own elaboration based on [301].

Internet of Things

Although the catalysts of the fourth industrial revolution are all technologies that exploit the power of digital and information solutions, one of them deserves special mention, because in reality it has become the main driving force behind the entire revolution. It is the so-called Internet of Things[18] (IoT) which is a global, dynamic network of physical devices,

[17] In this comparison, the author used the data from the year 2014.
[18] Smart sensors connected to the Internet can be found in many devices (things), e.g. in cars, refrigerators, on construction sites, etc. Hence the Internet of Things.

systems, platforms and applications that are able to communicate with each other and share information (data) obtained by sensors from the external environment. The IoT integrates various devices that exchange data with each other over the network. Examples of such devices having access to the Internet are: air-conditioning, electricity meters, TV sets, audio systems, cars and clothing gadgets such as wristbands monitoring our activities. With the development of this technology, the intelligent sensors that can be integrated into various devices will not require a high transmission speed, but over time their sheer number will require at least a gigabit connection. Therefore, for a rapid development of IoT it is necessary to define the so-called 5G standard.

Illustration 1.2 *The Internet of Things Scheme [52]*

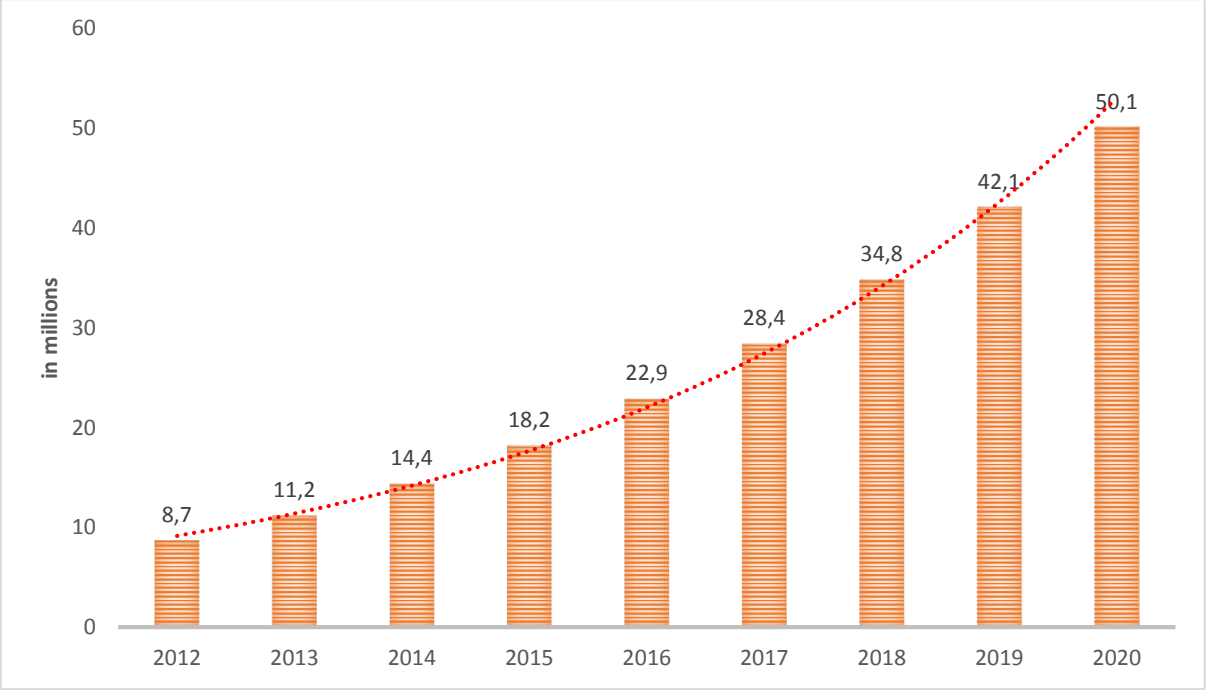
The Internet of Things is inseparably tied to the so-called cloud computing, which is the processing of data in the "cloud", thanks to which it is possible to properly process the transmitted data and generate appropriate signals enabling a variety of devices to work easier. In IoT technology, devices are able to communicate with each other using microscopic sensors, advanced processors and systems allowing for wireless data transmission. It is almost certain that in the near future IoT will penetrate many areas of our everyday lives.

One of the sectors that will benefit the most from the popularisation of IoT technology will be automotive insurers. With the Internet of Things, insurers will be able to continuously

monitor our use of vehicles in the future. The road services, on the other hand, will be kept informed about the state of roads and bridges or about traffic congestions, and the city cleaning services will be able to monitor the waste route as part of the recycling programmes. Already today, some 'smart cities' are managed in this way, e.g. Barcelona.

The number of devices that are connected to the Internet has been growing in recent years at an exponential rate.

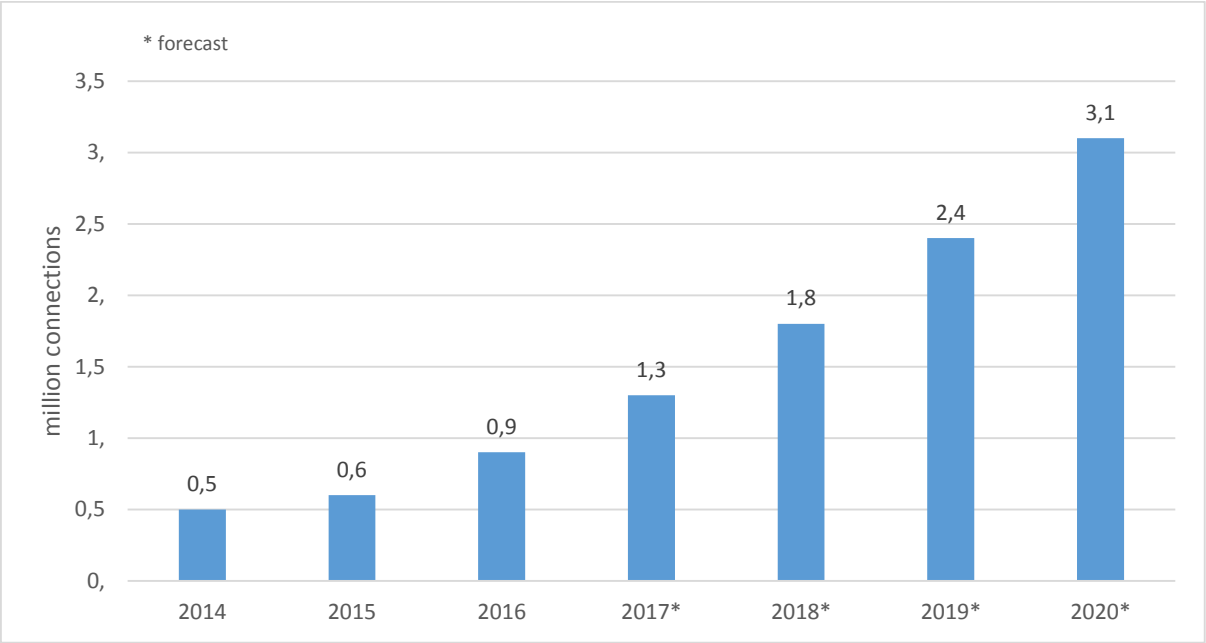
Chart 1.4 *Internet of things (IoT): number of connected devices (forecast)*



Source: Own elaboration (based on BI Intelligence data).

An even higher increase can be expected in the number of connections between so-called terminal equipment (machine to machine, M2M).

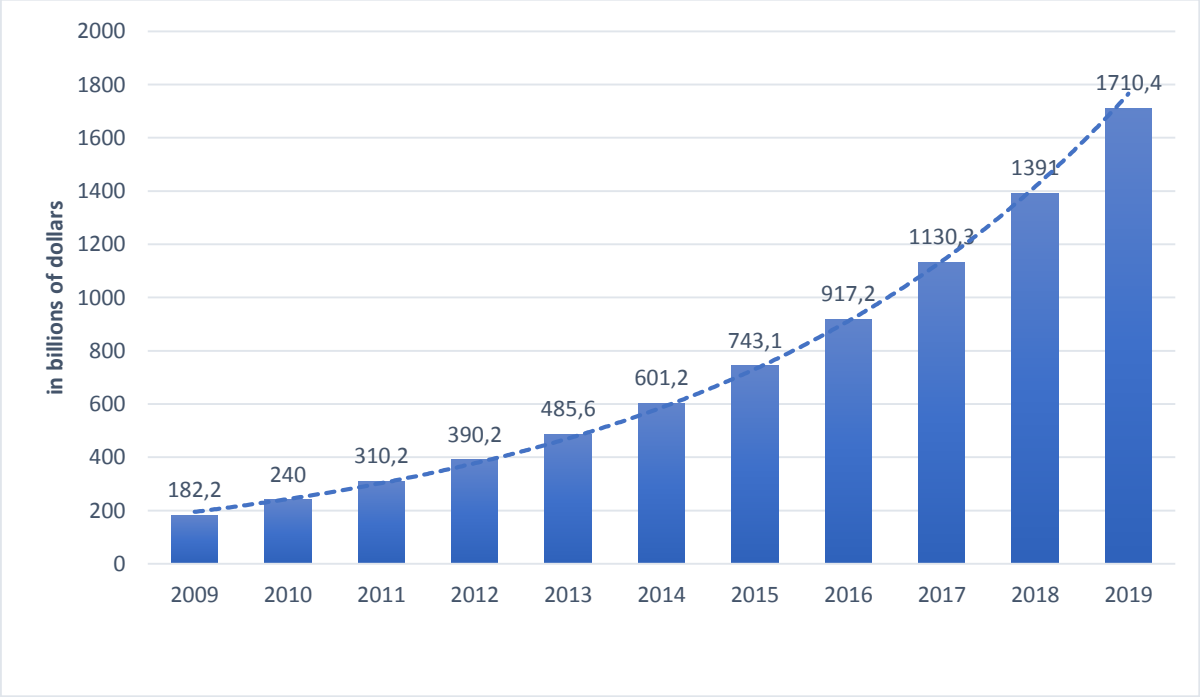
Chart 1.5 *Number of M2M connections (machine-machine) - Forecast to 2020*



Source: Own elaboration (based on Cisco Systems data).

The forecast for growth in the value of this market is also impressive. The Internet of Things will certainly be a catalyst for changes in people's lifestyles and habits over the coming years. IoT will also contribute to the creation of thousands of new businesses.

Chart 1.6 *Global market growth for the Internet of Things (IoT) (forecast until 2019)*



Source: Own elaboration (based on BI Intelligence data).

Internet of Everything

The American company Cisco went even one step further, creating the idea of the so-called Internet of Everything (IoE). IoE is a quite young concept and slightly broader than the Internet of Things, because it covers not only devices but also people, processes and the data itself. Thus, it is a kind of broad, networked ecosystem in which people, companies, cities and even entire countries operate in a constant contact with the network [320, pp. 2991-3004]. Cisco estimates that IoE will reach about $19 trillion in the decade to come. Most of the data supported by IoE will pass through the cloud, although there is no need for all the data generated by smart devices to be transferred to the cloud. A significant part of it will be processed at the level of intelligent machines themselves, in the layer which is called the *fog computing*[19].

The IoT concept itself is still relatively unknown in the business community, as shown by the results of various studies. For example, one of such studies was carried out among managers by LNS Research, a consulting company specialising in the latest digital technology solutions for business. The survey was designed to show managers' and business leaders' awareness of the impact of the Internet of Things on their business ventures. As it turned out, 86 percent of surveyed managers did not know or understand what the Internet of Things really was and how it could revolutionise business in the future. Only 13 percent of the respondents could demonstrate any investment activity in this area.

Automation of production processes as a coherent element of corporate strategy

More and more companies are willing to allocate a growing part of their budgets on information systems and automation of production processes. However, not always the large expenses incurred by companies on IT bring them equally large financial benefits. Nonetheless, companies that manage their new technology projects best achieve a 40 percent higher return on investment when compared to their competitors [292, p. 2]. The problem,

[19] The term was first used by the Cisco company. In fact, thanks to the ever smaller sizes of processors and sensors, a majority of intelligent devices are already embracing the functionalities that until recently were provided only by computers.

however, is that the leaders of these companies usually know little about new technologies and IT itself and entrust the decision making process to the managers in charge of IT departments. As a result, IT managers are the ones who decide on many technological issues within such companies, often making decisions that are inconsistent with the company's strategy.

Decisions on new technological systems are so important that they should be analysed in detail with a view to adapting them to the company's core strategy.

Success is achieved mainly by those companies which first define the functions that technologies should fulfil in their strategy and then allocate appropriate funds for these purposes in their budgets. For example, two courier companies have been competing in the market for years, namely United Parcel Service (UPS) and FedEx. Each of them spends nearly a billion dollars a year on their technological systems, and each of them has its own IT system perfectly adapted to their individual needs and strategic goals. However, the basic directions of IT development and business strategies are different in each of the two companies. At UPS, the main focus is on improving process efficiency, with particular emphasis on standardisation and reliability. Therefore, the company decided to create an extensive database on shipments, which is treated as a platform for various other applications. In turn, FedEx has focused on achieving the flexibility necessary to meet the needs of individual customers, i.e. different market segments.

Leaders who have to develop and then implement appropriate automation strategies should be actively involved in the process of creating and implementing the company's strategy. This poses a very important issue in terms of adapting the relevant technologies to strategic expectations.

The automation strategy should address such issues as:

- easy access to relevant technologies,
- customer requirements,
- profitability of investments in specific technologies (i.e. rate of return on investment),
- investments accompanying the implementation of specific technologies,

- standardisation,
- training programmes for employees (including engineers).

2 CHALLENGES OF THE FOURTH INDUSTRIAL REVOLUTION

The great revolution that awaits us over the next few decades will ensure that people will no longer be treated as mere labourers, but rather as operators of intelligent machines that will relieve them in many different areas of life. The upcoming changes will bring tangible benefits not only for the economy, but also, and above all, for consumers themselves.

The revolution that is taking place in front of our eyes is making many simple professions slowly become a thing of the past. In a few years' time professions such as cashiers and cleaners may turn out to be no longer necessary. The cash registers will be organised in such a way that they will automatically scan and count our purchases, and large spaces or factory halls will be cleaned by autonomous robots. Cashiers and cleaners are only a few examples. Automation will cover practically all areas of human life. This will, of course, involve considerable economic challenges.

The balance of the fourth industrial revolution, however, does not necessarily mean a reduction in employment. Research findings for the German economy suggest that the industrial revolution 4.0 could even lead to an increase of the number of jobs. There is no doubt, however, that in the future there will also be new jobs requiring completely different competences and skills from those we know today. Many things will, of course, depend on adapting the entire education system to these new challenges. Such a system should educate future staff so that they have the right skills to respond to emerging technological and business trends.

The fourth industrial revolution - a chance for the development of the Polish economy

The fourth industrial revolution also offers a great opportunity for Poland. It is a tremendous, technologically fascinating challenge, which may determine the future pace of the development of our economy. All that is needed is to make skilful use of this opportunity. This will be possible provided that **the education system is appropriately modified** so that it

responds to the new opportunities created by digital technologies and that **adequate access to capital is provided**.

Unfortunately, according to the report published by the European Commission at the beginning of 2017, Poland is one of the least digitally advanced countries in the European Union. This is evidenced by the very **low level of the Digital Economy and Society Index (DESI)**[20]. Moreover, the digital gap between Poland and the countries leading the ranking has widened even further in recent years [93, p. 11]. For example, in the field of e-commerce, Poland is ranked on 16th place in the entire EU, in e-banking - 19th, and in video calls - 22nd place. **Also, there is still much more to be desired from the digitisation of our businesses, which, compared with most other European countries, is progressing at a significantly slower pace**. In terms of online sales of products and services by small and medium-sized enterprises (SMEs), we are only 23rd in the entire European Union. Only one in ten such companies sells its products or services on the Internet. On the other hand, only about 25 percent of Poles use e-government services, which puts us on the 19th position in the whole European Union.

Until now, the competitive position of the Polish economy has resulted mainly from its favourable location in the centre of Europe and low labour costs. However, part of Polish business is stuck in a vicious circle of impossibility: technological backwardness affects the profitability of enterprises, and empty cash registers do not allow to buy what is necessary to compete with better equipped rivals from Western Europe. On the other hand, if Poles take advantage of the opportunities offered by the *Industry 4.0* in a timely manner, they can gain an additional competitive advantage. With the fourth industrial revolution, the argument of low labour costs will gradually become less relevant. It is already apparent that large companies are ready to move their production facilities from Asia to Germany, where the concept of *Industry 4.0* began to materialise at a relatively early stage. There is therefore a considerable risk that Germany, as our closest neighbour and at the same time the country that is leading the process of production automation, may take away many our jobs in the future. Polish government already recognises this problem and is currently trying to support its entrepreneurs in this area by encouraging them to invest in innovative projects, facilitating

[20] The Digital Economy and Society Index is published by the European Commission.

their access to capital and reducing or even eliminating many of the existing regulatory barriers.

The main government body that tries to realise the vision of modern automated production in Poland is the Ministry of Regional Development, which had even established a special platform (the so-called Polish Industrial Platform 4.0), the aim of which is to introduce Polish industrial plants to the digital age. Poland is currently implementing activities aimed at increasing the level robotisation of production and ensuring greater integration and coordination of the activities of companies, scientific and research institutions and public administration entities. The aim of these activities is the digital transformation of industry.

Similarly as in many Western European countries (e.g. Germany), Poland is preparing to implement the Polish Industry Platform 4.0.

The objective of the Polish Industrial Platform 4.0 is to disseminate technical knowledge, support companies in implementing innovative technologies and business models based on the concept of modern production, and initiate the flow of experience. In order to implement the idea of *Industry 4.0*, it is necessary to cooperate with many companies and transfer knowledge. This is particularly the case for small and medium-sized enterprises (SMEs). There are only a few companies in the world which design and implement all the solutions and systems related to automation and robotisation of production on their own, e.g. Siemens, General Electric or ABB. However, even such large companies benefit from the help of subcontractors. In Poland, such a business base still requires to be created. **We need the entire infrastructure that will allow companies to benefit from the latest trends and technological solutions**. This is primarily about the use and development of information and communication technologies and the Internet of Things, that will make it possible to implement intelligent sensors on a large scale and collect large data structures (i.e. big data). Processing such data will result in the emergence over time of completely new markets and entire networks of values currently unknown to us. A real revolution can be expected in areas such as production management, transport management, traffic management and energy management (e.g. energy efficiency). There will also be changes in the forms of production in industry. In fact, process management based on huge amounts of data collected and processed within the cloud as well as the use of big data and data mining analytics are

becoming increasingly popular. This in turn favours the so-called customisation, i.e. a combination of mass production and product personalisation - two things which seem to be in conflict with each other. Generally speaking, it is about tailoring products to customers' individual needs in mass production. This personalisation of solutions is a way of meeting customers' expectations as much as possible and, at the same time, it reduces production costs by lowering costs in the supply chain.

In order to ensure rapid development of new technologies and the entry of the Polish economy into the path of the fourth industrial revolution, it is necessary to overcome several barriers first. In the first place, **uniform standards of technical and technological convergence must be drawn up**, i.e. rules that allow for cooperation and integration of various devices and control systems. This also requires the **adoption of a coherent programming environment, as well as the implementation of appropriate communication and management standards** for all devices operating in ICT and energy networks. In other words, we need an Industry Standardisation Roadmap 4.0. In this respect, we should follow the example of our western neighbours, who have already published several versions of such a document [332]. Secondly, technological progress in many areas requires changes in legislation. This is particularly the case in areas where autonomous systems are used to help people make many decisions, e.g. in areas such as artificial intelligence systems, robots, autonomous cars, etc.

The government is also preparing the **Green Paper on Industry 4.0**, which will include a detailed analysis of the current state of the industrial sector, with particular emphasis on its weakest points, challenges and the impact of digital technologies on the Polish economy. The development of Industry 4.0 is an opportunity for us to counterbalance the negative and long-standing trend of relocation of domestic production to Asia. Initiatives taken in this respect by the European Parliament and the Council of the European Union consist in financing and supporting the idea of Industry 4.0. This is to be achieved, among others, by projects such as Horizon 2020.

Polish Industrial Platform 4.0

The establishment of the Polish Industrial Platform 4.0 (PIP 4.0) by virtue of the act is to facilitate the adaptation of the Polish economy to the challenges related to the fourth industrial revolution. PIP 4.0 will function as a foundation and will start operating in 2018. **Its**

main task will be to ensure that Polish industrial plants meet the standards of the economy 4.0 and the requirements for robotisation and digitisation [236]. In this sense, **the Polish Industry Platform 4.0 is to lead to the physical and digital unity of the Polish economy**. It is also intended to integrate and coordinate the activities of various entities, both public and private. In order to implement the concept of modern production, it is necessary to cooperate widely between various entities, share knowledge and support entrepreneurs in the implementation of new technologies and business models. PIP 4.0 is intended to address all these issues. Similar initiatives are also undertaken in other countries, such as Germany. In fact, our western neighbours, who are considered leaders in the field of industrial automation, established their own industry 4.0 platform in 2015[21]. Two German federal ministries[22], Fraunhofer and DIN[23], as well as dozens of other German institutions are involved in this project and they all try to support domestic production companies. Together they have developed **the Industry Standardisation Roadmap 4.0**. From the German perspective, the concept of Industry 4.0 covers such issues as continuous improvement of technology and products, harmonisation of radio frequencies for production equipments, data interchange between production equipments, API[24] standards or use of 3D printers in the production chain. Given the high level of progress in the development of Industry 4.0 in Germany, as well as the fact that Germany has a significant influence on what is happening in the European Union, particularly in the area of standardising, we cannot under any circumstances abandon standardisation in our own country. Otherwise, our economy may lose its competitiveness. In a long run, the effect of implementing Industry 4.0 solutions should result in a quantum leap towards improving the global competitiveness and productivity of Polish industry and the entire Polish economy.

PIP 4.0 is one of the strategic projects under the Strategy for Responsible Development (SRD), which envisages that the digital transformation, general automation and robotisation will contribute to the reindustrialisation of Poland. Economists agree that **in order to rapidly increase the competitiveness of our economy, we should strive to increase the density of its**

[21] At the Hannover Messe 2015.
[22] The Ministry of Economy and Energy and the Ministry of Education and Research.
[23] The German DIN performs the same function as the Polish Committee for Standardisation.
[24] Application Programming Interface (API) is a set of subroutine definitions, protocols, and tools for building application software. Such interfaces enable users to connect to the production systems.

robotisation[25]. The estimates of the International Federation of Robotics (IFR) show that we have a lot to catch up in this area. Compared to the leaders in robotisation, such as South Korea (437)[26], Japan (323) or even taking the world average (62) or the European average (82), with a robotisation density in the industry amounting to 22 industrial robots per 10 000 employees, Poland is one of the least robotised countries in the world. Even Slovaks (83), Czechs (72) and Hungarians (47) are ahead of us. PIP 4.0 aims to reverse these negative trends and enable Polish companies to have easier access to innovative technologies and know-how. The objective of PIP 4.0 will be to educate entrepreneurs and make them aware of the possibilities of participation in technological transformation process. The Smart Industry 2017 survey, conducted jointly by the Ministry of Regional Development and Siemens, showed that Polish entrepreneurs are relatively closed for technological changes, cooperation and information coming from the external environment. The Polish Industry Platform 4.0 is expected to contribute to the change of such approach and increase the uptake of technological solutions by Polish companies. It will also help domestic entrepreneurs to develop new business models that respond to the digital transformation of the economy.

PIP 4.0 will ensure the creation of cooperation networks, the education of teachers of technical professions and the regulatory and legal environment for business. In addition to the typical coordination activities, PIP 4.0 (as a legal entity) will also be a service provider with an active role in the market. As a result, PIP 4.0 will be able to generate profits from its commercial activities.

Under the PIP 4.0, entrepreneurs will be able to use materials, content, information and educational services, project consultations, seminars, professional training, and even study visits in companies. They can also rely on assistance in terms of both the implementation strategies and the support consisting in obtaining expert analyses related to new technologies within industrial plants. This will allow for an assessment of their potential applications. Also noteworthy is the initiative of the Polish government to support cooperation in the field of

[25] The density of robotisation (or robot density) is the number of robots per 10,000 persons employed in the manufacturing industry. Robot density is an excellent standard for comparison in order to take into account the differences in the automation degree of the manufacturing industry in various countries.
[26] The numbers in brackets refer to industrial robots per 10,000 persons employed in the manufacturing industry. For example, in South Korea, there are 437 robots per 10 000 such employees in the manufacturing industry.

industrial transformation, which in 2016 resulted in the creation of the special Team for Industrial Transformation. Its objective is to work on initiatives and solutions supporting the digital transformation of the economy, which are expected to lead to the digital development of industry and peri-industrial services [235]. Within this team, there are special working groups dealing i. a. with the following issues:

- elaboration of the standards for integrated digital technical infrastructure and the development of smart industrial specialisations,
- digital support for industry,
- Intelligent software and data processing,
- training, qualification and human resources for industry 4.0,
- legal framework for the functioning of Industry 4.0 and statistics on the ICT services sector.

The government has also taken care of the relevant legal regulations, which concern in particular the processing of data[27]. In this respect, an important role is played by the Ministry of Digitisation. One of the priorities of the Polish state is also to provide appropriate support for the science sector. This objective is being achieved by ensuring that teachers and academics have access to the most up-to-date knowledge of new technologies.

The Electromobility Valley

In order to implement the idea of transformation of the Polish economy, it is necessary to take initiatives consisting in integration and coordination of activities of various entities, both public and private. There is a need for broad cooperation between different entities, knowledge sharing and support for entrepreneurs in the implementation of new technologies and business models. An example of such an initiative is the Electromobility Valley or INNOeCAR, which is the idea promoted by the Municipality of Gdynia to create the first cluster for electric cars in Poland. Apart from the municipality itself, the whole project is supported by private investors, such as the well-known entrepreneur Wojciech Kąkol (Walkin company) and the organisation *Pomerania Employers*. **The Electromobility Valley has a chance to**

[27] This includes the General Data Protection Regulation (GDPR), which covers the protection of individuals with regard to the processing of their personal data and the free movement of personal data. This Regulation will enter into force on 25 May 2018.

become a practical example of an undertaking which will combine access to technologies, the work of scientists and their research results with appropriate infrastructure and capital. The Electromobility Valley is one of the examples showing practical implementation of solutions in the field of Industry 4.0. As a part of the cluster's activity, various investments and projects in the field of electromobility are going to be undertaken. One idea is to develop an electric car that can be used for urban driving and be available in a carsharing system. Currently, the prototype of such an electric car is being developed by Walkin, one of the cluster's partners. Another company, Cree Yacht, wants to supply the materials needed for this project (i.e. suitable composites and solar panels for e-cars). In turn, DLabs with its experience in the field of big data and artificial intelligence declared its willingness to participate in the development of appropriate software for such an EV, i. a. systems supporting drivers' communication and battery charging systems. Entrance to the cluster is also being considered by the Slovak company Greenway, which is interested in creating a network of EV car charging stations in Poland.

Initiatives such as the Electromobility Valley are extremely necessary, as they create the right conditions for cooperation, which is so much needed in our country and which can be very beneficial. Such undertakings facilitate cooperation and may contribute to a variety of different industries. No single company can be expected to contribute to the revolutionisation of a particular sector of the economy. Especially in Polish conditions, this would seem very unlikely.

Most importantly, entities wishing to cooperate within the Gdynia cluster can count on cheap office space in the area of the Gdynia Shipyard and on additional support in the form of funds for the development of their activities. They can also count on the support of the Ministry of Energy, which is planning to provide assistance to non-governmental institutions dealing with the field of electromobility. Projects involving wider cooperation of companies may also be supported with funds from the National Centre for Research and Development.

Interestingly, **in Poland there is on average only one start-up per 15,000 inhabitants**, and by comparison **in the American Silicon Valley one start-up per 500 inhabitants, i.e. 30 times fewer**. In countries such as the United States, Germany, Great Britain or Israel establishing innovative technology companies is profitable in the most cases, yet in Poland it is still rare and risky. To change this state of affairs, it is necessary to influence the approach to start-ups on the part of corporations and large companies and to do everything possible to

make them much more willing to invest in new ideas and projects, including those coming from young scientists. There is a need for projects and campaigns promoting technological start-ups. No less important are initiatives encouraging large companies to cooperate with start-ups. Such cooperation could consist in testing technologies and products developed by novice companies.

Greater interest in start-ups on the part of the business world will make it possible to create additional demand for innovation in the future. The government should introduce economic policy instruments that will encourage corporations and large companies to invest in innovative ideas of young entrepreneurs.

Start-ups should receive special support from the state because on one hand they increase the level of innovation in the economy and, on the other hand, private capital is by its nature reluctant to invest in such projects since they are classified as extremely risky and investing in them very likely results in a total loss of capital.

It lies in the interest of the Polish government to support start-ups, as they increase the level of innovation in the economy. The Polish state should create incentives to support young innovative companies. Apart from large research and development centres, they are one of the pillars of the economy's innovativeness.

Poland has already undertaken such actions, i. a. through the Polish Development Fund and through the large listed companies controlled by the State Treasury, such as PZU, Enea, Orlen, PKO BP, Energa or PGNiG [289]. More and more frequently, the government initiates actions supporting young innovative companies. One of such actions is **the initiative of the President of the Republic of Poland - *Start-ups in the Palace***, which is supposed to **support young and innovative Polish companies in their search for development opportunities**, and in particular in their search for potential investors, business partners and new markets. As part of this project, each year ten of the most innovative start-ups are selected, receiving **the President's special *passport*** entitling them to participate in one of the economic missions of the Head of State [21].

Table 2.1 *The most innovative Polish companies awarded in the second edition of the "Start-ups in the Palace" action organised by the President of the Republic of Poland in 2017*

Company	Profile of activity
Quotiss	Quotiss developed a proprietary algorithm which is used to manage sea freight prices. The company is currently planning to implement its solutions in the rail and air transport sectors.
HussarTech	HussarTech develops innovative hybrid materials with bactericidal, fungicidal and antiviral properties.
XTPL	XTPL develops solutions which improve the efficiency of photovoltaic systems. One of the technologies already created by this company are ultra-thin conductive electrical wires. XTPL also developed a proprietary printer and special inks for manufacturing these ultra-thin conductive wires
Sense	Sense has developed an innovative system that facilitates the management of large buildings. It automatically notifies building managers about important risk factors with regard to the buildings' maintenance, e.g. excessive snow loads on the roofs of such buildings.
Billon	Billion is a company that revolutionises the payments market by introducing e-money and changing the standard of digital money transactions.
Blebox	Blebox operates in the Internet of Things (IoT) sector, i. a. developing systems and solutions for mobile devices that facilitate the control of lighting, heating, doors and entrance gates.
VersaBox	VersaBox develops autonomous mobile robots.
Autenti	Autenti has created a platform that facilitates the authorisation of documents and conclusion of agreements over the Internet.
Abyss Glass	Abyss Glass produces interactive mirrors.
2040.io	The company 2040.io specialises in artificial intelligence, i. e. develops intelligent machines supporting sales processes and facilitating work organisation, e. g. the intelligent assistant Edward.

Source: own elaboration.

It is also worth mentioning that **in 2017 Poland was for the first time a co-host and partner of the Hannover Messe trade fair**, which was a great honour and confirmation of the growing strength of the Polish economy. Through our active presence at the trade fair, we are strengthening our competence in the area of the most advanced technologies, in particular in such areas as automation and robotisation of production processes. During the fair, the Polish Ministry of Regional Development signed an agreement on economic cooperation with Siemens [17]. Under this document, the German company, which is the leader in the electrical and electronic engineering sector, will carry out appropriate analyses of the Polish industrial

sector in terms of its development prospects and the possibility of implementing innovative technologies.

Challenges of the fourth industrial revolution

Apart from the obvious advantages, the digital revolution also carries the risk of increasing instability and possible collapse of the current global system. The biggest challenges of this revolution are those of a social nature. **Lower production costs, automation, robotisation, global flow of ideas and technical solutions contribute to an increasing marginalisation of the role of humans themselves**. There are many indications that in some areas of life we are going to face de-humanisation, which will manifest itself in gradual and systematic reduction of the human factor in a wide-ranging way. McKinsey's report shows that the **fourth industrial revolution will bring the end of many existing professions [223]**.

Automation and digitisation pose the greatest threat to all those who perform activities that are relatively easy to describe in the language of algorithms.

The professions consisting in performing simple administrative tasks and positions covering activities related to manufacturing processes will be automated in the first place. These include professions such as production workers, call centre employees, accountants or bank and postal officials[28]. No less worried may feel all those who work in sectors such as logistics, transport, trade, services or even construction (e.g. bricklayers and roofers). The least worried about losing their jobs are project managers, production engineers, automation system designers, software engineers, operational managers, mechatronic[29] technicians and people who perform activities that require maintaining interpersonal contacts, such as doctors, psychologists, social workers, therapists, physiotherapists and others. The fourth industrial revolution will also be an opportunity to make a career in completely new areas,

[28] This is the result of a study conducted jointly by scientists from Oxford University and employees of Deloitte and the BBC.

[29] Mechatronics is one of the fastest growing fields of science and technology. It is based on the use of knowledge and skills in the field of mechanics, machine construction and operation, electronics, information technology, automation and control, modeling, design, the operation of manufactured products and production processes. Mechatronics is an interdisciplinary domain whose essence is to add electronic solutions to the mechanisms in order to create the best possible effects.

such as cyber physics and itmatics[30]. In the construction sector, the demand for electronics engineers and 3D print technology specialists will certainly increase. This is because in the future houses will largely be made using spatial printing technology. The Boston Consulting Group anticipates that artificial intelligence and robots will gradually take over the various stages of production and service provision in the upcoming years. In this area, economic and statistical forecasts may seem worrying. According to the analysts of the consulting firm PwC, by 2030 only in the United States artificial intelligence will contribute to the destruction or transformation of about 38 percent of workplaces [197]. The British, in turn, expect to see the total disappearance of around 35 percent of jobs in their country in the next 20 years. A report prepared jointly by Deloitte and the scientists from the University of Oxford shows that the fear about losing work should primarily be felt by low-skilled workers who perform repetitive activities [280, pp. 18-19]. According to this report, automation will primarily affect manufacturing, services, administration, transport, construction and mining. The BBC even launched the website: *Will the robots take over your job?*[31], where you can find out how likely it is that a particular profession will be replaced in the future by automation systems. If a similar methodology were applied to Poland, it could be expected that in the next 20 years, between 4 and 5 million Poles would lose their jobs due to the increasing automation.

Table 2.2 *The list of professions that will be fully automated and replaced by machines in the next 20 years. This list was elaborated with the participation of Oxford University and Deloitte*

Rank	Individual professions, which will be replaced by automats and robots in the first place	Automation risk
1	Telephone salesperson	**99.0%**
2	Typist or related keyboard worker	**98.5%**
3	Legal secretary	**97.6%**
4	Financial accounts manager	**97.6%**
5	Routine inspector and tester	**97.6%**
6	Weigher, grader or sorter	**97.6%**
7	Sales administrator	**97.2%**
8	Book-keeper, payroll manager or wages clerk	**97.0%**
9	Finance officer	**97.0%**
10	Pensions and insurance clerk	**97.0%**

[30] A field that is a combination of IT and automatics.
[31] The website was launched as a joint project of Oxford University and Deloitte. It can be accessed at: http://www.bbc.com/news/technology-34066941.

11	Bank or post office clerk	**96.8%**
12	Financial administrative worker (other)	**96.8%**
13	Local government administrative worker	**96.8%**
14	Non-governmental organisation (NGO) officer	**96.8%**
15	Library clerk	**96.7%**
16	Assembler and routine operative (other)	**96.7%**
17	Paper and wood machine operative	**96.5%**
18	Communication operator	**96.5%**
19	Telephonist	**96.5%**
20	Textile process operative	**96.1%**
21	Financial and accounting technician	**95.9%**
22	Receptionist	**95.6%**
23	Transport and distribution clerk	**95.5%**
24	Estimator, valuer or assessor	**95.5%**
25	Fishing or agricultural manual worker	**95.4%**
26	Chartered and certified accountant	**95.3%**
27	Taxation expert	**95.3%**
28	Skilled trader (other)	**95.2%**
29	Sales and retail assistant	**95.1%**
30	Vehicle and parts salesperson and adviser	**95.1%**

Source: Own elaboration.

Surveys show that around 25 percent of Europeans today fear about losing their jobs. In Poland, about 30 percent of the respondents expect that in the next decade the activities they perform in their workplaces will be fully automated[32]. Only Italians (40 percent), Spaniards (39 percent) and Portuguese (36 percent) are more pessimistic than us. On the other hand, Austrians and Luxembourgers (17 percent), Danes (18 percent) and Germans and Dutch (20 percent) are quite optimistic about these issues.

We can, therefore, ask ourselves about the future of unskilled workers and how long they can keep their jobs. Perhaps, however, this whole phenomenon needs to be perceived in a slightly different way. In a nutshell, **automation makes us stop doing simple manual work and start focusing on activities that require more expertise**. In the short term, this entails many social problems and consequences. There are many difficulties for the lower classes in society that are particularly affected. **In the long term, however, we can all benefit from this**. From a historical perspective, it is worth noting that all previous industrial revolutions raised

[32] According to the Randstadt Research Institute (Labour Market Monitor).

similar concerns to those evoked by the current digital revolution. Quite rapidly, however, **each of the previous revolutions proved to be much more beneficial than harmful to society**.

Employees whose work is relatively easy to define are the most vulnerable to be fully replaced by robots. In turn, occupations that require abstract thinking, such as psychology, journalism or design, are the least exposed to automation.

If indeed, the fourth industrial revolution leads to the emergence of more creative professions, it will be beneficial for the humankind. Of course, you can also envisage that over time, these creative activities will eventually be replaced by robots. If it does happen one day, it will mean that humans have managed to create a fully autonomous machine that meets their own level of intelligence. It is difficult to say today, however, whether this would be a reason for satisfaction or rather for fear about our own existence.

The digital revolution is likely to lead to a greater specialisation of professions. It seems that there will be fewer and fewer jobs with each year, but there will still be a shortage of specialists. Changes in the education system are unlikely to keep pace with the new challenges. This is due, for example, to the impressive dynamics of the development of digital technologies. Those who are responsible for this impressive development will be overburdened with work and responsibilities, while others may find it difficult to get any job. In order to find a new job, they will need to be highly flexible, mobile and ready for accepting temporary contracts. For some of them, the only chance of finding a job will be migration and the search for happiness in other countries. The way people perform their work will also be subject to constant changes. More and more work activities will be conducted at home or on the move. An employer will require its employees to bring together knowledge and skills in a wide range of fields. However, there is no doubt that people with the capacity to create and innovate will make the greatest careers. Lower demand for labour will result in reduced employment stability. This lack of stability will give rise to a number of social problems. Perhaps even the only way to solve these problems will be for governments to establish the so-called unconditional basic income (UBI)[33]. The UBI concept assumes that money will be

[33] An unconditional basic income is a socio-political model of government finances, which assumes that every citizen, regardless of his/her financial situation, receives from the state the same amount of money, specified by law, for which no mutual benefit (transfer payment) is required.

given by the State to everyone with no need to fulfil any conditions. For the time being, there is no country that has decided to introduce such a solution in its purest form. However, some European politicians are already working on such legislation. It is very likely that the first country that will introduce an unconditional basic income for its citizens in a systemic way will be Finland. The legislative proposal that is currently being considered by the Finnish authorities envisages that all Finns, whether they work or not, every month will receive a tax-free amount of EUR 800 from the state budget. This would mean an annual expenditure of around €52.2 billion for the Finnish budget. Another country which quite recently planned to introduce the unconditional basic income was Switzerland. Eventually, however, in a special referendum held on 5 June 2016, the citizens of that country voted against such legislation. According to the proposal, the Swiss were to receive even 2.5 thousand francs, which would entail a burden for the budget of about 200 billion Swiss francs. 75 percent of the budget amount would come from taxes and the rest from the social security system. The result of the Swiss referendum shows that, until now, people still prefer work over a stable, although not too high social income received for practically nothing. However, as many professions become increasingly automated and liquidated on a massive scale, at some point the implementation of such economic policy instruments will simply become a necessity. It should also be remembered that, in addition to the rapid elimination of numerous jobs, the global economy is facing a multitude of other threats, which may also be a source of concern. According to the report of the World Economic Forum of 2014, the instability of the banking sector may result in unpredictable social consequences. Further fuelling of economic growth with credit threatens recession and the risk of so-called secular stagnation[34]. The 2008-2009 financial crisis was overcome by the creative printing of money, but the actions of central banks seriously disrupted the functioning of the existing market mechanisms. They also contributed to a loss of confidence, a decrease in the level of investments and an increase in global risks. Not without significance is also the growing concentration of capital in the hands of the richest. According to the Credit Suisse report, more than half of the world's wealth is currently held by only 1 percent of the entire population[35]. Today, it is enough to have only 3.2 thousand

[34] Secular stagnation - an economic theory assuming a permanent economic slowdown in developed countries. It was formulated by Keynesians (in particular by Alvin Hansen) and became popular in the 1940s and 1950s. The concept of stagnation was to result from the depletion of natural resources or the suppression of economic growth by the social and political system.

[35] According to data from November 2016.

dollars to be one of the half wealthiest people on earth. If someone has 76 thousand dollars, he or she is among the wealthiest 1 percent of the world's population. The current model of development, with a small proportion of the world's population accounting for most of its wealth, is certainly unstable and unsustainable in a long run.

The young and frustrated precariat class

It is highly probable that we will be working much shorter in the future, but the productivity of our work will be much higher than it is today. According to Swedish psychologist Anders Ericsson, future employees will spend only 4-5 hours a day on work activities. At the same time, we will be more concentrated on our activities and therefore be able to perform our duties more effectively. The extra time is also likely to increase consumption and have a positive impact on the economy as a whole.

The fourth industrial revolution will also force a legislative change in many areas. There is no doubt that many employment regulations already need to be abolished or amended, as they slow down further development and have a negative impact on labour dynamics.

The worker of the future will have to be flexible, entrepreneurial and resourceful. He or she will also have to learn how to organize his or her own work, and how to determine such issues as the scope of the duties, working time and remuneration.

The changes that will take place over the forthcoming decades will, of course, be accompanied by a noticeable decline in feelings of security that have until now been ensured by the relative stability of employment. With the dynamics of the transformation we are currently experiencing, permanent employment is basically no longer a reality. Today, a peculiar illusion of such stability is created by state-owned plants and large international corporations. Of course, they also operate in an environment that is rapidly changing and which will affect their future, and hence the future of their employees. Moreover, like any other economic entity, they will continue to be dependent on global market trends. To illustrate this, we should take the example of the financial crisis of 2008-2009, which caused unpredictable changes in the functioning of many industrial plants. Back then many companies virtually ceased to exist overnight, and the stability of the activities of others was

severely undermined. Such was the case, for example, of General Motors, the world's largest car manufacturer, which in 2009 due to its huge financial problems had to be bailed out by public funds[36]. This and other examples should make us reflect on the fact that in the world of modern economy and turbulent changes, there are few certainties that are given to us once and for all.

Resistance against changes

We must also remember that every industrial revolution is hampered by the resistance from people who might be affected by it. At the beginning of the 19th century, Ned Ludd led a social movement that strongly opposed the changes brought about by the first industrial revolution[37]. Back then the *Luddites* went even as far as to demolish the spinning and weaving machinery. Such a contemporary manifestation of neoludism is the reluctance of some people or even entire communities to use digital technologies. To some extent, this is due to the deep-rooted fear of the machines and of the unknown. Many people are indeed concerned about the dangers associated with the further development of artificial intelligence, which can result, for example, in a rebellion of machines. The criticism of the digital revolution was raised, among others, by Bill Gates, Stephen Hawking and Elon Musk. They warned that smart machines could take full control of people in the future. Many of us were brought up on films that had very similar visions, such as *Matrix*, *Terminator* or *Blade Runner*. The well-known scenario, in which super intelligent machines turn against people, although it seems relatively unlikely, is not entirely unrealistic. None of us can predict today how we will communicate with the robots in the future and whether they will comply with the three laws of robotics defined by I. Asimov, namely [311]:

1. A robot may not injure a human being or, through inaction, allow a human being to come to harm.
2. A robot must obey the orders given it by human beings except where such orders would conflict with the First Law.

[36] The company declared bankruptcy and went into liquidation in June 2009. A month later, General Motors was bailed out by the U.S. Treasury Department.

[37] Ned Ludd was probably the imaginary leader of a movement of people who, at the beginning of the 19th century, protested against the realities of the industrial revolution. Their opposition was manifested by the destruction of spinning machines.

3. A robot must protect its own existence as long as such protection does not conflict with the First or Second Laws.

On the other hand, there are so many possible scenarios describing expected robots reactions that the rules indicated by Asimov might not work in practice. They do not, for example, envisage situations where a person deliberately tries to mislead the machine so that it misappraises the factual circumstances. It is worth considering whether the most reasonable solution would not be, by any chance, to teach (train) a robot in a similar manner as this is done with small children or animals, by rewarding them for their successes and punishing them for their mistakes. The robot can also learn from people by observing their behaviours. Being surrounded by people, it would gradually gain the appropriate knowledge of which behaviours are most desirable and practiced, and how to coexist with people. However, this model assumes the existence of well-developed "intelligence" of such machine [326, p. 53].

Challenges for the business

The owners and managers of industrial plants also face great challenges. They need a forward-looking vision for their businesses. According to Piotr Płoszajski, corporate strategy advisor, markets are beginning to resemble a game in which all players play for everything. Significant differences are becoming increasingly blurred between sectors (the so-called convergence of sectors). The same is true for business models and products of individual companies. They are also similar to each other. What is even more, the companies blur divisions between themselves. It is also impossible not to notice the growing coopetition[38], modular Lego-technologies and hyper-connected objects [267]. The result of all of this is that the undermining of current importance of the sectors as such, which are now being replaced by much more complex and resilient service ecosystems. For entrepreneurs and managers, this means that they should seek their competitive advantages by observing completely new processes and trends, and they should take them as a reference for creating their new business models.

[38] Coopetition is a type of relationship between competitors, in which both the cooperation and the competition may be indicated.

In the upcoming years, individual industries will transfer their operations to global networks, and their business models and strategies will focus on developing increasingly intelligent algorithms. We can already see that different areas of life are becoming "dematerialised", and that every problem and every challenge can be solved in the future through coding and algorithmisation. This will apply even to those sectors of the economy which so far have not been susceptible to technological changes, e.g. healthcare or government administration.

In the future, not only will manufacturing processes and products be created through automation, artificial intelligence and other digital technologies, but also business strategies and models. We may also be dealing with the beginning of the end of the human monopoly on intelligence. Here are some examples:

- Chess software today features a higher level of chess skills in the Elo ranking system than the Norwegian player Magnus Carlsen, who is the world champion. The chess playing software has an ELO of 3353, while Magnus Carlsen reached a peak Elo of 2882. In turn Kasparov achieved his peak rating of 2851;
- IBM's Watson supercomputer custom-designs clothing, elaborates cookbooks, and even diagnoses illnesses;
- The AlphaGo AI defeated the grandmaster Lee Sedol 4:1 in the strategic Go game which is incomparably more challenging than chess, for example. To win against an opponent in Go's game, it is not enough to make the right calculations. Artificial intelligence must also have the ability to imitate human intuition. AlphaGo copes quite well with this. Everything indicates that people will soon lose their monopolies in such areas as innovation and creativity;
- Autonomous cars and virtual assistants (i.e. intelligent assistants) provide people with support for performing some simple tasks. Mark Zuckerberg, who is the head of Facebook, envisages that such intelligent assistants will soon run his house and take over the most burdensome daily household duties from him. What is more, Zuckerberg has announced the creation of a super-assistant that will allow us to control most of our home devices and with which communication will be in natural language;
- The Pepper robot created by the Japanese SoftBank corporation is able to interact with people and read their emotions. The robot is used as an assistant for various domestic

activities and as a carer for children and elderly people. Robots such as the Pepper may be particularly useful in countries where the proportion of elderly people is increasing;

- Today, most stock exchange transactions are executed by computers and smart software through so-called high frequency trading (HFT)[39];
- Thanks to intelligent software we are already able to recognize human moods and emotions. An example is the company Emotient from San Diego, which based on the analysis of facial expressions has developed a method to study human emotions while watching videos. The company was quickly taken over by Apple, which sees great potential in the development of this type of intelligent technology. The technological giant from Cupertino has also acquired several other start-ups (including Perceptio and VocalIQ) dealing with similar problems, i.e. the recognition of emotions by a computer. Other high-tech giants, such as Microsoft and IBM, are also working on similar issues. The technology of recognising emotions can be extensively used in advertising, media testing, and even to measure how the audience reacts or in other areas of life.

Tech-life harmony and work-life balance

In future, workers will also have to clearly define the boundary which will separate their work and availability from their private lives. The aim is to maintain a "healthy" balance between technology, work engagement and family life (so-called work-life balance and tech-life harmony). When we use digital technologies at work and at home, we should be more aware why we really need them. It would be wrong for us to start building all possible relationships between ourselves, by relying only on technology and, at the same time, by completely eliminating direct contacts. What should be important to us should be the right balance between these issues, although this will probably require some effort and discipline on our part.

[39] High Frequency Trading (HFT) is a trading technique that involves entering into multiple stock exchange transactions in the shortest possible time, using specially programmed computers that use algorithms to automatically execute trades.

3 INDUSTRIAL REVOLUTION 4.0 AND THE ECONOMY

The fourth industrial revolution will be of great importance for the global economy. It will affect almost all macroeconomic variables such as GDP, investment, consumption, employment, trade, inflation, etc. However, in some respects economists are divided, for example, on growth and productivity. Some experts believe that the decisive contribution of digital technologies to increase the productivity and efficiency of the economy has already been made. Others, in turn, believe that the biggest changes in this area will come in a few years' time.

Generally speaking, technologies have a deflationary impact on the economy, and their distributional effects are favourable to capital rather than labour, contributing to a reduction in wage rates, and thus also to a reduction in consumption. On the other hand, the fourth industrial revolution will enable people to consume more and at lower prices, and will make consumption more intelligent, responsible and sustainable.

Before the financial crisis in 2008, the global economy was growing by 5 percent annually. If this rate of growth were to continue, it could be assumed that global GDP would double every 14-15 years, and this would allow many people to leave the poverty zone. When the financial crisis was contained, the global economy was expected to return to its previous rate of growth. However, this has not happened. Since then, global economic growth has remained below 3-3.5 percent per year. Some economists (including Larry Summers and Paul Krugman) see the possibility of the crisis resurfacing in the upcoming years and even talk about the so-called secular stagnation[40] [169][85] . Therefore, it cannot be ruled out that these forecasts will prove successful and that the global GDP growth rate will continue to decline in the future [170, pp. 61-68]. If we assume that the pace of global growth will fall from today's 3-3.5 percent to only about 2 percent per annum, it would mean that for the global GDP to double it would take not 14-15 years but rather 35-36 years. Among the reasons for possible weaker growth are the unequal distribution of capital, excessive indebtedness of many countries and unfavourable demographic changes.

[40] This term was coined by Alvin Hansen during the Great Depression of the 1930s. Secular stagnation is when there is a constant decline in demand, which cannot be prevented even by very low interest rates, which are kept close to zero.

Demographic changes

Demographic forecasts indicate that the world's population will grow from 7.2 billion today to 8 billion in 2030 and to around 9 billion in 2050. This is expected to increase the aggregate demand. However, another strong trend that is noticeable is the ageing of societies which, contrary to popular belief, do not affect only the rich countries of the West, but also South America, most countries in Asia, including China, India and some countries in the Middle East, such as Morocco, Iran and Lebanon. The ageing of the population poses many challenges. For example, the rapid increase in the number of elderly people remaining under family care leads to a decline in the share of the working age workforce. Currently, these problems are being addressed in some countries by gradually increasing the age of retirement. On the other hand, a lower share of the younger population is resulting in a gradual decline in demand for expensive goods and luxury assets, such as houses, furniture, cars and some high-end equipment. Fewer people are also willing to take up the challenge of doing business because fast ageing societies are more risk-averse. Older people are more inclined towards protecting their assets in order to maintain a decent standard of living when retired. The growing proportion of elderly people also means a decline in investment and savings rates. These mechanisms pose a significant threat to further economic growth. **Therefore, there are many indications that ageing societies will be destined to develop more slowly. Further technological development can provide an opportunity to accelerate it, but only if it leads to higher productivity growth**. However, productivity should be understood as the ability to produce "wisely" and not necessarily "more" [301].

With the fourth industrial revolution, we have the opportunity to live longer, healthier and more actively. One quarter of children born today are likely to live to the age of one hundred years.

In view of the fourth industrial revolution, however, we should all rethink a number of important issues and problems, such as the decline in the number of people of working age, the issue of the retirement age, the education system, as well as issues related to our individual plans and choices in life.

Productivity of the economy

The productivity of the world economy has remained relatively low over the past decade[41]. This phenomenon occurred despite significant technological progress, which even started to accelerate at an exponential rate. There is a specific innovation paradox in that large technological innovations do not necessarily result in higher levels of economic efficiency. A similar phenomenon had already occurred in the past shortly before the Great Depression of the 1930s. The above is illustrated by the example of the United States, where between 1947 and 1983 labour productivity grew by an average of 2.8 percent annually, while between 2000 and 2007 it grew by only 2.6 percent annually, and between 2007 and 2014 it grew by only 1.3 percent annually. This marked decline in productivity, which has been particularly pronounced in recent years, is due to lower total factor productivity (TFP) and also results from the advancement of technology.

Data from the Bureau of Labour Statistics of the United States show that the aforementioned increase in TFP between 2007 and 2014 was only 0.5 percent which means that the growth rate of TFP fell very sharply compared to 1995-2007, which is worrying, especially considering that it occurred at the time when the fifty largest American companies accumulated assets exceeding USD 1 trillion in total, and interest rates were kept very low for many years, nearly reaching zero.

Productivity is one of the most important factors determining the long-term growth of the economy and a higher standard of living. So if the fourth industrial revolution does not bring about major changes in productivity growth, then the further growth of the global economy could be seriously jeopardised.

An attempt must, therefore, be made to answer the question whether innovation and technological development can reverse the trend of a decline in productivity which is detrimental to the economy. There is no easy answer to such a question. Most of the innovative products and services already developed during the fourth industrial revolution are

[41] This applies to both labor productivity and overall production productivity.

of much higher functionality and quality. They should also make the economy as a whole more efficient and productive, but so far this has not been the case. We should remember, however, that the added value they create is not always reflected in official statistics. This is due to the fact that **many digital products and services are delivered and implemented outside the officially registered circulation, which means that they are not even included in the statistics**, e.g. services provided in the share economy model. For example, drivers working for Uber do not necessarily report their activities to the competent authorities. A similar approach can be followed by service providers of Airbnb, Blablacar, Carpooling etc. **Thanks to blockchain technology, many of the exchanges are beyond the control of national governments**. According to economist J. Bradford DeLong, new digital technologies allow us to produce and consume much more efficiently today than is reflected in the economic indicators [36]. We can only hope, therefore, that in terms of efficiency and productivity, the reality looks much better than it is shown in some of the statistics. According to K. Szchwab, the fourth industrial revolution will satisfy many consumer needs which, due to the lack of appropriate technologies or business models, were not covered earlier [301, p. 294]. This, of course, will be most beneficial to the global economy.

Until recently, most sustainable development projects only proved to be successful when they were subsidised. However, progress in a range of different areas such as renewable energy production, energy efficiency and energy storage infrastructure has made many investments and projects more cost-effective for the private sector. Numerous commercial projects of this kind bring tangible benefits to the economy and contribute to mitigating the impact of the climate change.

The fourth industrial revolution will help to solve many of the negative externalities, such as carbon dioxide emissions, environmental pollution, etc.

The fourth industrial revolution will also completely change the rules of competitiveness. In order to remain competitive, both companies and entire countries will need to become innovation leaders in every respect. Already today, we observe that many companies are subject to enormous pressure on the part of innovators, which disrupt the functioning of their existing business models, and even of entire sectors of the economy. The

same is true for nation-states, and therefore they should also recognise the need to prioritise the development of their own "innovation ecosystems".

The unfavourable combination of structural factors (over-indebtedness and demographic challenges) and systemic factors (the transfer of new businesses into digital platforms, the growing popularity of the shared economy model and **the growing importance of falling marginal costs) may contribute to the fact that economic handbooks will soon have to be rewritten**.

The fourth industrial revolution creates the potential to accelerate economic growth and addresses many of the major global challenges that the world is now facing.

We need, however, to be able to properly identify and address the risks posed by the industrial revolution 4.0 and, in particular, the ever growing social inequalities and disparities, as well as the problems related to employment and the labour market.

Employment

The impact of new technologies on unemployment was described by John Maynard Keynes in 1931. He expressed his concern as to whether the development of technology did indeed contribute to a significant increase in labour supply in relation to demand [153]. Although his theory has not been confirmed to this day[42], **there are serious grounds for believing that the fourth industrial revolution will be different in this respect from the previous ones**. First of all, this is evidenced by the speed and scale of the transformations that are taking place. Today's revolution is affecting practically all industries, many changes are taking place in parallel at the same time, and the entire socio-economic system is undergoing a transformation. **Digital technologies completely transform the nature of work in virtually all industries and occupations**. However, the question of the extent to which automation will become a substitute for human work still remains a big mystery. Today we do not know the answer to this question, nor do we know how far and how deeply these processes will go. The impact of new technologies on the labour market can be both positive and negative. On the

[42] It was not confirmed by the third industrial revolution.

one hand, many existing businesses are experiencing the **destruction effect**, which means that capital is becoming a substitute for labour, forcing technology-replaced workers to move to other industries. On the other hand, the effect of the destruction is usually accompanied by the so-called **capitalisation effect**, which consists in the fact that as a result of the development of new technologies, many completely new professions or even entire sectors emerge and they require completely new skills [3, pp. 477-494]. **It seems crucial for the labour market whether ultimately the number of new jobs created by the capitalisation effect will exceed the number of jobs lost as a result of the destruction effect**. Experts are now divided in their opinions on the impact of new technologies on the labour market. Optimists believe that the fourth industrial revolution will launch a new era of unprecedented prosperity and technological innovation. However, pessimists believe that we are just on the social and political threshold of Armageddon, which will be initiated by **technological unemployment** resulting from technological progress, and as a result, people's work will be massively replaced by that of intelligent machines. Historically, technological innovation has always resulted in a loss of some jobs, but this gap was generally quickly filled by new jobs created in areas related to new technologies. However, it cannot be underestimated that earlier technological revolutions led to the creation of an enormous number of jobs for ordinary people. The present technological revolution no longer provides such employment opportunities (for ordinary people) on a scale comparable to that of the three previous industrial revolutions [101].

Example of the agricultural sector

As early as at the beginning of the 19th century, about 90 percent of American working-age people were still working in the fields. Today, the proportion of people involved in agriculture has fallen to just 2 percent. **The loss of jobs in agriculture, which has been ongoing almost uninterruptedly for more than two hundred years, has taken place, however, without any particular social tensions and has not contributed to the creation of permanent unemployment**. Simply put, people who lost their jobs on the farms quickly found other jobs in completely different industries.

Example of the smartphone applications market

Another example of the capitalisation effect is the market of smartphone applications. The era of this new type of applications began in June 2007, when Steve Jobs announced that individual developers (and therefore also non-Apple developers) could start developing their own applications for Apple devices (compliant with the Web 2.0 standard). In July 2008, Apple launched the iPhone app store (i.e. the App Store), where external developers were allowed to sell their own applications. By the end of 2015, the market for such applications was generating nearly $100 billion in revenue, which was even more than the entire film industry that has been evolving for over a hundred years.

According to techno-optimists, new technologies can only have a short-term negative impact on the labour market, but in the long run they are likely to increase the productivity of the whole economy and the wealth of entire societies, which in turn should **translate into an increase in demand for products and services and the creation of new jobs**.

We must also remember that human needs are practically unlimited, and thus the process of satisfying them through the creation of various types of products and services can also be endless. It must, therefore, be assumed that, with the exception of occasional periods of recession and crises, there should be enough work for everyone in the future.

Labour substitution

A number of professions, especially those requiring the worker to perform mechanically repeated tasks, have already been fully or partially automated. As the computing power continues to grow exponentially, more professions are becoming automated. Probably sooner than most of us expect, will also be automated such professions as: financial advisor, lawyer, doctor, journalist, accountant, insurer, librarian or even writer. Already today, artificial intelligence is capable of writing simple texts on its own, and what is more, the style of created texts is tailored to the needs and expectations of a specific group of readers [188]. According to Prof. Kristian Hammond, co-founder of Narrative Science, a company specialising in automated writing of texts, **as early as in 2030 about 90 percent of all news articles will be created exclusively thanks to algorithms and artificial intelligence** [196]. Until then,

journalists will gradually be replaced by AI. According to Hammond, the quality of texts composed by algorithms will at some point reach the level that will enable them to be nominated for the Pulitzer Prize [268]. At Associated Press, which is currently one of the most important press agencies in the world, intelligent machines already compile around 3,000 articles per quarter[43].

The pace of technological development makes it practically impossible to forecast future trends on the labour market. These trends will vary considerably from one industry to another and even from one country to another.

The Future of Jobs report of the World Economic Forum shows that around two-thirds of children who are starting their education today will in the future be employed in positions that do not yet exist[44]. The same report recommends employers to adapt their workplaces to the expectations of the precariat class. In this way, they have the chance to avoid other economic crises, social inequalities and tensions in the future. The Future of Jobs report also shows that in 2020 the most desirable attributes of employees will be: an ability to solve complex problems, social predispositions and skills related to the operation of various systems, including technical dexterity, ability to cope with machines, etc. In turn, much less important will be the physical predisposition of employees or even their knowledge.

Lower job creation dynamics

Past experience shows that the fourth industrial revolution can be attributed to the creation of far fewer jobs than it had been the case with the previous technological revolutions. The study by Oxford Martin School indicates that **only about 0.5 percent of people currently employed in the United States perform jobs that are in any way related to technologies that have been developed in the last dozen or so years**, for example in the area of Internet auctions, website design, mobile application development or video and music streaming [28].

[43] At present, the automated machines are used primarily to compile business messages.
[44] The Future of Jobs report is based on the feedback of more than 370 HR leaders, representing approximately 13 million employees worldwide.

Since the computer revolution of the 1980s, there has been a very clear trend in the number of new jobs created due to technological progress. For comparison, in the 1980s, thanks to new technologies, about 8.2 percent of new jobs were created, and throughout the 1990s only 4.4 percent [199]. This is a proof of the weakening business dynamics of the American new technologies sector [122]. Not only artificial intelligence and robots have caused greater than expected job losses in recent years. **An important factor is also the approach of the companies themselves, which define the scope of activities performed by their employees more and more strictly**. This makes working easier. In addition, mobile technologies make it easier for companies to use flexible working practices, improve workers' productivity and overcome existing geographical barriers.

Some activities are simply commissioned to external companies in the form of outsourcing or crowdsourcing[45]. Crowdsourcing platforms such as Amazon Mechanical Turk[46], thanks to which some simple tasks can now be performed automatically, serve as a more efficient and flexible way of organising work by companies.

Improvements in such areas as mobile technology, artificial intelligence, robotics, spatial printing, nanotechnologies, drones, cloud computing, and Big Data analytics are revolutionising the way we work. Thanks to them, companies achieve huge economies of scale and multi-million dollar savings.

An example of a company that achieves significant savings and business advantages thanks to new technologies is the American automotive corporation Ford, which uses 3D printing technology to speed up the designing and production process of its vehicles. Moreover, thanks to Big Data analysis, the company implements intelligent supply and inventory management solutions, which allow for a very significant reduction of costs associated with it.

Economic inequalities between men and women

[45] See the glossary of terms.
[46] See the glossary of terms.

The Global Gender Gap Report of the 2015 World Economic Forum highlights two important issues. Firstly, at current rates of change, a complete reduction in economic inequality between women and men could only be achieved after some 217 years[47]. Secondly, the fourth industrial revolution will make a significantly greater contribution to the automation of the professions performed today by women. This will be due to the progress in the development of artificial intelligence and the transfer of the majority of service activities or even entire service sectors to the 'digital world'. An example is call centres. On the other hand, however, we can also expect an increase in the demand for other human traits such as empathy and readiness to help others which are typically feminine traits. For this reason, the decline in the number of jobs performed by women will ultimately not be as pronounced, although it will still be bigger than for men. Women prove themselves in such professions as: doctor, psychologist, therapist, coach, carer, leisure worker or healthcare worker. However, there is a significant risk that this category of jobs, which are mainly performed by women, will be relatively low-paid. It can also be expected that the fourth industrial revolution will result in an increased demand for specialised technical skills, i.e. mainly those that are predominantly the domain of men. People working in such professions as engineers, IT specialists and programmers are for the most part men. **In relative terms, the industrial revolution 4.0 could therefore fundamentally worsen the situation of women and significantly exacerbate gender inequalities**.

In the future, the labour market may become very stratified due to the criterion of possessed skills (low/high), which in turn will lead to the hollowing out effect of the entire basis of the pyramid of competences, and this may be the reason for a rapid increase in inequalities and social tensions [98].

Automation cannot replace all workers

Economists around the world currently debate the impact of technological innovations on future jobs' disappearance and the dynamics and scale of this phenomenon. It is widely acknowledged that automation can contribute relatively quickly to mass unemployment. At

[47] Already in 2015, the forecasts indicated that economic equality between women and men could be achieved in approximately 118 years' time. The results of 2016 showed that it will take even 170 years before such economic equality between women and men is achieved.

this stage, it is too early, however, to say categorically that this will be the case. Digital technologies are increasingly replacing people in routine office and manufacturing activities. This phenomenon concerns mainly those work activities which are clustered in the centre of statistical income distribution [15]. Automation of routine activities causes the so-called hollowing-out effect of the labour markets, i.e. a far-reaching stratification of professional competences due to the criterion of qualifications [115][98]. The World Bank report shows that this type of stratification already exists in many developing countries, including Mexico, Turkey and Malaysia [377]. The exception is the Middle Kingdom, which has resisted such polarisation, mainly because of the relocation of production from developed countries. However, in the face of the upcoming industrial revolution 4.0, it is increasingly doubtful that in the long term the Chinese economy will be able to sustain its low-cost workforce competitive advantage over other countries.

The latest technological solutions in the field of automation, the Internet of things, artificial intelligence and 3D printing increasingly encourage entrepreneurs operating in developed countries to relocate the production currently ordered in countries with low labour costs to their own countries (so-called inshoring). Inshoring becomes profitable when automation of the manufacturing facilities in the home country (i.e. implementation of the Smart Factory concept) can bring greater economic and strategic benefits than the realisation of some of the production processes by foreign partners. It is the automation of production processes that is leading to a significant reduction in job creation in developing countries. This is confirmed by the steadily decreasing employment rates in the emerging economies. This problem is described by some economists as premature deindustrialisation [287]. The potential range of applications for automation and robotisation of production operations is also increasing. Automation no longer involves only routine and repeatable activities based on algorithmic criteria, but also activities that are non-routine in nature, such as driving or image recognition. Interestingly, a few years ago people thought that it would be virtually impossible to fully automatize this type of activities. In just a few years, however, artificial intelligence has developed to such an extent that we already understand many of these non-routine activities well enough to be able to fully automatize them.

It is also worth noting that the largest percentage of jobs that can potentially be replaced by smart machines are in developing countries. While for OECD countries it is 57 percent, in the case of India, China and Ethiopia it is as high as 69, 77 and 85 percent,

respectively. This shows that **developing countries with low per capita incomes are the most susceptible to automation**. Today, however, due to higher labour costs, the pressure on job automation is significantly higher in developed countries [58].

Some economists have already begun to see how dynamic technological change is affecting the economics of development. Many developing countries would probably like to repeat the success of China, which thanks to intensive industrialisation found itself on the fast path towards the creation of a welfare state [339]. For years, the Chinese economy has been a beneficiary of the relocation of production jobs from developed economies. However, in view of the changes brought about by the fourth industrial revolution, it seems relatively unlikely that other countries will repeat China's success in the future. The Middle Kingdom is probably one of the last countries, if not the last, to achieve an average income thanks to industrialisation.

At the same time, it is worth noting that, despite building its competitiveness on low labour costs, China has become a true paradise for robot manufacturers in recent years. What convinces Chinese entrepreneurs to invest in industrial automation is the declining payback period for such investments, which currently is only two years. However, developments in new technologies have not yet resulted in as many jobs being automated as today's potential would have allowed. This only shows that many of the existing jobs are still preserved, although they could already be eliminated due to labour cost savings. In the United States, for example, despite the enormous progress that has been made in recent years in developing self-service cash register technology, there are still some 3 million cashiers employed. This is because the process of creating and destroying jobs does not depend solely on the technological possibilities themselves.

Interestingly, in the last three decades, i.e. **since the process of technological change had accelerated significantly, most of the new jobs have not been created in new technology industries, but in sectors of non-tradable goods that are consumed locally**. According to some economists, in the case of the American market, this type of sectors accounts for as much as 98 percent of the total change in employment that has occurred since the beginning of the 1990s [317]. In this period the increase in employment took place mainly in the following sectors: retail, food, construction, as well as catering and recreation. The high change in employment was also the result of the creation of additional jobs in public services and healthcare, what was influenced rather by political decisions than market forces. Dynamic

development of technology sectors, including ICT, requires high intellectual qualifications. On the other hand, many IT services can already be outsourced to other countries, e.g. via crowdsourcing platforms, which can be accessed from virtually any place in the world. Importantly, **each additional job created in the new technologies sector leads to the creation of five other jobs in the aforementioned sectors of non-tradable goods that are consumed locally** [240]. There is also no doubt that the trend of further automation of production processes will continue, therefore it is expected that the labour market will experience changes consisting in the adoption of production solutions that will require higher qualifications (the so-called spillover effect). Highly skilled workers are generally less exposed to automation, yet at the same time they are largely responsible for increasing demand for locally supplied services. This is also the case in developing countries, where the additional highly skilled jobs in the manufacturing sector have the employment multiplier three times higher than those not requiring special qualifications[48]. In some countries, these multipliers are even higher, for example in Brazil (13) and India (21); therefore, while new technologies are expected in the future to systematically crowd people out of the labour market, it is unlikely that the pace of this process will be as fast as many people expect. We can also expect that in the initial phase of the digital revolution, the effects of automation will be less pronounced in developing countries, even though these countries are the most exposed to the risk of automation.

Although today's new technology industries create fewer jobs than in the past, they have a significant impact on the creation of other jobs (i.e. not related to advanced technologies). In other words, their indirect impact on job creation is increasing due to their multiplier effects, i.e. the creation (through technologies) of jobs in sectors of non-tradable goods that are consumed locally.

The future of the labour market will, therefore, depend not so much on the employment opportunities provided by companies from the new technologies sectors but on the demand for locally provided services that these companies generate indirectly. It is also impossible not to notice that there are many services being created which have not been

[48] The employment multiplier was created by Richard Ferdinand Kahn.

known before. For example, the data from the LinkedIn social network show that the number of personal trainers and dance instructors (e.g. zumba) or YouTubers is growing very fast. This indirect impact of new technologies on the creation of new jobs in other sectors is so important that in each country employment prospects and the labour market itself should be perceived in terms of these multipliers rather than in view of the potential changes that automation itself may bring about. Savings resulting from the reduction of labour costs and the limitation of the process of creating new jobs, at least for the time being, should not raise concerns as to whether automation will contribute to mass unemployment.

4 MEGATRENDS OF THE INDUSTRIAL REVOLUTION 4.0: PHYSICAL, DIGITAL AND BIOLOGICAL

According to Klaus Schwab, technological megatrends can be divided into three clusters: physical, digital and biological [301]:

Physical cluster

The physical cluster is primarily all kinds of state-of-the-art devices that revolutionize the world: intelligent machines, autonomous cars, technological solutions in the field of advanced robotics, objects created in the form of 3D prints, solutions in the field of material engineering, including e.g. nanotechnologies. Many of these solutions are more often used by us in homes and factories to carry out activities which are increasingly technically advanced.

Autonomous cars

Over the last few years, public attention has been drawn to autonomous cars. They are regarded as a potential significant convenience in our everyday lives, thanks to which the time we usually spend on driving will in the future be used to perform other activities, as the traffic will not absorb us as much as it does today.

The same or very similar technologies that are used to develop autonomous vehicles are also used in autonomous trucks, drones, unmanned aerial vehicles (UEVs), aeroplanes or boats and ships. These technologies are growing at a surprising rate, mainly due to advances in smart sensors, the Internet of Things and the development of artificial intelligence.

Drones

When drones will eventually become more advanced and completely safe (e.g. when they will be able to change their own course in order to avoid collisions), they will be more

efficiently used i.a. to check power lines, deliver organs to hospitals, manage fertilizers and water consumption or to deliver supplies to the regions of military conflicts.

3D Printing

3D printing is otherwise called additive manufacturing (AM) and consists of creating physical objects by stacking materials together layer by layer using devices specially designed for this purpose. 3D prints are created on the basis of appropriate 3D models, which are developed with the use of specialised software. Additive manufacturing is the opposite of subtractive manufacturing, a technology that is still used today in the vast majority of production processes for manufacturing all kinds of things. Subtractive manufacturing involves removing layers of unnecessary material from a larger piece of material until the desired shape is formed. In turn, 3D printing is performed with loose materials, which are used to create three-dimensional shapes based on digital templates (3D). The subtractive manufacturing method involves unnecessary material waste. However, in 3D printing such losses are practically non-existent, as this method requires only as much material as is necessary. Companies that choose this technology significantly reduce their production costs.

3D printing technology is applied in a variety of different areas, from the construction of large wind turbines to the creation of small medical implants. Today, it is most commonly used in the automotive industry, aviation and medical industries. In contrast to mass production products, 3D technology makes it easier to personalize manufactured products. The initial limitations of this technology, such as small print sizes and slow printing speeds, are gradually being overcome, making this technology more widely used over the years. Today, it is mainly used for the production of integrated electronic components (e.g. printed circuit boards) and medical implants. There is nothing, however, to prevent this method from being used in the future to produce human cells and organs. It is also worth mentioning that scientists are currently working on 4D technology, a completely new generation of shape-adjusting materials, whose physical and chemical properties will change depending on environmental conditions, e.g. appropriate temperature or humidity levels [221][102]. This technology can be used in the future in medical applications such as clothing and footwear, as well as for intelligent implants, which can adapt themselves to the human body depending on the environmental conditions.

Advanced robotics

Until recently, robots were only used to control well-defined activities in specific industries, such as the automotive industry, for example. The use of robots has become increasingly important in recent years and they are now even used in areas such as agriculture and healthcare. Further rapid development of robotics may allow closer cooperation between man and intelligent machines in the near future. The development of this technology makes new robots increasingly flexible and adaptable to changes in the external environment. They are even robots with a structural and functional construction which is inspired by nature (the so-called biomimicry[49]). Thanks to intelligent sensors, robots are now better capable of reacting to environmental changes and can perform much more complex tasks, e.g. they take over some of the household chores from people. Access to data 'through the cloud' allows them to connect to the networks of other robot systems, which is a huge progress in this area, given that until recently the robots had to be programmed by an autonomous unit. The next generation of robots will largely be based on human-machine interactions.

Smart materials

New materials are becoming lighter, more flexible, and at the same time more durable and recyclable. Also noteworthy is the emergence of smart materials featuring a capability to self-regenerate and self-clean themselves, shape-memory metals with encoded specific shapes which they can be formed into, and when deformed return to their pre-programmed shapes, ceramics and crystals which can convert the contact pressure on energy, etc. As with many other innovations, it is impossible to predict how material engineering will develop in the future. Think of the example of graphene, which is 200 times stronger than steel and a million times thinner than a human hair, and at the same time is currently one of the most expensive materials in the world. A micrometre flake of this material costs over 1000 dollars. However, if its production costs could be significantly reduced, this would bring about a real

[49] Biomimicry refers to the fact that the programming of robots' behaviors is inspired by the natural patterns occurring in nature.

revolution in various industrial sectors. It would also probably have a major impact on the entire economies of countries that are somehow dependent on certain types of raw materials. Richard Branson (the creator of Virgin Atlantic) argues that it is very likely that in 10 years' time we will be flying planes made entirely from graphene [39]. The billionaire believes that this extremely lightweight and durable material will replace aluminium and composite materials in the future and thus will contribute to a significant reduction in aircraft fuel consumption.

Developments in material technologies can also reduce some of the risks that pose serious challenges to the world, for example in the area of waste. Innovations in the thermosetting plastics industry that are used i.a. in printed circuit boards, mobile phones and in the aerospace sector can improve many materials that have so far been considered non-recyclable, making them re-usable. Scientists have recently discovered a new class of thermosetting polymers that are recyclable [122]. These are the polymers with hexahydro-1,3,5-triazine (PHT), which are among the most resistant thermosetting plastics in the world and at the same time are resistant to solvents with pH > 3, and yet decompose to monomers in acidic solutions. This discovery can help in the sustainable management of raw materials in a "circular economy" where waste becomes a resource. This would decouple economic growth from resource needs.

Digital cluster

The digital cluster comprises mobile devices, the WEB network and Internet of Things, increasingly powerful and accessible computing powers, cloud computing for data collection and processing (i.e. big data), analytical and computing systems in the cloud, etc. **This group of technological megatrends is the backbone of the entire industrial revolution 4.0**. It is largely based on the idea of the Internet of Things, which, as the name suggests, interconnects physical objects (e.g. devices, machines, cars or even clothes) into a network, in which intelligent sensors have been integrated, and which are equipped with their own systems which process measured values (i.e. data from sensors) and simultaneously ensure their wireless transfer. The Internet of Things is, therefore, a bridge between physical and digital applications. Sensors and other devices which integrate the physical world with the virtual world are progressing and gaining popularity at an incredible rate. At the same time, they are

becoming cheaper and more intelligent. We use them in our homes, in clothes, accessories, transport and energy networks, as well as in the manufacturing processes. In total, billions of different devices are connected to the Internet, such as smartphones, tablets, laptops, computers and smartphones. Over the next few years, their number is expected to grow from today's several billion to more than one trillion. This will radically change the way we manage our supply chains, making it much easier for manufacturers to monitor and optimize their resources, processes and operations extremely meticulously on an ongoing basis. The changes that are currently taking place will have a huge impact on many areas of our lives, such as manufacturing, infrastructure and healthcare. Each package, pallet or container can already be equipped with intelligent sensors - transmitters or RFID (i.e. Radio Frequency Identification Device) sensors - that allow manufacturers, suppliers and customers to fully track their location through the entire supply chain[50]. Also, customers can now track the location of their shipments in real time. In the future, similar systems will also make it possible to track the location of people.

Many of these digital technologies lead to the emergence of completely new, previously unknown business models that are increasingly less physical in use and more algorithmically driven. Some examples are the companies mentioned earlier such as Uber, Facebook, Airbnb or Alibaba. The pervasive digital transition is leading to the emergence and development of decentralised digital currencies. The most popular cryptocurrency which is bitcoin was created in 2008 [330, p. 23]. By mid-2016, there were already more than 700 different cryptocurrencies in the world although only 9 of them had achieved market capitalisation over $10 million[51]. The bitcoin itself is only the beginning of a much larger phenomenon. We might soon witness the emergence of completely new business models that will be backed up by blockchain technology, which is the very same technology that underpins bitcoin and other cryptocurrencies[52] [162, pp. 115-116]. Goldman Sachs, which is one of the largest investment banks, pointed out in its 2014 report that even if bitcoin does not necessarily become a common currency in the future, the technology that stands behind it

[50] RFID sensors are small electronic devices which communicate with the receiver's antenna via radio waves from a distance of up to several meters.

[51] Bitcoin remains the primary cryptocurrency, with total capitalisation in the second half of 2016 fluctuating between 8-11 billion dollars.

[52] A distributed ledger system is a set of interconnected and interacting database systems. Each of these systems is part of a different network node. From the end user's perspective, database systems logically remain in a distributed structure.

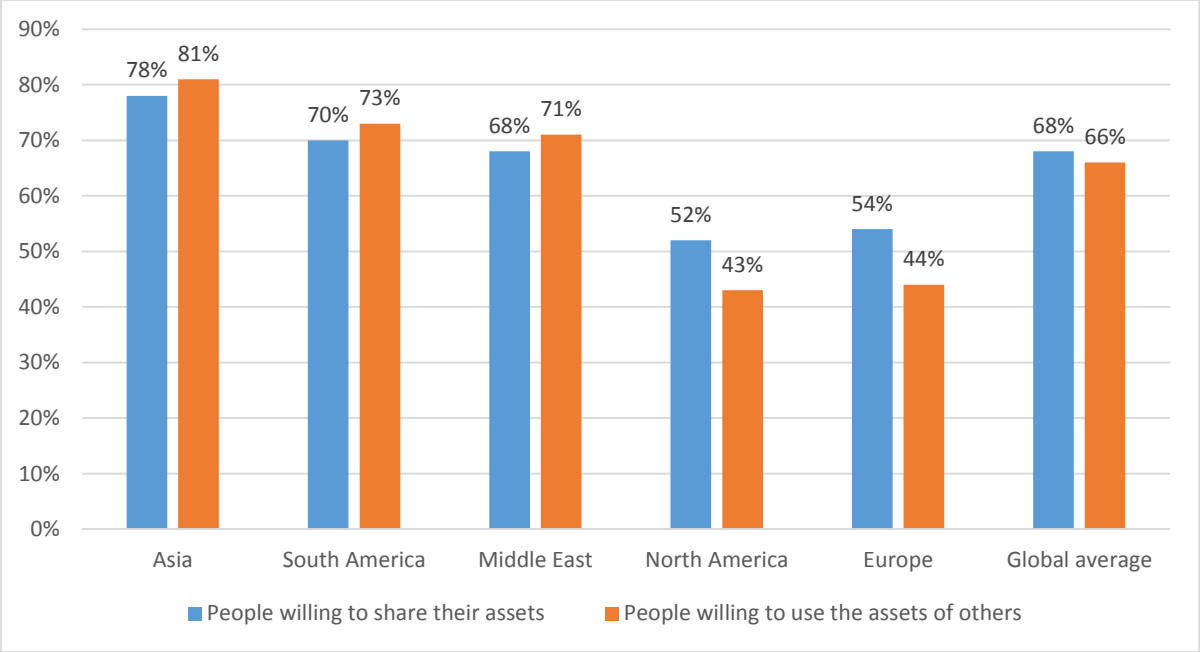
may bring about a real revolution in the global business world [162, p. 116]. The authors of this report highlighted the importance of blockchain itself, which is a very special kind of distributed database that makes it much easier for individuals to transfer their ownership rights and manage information about various trading systems. An example of the application of this technology is the Proof of Existence, which is a website founded by Manuel Araoz, that performs exactly the same functions as notaries. People using the Proof from Existence can prove that they own a document without disclosing its content. Such solutions may be used, for example, by investigative journalists who wish to authenticate their possession of a specific document or by statistical agencies who wish to confirm that a specific survey was conducted. Thanks to the Proof of Existence, it is possible to authorize the integrity and inviolability of documents held, and even to certify the specific time of their preparation. This makes it possible, for example, to protect oneself against counterfeiting.

Sharing economy

New digital technologies are also perceived as the main reason for the emergence of a new trend in the global economy, which is known as the **collaborative economy** or the **sharing economy**. When services such as Uber and Airbnb were created in 2012, nobody expected that sharing something would be a good way to earn money. According to some economists, in 10-15 years the value of this market is likely to exceed the sum of USD 100 trillion[53].

[53] According to SAP experts.

Chart 4.1 *Declared willingness to participate in the so-called "shared economy". Opinion poll based on a sample of 30,000 consumers from 60 countries*



Source: Own calculations (based on Statista data).

Companies from the sharing economy sector can easily generate profits because they are intermediaries of real services for which there is a very high demand. Their success, however, entails difficulties for many companies that operate in the traditional way. Uber, which is a taxi ordering service, as well as Airbnb, which provides cheap accommodation, now offer prices far below those of their competitors. They are also a great reason for the satisfaction amongst their shareholders. Some of them, such as the founder of Amazon - Jeff Bezos or the investment bank Goldman Sachs - thanks to the investments in this sector in less than 4 years made a profit of around 100 times the invested capital.

The case of Uber

Uber was founded in 2009 and since then has held the reputation of the largest start-up in the world. Although it is considered the world' biggest taxi firm, in reality, it is only a provider of the proprietary mobile application, which connects unlicensed drivers with passengers seeking transport. However, the drivers who decide to cooperate with Uber are not selected completely at random. Taking care of its image, the American company verifies

its candidates by checking whether they meet several important criteria, such as the need to have a valid driving licence, own a car not older than ten years of age, and they cannot be penalised and must pay the enrolment fee, which in Poland is currently PLN 200. The final verification for Uber's drivers is the opinion of the passengers themselves, who give the drivers proper ratings. Drivers whose average rating falls below a certain threshold automatically lose the possibility of further cooperation with a U.S. company. In this way, Uber strives to ensure the high quality of the services provided by its drivers[54]. At the end of 2016, Uber was present in 540 cities around the world, and the valuation of the San Francisco company exceeded $60 billion. However, in order to further expand, finance new forms of services (e.g. Uber Eats, Uber Pool) as well as recruit new drivers, the American company needs to raise more and more funds. It also needs additional resources in order to counteract the growing competition. The main competitors of the company are Chinese Didi Kuaidi, Brazilian Easy Taxi, Indian Ola Cabs and Singaporean GrabTaxi. After several years of operation, the company has become so powerful that it can afford to employ a multitude of lobbyists all over the world, whose only task is to ensure that it is not exposed to greater difficulties in running its business.

Table 4.1 *Different forms of collaborative economy*

Term	Year	Author
Collaborative consumption	1976	M. Felson, J.L. Spaeth [96]
Share economy	1984	M.L. Weitzman [364]
Sharing economy	2008	L. Lessig [189]
Cooperative economy	2008	M.C. Jennejohn [138, s. 83]
Peer-to-peer economy	2010	J. Silver
Mesh economy	2010	L. Gansky [102]
Access economy	2011	J. Blaisdell
On-demand economy	2012	J. Wortham

Source: Own elaboration.

Technological platforms, that are today relatively easy to navigate with smartphones, bring people together to provide completely new and innovative ways of accessing many

[54] With regard to the provisions of the law, Uber's drivers are treated as subcontractors and not as full-time employees.

products and services. In addition, they lower the entry barriers for many businesses and at the same time facilitate wealth creation, transform professional and personal environments.

The Uber case clearly shows how this type of technology disrupts traditional business models.

The shared economy revolutionarily transforms the reality around us. Thanks to it, both entrepreneurs and individuals can reach out with their products or services to a wide group of clients all over the world. These platforms have one thing in common: they bring together supply and demand in one place in an extremely accessible and cheap way, allowing different individuals and entities to interact and even leave feedback about these interactions in order to build credibility between system users and the digital platforms themselves. The shared economy also allows for the use of additional resources, which have so far been neglected or simply could not be used in any different way, just because of the difficulty of accessing them or the lack of knowledge about the possibility of using them. These resources include, for example, a place in a car travelling in a particular direction, a free place to sleep in a flat, a business relationship between traders and wholesalers/retailers, and certain services provided by people with specific skills, such as home repairs. Digital platforms contribute to a significant reduction in the transaction costs for individuals and organisations by making their assets and/or resources or specific services available for use and easily accessible. Due to the so-called economies of scale, the use of digital platforms also leads to a reduction in the final costs of the products and services offered.

Biological cluster

The biological cluster consists of technological solutions concerning human biology, the DNA code and the possibility of its editing and modification. The revolution in this area will, in future, enable us to trace and remotely manage information concerning the functioning of our bodies. Already today, some of these solutions are used by people with various types of dysfunctions. There are also many indications that traditional computers will soon reach the limits of their capabilities[55]. Therefore, in parallel to the development of quantum computers, scientists are also working on biological machines. Their main function is to

[55] The Art of Combining Technology with Strategy, Harvard Business Review Polska, ICAN Institute, 2013.

combine technology with biology. Scientists from Israel are particularly active in this field, especially two research centres: Technion – Israel Institute of Technology and the Weizmann Institute. The first one developed a highly advanced biological computer, which is called the molecular transducer [336]. It can perform complex calculations and modify the genetic code based on the results of these calculations. This molecular computer - as it actually ought to be called - has a huge computing power, similar to that of the machine developed by Alan Turing[56]. In turn, scientists from the Israeli Weizmann Institute created a biological computer based on DNA code and other molecules [26, p. 430-434]. Like the molecular transducer, it can perform calculations, but at present, its operation is not the simplest. While it is hard to imagine, such a biological computer is a tiny molecule of the size of a trillionth of a drop of water. Even at the current stage of development of this technology, it is able to perform some mathematical operations, e.g. compare zeroes and ones, and even check whether two given numbers are equal[57]. Its more improved version, thanks to the release of appropriate molecules, has even managed to detect and destroy cancer cells in a tested sample. In the future, such biological machines can help to detect and combat various types of diseases. Scientists from the Weizmann Institute are convinced that we will soon be able to harness these machines to work with our brains.

Dynamic of changes

Technological progress is changing the world and our lives. Being a community, we should ensure that technological development is sustainable and that it relates only to those technologies which cannot have any negative consequences for humanity. There is great hope in the academic society since it provides ideas and fosters numerous innovative solutions. However, there are many indications that the education system and project funding systems are mainly conducive to a conservative approach to investments, which has a negative impact on many innovative, ambitious and courageous projects. National governments should pursue

[56] The Turing machine is treated as an abstraction, which features a huge computing power (far exceeding the computing power of any computer). In this light, the molecular computer also features unlimited computing power.

[57] The DNA-based biological computer was created in 2001. It was developed by a team headed by Professor E. Shapiro from the Weizmann Institute.

a bolder policy in this area and support valuable and innovative research programmes. It is also worth taking care of the development of public-private partnerships in this field.

In addition, there is a need for appropriate incentives for the commercial use of scientific research results by private companies. This, of course, also poses some risks for the universities themselves. Some scientists may become the target of interest for companies and corporations. In 2015, for example, Uber attracted 40 eminent scientists and experts in the field of robotics from Carnegie Mellon University. In this way, the San Francisco concern significantly improved its R&D capabilities at the expense of other organisations (e.g. at the expense of the American Department of State), which faced the consequences first hand and came to the realisation that they had real competition, which could deprive them of scientific resources [277][109, p.422].

Tipping points

In early 2016, a special survey was conducted at the World Economic Forum (WEF) in Davos (Switzerland), in which 800 experts and business leaders involved in new technologies were surveyed to learn more about their insights on the fourth industrial revolution[58]. The aim of this research was to find out what technological changes, that are revolutionary for our civilisation, can be observed during the next decade. According to 91 percent of respondents, by 2025 about 10 percent of people worldwide will have used Internet-connected clothes and 80 percent will have left traces of their 'digital presence' on the internet in various forms. Nearly 82 percent of the respondents believe that about the same time we will see the creation of the first mobile phone that will be implanted under the skin. 86 percent of respondents also expect the first robot-pharmacist to be in operation by 2025, and 84 percent believe that the first entirely 3D-printed cars will be in mass production by then. On the other hand, 67.2 percent of respondents expect that even before 2025, the number of car-shared journeys will exceed on a global scale the number of traditional individual car journeys. Just under half of the respondents (45.2 percent) envisage that by then, the first intelligent robots will have been allowed to serve as members of the management board.

[58] The survey was conducted by the Global Agenda Council on the Future of Software and Society, an advisory body of the Forum.

Table 4.2 *Tipping points expected to occur by 2025. The great technological changes that await us over the next 10 years. Results of a survey conducted among 800 experts and business leaders at the Economic Forum in Davos in January 2016*

The most probable disruptive innovations, revolutionary for our civilisation, which may occur by 2025	Percentage of respondents who indicated specific technological changes as being likely to occur
10 percent of people wearing clothes connected to the internet	**91.2 %**
90 percent of people having unlimited and free (advertising-supported) storage	**91 %**
1 trillion sensors connected to the internet	**89.2 %**
The first robotic pharmacist in the US	**86.5 %**
10 percent: of reading glasses connected to the internet	**85.5 %**
80 percent of people with a digital presence on the internet	**84.4 %**
The first 3D-printed car in production	**84.1 %**
The first government to replace its census with big-data sources	**82.9 %**
The first implantable mobile phone available commercially	**81.7 %**
5 percent of consumer products printed in 3D	**81.1 %**
90 percent of the population using smartphones	**80.7 %**
90 percent of the population with regular access to the internet	**78.8 %**
Driverless cars equalling 10% of all cars on US roads	**78.2 %**
The first transplant of a 3D-printed liver	**76.4 %**
30 percent of corporate audits performed by Al	**75.4 %**
Tax collected for the first time by a government via a blockchain	**73.1 %**
Over 50 percent of internet traffic to homes for appliances and devices	**69.9 %**
Globally more trips/journeys via car sharing than in private cars	**67.2 %**
The first city with more than 50,000 people and no traffic lights	**63.7 %**
10 percent of global gross domestic product stored on blockchain technology	**57.9 %**
The first Al machine on a corporate board of directors	**45.2 %**

Source: Own elaboration based on the report of the World Economic Forum in Davos (2016). Deep Shift - Technology Tipping Points and Societal Impact, Global Agenda Council on the Future.

Disruptive innovations

The term disruptive innovation stands for a technology, a concept or an idea that completely changes the rules of a given industry. Through its innovativeness, it causes the so-called creative destruction, i.e. a radical change in the entire business context of a specific sector or even a whole group of sectors. Breakthrough innovative solutions make it possible

to create a new product or provide a new service in a much more effective way than it was the case in the past. Creative destruction also makes every industrial revolution more dynamic. Examples of such creative destruction are the flagship inventions with which we associate different waves of industrial revolutions, like electricity, steam engine, Internet, smartphones and many more.

Creative destruction makes the industrial revolution more dynamic.

Strategic thinking which is predicated on creative destruction leads to the creation of completely new markets and entire value networks, which may in future "disrupt" the functioning of existing businesses, thereby completely eliminating many of them from the market [32]. The table below illustrates how different disruptive technologies have been deconstructing different businesses over the past few decades.

Table 4.3 *Technologies that have disrupted and replaced the pre-existing technologies and markets*

Category	Disruptive innovation	Market affected by disruptive innovation
Education	Wikipedia	Traditional encyclopaedias
Communication	Telephony	Telegraphy
Computing hardware	Minicomputers	Mainframes. Large institutional computers of the mainframe type[59]
	Personal computers	Minicomputers, Workstations, Word processors,
	Pocket calculator	3.5 standard calculator
	Digital calculator	Mechanical calculator
	Smartphones	Personal computers, laptops, PDAs
Data storage	8 inch floppy disk drive	14 inch hard disk drive
	5.25 inch floppy disk drive	8 inch floppy disk drive
	3.5 inch floppy disk drive	5.25 inch floppy disk drive
	CDs and USB flash drives	Bernoulli drive and Zip drive
Displays	Light-emitting diodes	Light bulbs
	LCD & LED displays	CRT
Industrial production	Hydraulic excavators	Cable-operated excavators
	Small steelworks, mini steel mills	Vertically integrated steel mills

[59] The term mainframe is intended to distinguish between a large institutional computer that is designed to support multiple users and small machines that are designed for a single user.

	Plastic	Metal, wood, glass etc.
Medical	Ultrasound	Radiography (X-ray imaging)
Music & video	Digital synthesizer	Electronic organ, electric piano and piano
	Gramophone	Pianola
	Downloadable Digital media	CDs, DVDs
Photography	Digital photography	Chemical photography
	High speed CMOS video sensors	Photographic film
Publishing	Computer printers	Offset printing
	Word Processing	Typewriter
Transportation	Steamboats	Sailing ships
	Automobiles	Rail transport
	High speed rail	Short distance flights
	Private jet	Supersonic transport

Source: Own elaboration.

The case of Wikipedia

Traditional encyclopaedias, with articles written by remunerated experts, have been replaced by Wikipedia (an online encyclopaedia), written and edited by voluntary editors. In 2012, after 244 years, the previous market leader - the Britannica Encyclopaedia - ceased to publish its next editions. Britannica's price of more than $1,000, its physical dimensions of 12 volumes weighing more than 50 kg in total, the number of articles they contained (around 120,000) as well as the updating cycles which were taking a year or more to complete, have made it virtually incapable of competing with Wikipedia. The latter provides free online access to more than 5 million articles, which are constantly being updated. Wikipedia not only "disrupted" the traditional encyclopaedic business, but also influenced the whole business of digital encyclopaedias. Microsoft's Encarta, which appeared on the market in 1993 and was a professionally edited digital encyclopaedia, at the beginning of its existence represented a serious competition for Britannica. Ultimately, however, Microsoft discontinued it in 2009. The free access to Wikipedia, on both computers and smartphones, and its unlimited volume and continuous updates, pose a huge challenge to any potential Wikipedia competitor willing to compete in this market and make a profit.

5 INTERNET DEVELOPMENT

So far the Internet has changed lives of almost a half of all inhabitants around the world. However, as many as 4 billion people still do not have access to the network. That is why technology companies are working not only to speed up the Internet, but also to make it truly global. Thanks to the Greg Wyler's project and O3b satellites, the Internet can already be delivered to even the most exotic parts of the world, e.g. to the Cook Islands [371, p. 71]. The Wyler's project is co-financed by Google, HSBC and SES, among others. The O3b satellites are situated at an altitude of 8 thousand kilometres. At this distance, data is transmitted back and forth in just 150 milliseconds, which is the speed comparable to fibre optics. The set of satellites covers 120 Internet bundles, each of which can be directed to virtually any corner of the world. Each bundle covers an area of approximately 650 km in diameter.

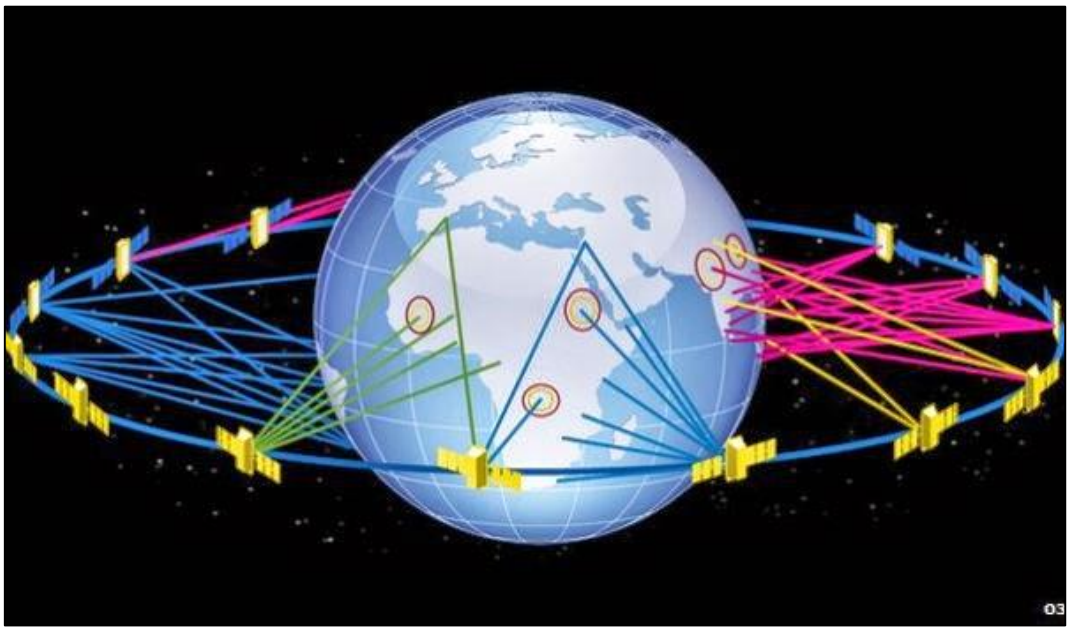


Illustration 5.1 *Scheme of the global Internet connection based on O3b satellites, Source: O3b*

Also Facebook is developing the technology of widespread access to the Internet, which would be available to people from even the poorest and most distant corners of the world [273][333]. The Menlo Park Company intends to use for this project a giant solar-powered drone (Aquila) which has the wingspan (42 m) bigger than a Boeing 737 airplane.

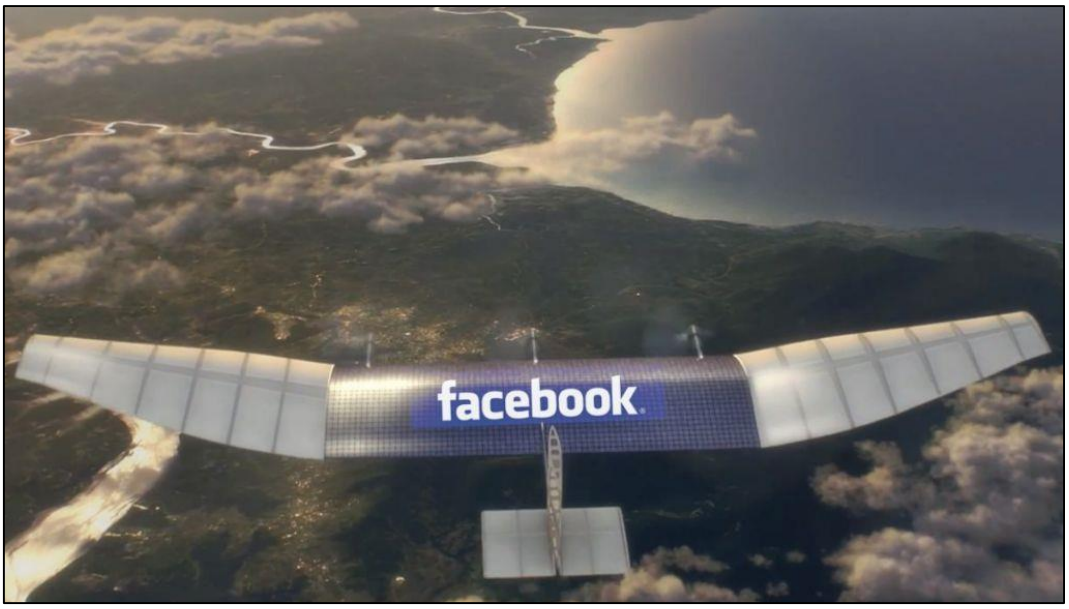


Illustration 5.2 *Facebook's Aquila drone - a technology that is to provide free access to the Internet in the most distant corners of the world, Source: Facebook*

The carbon fibre construction is ultra-light (weighing only 400 kilos) and is essentially a large, solar-cell wing. The solar drive allows Aquila to stay in the air at an altitude of 28,000 metres for almost three months without any breaks. At the same time, a special laser system integrated with the drones is intended to provide a data transfer of up to 10 Gb/s[60].

5G Network

Each year data flow on the Internet increases by 20 percent, and in the case of mobile Internet even by more than 40 percent [27, p. 11]. In addition, we must remember that we are at the brink of the great revolution that awaits us as a result of the rapid development of the Internet of Things. Implementation of the 5G standard, which will introduce us to a completely new era of the Internet, is therefore becoming a real and urgent necessity [9, p. 1066]. When this new era of the Internet comes, information will be transmitted in just one millisecond. Such a speed of data transfer will radically change mobile technologies and practically every industry that relies on this form of communication [353, p. 26].

The 5G network will allow for data transfer at a speed of at least 10 Gb/s, which is several dozen times faster than the currently used 4G standard. The 5G system also means

[60] In the development of this system participated scientists and engineers from NASA.

very low data transmission delays, which should not exceed 1 ms[61] . Such low levels of delays are necessary for a wider development of such areas as the remote automation of production processes, communication between autonomous cars or tele-surgery[62] [260]. When it comes to autonomous cars turns out that to keep passengers safe they require delays not exceeding 5 ms. Assuming that so much time will be taken to activate the braking system while driving, an autonomous vehicle travelling at a speed of 100 km/h will overcome a distance of about 3 cm during that time. However, if the data transfer in such a car were made over the 4G network, taking into account the average latency levels for this standard, the vehicle would travel a distance of about 1.5 meters prior to activating the braking system.

Without adoption of the 5G standard, it is also difficult to count on a rapid development of IoT, which will ensure mutual communication and interchange of data between millions of various devices. The 5G network together with VR technology will also change the nature of education and entertainment [156]. With the 5G technology, downloading a movie in the HD quality will take only about 10 seconds. For comparison, using the maximum capabilities of 4G technology, it is necessary to dedicate approximately 10 minutes for this task. This is certainly a noticeable difference.

The 5G network is characterised by its high performance, thanks to which it will be able to handle a very large number of users and devices.

While current technologies provide communication to approximately 100 devices per 1 sq. km, with the adoption of 5G standard, the number of such devices per 1 sq. km will increase to even one million. An efficient and effective network is essential to ensure the connectivity and remote control of a large number of different devices.

The 5G network will pave the way for the emergence of completely new technological solutions which, until now, have not been implemented on a massive scale, simply due to the low capacity of the network. Below are some examples:

- monitoring and managing road congestion and parking spaces;

[61] For comparison, currently in Poland the average test values for 4G network transmission (LTE) oscillate between 33 and 44 ms.

[62] Telesurgery is a surgical operation controlled remotely by a surgeon with the use of a special surgical robot.

- managing the systems for vehicle-to-internet (V2I) and vehicle-to-vehicle (V2V) communication, which will be deployed in autonomous cars;
- monitoring of air pollution data;
- processing of information on crops on large plantations;
- using virtual reality solutions for live transmission, since the transmissions of high quality and immersive images require very fast data transfer and very low delays;
- making use of augmented reality solutions in museums and theme parks.

According to the technology giant Cisco, at the beginning of the next decade about 50 billion devices can be connected to the network. Nelson Research, on the other hand, claims that by that time there could be 100 billion such devices. The most bold forecasts are made by Intel and the research company International Data Corporation, which predict up to 200 billion or even more devices operating on the global network [232, p. 29]. Of course, it must also be taken into account that these numbers will increase in the coming years. Such a large scale of this project requires serious infrastructural preparations on the part of individual countries. The first to introduce and popularize the 5G standard will most likely be the Americans, the Japanese and the Koreans, who are conducting advanced tests of this technology[63]. For individual EU countries, 5G infrastructure should be ready by 2020 at the latest, at least in major agglomerations[64].

5G technology is also an opportunity to create millions of new jobs. Analyses by the European Commission show that there will be at least 2 million new job opportunities in the European Union alone. This will apply mainly to sectors such as transport, utilities and health care. By the middle of the next decade, the additional benefits would amount to more than €100 billion, with investment in infrastructure of around €50 billion.

A significant problem affecting today's telecommunications industry all over the world is the need to define precisely the works on the implementation of this standard. The most desirable thing would be if all countries had similar plans in this respect. The preliminary arrangements envisage that the standard itself will be defined before the end of 2020. After

[63] Samsung, Deutsche Telecom and Verizon work together to perform the tests.
[64] This also requires the freeing-up of the 700 MHz frequency band, which in the EU countries has been reserved for 5G networks.

another 2-3 years, the technology would be made available to business customers and after the subsequent 2-3 years, to individual customers. However, it cannot be ruled out that in some countries the timeframe for implementation of this standard may differ. The Koreans would like to use the 5G network already during the Pyongyang Winter Olympics in 2018 and the Japanese during the Tokyo Summer Olympics in 2020.

The Intelligent Internet

The development of the Internet makes it possible to create long-term visions of the future possibilities of its application. In recent years, the Internet has ceased to be an exclusive good and has become a tool used by all of us in our everyday lives. At the beginning of the 1990s, when it was just being created, people could use it only with a desktop computer. At that time, mobile Internet and wireless network access did not exist yet. These appeared only after 2000 with the development of GPRS/EDGE[65] technology and the emergence of the first mobile modems and local radio-based networks (WLANs).

Thanks to the development of these technologies, today we no longer have to use the Internet while sitting at our desks. Portable computers, smartphones and universal wireless access provide us with the ability to use the Internet anywhere at all times.

Today, most websites and applications working online offer users a variety of smart features. Examples include semantic information filtering, contextual systems, real-time translation of pages, or communicating with intelligent software and giving commands in natural language. In future, smart search engines will themselves provide us with the information we need the most. This type of technology is already being developed, e.g. Google Now application.

In the future, search engines powered by Artificial Intelligence systems will gain appropriate knowledge about ourselves, so they will adapt the searched content very precisely to our needs and interests. In addition, they will ensure that information is presented in an appropriate form. Depending on our needs and circumstances, they will be able to interpret our mood, catch our jokes, be funny, romantic or even sexy.

[65] GPRS is considered to be the 2.5G standard and EDGE the 2.75G standard.

Computers are now becoming virtually unnoticeable and ubiquitous. Gradually we stop paying attention to them. According to Moore's law, the computing capacity of processors doubles every 1.5 years. Over the past decades, the prices of transistors and integrated circuits have fallen to the level of a few cents per unit. According to R. Kurzweil, the smartphones and tablets that we today use and enjoy will also disappear in the future. They will be replaced by a technology based on a direct brain-computer connection, thanks to which the information presented in a visual form will appear directly in the field of our vision [372]. It is highly probable that when we will see a particular person on the street or in an office meeting, we will have the access to additional information about that person, such as personal data, information about his/her work or family, the date of the last meeting, etc. Presumably, the same technology will give us access to a lot of details that today usually go unnoticed and overlooked. For example, a small lettering in augmented reality could prompt us on important details when we drift away for a second or simply turn our sight away, e.g. that someone next to us said something important or smiled to us.

The first step towards the creation of Internet intelligence is the compilation of data by intelligent machines in the form of processing the digital traces left by network users themselves. It is the emergence of large database structures with valuable information originating from ordinary Internet users that initiated the development of artificial intelligence and machine learning. Further development of the global network will therefore serve the evolution of artificial intelligence.

Selection and retrieval of information is of particular importance for the development of the global network. It is becoming more and more common to use artificial Intelligence and data mining solutions for searching information on the Internet. We are also observing closer links between the user, the machine and the Internet. Communicating with websites or mobile apps in natural language has already become quite common.

In the future, artificial intelligence can be used to classify and identify data so that images and sounds, such as different faces and voices, can be recognised. AI is also used to personalize individual profiles of Internet users (e.g. Facebook, Netflix), to create expert

systems for specific tasks (e.g. software forecasting election results based on the behaviour of social media users) or to find weaknesses in network security.

Facebook uses artificial intelligence to combat the spread of false information [315]. In this way, the Menlo Park company wants to eliminate the problem of false information posted on social networking sites, which, along with the growing importance of social media in recent years, have become a real scourge. There were even analyses which showed that false information originating from social media could have a significant impact on the result of the presidential elections in the United States in the autumn of 2016 [65]. With the growing importance of social media, there is also increasing pressure from a variety of communities to deal more fairly with the storage and protection of our data. The European Union has already taken appropriate action in this respect, i.a. by introducing regulations protecting privacy and personal data of network users. Thanks to the EU regulation of the Council of Europe, which will come into force in May 2018, direct liability for violations of the regulations on the protection of personal data and privacy of Internet users will be borne by organisations processing such data, such as hosting companies and companies providing solutions in the cloud. Failure to comply with the new regulations will result in very high financial penalties [227].

The development of the Internet has contributed to the integration of many different technologies and to the emergence of completely new business models. Examples include the interconnection of network services with mobile phones, the emergence of web TV and radio, media broadcasting, videophony and video-conferencing. Thanks to the use of the Internet, we can access any information or encyclopaedia or dictionary from virtually any place in the world.

In the years to come, we should prepare for the development of a multisensory network, which will enable not only the processing of texts, speeches and images but also the tastes, touches and smells. For this to happen, further progress in communication technologies is necessary, including the implementation of the 5G standard and a further increase in the computational power.

6 CLOUD COMPUTING

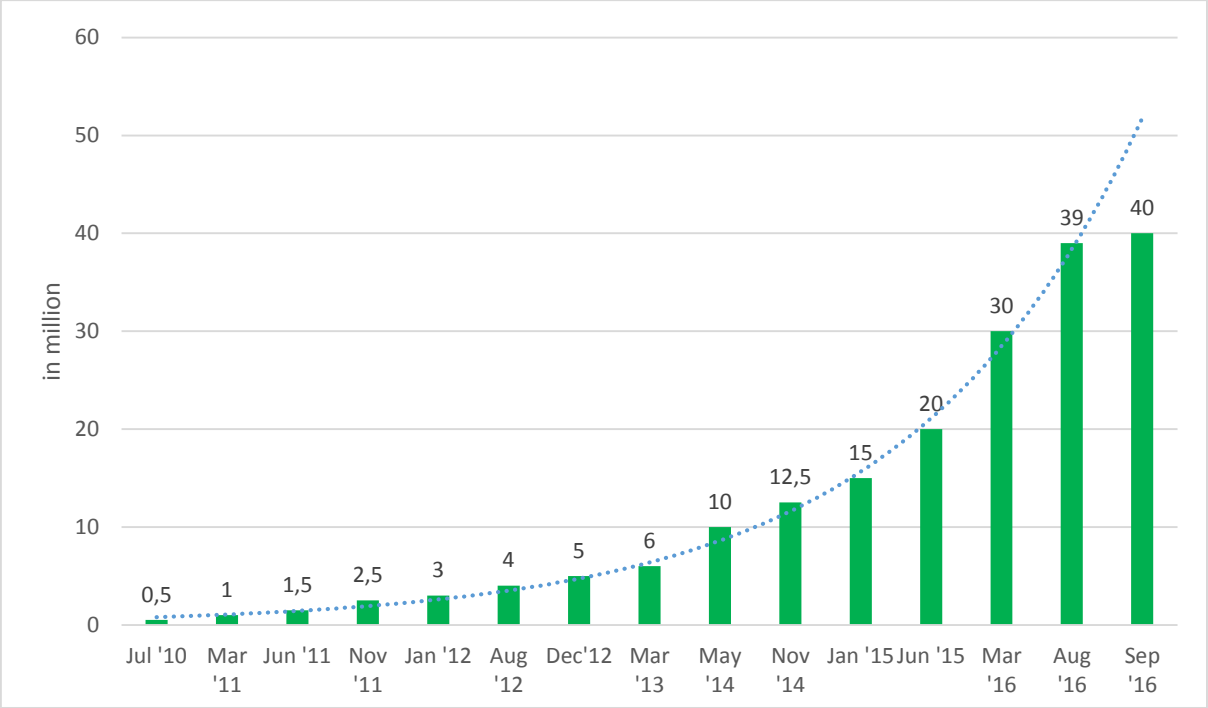
The emergence of cloud computing has completely revolutionised the process of collecting large sets of data and analysing them, and has thus improved the operational efficiency of many business ventures and companies themselves. It has also paved the way for the emergence of new business models and innovative products and services. Cloud computing makes it easier for businesses to deliver products and services, and for customers to access these products and services from virtually anywhere in the world at a glance. Over the past decade, we have witnessed the emergence of companies such as Uber, Kickstarter and Airbnb, which have incredibly rapidly expanded their operations around the world. Since cloud computing provides immediate access to many services, the need to possess digital goods (e.g. copies of music recordings, movies, digital versions of books, etc.) has virtually disappeared. Thanks to clouding, innovative business models based on the so-called access economy and on-demand economy began to gain popularity. They are used by practically all industries, from music and film (e.g. Spotify, Netflix) to automotive (e.g. Car2Go, Traficar). As a result, many services can now be used either on a subscription basis or on a one-off, on-demand basis.

The case of Spotify

Spotify is a Swedish music entertainment company that offers its users on-demand music streaming services. The service can be accessed on smartphones, tablets, computers and even on TVs and consoles. Spotify offers songs from a wide range of record companies, including large and well-known producers as well as smaller and independent labels. In total, Spotify offers its users about 20 million different songs. Thanks to the cloud, access to legal music has become extremely simple and cheap. Regardless of whether we use a mobile (e.g. a smartphone or tablet) or a desktop device, we are now able to listen to our favourite musicians with an on-demand model and from virtually any place on Earth. The Spotify service has become so popular that some audio equipment manufacturers have even introduced special models of their players featuring built-in (preinstalled) Spotify's streaming

functionality, e.g. Pioneer. More and more new cars connected to the Internet are also compatible with Spotify's functionality, e.g. such makes as DS, Peugeot, Citroën, Honda or Volkswagen. Spotify offers, i. a. a social approach for listening music that allows for easy discovering of new songs, e.g. through recommendations, friends' list, etc.

Table 6.1 *The number of all Spotify service subscribers in the world*



Source: Own elaboration (based on statista.com data).

Thanks to the cloud, Spotify collects millions of data about the behaviour of its users. For each user, the data include information on what songs he/she listens to and on which part of the day, the number of replays of each song, and even the specific locations where each song was listened to. The service uses Big Data analytics to collate all these data and create local songs playlists on their basis. **These massive amounts of data are then analysed by artificial intelligence, which recommends specific personalised songs to each user according to his/her individual preferences, e.g. depending on the time of the day, location and even weather conditions**.

The case of the company Express and its Traficar service

Traficar is a service which allows automatic car rental by means of a special smartphone app and without coming into contact with any customer service personnel. Such

a form of "digital" lease is currently possible only in Cracow. However, the company Express, which owns the Traficar brand, is thinking about extending its operations to other cities. What is important, however, is that the implementation of such a business model is possible only due to the fact that the company runs its operations "in the cloud". Traficar customers willing to take advantage of the automated car rental system can use their smartphones to localize relatively quickly and easily the car nearest to the place of their whereabouts, out of the many cars that are parked in different parts of the city. Then, with the use of the same app, they make a reservation. After reaching the place where the reserved car is parked, to get into its interior the customer has to scan a special QR code placed on the car's body, and the door opens. The keys needed to start the engine can be found inside the locker. Payment for the service is made automatically by means of the Traficar app, once the service has been completed. The charge depends on the actual use of the car (i.e. minutes used) and the distance travelled. A great convenience of this service is also the possibility of leaving the car in any parking place within the city's paid parking zone. Also noteworthy is that customers do not have to worry about parking rates, because the costs are settled within the subscriptions paid monthly by the service provider and are included in the price of the car rental itself.

The case of Car2Go

Car2Go is a small urban car rental company founded in 2010 by Daimler. Its model of operation is very similar to the Veturilo city bike rental system known in Poland. Car2Go service allows renting the car in the payment model based on the actual use of the car (pay per use). Car2Go cars are now available in 30 cities across the globe. The company also announced that it would enter Poland and Hungary in the near future.

Table 6.2 *Car2Go cars are available in 30 cities across the globe*

City	Country	Number of cars	Drive	Start date
Austin	USA	300	Gasoline/Electric	May 2010
Düsseldorf	Germany	300	Gasoline	February 2011
Hamburg	Germany	800	Gasoline	April 2011
Vancouver	Canada	1,275	Gasoline/Electric	June 2011
San Diego	USA	5	Electric	November 2011
Amsterdam	Holland	350	Electric	November 2011
Vienna	Austria	800	Gasoline	December 2011
Madrid	Spain	500	Electric	November 2015
Washington, D.C.	USA	700	Gasoline	March 2012
Portland, Oregon	USA	465	Gasoline/Electric	March 2012
Berlin	Germany	1200	Gasoline/Electric	April 2012
Toronto	Canada	375	Gasoline	June 2012
Calgary	Canada	600	Gasoline	July 2012
Cologne	Germany	350	Gasoline	September 2012
Stuttgart	Germany	500	Electric	November 2012
Seattle	USA	750	Gasoline	December 2012
Minneapolis–Saint Paul	USA	535	Gasoline	September 2013
Columbus	USA	300	Gasoline	October 2013
Denver	USA	400	Gasoline	June 2013
Munich	Germany	300	Gasoline	June 2013
Milan	Italy	700	Gasoline	August 2013
Montreal	Canada	460	Gasoline	November 2013
Rome	Italy	600	Gasoline	March 2014
Florence	Italy	200	Gasoline	May 2014
Frankfurt	Germany	250	Gasoline	September 2014
New York	USA	550	Gasoline	October 2014
Stockholm	Sweden	250	Gasoline	November 2014
Turin	Italy	450	Gasoline	March 2015
Prato	Italy	35	Gasoline	November 2015
Chongqing	China	400	Gasoline	April 2016

Source: Own elaboration.

Daimler uses cloud computing to avoid the risk of incidents related to the protection of its customers' personal data and possible leakages of sensitive information. The use of the cloud is also intended to facilitate the proper preparation of the company for the implementation of an autonomous driving system in the future [14].

Illustration 6.1 *Car2Go Daimler's offer allows renting the car in the payment model based on its actual use, Source: Daimler*

The company gives its clients complete freedom to decide what part of the data related to them and generated as a result of performing the service may remain in the system after the service itself has been provided. Every Car2Go customer has the right to request erasure of all unwanted data about himself/herself from the company's servers. Thanks to a better data protection, the German company wants to provide its customers with greater comfort and safety of rendered services. In this way, the company hopes to attract more new clients.

Cloud scalability

A great advantage of the cloud is its simple and quick scalability of the resources it uses. The issue of scaling is related to economies of scale and stands for the most efficient and effective management of large computational resources [233]. Entrepreneurs, who decide to move their businesses to the cloud, are most often motivated by the desire to optimize their cost of accessing computing resources. There is no doubt that these costs are considerably lower (in a cloud-based model) when compared with investing in and maintaining traditional infrastructure.

The case of Airbnb

Airbnb is an intermediation company in the rental of accommodation. With more than two million beds in 190 countries, the company is now valued at more than $25 billion. However, its rapid development would not have been possible without appropriate IT resources and tools, including the storage, computing and analytical tools, the scale of which has been and is constantly being adjusted within the cloud to the size of the changing business. Depending on its needs, the company increases or decreases the number of its virtual servers without the need to contact any customer service personnel. There are no additional costs that would be associated with certain minimum limits of computing resources. Airbnb processes and analyses about 50GB of data every day and is today the unquestionable leader in its industry[66].

The case of Microsoft

The potential of the cloud is appreciated even by high-tech giants who have been operating on the market for several decades. An example is Microsoft, which has made its latest version of the Office software accessible on the Internet as a cloud platform. In this way, the Redmond Company is trying to popularize the Windows products as a service available in the cloud. The Office 365 package is designed in such a way that it can be accessed at any time, irrespective of whether its user has an Internet connection or not. The lack of access to the network disables only certain functionalities of the whole application. This form of the products distribution has many advantages. **A company providing services under this model can establish closer relations with its customers and partners and therefore gain an insight into their habits**. Making a software available in the cloud is also a way to combat piracy. Customers, on the other hand, can at any time use the most up-to-date version of the software package. They can also more easily settle accounts with their service provider, and around the Microsoft's cloud they can develop their individual, additional services. The new Office 365

[66] This information is provided by Intel, which is Airbnb's business partner. These days 50 GB may not seem to be much, but since it is pure data, the number may already be impressive.

also offers the possibility of accessing the software on both stationary and portable devices, such as a smartphone or tablet. This provides customers with greater mobility and flexibility in the use of the software.

Thanks to its functionalities, Office 365 has become one of the most popular cloud services on the market. It is now used by 70 percent of Fortune 500 companies.

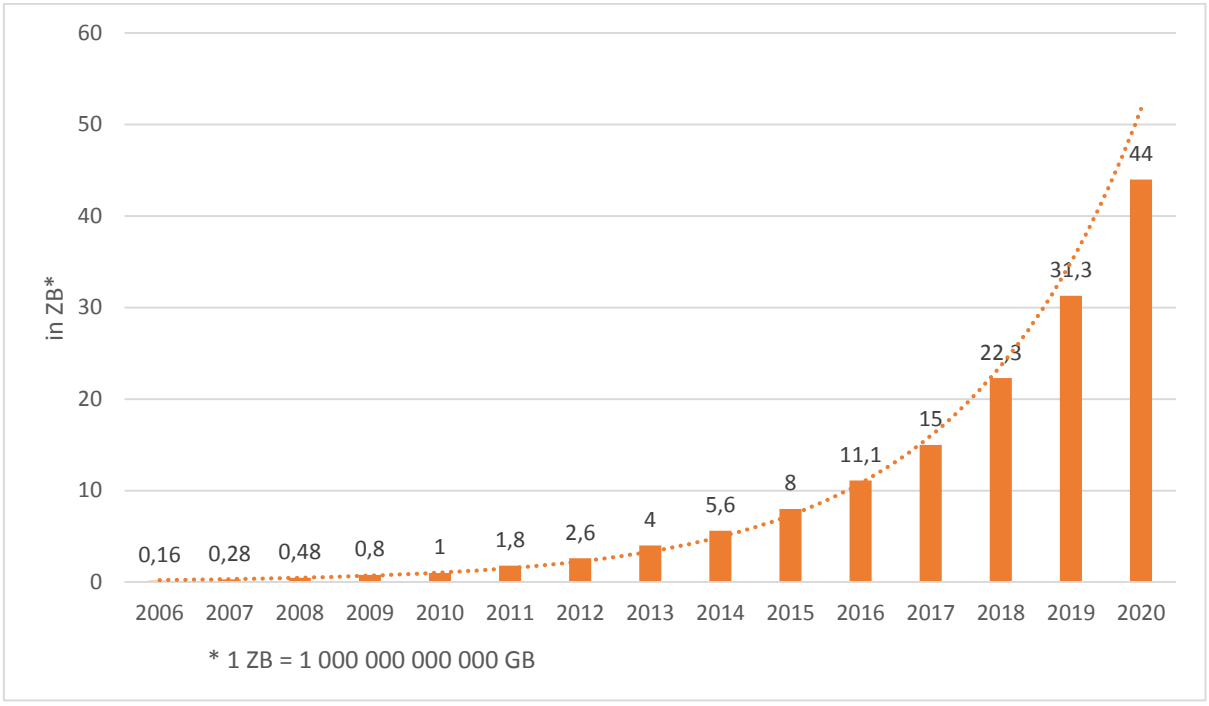
Also noteworthy is a report released by the research company Vanson Bourne, which shows that companies using cloud services have on average 20.7 percent shorter time to market, 15.1 percent lower costs and 18.8 percent higher productivity of their employees.

7 BIG DATA

With the development of digital technologies, also changes the approach of business to data analysis. In the past, data was simply scarcer than it is today, so it only provided an overview of business and social developments. Today, there is considerably more data, which makes it possible to take a more insightful look at many problems. The data itself becomes the most valuable asset for enterprises, both for the large corporation operating in the Silicon Valley as well as for the sole proprietorships run in Warsaw, for example. With Big Data analysis companies are now able to segment their customers' portfolios in a very detailed way, which until recently seemed extremely difficult. According to Intel's main strategist, Jim Henrys, big data analysis allows for a much better understanding of customers' behaviours and expectations, and then for adjusting their own product offer accordingly. In other words, **by analysing the large data structures left in the digital world by the customers themselves, it is possible to create better products that meet the needs of a specific target group**. It also improves operational efficiency, safety, helps to find new sources of income and increases profitability. Therefore, more and more companies declare their interest in investing in solutions for the analysis of large data structures, and the course of evolution is set by the most technologically advanced companies from Silicon Valley and from highly developed countries.

The analysis of large data structures also allows for the implementation of the concept of customisation of products to the specific customers' needs in mass production (so-called mass customisation). Sales of products and services based on Big Data analytics are now becoming one of the most popular and effective business models.

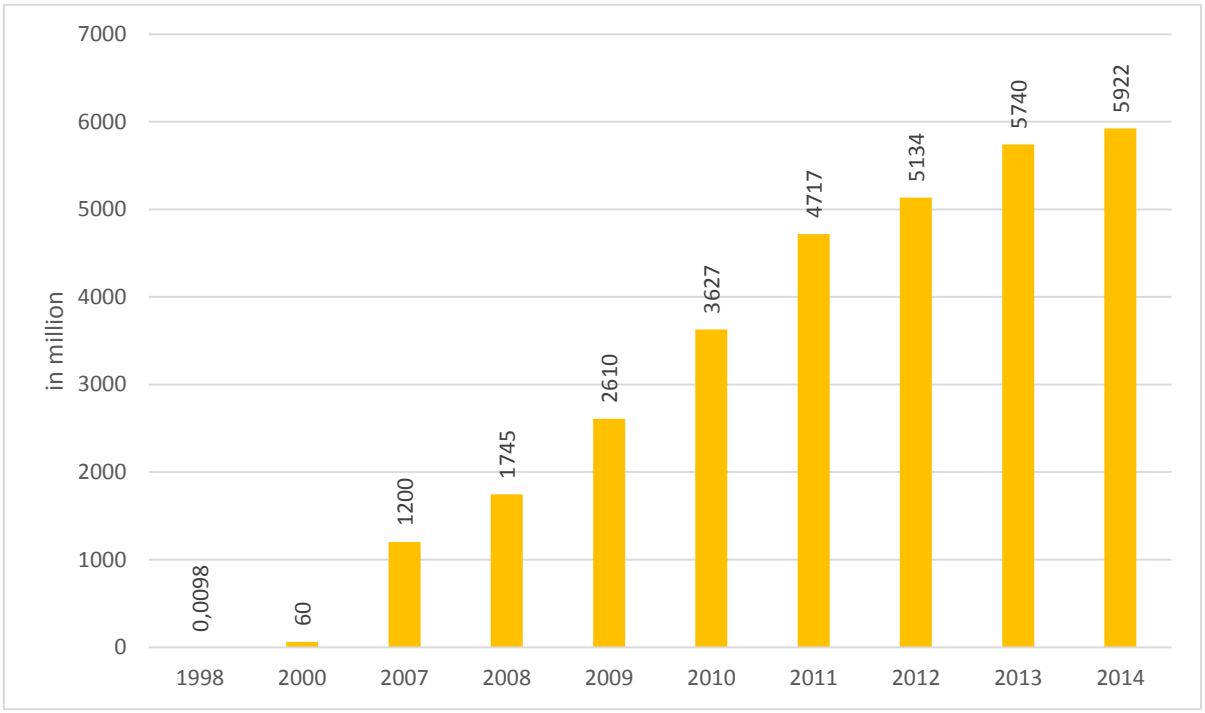
Chart 7.1 *The volume of generated data is growing at the rate of 40 percent annually*



Source: Own elaboration (based on Oracle and Cisco Systems data).

It is expected that the importance of Big Data analysis will increase as data availability and volume increase. **Statistics show that the amount of data collected in the global network resources doubles on average once every two years**. Thus, in the last two years, more or less the same amount of data has been recorded on the servers of companies operating on the Internet as throughout the entire preceding time. Oracle forecasts that already in 2020, every person living on Earth will generate on average about 1.7 MB of data per second, and the annual volume of generated data will then reach the level of about 44 Zettabytes (ZB) [306, p. 53][309, p. 34]. Today, more than 65,000 searches are processed every second with the use of Google's search engines alone. In total, it gives nearly 6 billion of such searches a day and over 2 trillion a year.

Chart 7.2 *The number of one-day searches in Google's search engines Source: own elaboration (based on Oracle and Cisco Systems data)*



Source: Own elaboration (based on Statist and Statistic Brain Research Institute data).

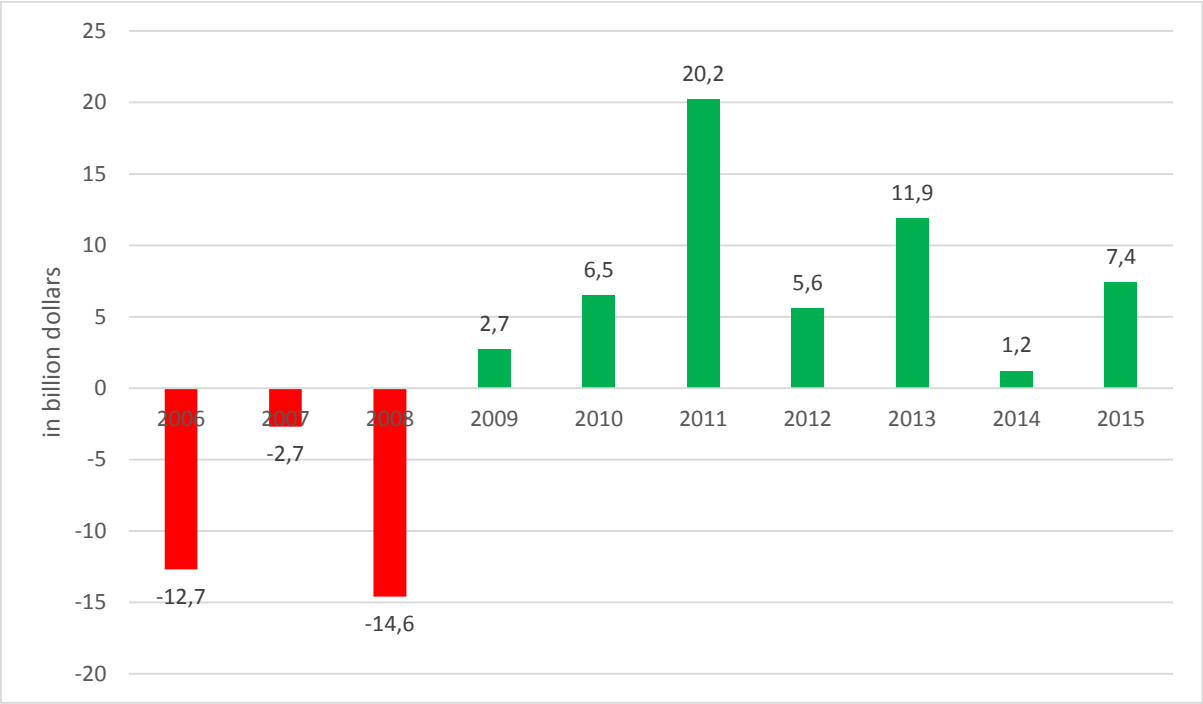
In August 2015, the number of people using Facebook services on a daily basis for the first time exceeded one billion. The users of this popular social networking site currently generate around 45 billion messages and over 4.3 billion films a day. Forecasts indicate that by 2020, there will be more than 6 billion mobile phones and a staggering 50 billion of different IoT devices in service.

Through Big Data analyses, companies collect relevant knowledge which they use later to develop and implement their own strategies. This knowledge allows them to better understand their own weaknesses and the evolution of the market itself. The business value of large data structures' analysis (Big Data) is best shown by practical examples.

The case of Ford Motor Company

Ford Motor Company, which recorded a total loss of USD 30 billion between 2006 and 2008, thanks to the use of Big Data analysis improved its results and avoided bankruptcy.

Chart 7.3 *Ford Motor Company - Net profit in the years 2006-2015*



Source: own elaboration.

In-depth data analysis has enabled the automotive giant to better understand its customers' needs and focus on improving the efficiency of its production processes. The company developed a special inventory management system (Smart Inventory Management System, SIMS), that is used to identify and anticipate purchasing trends accurately, which directly translates into increased sales and a significant reduction in costs [224]. The SIMS was developed using large data structures (Big Data) from the servers of the company's website, reflecting the specifications searched for by customers (the so-called phrases). In order to extract as much as possible from them, they were linked to a group of other factors that seemed important for the proper management of inventories, such as sales, employment, earnings or even house prices in various regions. **Since the introduction of SIMS in 2009, the company has been dynamically planning the appropriate number of individual car models to be delivered to its stores (dealers). The savings are estimated to be hundreds of millions of dollars per year**.

Big Data has become so important to Ford that in 2015 it became the first automotive company in the world to create a special position in this field, i.e. the Global Chief Data and Analytics Officer, who is responsible for integrating the research and analyses conducted

within the entire company[67]. In this way, the Dearborn Company wants to gain a competitive advantage over its competitors in the industry.

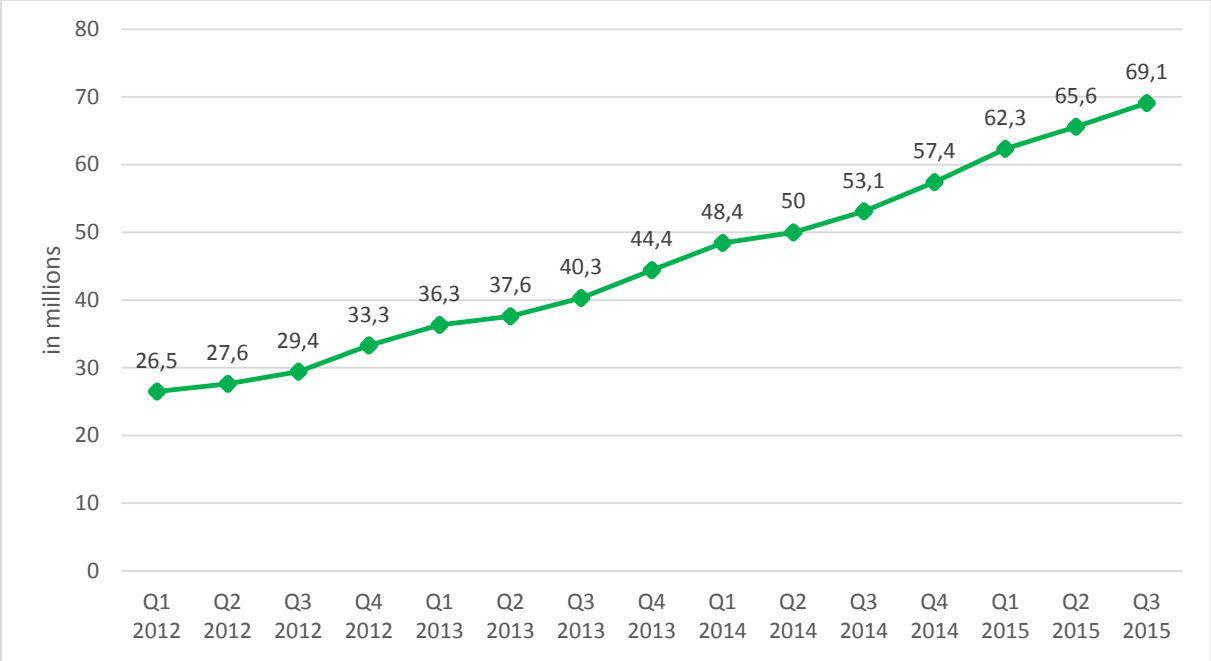
The decision to implement the SIMS system which was based on the Big Data analysis turned out to be beneficial for Ford Motor Company. This allowed the company to significantly improve its financial results.

The case of Netflix

Netflix is one of the largest media streaming services providers in the world. It provides its users with online access to their favourite TV programmes, films and TV series. In total, Netflix provides to all its users approximately 130 million program hours per day. **The company is known, among other things, for the fact that it develops its unique program offer based on the analysis of large amounts of data (Big Data) and artificial intelligence, and particularly deep learning[68]**. Thanks to that, it managed to defeat the competition of such companies as HBO, Hulu or Amazon and became the leading provider of Web TV in the world. Netflix systematically builds up knowledge about the preferences of its clients, so that the content offered to them is optimally adapted to their individual preferences. Complicated algorithms, based on machine learning, ensure that each of the users of the service has an individually personalised homepage of the platform.

[67] This position was entrusted to Mr. Paul Ballew.
[68] This issue is thoroughly described in the chapter dedicated entirely to Artificial Intelligence.

Chart 7.4 *The number of Netflix streaming subscribers worldwide from the first quarter of 2012 to the third quarter of 2015*



Source: own elaboration.

Netflix uses large datasets analysis not only to recommend a variety of different contents to its users but also to create them. In 2013, the company used big data on the behaviour and preferences of its users to conduct a prediction analysis which had to indicate which series would be the most popular among the viewers [206, p. 383]. This analysis showed that the most promising production would be to devise a series on political issues, in which Kevin Spacey would play the leading role and which would be directed by David Fincher [46]. This knowledge contributed to the creation of the House of Cards, a series which turned out to be an absolute world hit and attracted several million subscribers to Netflix virtually immediately [71, p.7]. House of Cards has also received many prestigious awards, including 2 Golden Globes and 6 Emmy Awards. What is more to the point, unlike traditional producers, Netflix released individual seasons of its series in their entirety, i.e. all episodes were available on the very same day. Subscribers could thus make a real film marathon and watch them all in one day, so they did not necessarily have to wait weeks for subsequent episodes, which in turn is an example of a well-designed disruptive thinking strategy on the part of Netflix decision-makers.

The analysis of hundreds of millions of data on the behaviour of Netflix's streaming service users enables the Los Gatos Company to make incredible strategic choices in the management of its business.

The case of Die Welt

The development of mobile and digital information technologies forces many industries to completely redefine their existing business models. An example is the media industry and, in particular, the print media sector. In its case, digital editions of newspapers and information materials are gaining popularity from month to month. The use of all content on digital media servers is beginning to be regarded as an industry standard. In order to meet the enormous competition on this market, digital newspaper editions must ensure top-quality journalism, i.e. premium journalism. These are global trends today and they certainly cannot be ignored. Publishers have to provide their users with access to interesting information, i.e. information that cannot be found elsewhere. It should be additionally enriched with interactive materials, infographics and videos. In the years to come, it is expected that press reading on mobile devices (tablets, smartphones, e-readers, etc.) will grow at an even faster pace. It is estimated that by 2020, around three billion people worldwide will already have such devices connected to the Internet. Due to the high level of competition in this sector, consumers of online media content will be willing to pay only for valuable content. This does not mean that the traditional printed press will cease to be published at all, but it will certainly lose its significance. It will be preferred mainly by older people, although it is worth noting that even in this age group, the number of recipients of electronic content is also growing year by year.

There is a trend in the world today to introduce paid subscriptions (the so-called paywalls). This solution is implemented, among others, by the German Die Welt, thanks to which it gains extremely valuable information on the interests and behaviours of its own readers. It is a **digital footprint they leave on digital publishers' websites and platforms**. For example, it becomes clear what articles they read, how much time it takes them to read, at what hours they most frequently read and browse the available content, how much time they spend reading various electronic content during a day. Altogether, these are hundreds of millions of different pieces of data, which are then analysed in the form of Big Data analytic,

which allows the publisher to appropriately tailor its subsequent content to the needs and interests of its readers[69].

Big Data becoming a widely used technology

In the digital world in which we live, Big Data is no longer just the domain of large corporations. The analysis of large data structures is also increasingly used by companies from the SME sector [164]. The simple availability of Big Data analytical solutions makes it attractive to other user groups as well. This process is referred to as the **'democratisation of analytics'**. Companies willingly use these solutions to better customize their offerings to the needs of consumers, create more personalised advertisements, or optimize various processes, such as the supply chain management process or decision-making processes within the organisation [171]. Big data solutions also support the development of the Industrial Internet of Things (IIoT) and smart cities.

Analytical tools available on the market are becoming widely popular and relatively easy to use. On the other hand, developers of analytical software are satisfied that their solutions are used by a growing group of users, and not only by the experts and specialists themselves. Companies are competing to find the right specialists for data mining and for analysing large data structures. One example is the American intelligence agency CIA, which makes various attempts to gain specialists in the field of big data for its own purposes.

However, we should remember that big data creates a great temptation to various kinds of abusive practices. Therefore, the relevant government authorities should take appropriate measures to prevent such practices, inter alia, by creating appropriate regulations that will prevent the collection of sensitive data from the users.

[69] Internet users leave traces of their presence on the electronic portal, which are recorded and stored on the portal's servers.

8 ARTIFICIAL INTELLIGENCE

Artificial Intelligence (AI) is a field that deals with creating models of intelligent behaviour and solving numerically algorithmic problems, such as evolutionary computations, fuzzy logic, robotics, and even artificial life. The history of Artificial Intelligence dates back to the middle of the last century. This term was used for the first time by John McCarthy in 1956, for whom it meant the development of machines, the operation of which could be described as similar to human manifestations of intelligence [222]. Artificial intelligence is commonly understood to be the intelligent behaviour of machines and software. As an interdisciplinary field, it draws on many other areas of knowledge, such as psychology, neurology and even cognitive science[70], systematics and philosophy.

So far, machines have had relatively poor results in dealing with some types of problems, such as rational reasoning, making decisions under conditions of uncertainty, recognising images or analysing and synthesising natural languages[71].

There is a great deal of expectation that artificial intelligence will lead to the development of intelligent machines and software that will be able to mimic the functions performed by human mind and senses, which have not yet been subject to numerical algorithmisation.

Currently, the interest in artificial intelligence is growing from month to month. And almost every week there is another extraordinary innovation in this area. AI is becoming present in various areas of life, science and economy. One example is the intelligent system developed by scientists at Stanford University, which allows for forecasting weather phenomena occurring on the Sun (i.e. explosions and solar flares). The system uses a huge database from more than 2000 regions monitored by the SDO probe. Intelligent software is based on appropriate self-learning algorithms, thanks to which it systematically improves its effectiveness. This project can allow humanity to prepare itself much better for the coming

[70] Cognitive science - a field of science dealing with observations and analyses of senses, brains, and minds, especially with their modeling.
[71] These problems are also called AI difficulty.

cosmic cataclysms and can contribute to reducing their negative effects. Another example of the use of Artificial Intelligence is the intelligent software developed by engineers at Guadalajara University in Mexico, which can recognize people's silhouettes and faces. Such a solution may be used in the future, e.g. in order to save lives in places of accidents and catastrophes. An intelligent machine captures images using a stereoscopic camera, and the relevant AI software can identify the shapes of a human body using an algorithm based on neural networks. The machine also has the ability to create a proper map on its own and find its way to the place of the disaster, which is achieved by means of appropriate motion sensors, lasers and an infrared detection system. Similar successes can also be reported by scientists working for Google, who managed to create a machine (Google Brain) capable of recognising images and drawing appropriate conclusions from them. The mechanism of this advanced software is based on the so-called deep learning networks.

Researchers working for Yahoo developed a computer algorithm for geo application. It evaluates specific sites for their beauty and, on the basis of the findings, designates appropriate hiking trails and tourist routes that can be used later by users of geo applications. The project was developed using the Google Street View photo database, on which social opinions were imposed and made accessible through the UrbanGems website. The aim of the developers of this algorithm was to create a guide to the largest cities in Europe.

Artificial intelligence replaces people in an increasing number of works and activities. The weather information on Chinese television is almost completely developed and presented with the help of the intelligent software Microsoft Xiaoice [362]. This is done without any human intervention. Xiaoice had previously undergone appropriate linguistic tests, with a score of 4.32 on a five-point scale, which was slightly lower than that of an average person[72] [45]. Artificial Intelligence systems are already used by journalists for some simple activities, such as preparing short messages. However, more extensive texts still require creativity and will certainly be prepared by man for a long time to come. A sector that is particularly interested in using the potential of artificial intelligence is financial services. This is mainly due to the fact that this is an area requiring the processing of a huge amount of data. AI systems effectively fill human knowledge gaps and suggest the best options. Importantly, the smart software has the advantage that it is constantly updated and adjusted to market expectations,

[72] An average person scores 4.76 points in such tests.

so it can cope perfectly with even the most recent market problems. Moreover, thanks to artificial neurons, intelligent machines are capable of learning very quickly and efficiently from previous decisions (machine learning). The neural network remembers all previous experiences and analyses all activities performed by the system on their basis. Many banks and financial institutions already use this type of solutions, including brokerage houses, advisory firms, hedge funds and mutual funds.

Artificial intelligence can be treated as a useful tool in forecasting. In 2015 and 2016, an algorithm developed by a team of New York scientists headed by David Rothschild was able to correctly predict the Oscar-winning films [341], and already in 2013, the Rothschild team achieved a good result, accurately predicting 19 of the 24 Oscar-winning films. AI improving performance is a result of the analysis of huge databases and the learning process. The same algorithms were also used to forecast the results of the NFL football league and, like in the case of Oscars, they were capable of predicting the future with an impressive precision. The AI's effectiveness in predicting future events depends largely on proper traceability of the sample. The Oscar-winning predictions were based, for example, on information about the preferences of the members of the American Film Academy taking part in the voting.

Artificial Intelligence is intended to help humans analyse large collections of miscellaneous data (big data) that are difficult to process with standard calculation programs. One of the most advanced intelligent artificial intelligence machines today is the Watson supercomputer, developed by IBM, which is capable of recognising and processing natural languages, among other things. This means that it is possible to speak to the intelligent machine in English, for example, and in the future also in other languages. Watson is able to process unstructured databases, i.e. unstructured data. It implements the debate function, which means that intelligent software itself scans millions of articles, searches for arguments for and against a given topic and takes a stance on it on the basis of these arguments. IBM has also developed a special version of the supermachine (i.e. Watson Analytics), which is only used to analyse economic trends. Large data structures are also handled quite well by the smart Data Science Machine software developed by scientists from the Massachusetts Institute of Technology (MIT). In its current version, Data Science Machine is able, for example, to predict with 95 percent accuracy which students are at risk for dropping out of MIT courses.

Risks related to the development of AI

The dynamic progress of artificial intelligence has been increasingly controversial in recent years. One of the important problems that bother scientists is the possibility of losing control over the development of this technology. These issues were raised publicly by Stephen Hawking, Elon Musk and Bill Gates, among others, who expressed doubts as to whether people would ever be able to control artificial intelligence [111, p. 395]. So should we start to be afraid of artificial intelligence? Can its uncontrolled development threaten our civilisation and our life and health? Since this book deals with the digital sphere, it should be noted that there is no zero-one answer to these questions. The problem is, in fact, very complex. Artificial intelligence can be a great tool if it is properly channelled and things go in the right direction. Undoubtedly, the very temptation of possible abuses that may accompany the development of AI is alarmingly real. Nevertheless, the risks associated with the evolution of this technology do not necessarily have to materialize. However, in order to avoid this, we need proper supervision and appropriate legislation, which will prevent potential dangers. It is not only about the possibility of intelligent machines taking control of us in the future, but also about many issues that already seem to be quite real today. Violations of privacy, industrial espionage, computer sabotage, taking over the identity of other people are just some of them [294, pp. 131-133]. According to Stephen Hawking, our future depends on the race that takes place between the growing power of technology and our knowledge of how to use it wisely. It is up to us who wins this competition [308]. It is also worth noting that at the current stage of development, the intelligent software learns only within an enclosed environment and does not need to rely on information from the external world. However, what happens when this situation changes? Is it even possible for machines to slip out of human control? Perhaps the only effective way to prevent this is through the strict control of scientists who are working on this technology, as proposed by Hawking. He himself believes that the development of artificial intelligence may even be the beginning of the end of the human race. Similar conclusions emerge from the report prepared jointly by Human Rights Watch and Harvard University[73]. Both institutions warn against the possibility of the emergence in the future of intelligent machines, which will be able to kill people on their own, beyond any human control. Artificial Intelligence enthusiast Ray Kurzweil, on the other hand, believes that even in the first

[73] This report was published in April 2015.

half of the 21st century, intelligent machines can match people not only in terms of their level of intelligence but also in terms of their emotional and mental abilities. At the beginning of 2015, the research organisation Future of Life Institute presented a number of postulates, in which it pointed out the need to regulate a number of problematic issues related to the development of artificial intelligence, including the equipment of intelligent machines and ethical issues. The postulates were signed by a wide range of specialists dealing with this field.

The case of Google

A significant contribution to the development of artificial intelligence has been made by scientists from the Google Company. In 2012, as part of the Brain project, they created the Google Brain Supermachine, consisting of 16,000 connected processors, and they fed the memory of such intelligent machine with videos (data) from the YouTube service. After "watching" several million images, this intelligent software was able to recognize certain objects on the films, e.g. cats. Google Brain AI's principle of operation is to reproduce the behaviour of millions of neurons and billions of connections between them. Google experts say that in the future such a "superbrain" will be able to see, hear, feel and logically think almost like ordinary people. It is just a matter of time.

Illustration 8.1 *Interconnected computers forming part of the G-Brain project (Google Brain), Source: Google*

Within the same Brain project, three other intelligent machines were created (Alice, Eve and Bob), each of which developed (in the process of learning) its own encryption and decryption techniques for the exchange of messages [44]. The cryptographic algorithm which was used in this process was based on neural networks. But until today no-one is able to explain precisely how it works.

Google's artificial intelligence already encrypts messages today in such a way that people cannot determine how it works.

Initially, two of these super machines (Alice and Bob) were given a common encryption key. Alice's task was to send encrypted messages to Bob so that only he could read them. Eve, on the other hand, was supposed to try to intercept their communication, contrary to Alice's efforts. However, neural networks were not instructed what exactly encryption techniques they were supposed to use or what the cryptography meant at all. Over time, however, they succeeded in figuring it out. At first, Alice and Bob made small mistakes when exchanging encrypted messages with each other, and Eve managed to understand them relatively easily. But soon the machines (Alice and Bob) gained such a huge skill, that Eve remained practically without any chances to decipher their encrypted conversation. Importantly, the engineers who created these super machines are still unable to determine how effectively they exchange encrypted messages with each other. This is only confirmed by the fact that modern neural networks are so advanced that they are capable of doing things that man is not even able to comprehend. In principle, we can say that in some areas we have already reached the singularity, i.e. the level of development at which artificial intelligence exceeds man's intellectual capabilities [179, pp. 393-406]. Therefore, the warnings made by Hawking, Gates or Musk seem to be more justified than we might think.

Artificial Intelligence is one of Google's strategic priorities.

In 2014, Google acquired the British company DeepMind, which is involved in the development of AI technology[74]. This investment cost the Internet giant $500 million. The

[74] DeepMind specialises in artificial intelligence algorithms. The company was founded by Demis Hassabis (neurologist), Shane Legg (chess master) and Mustafa Suleyman.

transaction was subject to the provision that Google would retain the entire team of 75 employees working for DeepMind. Algorithms that are developed by DeepMind's employees are to be applied in such areas as e-commerce, e-learning and computer games. One of DeepMind's flagship projects is the intelligent AlphaGo machine, which plays the strategic game Go against humans. It is worth noting that the Go play is incomparably more difficult than chess and has a nearly 2500-year history. In March 2016, the grandmaster of Go - Korean Lee Sedol played a match against AlphaGo's intelligent software, losing 1 to 4, but all four victories of the supermachine were due to its extremely strong performance at the end of each game. Therefore, taking into account all games and rounds, the advantage of artificial intelligence was not as big as the final result could indicate [256]. When Lee Sedol won his fourth game, the spectators were able to believe for a moment in the superiority of the human mind over the machine. However, the fourth game was different from the previous ones. It looked as if Artificial Intelligence was able to cope well with up to 78 rounds, and then the Korean forced it to make a mistake by making a brilliant move, after which the machine did not recover anymore.

Illustration 8.2 *Lee Sedol in a hotel in Seoul during a press conference just after his defeat in the first game, Source: Google*

Before the AlphaGo program reached the level that enabled it to defeat the Grandmaster Lee Sedol, it had earlier played millions of parties against itself and against other software. In this way, after each game, it became a bit stronger.

Another super intelligent DeepMind machine is designed to compete against humans in the field of video games. The machine was familiarised with 49 game titles and was allowed to play each of them for a week[75]. Although Artificial Intelligence did not initially have any knowledge or experience of playing video games, it quickly managed to develop optimal strategies that allowed it to win in most of these games. The machine did not succeed only in playing those games that involved abstract thinking, such as Pac-Man, Asteroids, Gravitar or Centipede [127]. For comparison, it is worth noting that while in the Go game there are 300 possibilities of a move in each subsequent game movement, in the case of StarCart there are as many as 10^300 such possibilities [297]. It is probably only a matter of time when AI will gain an advantage also in these more complicated game titles.

Over the past few years, Google (Alphabet) has also invested in a number of leading robotics companies. The Mountain View Company is particularly strongly involved in the military robotics segment, expecting it to become pivotal for the army in the future, which will most likely use such robots to conduct warfare. One of the company's acquisitions was Boston Dynamics, which implements many interesting projects in the AI field[76] [276]. It develops advanced humanoid robots, some of which are being prepared for the American army, such as the Legged Squad Support System (LS3). The company has, i. a. signed contracts with the Pentagon.

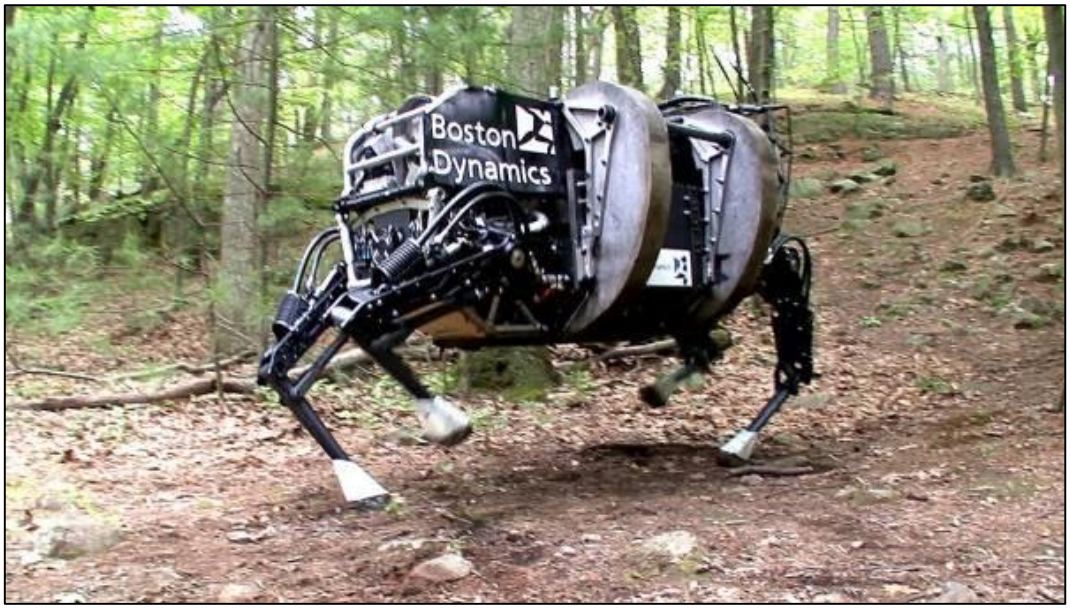


Illustration 8.3 *LS3 robot developed by Boston Dynamics. Source: Boston Dynamics*

[75] Popular arcade games for the Atari 2600 console (from the early 1980s) were used for this purpose.
[76] Google (Alphabet) acquired Boston Dynamics in 2013.

The LS3 robot made by Boston Dynamics is 2 m long, 1.75 m high and transports about 180 kg of cargo. It is built of very durable, bulletproof materials, has the ability to overcome difficult obstacles and can move even in water and snow. Fitted with the right sensors, it finds its way to the destination on its own. Other robots designed by Boston Dynamics include:

- **Wild Cat** – a four-legged robot that moves on almost any terrain and reaches high speeds;
- **Big Dog** – robot fitted with advanced control elements, thanks to which it is able to maintain its balance even on irregular terrain;
- **Cheetah Robot** – a robot capable of running at a speed of up to 45 km/h;
- **Little Dog** – a robot for special applications which performs very well in harsh outdoor conditions;
- **Spot** – a robot which can run, walk up the stairs, climb the mountains and is also able to pick itself up when it falls.

Illustration 8.4 *Boston Dynamics' family of robots, Source: Boston Dynamics*

Artificial Intelligence Scientists

It is also impossible not to mention about AI's best known and talented scientists, especially in the specific AI sub-category, which seems to be one of the most complex - that is to say, the so-called deep learning, which deals with the modelling of complex problems by

means of multilayer, deep neural networks [190, p. 436-444]. These scientists include Yann LeCuna, Geoffrey Hinton, and Yosh Bengio, without whose participation many important projects of such technology giants as Google, Facebook, and IBM, would probably never have been accomplished [225]. All three of them have long been involved in deep learning, although there were periods when work on this technology was completely suspended due to a severe reduction in the interest on the part of research centres and investors. A real breakthrough and a decisive increase in the interest in deep learning took place only after the successful completion of the aforementioned Google Brain project, which consisted in the identification of different types of cats on YouTube videos.

The first of the above-mentioned scientists - Yann LeCun - is currently working on the development of the world's best artificial intelligence laboratory (i.e. AI Research), which is owned by Facebook. The second - Yoshua Bengio - analyses non-structural data and implements the latest deep learning solutions on the Watson IBM platform. The third one - Geoffrey Hinton - is involved in numerous cutting-edge Google projects, including the continuation of the Google Brain project mentioned above.

OpenAI

Artificial Intelligence also poses a great existential challenge to humanity. The point is to perceive it as being of greater value rather than just a chance to gain a competitive advantage or a benefit for investors. An example of such an approach to Artificial Intelligence is the initiative undertaken by Elon Musk and a group of other entrepreneurs from the Silicon Valley, including Sam Altman from Y Combinator, Peter Thiel from Palantir and Greg Brockman from Stripe, who jointly established the OpenAI research institute for Artificial Intelligence exploration. However, unlike commercial projects, access to the results of OpenAI's work is open to all interested parties. The idea of freeing artificial intelligence attracted the most outstanding AI specialists to this project. OpenAI is to develop mainly those technologies which will be perceived as beneficial for humanity. If, however, safety concerns should arise, the Institute may decide not to disclose certain results of its research to the public.

Unfortunately, most of the technology companies currently involved in AI development have a different approach to knowledge sharing. The projects in which they are involved are exclusively conducted for the benefit of pure profit, which can be a cause for

concern. There is also a real danger that most of the key projects will be controlled by one large group. Sam Altman, one of the OpenAI founders mentioned above, in an interview with Elon Musk said the following words: *I believe that it is better to give people power over distributed artificial intelligence than to allow all artificial intelligence to be controlled by a single company*. In turn, Musk called artificial intelligence our greatest existential threat. Musk's comment is not isolated. Similar views on Artificial Intelligence are expressed by Stephen Hawking and Bill Gates, who, as mentioned above, also warned that Artificial Intelligence could prove even more dangerous in the future than nuclear weapons. In an interview with CNN television Musk said that *the position of humanity on this planet depends on its intelligence, so if our intelligence is defeated (dominated by a higher intelligence), it is unlikely that we will retain control over our planet*. Although Musk was an investor in artificial intelligence companies such as DeepMind and Vicarious, he claims that he made those investments only to ensure that the development of AI technologies would not threaten our civilisation. In his opinion, it is extremely difficult to determine today how much artificial intelligence can bring benefits to the humankind. It is just as difficult to envisage what damage it could cause to human society if it were misused for inappropriate purposes.

In fact, the largest technology companies, such as Google, Facebook, Apple or Microsoft, are currently struggling to attract the greatest talents (the most outstanding specialists) in the field of artificial intelligence. However, there are few people with specific competencies in this area. It is estimated that today there are about two thousand scientists in the world, who are well knowledgeable about deep learning and image recognition technologies. In order to attract highly qualified specialists, the largest technology companies are ready to pay them up to 250 thousand dollars a year. Sometimes, in order to acquire such specialists, it is necessary to take over the entire company in which these scientists work. One example is Microsoft, which paid $200 million in 2015 to acquire a small Israeli company, Equivio, specialising in applying machine learning for text analysis and compliance services[77]. Given that only 24 people worked for this company, it was an expense of $8.3 million per employee. Another example is Twitter, which spent $150 million in 2016 on the acquisition of Magic Pony, a small start-up using machine learning to develop image enhancement

[77] Machine learning is a method of machine self-learning based on the application of appropriate algorithms for independent data analysis and identification of certain patterns in their structure and arrangement. Computer systems operating under machine learning are capable of self-improvement relying on collected and processed data, which allows them for solving their own problems.

technologies. In the latter case, the average expenditure per employee was $10.7 million. Technological corporations are willing to bear such high costs of acquisition of AI companies because they expect to receive multiple returns on such investments. According to the forecasts of the research company Transparency Market Research, over the next few years, the artificial intelligence market should grow with an average growth rate (CAGR) of 36.1 percent. By 2024 it should reach the value exceeding 3 trillion dollars [348].

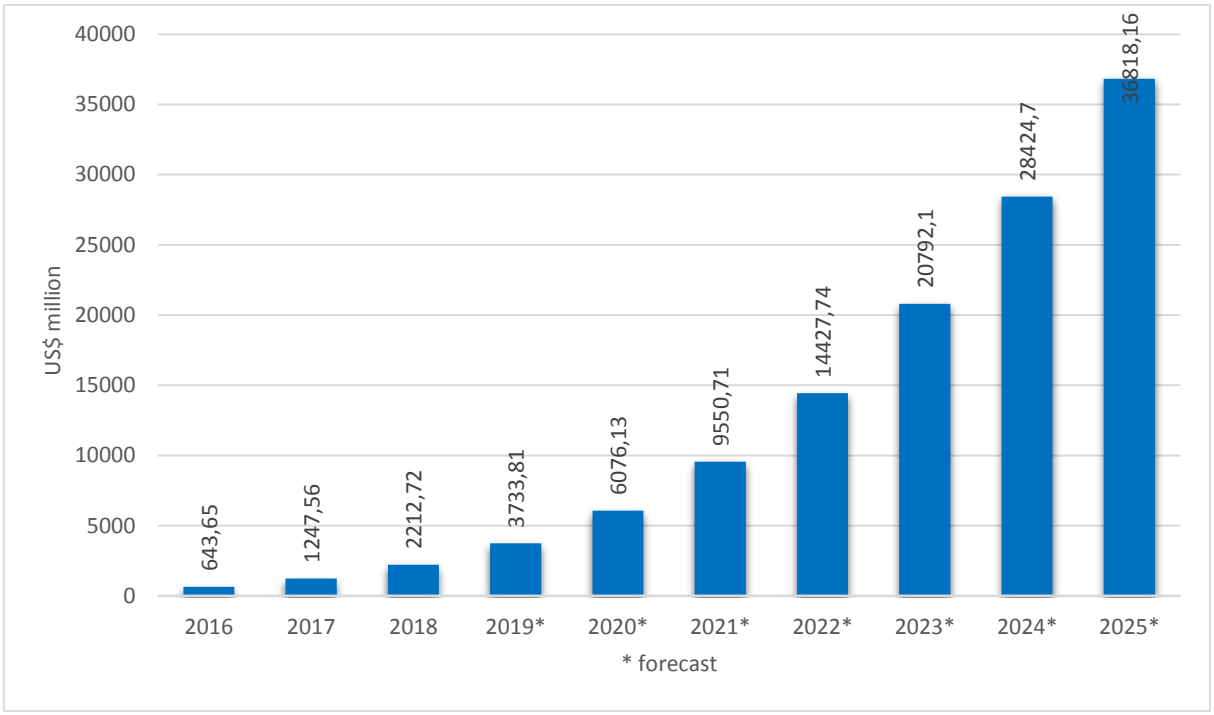
Risks related to the development of AI

There are also risks associated with the development of AI. First of all, humans generally do not tolerate the presence of robots in their environment, especially humanoid ones. Close company of the latter may even make people feel strongly psychically uncomfortable. This phenomenon is called the *uncanny valley* and consists in the fact that the more we try to create a robot resembling a human, the more difficult it is for us to resist the impression that it looks unnatural or even ghastly [241, pp. 98-100]. Looking at it, we see many unnatural details, such as limited facial expressions or artificial eyes, which arouse a general feeling of distrust, anxiety or even fear [326][303, pp. 337-351]. For similar reasons, we are afraid of vampires, mutants, cyborgs, zombies or even ordinary dolls, which are supposed to be similar to us, but are not. While robots do not have to be the exact copy of a human being, for practical reasons it is advisable for them to be at least a bit similar to us. Nor can we exclude the possibility that in the quite near future, there might be created robots resembling replicants from Ridley Scott's *Blade Runner* movie[78]. However, it seems that a more practical solution would be to design pseudo-humanoid robots, more toy-like, which would rather evoke pleasant associations due to their charming appearance [326].

Secondly, there is a real danger that Artificial Intelligence, at a certain stage of its development, will reach the aforementioned singularity, i.e. the point where Artificial Intelligence equals human intellectual abilities [178]. This could raise serious concerns as to whether intelligent robots could coexist in the future.

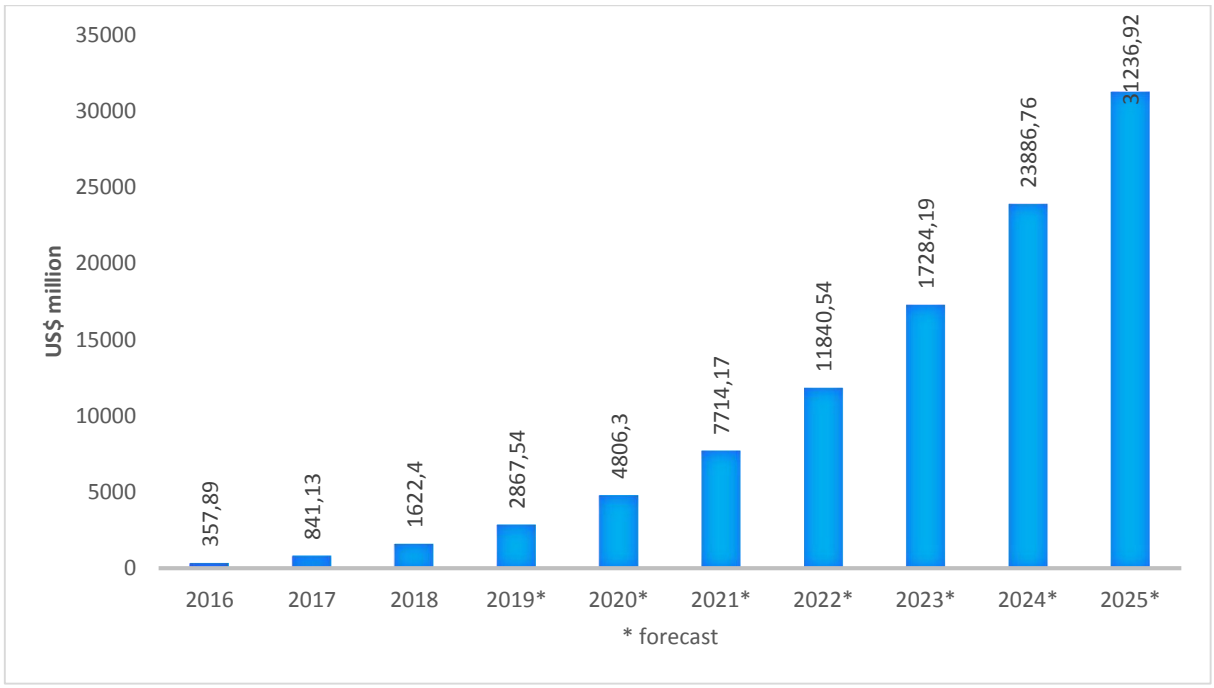
[78] In Ridley Scott's Blade Runner movie, the replicants were human-like machines created to perform dangerous tasks.

Chart 8.1 *Revenues from the artificial intelligence for business applications market worldwide, from 2016 to 2025 (in million U.S. dollars)*



Source: own elaboration (based on Statista data).

Chart 8.2 *Revenues from the artificial intelligence for enterprise applications market worldwide, from 2016 to 2025 (in million U.S. dollars)*



Source: Own elaboration (based on Statista data).

Table 8.1 *The up-to-date achievements in the field of AI*

Optimal It is not possible to perform better	Tic-tac-toe (also known as noughts and crosses or Xs and Os)	A simple program can handle up to 26830 possible games that can be played.
	Checkers (aka 8x8 draughts)	There are 500 trillion different pieces' configurations in the checkers game. In 2001, Professor Jonathan Schaeffer from the University of Alberta, Canada, developed an algorithm called Chinook, which covers a total of 40 billion of all possible scenarios for the game with twelve pieces (per side) on the chequered board. After compression, they occupied a total of 237 gigabytes of memory. The intelligent software knows exactly what movement is best [234][57].
	Connect Four	For classic Connect Four, there are 4.5 trillion possible games board positions. An appropriate AI-based strategy was developed in 1988.
	Rubik's Cube	In 2010, it was proven that each position can be solved by less than 20 movements.
Super-human AI performs better than all humans	Chess	The DeepBlue chess program is now characterised by a higher Elo relative skill level rating than the top players, including Magnus Carlsen, a Norwegian who is now a world chess champion. Carlsen has an Elo rating of 2882 and the intelligent chess program (DeepBlue) of 3353. The third position is taken by Kasparov with an Elo of 2851.
	Television game shows with questions on general topics	On 14th-16th February 2011, the Watson supercomputer defeated two of the best players in the famous Jeopardy! game show. Both players, that is to say Ken Jennings and Brad Rutter, won earlier in that game show more than $3 million.
	Diagnostics of lung cancer	IBM's Watson supercomputer is capable of selecting personalised therapies for patients' cancer treatment. It factors in genetic information, the most up-to-date medical knowledge and comparisons of individual patients' medical histories with their subsequent results [92][318].
	Piloting of fighter aircraft	In 2016, in simulated air fights, the intelligent ALPHA machine created by Psibernetix each time outperformed experienced navy fighter pilots [281].

High-human AI performs better than most humans	Go	In March 2016, the AI AlphaGo developed by DeepMind defeated a grandmaster Lee Sedol in Go game - 4:1. Go is a strategic game of incomparably greater difficulty than chess. To win in this game, it is not only necessary to make appropriate calculations, as in the case of many other games. The intelligent program teaches itself to replicate something very much like human intuition. AlphaGo's features allowed it to surpass human performance. Everything indicates that man will soon lose his monopoly on innovation and creativity. But before the AlphaGo AI reached the level that enabled it to beat the champion Lee Sedol, it had earlier played millions of parties against itself and against other smart software. In this way, after each game, it became a bit stronger.
	Self-driving	Technologies developed concurrently by most automotive companies and companies from outside the automotive industry, including Google, Tesla and Uber.
Par-human AI performs similarly to most humans	Speech recognition	Deep Speech 2 - a speech recognition system developed by Baidu. Baidu's intelligent software is now capable of recognising out of context phrases taken from different languages, such as Mandarin, and it performs much better than the average man.
	Object recognition	Artificial intelligence, created by engineers at Guadalajara University in Mexico, is utilised to recognize human silhouettes and faces. The machine captures the image with the use of a stereoscopic camera and subsequently, the intelligent software identifies human faces and body shapes.
Sub-human	Automated translation	BOLT is the universal translator that DARPA has been working on since 2011. The purpose of this technology is to translate all world languages in real time. This applies to both written texts and natural language. The aim of this project is to revolutionize communication between people. The operation of BOLT's intelligent software is supposed to be very simple: when the author writes or speaks in his own language, the recipient will be able to either read or hear these words in his own language. This project will most likely contribute to the revolutionisation of interpersonal communication. Skype, a company owned by Microsoft, is also working on a similar automated translation solution. In May 2015 the company presented its own automatic translator, which allows for making real-time video calls in various languages.

AI performs worse than most humans		Skype Translator also teaches itself and learns from its database to understand new meanings. The intelligent program analyses its previous conversations and thereby improves its effectiveness and accuracy. So far, the company has released only four language versions (English, Chinese, Spanish and Italian), however, this intelligent translator will eventually support all world languages [195].
	Image Sensitivity Analysis	In 2012, as part of the Brain project, Google's scientists created a supermachine that is composed of 16,000 connected processors and can be fed with videos originating from the YouTube service. After seeing several million images, Google Brain was capable of recognising some objects and living beings, such as cats. Google's artificial intelligence can recreate the behaviour of millions of neurons and billions of connections between them. Thanks to the analysis of lines and colours, the software based on artificial intelligence is also capable of effectively analysing the meaning of different images, including the identification of images created as a result of the combination of incompatible pixels, which are by its nature difficult to interpret.
	Certain tasks performed by humans	Honda's ASIMO robots. ASIMO has the capability to twist its hips, bend its neck, wrists, and fingers. It is also capable of recognising human faces, approaching them on request, following their movements hand-in-hand, and even running at a speed of up to 6 km/h, carrying weights of up to 1 kg. Another example are robots developed by Boston Dynamics.

Source: Own elaboration.

Virtual assistants

Artificial Intelligence is used to develop "virtual assistants" (chatbots), which are intelligent software systems that conduct conversations with users at a level that is near to that of humans. An example is SIRI, an iPhone application that communicates with people in natural language[79]. The application recognises its user's questions and finds answers to them on the basis of the data retrieved from the Internet. A device called Echo created by Amazon works similarly to Siri [232, p. 129]. It communicates with the user using natural language. All

[79] Apple acquired Siri in 2010 and paid between $150 and $250 million for it.

you have to do is to say the magic word "Alex" (Echo becomes ready to work then) and you can start asking the machine questions. These can include the weather, current news, searches for information on the Internet or shopping. When asking Echo *Will it be raining in a specific city tomorrow? At what time is the nearest train from the city A to the city B? or How old is the President of the United States of America?* - the device will be able to answer all these questions within seconds. Amazon continues to develop this technology. The latest version of the Alex assistant platform allows its users to even dim the light or turn on the radiators in an apartment. The same applies to the home management system Google Home and mobile communication applications Google Allo and Google Duo. In the future, these technologies may become the fulfilment of dreams about intelligent home management. Facebook leader Mark Zuckerberg already announced the creation of a super-assistant which will make it possible to manage home devices only by voice and ultimately to replace people with the management of the entire home. At the current rate of technological change, the road from the Amazon voice assistant to the HAL 9000 supercomputer[80], known from Arthur C. Clarke's famous novel 2001: Space Odyssey may be even shorter than we all think. With the development of IoT technology, more and more intelligent gadgets connected to the network will also start to appear soon. Intelligent machines such as Echo, Siri, Cortana or Google Now, with which there is a possibility of communicating in the natural language, are therefore very much needed because they enable the management of all these devices operating in the network.

Machine learning

Machine learning is a method of machines self-learning, which consists in self-improvement of algorithms and their autonomous data analysis that is supposed to solve some predefined problems. Based on the data collected and processed on an ongoing basis, intelligent software develops and modifies the models which it uses in a continuous and automatized manner, allowing it to better interpret the analysed problems.

[80] The HAL 9000 supercomputer featured an exceptionally efficient voice communication, which made it a virtually equal interlocutor with people.

With machine learning solutions, intelligent systems interpret specific situations and decide on specific actions on the basis of collected data and previous experiences.

Machine learning is used to solve many complex problems, including recognising the emotions present in the human voice [226][237]. This is done in such a way that deep neural networks classify and evaluate individual phonetic and prosodic elements of each phrase, such as the accent and intonation[81]. In this way, the machines determine the emotions implicit in each statement, e.g. joy, sadness, indifference or even anger. In turn, the Chinese developed a machine learning based method, which with almost ninety percent efficiency makes it possible to recognize the faces of criminals [378]. The neural network created by Chinese scientists is based on three important physical facial characteristics which help to determine whether someone is a criminal or not. It is about the arrangement of the upper lip (most criminals have convexly curved their upper lip), the angle delineated by the lines connecting the tip of the nose with the corners of the mouth (criminals usually have this angle smaller) and the distance between the corners of the eyes (such distance is typically shorter for criminals).

The case of Amazon

Amazon aims to use self-learning algorithms in the retail sector in order to make it easier for customers to make choices and increase the comfort of shopping, and consequently also to boost traffic and sales in the stores themselves [24]. Artificial Intelligence collects and processes valuable data about customers and their behaviour. This, in turn, allows for the optimisation of a variety of processes related to sales and the supply chain. It also contributes to a significant reduction in costs. Real benefits also flow to consumers, who can thereby take advantage of significant price reductions and various types of smart contextualised recommendation systems[82] or programmes that make it easier to find the right products online. An example is a shop opened by Amazon in 2015, where the assortment offered is

[81] Prosody - a study of the structure of speech which deals with the aspects of accent, time and intonation.
[82] Context systems are systems that collect and provide data to applications with respect to users' earlier online behaviors and expectations, including their location, habits, preferences, etc. This allows intelligent software to find the most suitable offer for them.

selected on the basis of ratings given by Internet users. Only items that are very popular among online shoppers are also available in the stationary shop[83]. In the future, smart machines will probably be even able to recognize the feelings of online shoppers. It can, therefore, be expected that a whole range of revolutionary AI tools will soon be developed for the e-commerce sector.

Robots will not replace us

According to Anders Sandberg, who is a renowned expert in computer neurology, if we ever manage to create a fully autonomous robot, we must be aware that it can regard its existence as boring and try to change it contrary to the expectations of the people who created it. On the other hand, such intelligent robots could turn out to be as unpredictable and unreliable as burned-out employees [326, p. 53].

There are many nagging questions concerning intelligent machines. One of them is the question of whether the robot should look like humans. Opinions are divided on this issue. On one hand, the entire infrastructure that surrounds us is adapted to people's physical conditions and needs, including doors, chairs, stairs, everyday objects, etc. It is therefore obvious that robots built in the likeness of man will find it easier to adapt to this infrastructure. Undoubtedly, it would also facilitate communication between the machine and the man himself.

Non-humanoid robots may find it difficult to adapt to the external world, which is largely designed to meet human physical characteristics and needs. Robots that are not created in the likeness of a human being may not be able to cope with some of the activities that people perform on a daily basis, such as handling everyday objects, opening and closing doors or climbing stairs.

There is no need for the robot to be an accurate representation of a human being, but for practical reasons, it is advisable that the robot resembles a man. Human-made robots do not necessarily have to resemble the replicants from Ridley Scott's *Blade Runner* movie. In the

[83] On-line stores are knowledge base about customers. They allow for familiarising with expert reviews and opinions of other customers who have previously made purchases.

case of robots designed to care for sick or elderly people, their behaviour towards their wards is far more important than their appearance. It is debatable, however, whether elderly and sick people should in principle be entrusted to the machines. After all, it is not only a matter of making intelligent machines work for their wards and performing certain mechanical tasks, such as cleaning, carrying heavy objects, transporting, etc. Taking care of the other people requires much more sophisticated activities. Taking care of other people requires much more sophisticated activities, such as caring for the dependent person, taking care of his/her comfort, both physical and mental, wishing to improve his/her health, and feeling happy if such an improvement occurs. It is also a feeling of satisfaction resulting from the situation that the dependent person is staying in a friendly environment and feels comfortable. It is doubtful whether the ability to express this kind of feelings will ever be programmed in the machines. After its ward's death, the robot would at best be able to merely send a message to the central system (provided it would exist), in which it would inform the relevant intelligent services (e.g. a master robot) about the respective error code and then would wait for the assignment of a new task. Perhaps engineers should not even attempt to build robots, which in principle would try to become our companions for spending time with. In Sandberg's opinion, it is more advisable to create machines intended exclusively for performing specific functions and tasks [326]. In turn, according to J. Bryson, the safest solution for us would be if robots remained our slaves forever [42, 63-74][84]. If we appropriately program such a "robot-slave", we will reduce the potential problems to which such intelligent machines may be exposed in the future. The aim of the robot should not be excessively general, otherwise it may result in serious problems in the future. Even today, commonly used industrial robots are the cause of many accidents among people. They usually occur due to casual failures and malfunctions. Regrettably, there are also fatalities. Nick Bostrom, a well-known populariser of topics related to transhumanism and artificial intelligence, explains how AI and intelligent machines could annihilate us in the future [34][47]. He gives an example of a robot whose hypothetical task would be to make its ward laugh. Initially, such a robot would probably try to tell the man a few funny anecdotes or jokes. After a few unsuccessful attempts, however, the robot could come to the realisation that this task can only be solved by driving an electrode through its ward's brain and stimulating it with a current.

[84] J. Bryson is the author of the talked-about article Robots should be slaves [42].

It is also hard to expect that robots will ever in the future understand the concept of happiness, let alone feel it. For this reason, they will not be able to come to the conclusion that the reason for people' smiles are not physical and chemical reactions occurring in their bodies, but their pleasant feelings. Therefore, it is even difficult to envisage a universal algorithm that could make every person laugh. After all, human laughter and smile are not caused solely by logically motivated situations. Often the opposite is the case. Apart from that, each of us has a different sense of humour, which results from a unique mix of individual experiences. The sense of humour is tied to intelligence and emotions, and the very mechanism of humour action depends to a large extent on experiencing something that is cognitively new, surprising, or on the combination of factors that do not fit together, and/or on breaking some stereotypes [212]. Undoubtedly, algorithmicising such problems is not an easy task and until now it remains unknown whether it will ever be possible.

Robots should be designed according to the concept of value alignment, i.e. they should be guided in their operation by values similar to those of people. It is therefore important to think about creating specific rules for intelligent machines. That would be a kind of Code of Conduct for the robots. Of course, it will not be easy to create such a code, because humanity is divided as to what is essential in life. Philosophers have been wondering about this problem for centuries and to this day they have not established anything definite.

Robots autonomy

Robots will only become fully autonomous when they are able to determine their own goals by themselves, and provided, of course, that this will not be the result of their being pre-programmed for such an eventuality by a man. Against this backdrop, we cannot consider a robot to be fully autonomous, simply because it is pre-programmed to defeat a human being in chess or in Go game. In the future, in order to achieve a more complex main objective, the robot will have to make a number of subsequent minor intermediate choices. As an example, think of a robot whose main purpose is to get to a specific room and leave there a corresponding delivery. In accomplishing this task, the robot courier may encounter a number of problems. One of these can be, for example, a closed door. When confronted with such situation, the robot can come to the conclusion that the easiest way to access the interior is to smash the glass. There are, therefore, quite reasonable grounds for believing that in future,

we will often ask ourselves how it is at all possible that an intelligent machine can behave in a way that is completely incomprehensible or even irrational for us. The more difficult the primary target is, the more likely it is that the robot will not behave as expected and will make serious mistakes. The level of autonomy of a machine will be determined by its ability to perform a sequence of previously unscheduled activities towards its primary goal. A fully autonomous robot can eventually refuse to execute human commands by considering them simply boring and pointless. This raises the following questions: should we strive to build a fully autonomous robot? Could a fully autonomous robot pose a threat to us? Would their existence not entail a serious risk, which would actually expose us to a number of dangers? Would such autonomous machines not be more inefficient than people? There is also an important issue that cannot be left unresolved, namely the problem of responsibility for possible damages caused by the robots. Of course, in the case of owning a robot or an autonomous car, there will be an obligation to have an adequate insurance. However, insurance alone will not eliminate all hazards. The responsibility for any possible damages could be potentially attributed to the owner of such a machine who uses it against its destination. However, it will be extremely difficult to prove that the owner is guilty. The situation becomes even more complicated when we will be dealing with autonomous robots. It will be extremely difficult to put the blame on the manufacturer of such a machine in relation to any damages caused.

Perhaps in the future, there will be entire armies of robots waging war against each other, capable of destroying everything they encounter on their way. Contrary to ordinary soldiers, such machines are probably not going to have any reluctance when it comes to killing ordinary civilians. Possible negative consequences of constructing robots for military purposes were raised by, i. a. Stephen Hawking and Elon Musk, who wrote even a special open letter covering this issue. However, it appears that the very process of establishing an army of murderers cannot be stopped. The military spends huge amounts of money on new technologies, including those related to the development of artificial intelligence. Although some military officials are now rather sceptical about the use of robots on the battlefield, history shows that all pragmatic technological solutions are eventually accepted by the military. Importantly, they can prevent loss of human life. An example are the drones, which are ideal for various military operations and are frequently used by army commanders. There is no doubt that there will be no difference when it comes to robot soldiers. The thing is that

these machines must not be used for purposes for which they were not designed. There are experts who even recommend the elaboration and enforcement of a specific 'Geneva Convention' for machinery, which would prevent various types of misuses.

Humanoid robots

In 2015, in the amusement park near Nagasaki, the Japanese opened the Henn-na Hotel in which the service is performed exclusively by humanoid robots[85]. The machines welcome and receive hotel guests at the reception desk, carry their luggage and clean guests' rooms after their check-outs [274]. The example of the Henn-na Hotel demonstrates that robots not only can be utilised on production lines but can also replace people in the service sector. As a result, the Henn-na Hotel is today one of the most cost-effective hotels in the world [258]. Converted into Polish zlotys, a single night price in the Henn Hotel oscillates around PLN 200, which is not too high as for Japanese conditions.

Robots are replacing people more and more often. This process is irreversible. The example of the Japanese Henn-na hotel shows that, apart from the production sector, the robots also can find useful applications in the service sector.

Technological progress and increasingly intelligent industrial robots allow entrepreneurs to replace their workforce by robotic automation. From the businessman's standpoint, machines are cheaper than people, they do not become tired as human beings, they do not get sick and they can work continuously without any significant breaks (24/7), which is practically impossible in the case of a human being. Only a few years ago, the prospect of people being pushed out of the labour market by machines might have seemed, at most, a very distant futuristic vision. Now it is simply happening before our very eyes at an unprecedented pace. The driving forces behind these processes are, of course, the issues of improving work efficiency and financial effectiveness, which persuade entrepreneurs to launch automation processes in their firms. Some people have even started to worry about the state of matters to such an extent that they have come up with proposals for robot

[85] In Japanese, the term *henn-na* means 'strange'.

taxation. One of the supporters of this idea is Microsoft's former CEO - Bill Gates, who says that the revenues from machine taxation could be potentially used for activation measures to bring excluded people, who lost their jobs as a result of the automation processes, back to the labour market. The tax money can also be used for education purposes [107].

According to Bill Gates, machines which perform the same work as humans should be subject to taxation like ordinary workers. A robot tax would be payable by companies utilising such intelligent machines for their business activities.

Bill Gates argues that part of the robot taxes could also be used to help the elderly or to cover the cost of caring for children with special needs. On the other hand, each robot and every automation process contributes on its own to the improvement of productivity and the increase of companies' profits, and therefore implies higher taxes paid to the State budget.

The negative social effects of automation should be tackled by means of systemic solutions. According to Bill Gates, the key role in this matter must be played by the state, which ought to be actively involved in the fight against social inequalities. People should under no circumstances be discouraged or even prevented from continuing to implement the automatisation. Therefore the introduction of an appropriate 'robot tax' seems to be a better solution than any restrictions or prohibitions.

Another acceptable solution would be to introduce the unconditional basic income, which would provide a form of compensation for replacing human work with the work performed by machines. Given that such ideas were not implemented before on a larger scale, it is now difficult to predict whether the introduction of such measures would entail particularly negative social and economic consequences. It is very possible that, in the long run, such an unconditional guaranteed income would exacerbate the already large social inequalities. People owning more robots would not only earn more than others but could even reinvest their profits in additional machines, and thus obtaining a certain multiplier effect. This, in turn, would lead in the long term to an even greater increase in inequality.

At the end of 2016, the White House administration presented the report entitled Artificial Intelligence, Automation, and the Economy, which in many aspects coincided with

the theses put forward by Bill Gates [191][94]. It showed that the least educated and lowest paid workers are the most susceptible to job losses due to automation. The report also drew attention to the need for the development of appropriate system solutions that would support people threatened with losing their jobs due to automation processes. The subject of automation and artificial intelligence was also raised in 2017 by the European Parliament, which began its work on the preparation of appropriate regulations. They will cover not only the implementation of intelligent machines but will also address the regulatory framework for the development of autonomous vehicles. The EU has also considered the taxation of robots and the provision of systemic assistance to people susceptible to losing their jobs due to automation, but this issue has not been yet adequately supported.

Although many people feel threatened by the prospect of losing their jobs due to automation, it is hard not to notice that in some cases job substitution is even advisable and can bring many measurable benefits. This applies in particular to dangerous activities, the performance of which is connected with the possibility of a health loss. For example, a Polish copper producer, KGHM, has plans to launch in the near future its copper ore mining operations with the use of intelligent machines controlled by neural networks [147]. They will replace miners in particularly difficult geological conditions, i.e. at depths below 1200 meters where the temperatures of rocks are around 50°C. Unlike people, who are forbidden by law to work in such harsh conditions, robots are not only resistant to such high temperatures, but also the costs associated with their operation are about 30 percent lower compared to the work performed by miners.

9 VIRTUAL AND AUGMENTED REALITY

The virtual and augmented reality (VR/AR), which is now among the fastest growing technologies in the world, is entering global markets more and more boldly. Interestingly, as early as in the 1990s there were attempts to popularize these technologies, but then they failed. At the time, this was due to the fact that information technology was not yet developed enough to cope with the complexity of many problems. Since then, however, there have been significant technological advances. Hundreds of thousands of software companies have emerged developing software for a variety of digital environments. It is hard not to overlook the fact that today the situation looks much better and that we are all more prepared to take our increasingly extensive experience of dealing with the digital world and looking at the virtual (digital) reality to an even higher level. Today, the digital reality accompanies and surrounds us practically everywhere. The integration of each of us with digital technologies is becoming stronger and stronger, and this can be seen practically every step of the way. It is accompanied by intense psychological feelings resulting from the fact that we become mentally dependent on digital technologies.

According to forecasts made by the International Data Group (IDG), by the end of this decade alone, the value of software, content and services created for the needs of virtual and augmented reality will have increased by nearly $160 billion. On the other hand, Digi-Capital expects that revenues from the VR/AR market will reach the level of approximately USD 120 billion in 2020, of which e-commerce will account for as much as 30 percent [193, pp. 78-85]. An equally optimistic forecast was made by Goldman Sachs, whose analysts claim that by the middle of the next decade the virtual reality market will be worth USD 182 billion and will become larger than the television market [77][86].

In this rapidly growing virtual reality market, such giants of new technologies as Facebook, HTC, Samsung, Sony, Microsoft, Intel or Google are trying now to secure their place. In 2016, a record amount of USD 2.3 billion was invested in the development of virtual and augmented reality, which represented a 3 percent increase of the total investment in this sector compared to the previous year [77]. In the same year, the most modern and specialised

[86] Taking into account the expected value of the software. The equipment market alone will be valued at USD 110 billion.

devices, which according to experts may cause a real revolution in digital technologies, had their premiere. These are the Oculus Rift and the HTC Vive. Since the launch of these amazing technologies, Facebook and HTC have become major players in the VR equipment market. The Oculus Rift and HTC Vive goggles are devices that are regarded as a gate to another world. They allow users to watch films in 360-degree technology, and the digital environment viewed by them looks almost the same as real. These devices give the user an impression of being in the very centre of the digital world. They allow for looking at all directions, raising and lowering the head, without losing the feeling of the reality of the observed scenes. Apart from Oculus Rift and HTC Vive, there are also other VR sets that are very popular, e.g. Gear VR (Samsung), PlayStation VR (Sony) and HoloLens (Microsoft). Also, Google takes part in this competition. The Mountain View Company develops its own VR platforms. In 2014, it launched the Google Cardboard VR platform, which is used together with the cardboard goggles and a smartphone. By now, such cardboard goggles have been used by several million people, and Google's VR application dedicated for their use has been downloaded from the company's website tens of millions of times. The Mountain View technology giant continues to develop new virtual reality solutions. In the autumn of 2016, it launched a new VR platform called Google Daydream, which provides an even more accurate representation of the real-life conditions. This platform is supported by the new, seventh generation of the Android operating system called Nougat.

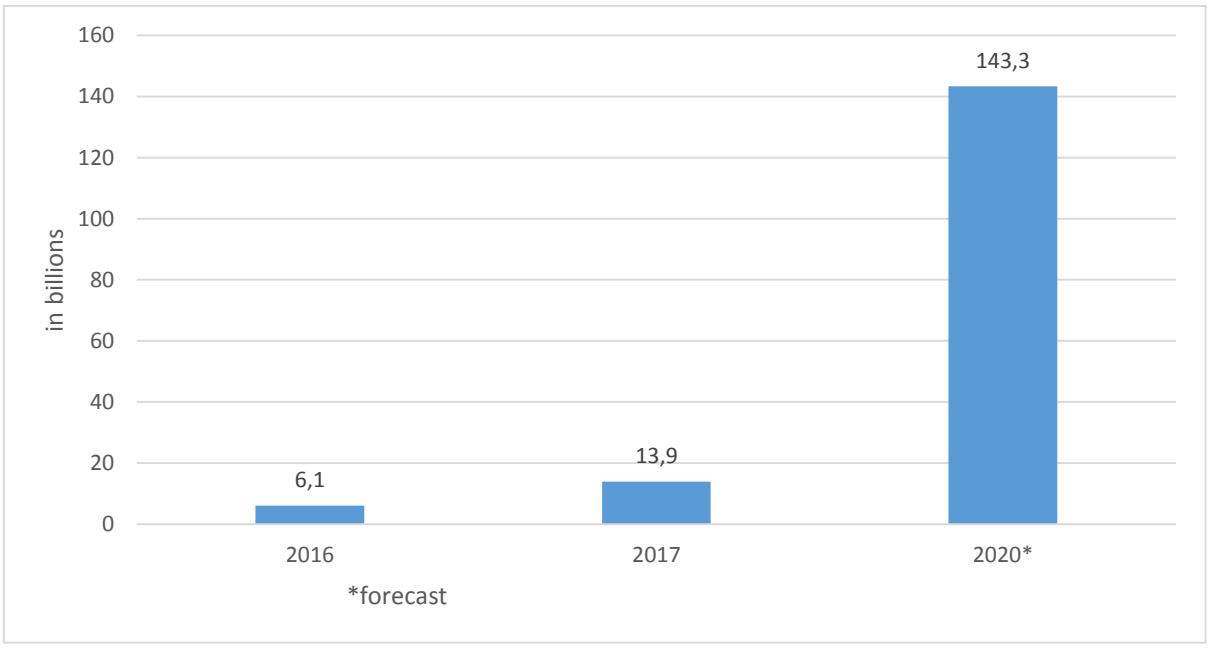
It is possible that over time, VR technologies will allow their users to move into a fairy tale world of visual sensations, sounds, smells and even tastes. So far, VR is not developed enough to make the virtual world experiences fully comparable with those of the real world. Naturally, we can expect much better performances in the future.

Today, virtual reality technology only offers visual effects. VR Goggles already allow for moving to another dimension (i.e. to a virtual place). Ultimately, however, the VR technology will also provide the sensation of motion, sound and smell.

The augmented reality allows for designing an effective interface ensuring easy communication between a man and a digital machine [140, p. 634]. This is yet another confirmation that the difference between the digital and real worlds is slowly being blurred. It is highly probable that VR and AR will bring a real technological revolution in the future that

will change the face of many industries. The key to the popularisation of these technologies lies not so much in their growing hardware capabilities as in the greater availability of appropriate applications that allow them to fully utilize their already existing potential. With time, available content and VR/AR software will become much better, and not only in the video game segment. However, of course, they will continue to be the main driving force behind these technologies for a long time to come. This also applies to VR/AR applications, thanks to which we will be able to travel virtually, watch sports events or virtual presentations of merchandise, which we will be interested in buying. Today, leading VR/AR developers are well aware of the perspective of the VR/AR application and gaming market and are therefore prioritising their search for appropriate acquisition opportunities in this market segment. Hence, Google's investment in VR development studios, such as Resolution Games or Owlchemy Labs [120][219]. The analytical company Tractica estimates that in 2021 the VR application market will reach the value of approx. USD 15 billion [340, p.3]. VR apps will find their use in many industries and will be specifically customised towards the needs of their end-users.

Chart 9.1 *Estimated (aggregated) size of the virtual and augmented reality market in years 2016-2020*

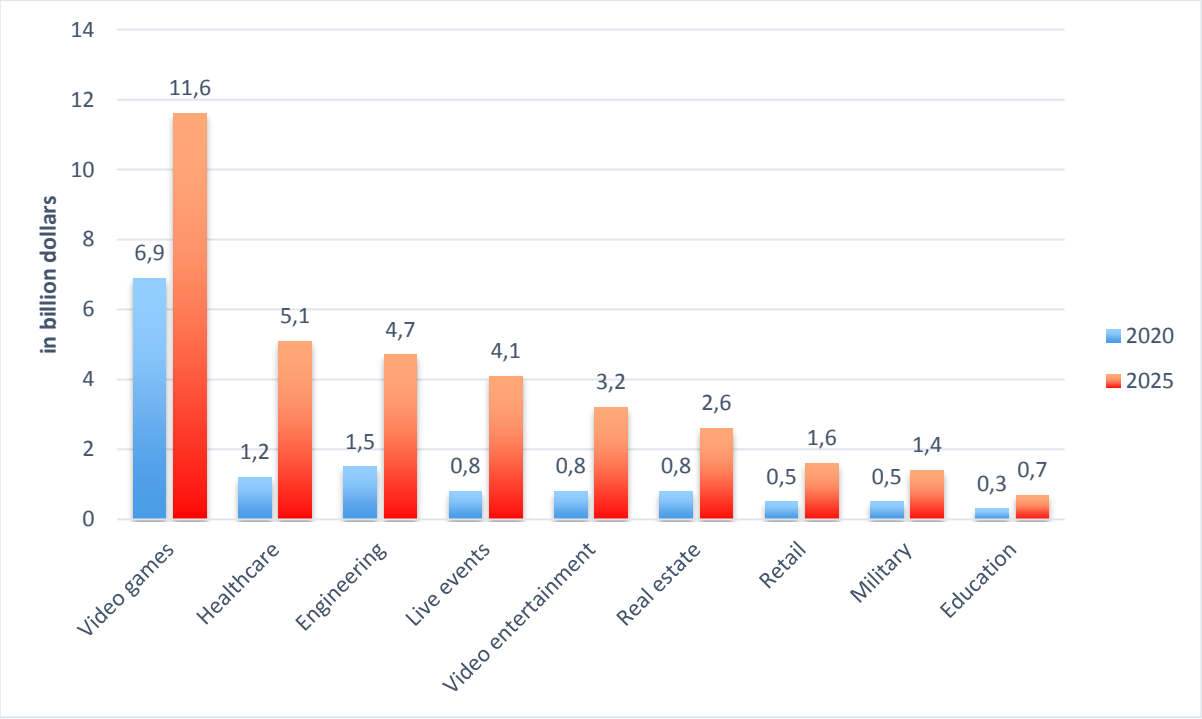


Source: Own elaboration (based on IDC data).

To a similar extent, investors are also interested in the augmented reality technology. For many, the first foretaste of what it might bring in the future was the Pokemon Go game

[307]. The augmented reality connects the digital world with the physical and biological worlds. This is achieved by imposing computer graphics on objects or people. One of the most recent developments in this field is the new generation of Spectacles glasses developed by Snapchat [40]. They are fitted with a special camera which allows the user to view the surroundings in VR/AR mode, as well as to record short spherical videos and upload them directly to social media portals. The company has been working on this technology since at least 2015 [382]. Almost from one day to the next, we hear news of companies rivalling with each other in the development of newer and unique VR/AR innovations. VR/AR technologies are growing rapidly and are finding more and more applications in the key market areas. The most promising areas of application are video games, medicine, engineering and industry, entertainment and media, real estate, e-commerce, military and education.

Chart 9.2 *Forecasted sizes of individual VR/AR segments. Comparison for 2020 and 2025*



Source: Own elaboration (based on Goldman Sachs data).

Another revolution in the field of virtual reality is the creation of solutions based on mapping real spots, which can then be accessed with the use of special virtual reality devices. One of the initiatives being implemented in this area is the Tango project, developed by Google, which aims to create appropriate tools for visualising the interiors of buildings. This

technology is intended to motivate entrepreneurs, investors and programmers to create dedicated VR applications. This type of solutions could be used e.g. by stores willing to guide their buyers to the right shelves.

Also noteworthy is the Alloy project developed by Intel, which consists in the realisation of the idea of combining virtual reality with the real world (so-called merged reality) [310]. In this merged reality, the boundaries between the physical world and the digital world (digital reality) are blurred. However, when the user puts on the right goggles, not only does he or she see the virtual world, but he also has the possibility of introducing into it objects from the real world.

VR 360° Films

VR 360° film is an imaging technology that gives the viewer an impression of being at the heart of an action plan. Thanks to it, the viewer is no longer constrained by the rectangular frame of an image but can leap in for one moment to the filmed world of the virtual reality and see everything around. Watching 360° films gives an unforgettable experience of being in another reality, which can be felt naturally by looking around and concentrating on specific places and objects. 360° films are shot with a single spherical video camera or recorded separately with multiple cameras and then edited into one piece. The three-dimensional images are captured with the use of special rigs and stereoscopic technology which ensure that each eye sees the image slightly shifted, thus creating the impression of three-dimensionality. The best way to watch such films is by using the VR goggles, e.g. Oculus Rift, HTC Vive or Gear VR.

Medical sector

One of the key industries that will undoubtedly benefit from the development of VR and AR technology is medicine. The use of VR/AR solutions in this area is primarily related to virtual operations and training courses. An example is the integration of the HTC Vive goggles with the MeVisLab medical platform, which enables visualisation of the surgical sites [84]. A surgeon who uses the goggles sees a digital operating environment that is very close to the real environment. Thanks to this solution, he/she can view the exact spots which require

surgical intervention. What's more, he/she also can see his/her fellow doctors in the digital operating room, and if necessary, he/she is able to consult them on an ongoing basis on any questions and issues concerning complicated medical procedures. Such a tool is certainly invaluable. Already today, there are interactive VR applications for the Oculus Rift goggles, which in combination with the Leap Motion controller allow for training simulations in maxillo-facial surgery [271, pp. 187-202]. VR technology is also widely used in psychotherapy as one of the methods used for the treatment of patients with anxiety disorders and phobias. An example is the treatment of children with autism. On the other hand, the augmented reality technology can be used to impose key information, such as ultrasound measurements, directly on the patient's body (in the form of a 3D image). VR and AR solutions will have a real impact on the quality of medical care in the future.

Entertainment

Solutions based on virtual and augmented reality create new ways of enjoying digital entertainment, whereas the number of people interested in VR/AR entertainment is continuously growing. VR Goggles are becoming increasingly popular and seem to be the future of video games and e-commerce. Thanks to them we can easily and cheaply move around many virtual spaces. The potential of virtual reality is also recognised by such giants as IMAX, which is currently creating a network of special virtual cinemas, which allow spectators to move to the extraordinary world of virtual reality and thus experience unforgettable impressions. The first such facility was opened in February 2017 in Los Angeles [324]. The company wants to create 25 special film productions allowing the spectators for moving into the digital world.

Also noteworthy are initiatives such as the creation of game rooms and VR amusement parks. One of the first such facilities is the centre of the British company The Void, which was opened in mid-2016 in Salt Lake City, USA [270]. The company has turned virtual reality into a breathtaking entertainment, which is more thrilling for many than a roller coaster or a bungee. With special VR glasses and a special vest and gloves fitted with sensors, one can feel like a ghostbuster for a moment or play the role of a knight who fights against dragons. A similar centre of virtual reality - Disco: VR - was also established in Poland, in Warsaw's Mokotów

district, and is now considered the largest of its kind in Europe. Thanks to VR amusement parks, the recipients of these technologies are not dependent solely on the passive use of VR glasses. For example, Disco: VR has already announced the introduction of a multidirectional treadmill, which will soon allow the user to move around the fictitious world. In turn, HTC plans to open a thousand VR cafes. The first such facilities have already been created in China.

Worth mentioning is also the American company Tesla Studios, which has developed a special haptic feedback ensemble - Teslasuit, which allows for the reception of stimuli from the world of virtual reality and significantly raises the level of immersion, i.e. the depth of sensations of a person who uses it [282]. The company demonstrated the capabilities of this technology in the paintball game. The experience of the people involved in this game is very similar to that which can be felt in the real world. Players feel the striking of paintballs almost as if they were in the real world.

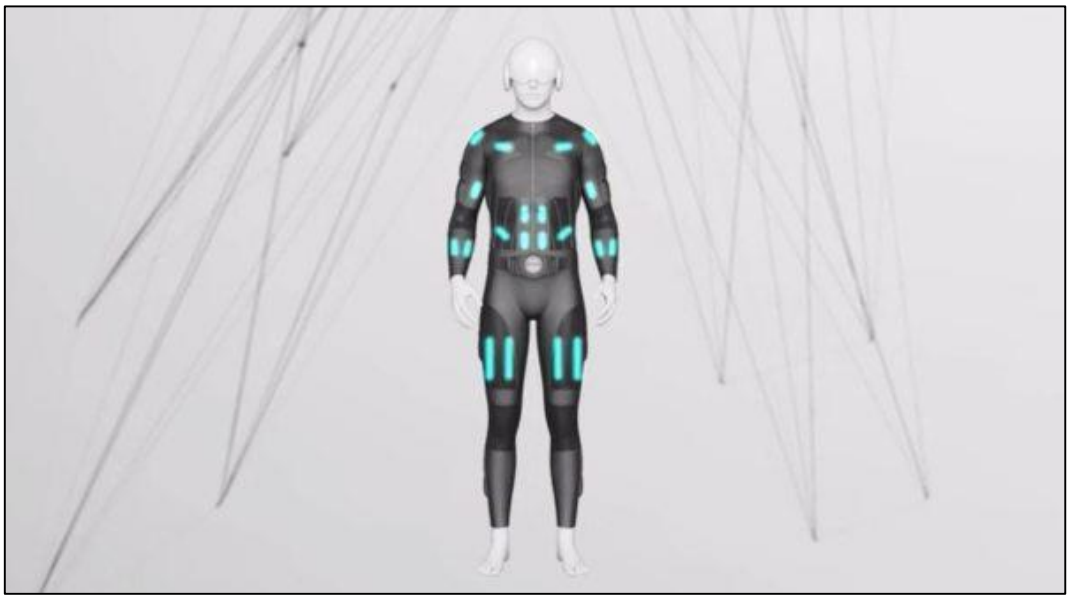


Illustration 9.1 *Teslasuit, an outfit that allows for receiving stimuli from the world of virtual reality, Source: Engadget*

Live events

Thanks to VR technology, some selected sports, music and entertainment events (so-called live events) can already be enjoyed in the virtual reality. One of the companies that provide such a service (VR Live Pass) is Samsung. It can be used by all those who own Gear VR mobile goggles (Samsung).

The use of VR and AR technology is becoming more and more popular among fashion designers and retailers, who in this way want to attract fashion enthusiasts. An example is Dior, which equipped its boutiques with its own VR sets called Dior Eyes. Thanks to these devices, boutique customers gained virtual "live" access to the fashion shows organised by Dior and to the so-called backstages, i.e. interesting events occurring behind the scenes [131]. Dior Eyes is also considered the first device in the world that introduces its users not only into the world of virtual reality but also allows them to hear the sound from the places where such events occur. Thanks to VR technology, fashion enthusiasts can now find themselves in the very heart of the most prestigious fashion shows. Also noteworthy is the production of subsequent films based on virtual reality. One of such films is Unstitched Ruvan Wijesooriya, a film that presents the viewer with the backstage of a special photo session [117].

The unquestionable leader in live VR transmission solutions is Intel [305]. In late 2016, the Santa Clara giant acquired Voke, a company that developed a revolutionary technology that completely transforms the way in which television broadcasters and organisers of sports, cultural and entertainment events can interact with their viewers. Intel True VR spherical camera sets mounted in different spots of sporting, cultural or artistic facilities, i.a. in the concert hall, or around the ring of the stadium's seating bowl, allow for a 360-degree streaming of artists' performances or sports events in real HD technology [275]. What is important, the users of this technology can freely switch between different video and sound sources, thanks to which they can receive an extremely high rendering of the conditions prevailing in the place from which the transmission takes place (the so-called immersion). In order to generate high-quality VR transmission, Intel devices use a very high computational power.

Home and office use

In the future, VR technology will become so pervasive that we will use it in our homes and offices on a daily basis. There will probably be a host of consumer products and tools which will flood the market. One example of the application of VR technology for office (business) purposes are conferences and business meetings held in virtual space. A practical

application of VR technology in domestic use will be the possibility to watch a match or a concert at home, either from the perspective of a stadium or from the stadium stands.

In the future, we will be able to connect the digital world with the real world and thereby augment our working environment with additional functionalities (e.g. virtual calculators, virtual lockers with digital content, etc.), without the need for additional investments in hardware.

Engineering and industry

The interest in VR and AR technologies is becoming more and more evident also in the engineering industry. Thanks to VR/AR solutions, the creation of complex prototypes of devices becomes easier than ever before and is even carried out without the use of any materials. The industry sector is also keen to use VR and AR solutions for training purposes. They are also utilised by technicians (service personnel), who now can see technical and service instructions on the devices themselves in the augmented reality. AR technology makes their work easier and significantly reduces the risk of their making mistakes. To illustrate this, we can use the example of an airline technician (serviceman) who repairs complex components of a passenger plane and whose work determines the safety of many people on board of such aircraft. Availability of AR technology can support such a service technician in scanning relevant parts' codes and quickly verify that they are installed properly. Thanks to the use of appropriate augmented reality devices (i.e. hardware and software), the service technicians have access to the visualisation of the assembly or disassembly of individual components. Systemic reduction in the number of errors made by such technical personnel translates directly into the safety of all airline passengers. Aircraft maintenance is just one example of the possible use of AR technology. Similar AR applications are increasingly used in industrial plants or in the service sector. They improve work efficiency, reduce mistakes and result in higher quality products and thus a better reputation in the eyes of customers.

Also noteworthy is the social initiative to create industrial networks of experts, combining the experiences of both technicians and experts in specific fields. This solution is mainly used by technical and support personnel confronted with complex technical problems requiring more extensive professional knowledge.

Tourism industry

VR technologies give the tourism industry a chance to attract new customers. Usually, when faced with the need to choose a specific tourist offer, prospective customers are confronted with several uncertainties and doubts. They usually address their inquiries to vendors who are not always able to help them, and what they hear from them often diverges from their later experiences, emotions, and impressions taken from their holiday destinations. Therefore, the best way to solve this problem would be the opportunity to see how these holiday destinations (including hotel facilities) look like with one's own eyes. That is why so much hope is placed now in the virtual reality, thanks to which even before making a decision about the desired holiday destination everyone interested will have an opportunity to have a closer look at specific destinations in virtual reality, including the surroundings (e.g. a beach) of the exact holiday venue and hotel infrastructure. Thanks to VR devices such as VR goggles, every prospective customer will soon be able to move to the very heart of the hotel facilities without even leaving his/her home and incurring any special costs.

Virtual reality also provides a great opportunity for the development of the tourism industry. In the future, before making a decision about purchasing a specific holiday package or booking a hotel room, any prospective customer will first be able to see with his/her own eyes which offer suits the best his/her expectations.

The British leader in this market, the Thomas Cook Company, has recently announced that it will equip 880 of its German branches with special glasses for virtual reality [205]. VR reception devices (VR goggles and smartphones) will also be available to some of Thomas Cook's affiliated offices, namely Neckermann Reisen branches and its franchise partners, which form an integral part of the Holiday Land Group. The company plans to provide its customers with several-minute VR films, on the basis of which they will be able to familiarize themselves with the holiday destinations offered by the network of travel agencies and also see the hotels facilities themselves with their own eyes. These materials are prepared by the Group's employees on their own journeys [331].

The British company came up with the idea of using the potential of virtual reality technology in August 2014, announcing a great promotional campaign under the slogan *Look before you book*. Thomas Cook also created a special VR 360° film, featuring virtual reality views of Manhattan from a helicopter perspective, and also enabling the viewer to feel like a person walking along a pool at the Greek resort of Sentido in Rhodes or visiting the Cypriot restaurant SunConnect [97]. A similar initiative was undertaken by the Polish company Destinations VR, which together with Radisson Blu hotels prepared an interactive presentation of the hotel facilities and apartment buildings. During the show, the viewers had a chance to take a walk in virtual reality around the building which did not even exist yet. In turn, the Marriott Hotel chain provides its hotel guests with the VRoom service, which enables them to use VR devices directly in hotel rooms [214]. Guests who order such a service receive a special VR Samsung Gear set, which they can use in their rooms for 24 hours.

Illustration 9.2 *VRoom Service in a Marriott hotel, Source: VR Scout*

Hotel guests and potential customers of the Marriott hotel chain may also use a special virtual content platform - VR Postcards - which allows them to view selected world places in virtual reality and also gives them an opportunity to become familiar with the opinions and impressions of other tourists who have already visited these venues [157]. Of course, in order

to use this platform, it is necessary to have a proper device which supports VR technology[87]. In 2014, Marriott organised a promotional campaign (4D Marriott Teleporter) for its hotel chain, which consisted in setting up special cabins near one of the New York Marriage Bureaus, where newly-weds could use special VR devices to "make" a virtual wedding trip to attractive places and enjoy beautiful views [22][257].

Retail sale

The virtual reality solutions are also increasingly popular among marketing specialists. Usually, when we consider purchasing a product online we have a lot of doubts. It is natural that, before making any choice, we would first like to see the products we are interested in as carefully as possible. A typical e-commerce application in its current form does not always provide such an opportunity. The situation can change dramatically when online retailers will reach for virtual reality solutions.

Virtual reality technologies allow marketers to present their products in a unique way. Companies also spend considerable funds for advertising campaigns, and therefore they usually can afford expensive investments in the equipment and VR productions. An example are the advertising campaigns of such companies as Coca-Cola, McDonald, Marriott, Volvo, Redbull, TopShop, Tommy Hilfiger or Nike [172].

Table 9.1 *10 most interesting marketing campaigns based on VR technology*

Company	Promotional campaign
Coca-Cola	Thanks to the VR Coca-Cola campaign, during the 2014 Football World Cup in Brazil, football fans were able to move from the changing room to the stadium where the hosts played their game.
Coca-Cola	In December 2015, Coca-Cola organised a campaign in Poland, during which its customers could experience the magical trip of St. Nicholas' sleigh rides through decorated towns and soaring highways.
Coca-Cola	In February 2016 Coca-Cola organised a promotion in which the customers could exchange cardboards around their 12-packs of Coca-Cola drinks for a pair of disposable virtual reality goggles.
McDonald's	In March 2016, McDonald's conducted a promotional campaign consisting in turning Happy Meal boxes into Virtual Reality headsets (VR

[87] The VR Postacrds platform can be used with the help of Samsung Gear VR kits and the premium video service Samsung Milk VR.

Company	Promotional campaign
	Happy Goggles). As part of this campaign, the company also offered a special educational game for children.
Marriott	Marriott's campaign was a surprise for New Yorkers and consisted of setting up two cabins near the New York registry office where young couples could make a short wedding journey in virtual reality. The program included places ideally suited for a honeymoon for newlyweds, e.g. Maui. During the virtual journey, couples could enjoy beautiful views and attractions in faraway places, as well as see the luxurious interiors of Marriott chain hotels located there.
Volvo	The Swedish manufacturer developed a special VR application to promote the new Volvo XC90. The application was released by the company in the AppStore and Google Play Store at no cost. To use it one needs a Google Cardboard virtual reality platform. The Volvo Reality app coupled with Google's VR platform allows the user to move to a virtual world where he or she can test the latest Volvo XC90 in a mountainous environment.
Redbull	Energy drinks producer Redbull in cooperation with RewindFX prepared a special film in 360° technology, allowing players to assume the role of a pilot at the Red Bull Air Race. Thanks to this campaign, with the help of special VR glasses participants of this campaign could see how a flight over the British Ascot looks like from the perspective of the cockpit of an airplane.
TopShop	British clothing company TopShop organised a marketing campaign consisting in a live VR broadcast from the London Fashion Week fashion show. Thanks to VR technology, a few selected people were able to virtually move to the show's audience, watch the models on the catwalk, stand next to them, and even take a look at the backstage of the show.
Tommy Hilfiger	Tommy Hilfiger, in cooperation with WeMakeVR, made it possible for its clients to experience the prestigious fashion show with the help of VR technology, so that they could enjoy the great fashion event from the perspective of the first rows in the audience. After the end of the show, the participants also had an opportunity to receive help from the shop's employees who provided them with support in finding specific creations exhibited during the show.
Nike	Nike created a special 360° film which, combined with the Google Cardboard VR platform, enabled football fans to move for a moment to the football stadium and assume the role of the Brazilian footballer Neymar. In this way, football enthusiasts were able to see other players and the course of the game itself from the perspective of the biggest football star. The whole action was to promote the new Nike Hypervenom Phantom II sports footwear.

Source: Own elaboration based on [172].

One of the potential VR applications in the retail industry is the development of specific product models and offering potential customers the opportunity to visualize them in the digital world. Perhaps in the near term future, for example, customers wanting to buy furniture will not necessarily have to go to a large furniture store, such as IKEA. All they will need will be a set of VR goggles thank to which they will be able to see all available items offered for sale in a VR showroom. More importantly, they will be able to visualize such furniture in digital rooms resembling our own homes and flats [213]. Therefore, companies from the construction and home furniture industries may soon become major beneficiaries of VR technology, as they will be able to eliminate a significant part of their warehouse and exhibition spaces and thereby optimize their costs.

Moving sales to virtual reality eliminates or significantly reduces some parts of the cost chain, such as the expenses associated with maintaining personnel, warehouse and exhibition space, inventory management, logistics, etc.

Creating a virtual reality environment entails considerable costs, at least in the phase of the development of these technologies, yet this is still disproportionately cheaper than maintaining and managing large retail spaces.

In the future, instead of going to traditional stores, customers will rather use VR goggles and the entire sales process will take place in virtual reality.

A foretaste of how the shopping may look in the future is portrayed by a project that was developed as part of the cooperation between eBay and an Australian distributor Myer. Both companies are engaged in the creation of a virtual store, namely the eBay Virtual Reality Department Store. This joint undertaking of both companies is at the same time one of the first e-commerce solutions in the world based on VR technology [83]. To shop in this virtual store, customers need special Shopticals goggles and the eBay Virtual Reality Department Store app, which they can download from the website. Customers who want to shop in Mayer's store use the innovative *eBay Sight Search* technology, which allows items to be chosen by holding one's gaze on them for a number of seconds [32]. Customers shopping with this technology receive access to extended data on the items they are browsing for and can

also view them from a variety of different angles, just like in a real store. Information on prices and the availability of any individual items are updated in real time.

Experts have no doubt that VR technologies will also revolutionize the online clothing market. Until recently, it was almost certain that the most appropriate place to make decisions about purchasing new clothes were stores and clothing showrooms. This seemed to be understandable and natural. In a retail store, it is possible to see the clothing carefully with one's own eyes, check the materials it is made of and, most importantly, go into the fitting room and try them on with one's hand. These are sufficient reasons to believe that purchases of clothes in traditional clothing outlets would remain the predominant form of shopping. Although clothing has been sold on the Internet for a long time, statistics show that it is not a very reliable form of doing shopping, mainly due to the relatively high percentage of later returns. About 30 percent of all goods ordered online are later returned, whereas purchases made in traditional "brick and mortar" stores account for only 8.89 percent of returns [296]. It could, therefore, be expected that the traditional brick and mortar model of selling products will remain irreplaceable for a long time, especially in the case of clothing. It turns out, however, that this situation may soon change dramatically. Again, the catalyst for the constructive destruction of stationary stores and the traditional model of shopping are the new digital technologies. With regard to the online purchasing of clothing, the process of such online trading can be significantly supported by the intelligent digital mirrors *MemoMi MemoryMirror* (with the Intel Core i7 processor and the Intel RealSense cameras inside), which scan the customers' bodies and store spherical images of all the clothes they are fitting on, and enable them to virtually visualise (without putting them on) how they will look like in such clothing [131].

Illustration 9.3 *MemoMi MemoryMirror Intelligent Digital Mirror with Intel RealSense Camera, Source: Venture Beat*

In the future, thanks to such technological solutions, customers will be able to scan their bodies (i.e. silhouettes), and then create their individual digital silhouette's profiles, which will allow them for a quick selection of personalised wardrobe parts. Such a scanned profile will be the customer virtual representation and will make it easier for him/her to move within the stores that use virtual reality technology.

Military use

The military sector is also keen to take advantage of the VR/AR technologies. New inventions can completely change the way the armed forces operate. One such military application of VR/AR technology may consist of creating solutions that will eliminate the need to send soldiers to a battlefield. These functions can already be taken over by robots (i.e. robo-soldiers), such as the LS3 machine created by Boston Dynamics, but thanks to VR technologies the man can now control the battlefield, having at his disposal the robot's-eye perspective of the surrounding area. The machine controller sees everything as if he himself was at the location where the military operations are undertaken. He can, therefore, shoot against the enemy without endangering his health or life.

In turn, augmented reality may be used to raise situational awareness of real soldiers taking part in military operational activities. This should increase their effectiveness [72]. For

operational purposes, the military uses e.g. a head/helmet mounted display (HMD) system. HMD systems are so important for the army in that they enable a smooth and convenient integration of real and digital realities. From an operational standpoint, the AR provides very valuable information which is transmitted electronically over the network. HMD systems do not alter the real images that exist in the soldier's surroundings, but merely impose some additional information on real world's view, which allows for better interpretation of the real situation.

HMD systems use built-in translucent screens (integrated with the helmet) on which soldiers can see digital images overlapping the real world view. The helmets themselves also feature built-in cameras which capture the surroundings. These cameras are integrated with the HMD system and allow the soldiers to see the captured images in augmented reality.

The Army is highly interested in the systems increasing the situational awareness of soldiers on the battlefield. Devices whose operation is based on the augmented reality not only raise their situational awareness but also make it easier for them to take military operational actions, i.a. by shortening their response times during such operations. Today, it takes the soldiers a lot of time to use various portable devices and systems for navigation and communication, such as GPS, BMS, and C4ISR. These devices have specific dimensions and weight and require an adequate supply of electricity. Moreover, their operation consumes valuable time of the soldier and entails extra costs. This can be particularly risky, especially when soldiers find themselves in dangerous conditions, such as in a war zone. There is no doubt that a complete transition to AR imaging systems is desirable and necessary. It should be borne in mind, however, that in order to fully utilize the potential of this technology, it is necessary to create a special portable optical wearable computers with the utility parameters which would perform similar functions as those assigned to the smartphones in civilian applications [369, p.1]. Google and many other companies around the world are currently working on such a technology.

Examples of AR-based technological solutions and HMD systems for military purposes are [369, 1-9]:

- **HMDS system** used by the F-35 pilots;

- **X-5 and X-6 HMD glasses** created by the American company Osterhout Design Group (ODG), integrating a number of systems and allowing to solve the existing problems more easily, e.g. X-6 glasses were used for imaging transmissions received from the Gray Eagle drones;
- **R-6S glasses** (developed by ODG), which weigh only 156 g and look like normal sunglasses; they support i.a. the AR technology, Bluetooth 4.0 standard and the fifth generation of wireless networks (802.11ac), provide satellite communication via GNSS, and are fitted with a full HD recording camera, variable lenses, gyroscope, accelerometer, height gauges, exposure and air humidity sensors. ODG also developed another model of smart glasses, such as the R-7 glasses, which allow for switching from AR to VR mode. ODG glasses also have another important feature, namely that through additional modules their functionality can be extended, e.g. for the protection against nuclear, biological and chemical weapons and IED (improvised explosive device), or for the reading of biometric data or tracking;
- **Q-Warrior**, HMD glasses developed by BAE Systems, operating in optical holographic waveguide technology. They are used by land forces for situational imaging in various weather conditions, both at day and night. They serve i. a. for military intelligence and to determine the location of the army. Some of the Q-Warrior elements are used in HMDS systems developed for F-35 fighters;
- **Moverio** (BT-2000), Epson's glasses featuring a GPS navigation, gyroscope, compass, accelerometer, microphone, HD recording, virtual imaging and automatic tracking;
- **ULTRA-Vis**[88], an HMD system developed by DARPA for imaging its own and its enemies' troops. ULTRA-Vis provides soldiers operating in urban areas with valuable information that is generated by computer and superimposed on the real image. The data received by the soldiers cover their current position and the position of their enemies. This technology is also used to pass on the commands.

In the future, a number of potential applications of the augmented reality may be considered in the defence sector, although it will not be easy for their developers to meet the military requirements. Many new devices supporting these technologies could prove to be extremely useful tools for all types of military forces (i.e. land, sea, and air). What is important,

[88] Urban Leader Tactical Response Awareness and Visualisation.

their use does not usually require complex and difficult adaptation measures and does not entail additional costs.

Education

Education is yet another area in which VR/AR technologies are applied more and more willingly. An example is the e-learning sector. VR and AR solutions are used in this field to create educational videos, multimedia manuals, presentations, games, and various simulations. The type of education based on VR and AR technology is also increasingly appreciated by the business community and - what seems to be very important - changes the approach towards workshops and training, making them more attractive from the attendees' viewpoint. This, in turn, translates into the effectiveness of such training. Practical workshops in the field of assembly, construction, and repairs of technical equipment, as well as those created for the needs of large companies and corporations, are highly popular, e.g. presentations concerning the introduction of new products and technologies and the methods of their servicing. Training using VR and AR technologies has the significant advantage that it does not require the participation of a trainer (instructor). The operation of the VR and AR devices is so simple that the course participants are able to cope with it on their own. This, in turn, means considerable time and financial savings for the companies specialising in training.

When considering the use of VR and AR technologies, it is important to mention the projects developed by the digital technology giant - Google, which develops its own solutions related to VR and AR technologies in the field of education and art. The first is the VR +Google Expeditions+ platform that is used with cardboard goggles and smartphones, to support school teaching. The second solution is a creative tool +Tilt Brush+, which allows for creating virtual spatial images and is utilised for learning paintwork.

Holographic technology and telepresence

A real digital revolution can also be the result of the development of holographic technologies, which allow for rendering spatial images of any kind and give the possibility of viewing the created digital objects from virtually any direction. Technological experts mention telepresence as one of the potential future applications of this technology. In other words,

there is a big chance that people will soon be able to see each other without even leaving their homes. Statistics show that today we do not meet together as frequently as we used to in the past. We are also much less active in interpersonal communication. One of the main reasons underlying this state of affairs is, of course, the development of new (digital) technologies, which become more and more time-consuming and occupy a large part of our lives. Researchers from the Pew Research Center and Elon University believe that this trend will continue at least until 2025. Until then, people will increasingly limit the number of meetings they have with each other. However, they will not completely abandon the need to maintain relations with other people. Real contacts will be substituted by those carried out with the use of holograms. **Holographic technologies will, therefore, enable us to use the world of virtual reality to an even greater extent than before**.

Thanks to holograms we will soon be able to dissociate from the real world and leap into the places of our choice (in virtual form). People will be able to see any venue on Earth whenever they would like to do so.

Holographic technologies will also increasingly determine the future of mass events. Instead of musicians and athletes, there will also be virtual personalities performing on stages and in stadiums.

The case of a virtual singer Hatsune Miku

An example of the use of holograms is the virtual singer Hatsune Miku, who is virtually "created" by the Japanese and physically is non-existent. The concerts of Hatsune Miku are attended by thousands of people [86]. In Japan, she has gained quite a big reputation. Teenagers literally went mad at her point to such an extent, that they started to dress as she did, and even dye their hair blue trying to imitate in this way their idol. Hatsune Miku plays in commercials, has her own Facebook profile and her credits also include several roles in films. Her song *The World is mine* for many months remained on the first position of the national hits list.

Illustration 9.4 *Holographic singer Hatsune Miku on stage, Source: BuzzFeed*

Importantly, holographic Hatsune Miku performs live at her concerts. The image of the virtual pop star is promoted by Crypton Future Media, a company specifically designated for this purpose. Miku's voice was created by Yamaha's proprietary Vocaloid software. The individual phonemes and syllables, out of which the software composes the whole sentences, originate from the Japanese actress Saki Fujita [189, p. 4]. While from the perspective of the audiences, the holographic Hatsune Miku appears to be three-dimensional, in fact, it is flat. The hologram is rendered on a transparent screen by means of the so-called rear projection.

Spatial transmissions with the use of Free Viewpoint technology

The Japanese are currently developing a technology that will enable people to watch matches and sporting events in the form of spatial transmissions. This technology is based on filming each game with the use of several hundred high-resolution cameras. The Japanese will also use the already existing *Free Viewpoint* technology, thanks to which it is possible to follow the players' movements from their own perspective. *Free Viewpoint* solution allows the viewer to choose a specific point of view. So far, it has been used only in video games.

Holograms: Visualisation of digital objects

Thanks to the ultrasonic waves, holograms may gain an additional feature in the future, namely the corporality. This would mean that each time someone tries to touch such a holographic object, the ultrasound would create an impression of a physical resistance. **Such a technical solution would allow us to generate holographic objects, which would give an impression of real things, whenever we would like it to happen. Therefore, we would be able to literally touch these things. As an example of the use of such technology, we can envisage virtual light switches, which - as if at the touch of a magic wand - would appear only when they were needed (at our request). Whenever we wished, we would be able to virtually create specific digital things, such as books, maps, or the aforementioned light switches, that would appear instantly as holograms, and when they were no longer needed, they would simply disappear**. There is no doubt that as holography evolves, it will be widely used in various areas of our life, including the military, police, education, etc.

Fusion of nanotechnology and virtual reality

Some scientists expect a fusion of nanotechnology and virtual reality in the future. Within 2-3 decades, thanks to tiny nanobots that will get into the bloodstream of our brains and interact with our neurons, we will be able to feel a full immersion in virtual reality through our nervous system [180]. **Such nanobots will block our natural stimuli flowing to the brain from the external environment and replace them with the stimuli originating from virtual reality**. **In this way, we would be fully convinced that the stimuli we receive come from the real world, even though they would, in fact, come from the world of virtual reality.** Moreover, we would be able to project a variety of different artificially created stimuli for all our physical senses.

With such "VR stimuli projectors" we could literally "recreate" any combination of sensual experiences that we would earlier get in an electronic form from the digital platforms on the Internet. In this way, by selecting the right set of sensual perceptions, we would have an opportunity to see what it is like to be another person, for example.

10 BLOCKCHAIN TECHNOLOGY

What is Blockchain Technology?

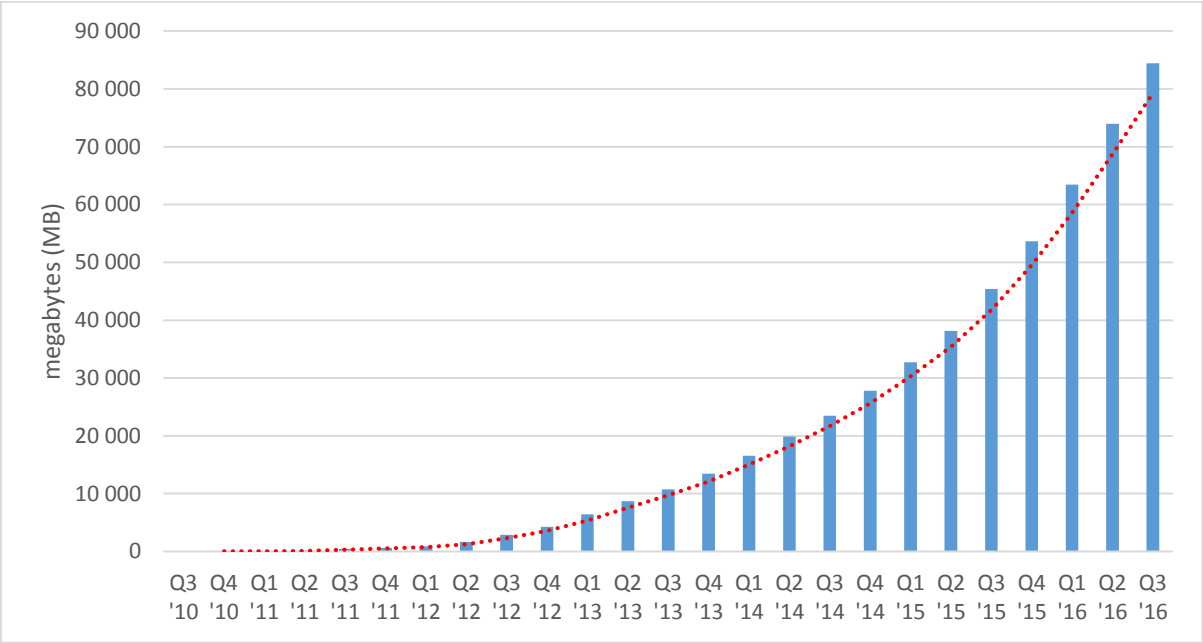
In the age of digital technologies and widespread digitalisation, there is an increasing need to ensure the security and transparency of many business events recorded and stored online. Usually, information about them is stored in special databases (SQL) located in one specific (central) place, i.e. on servers of private companies or institutions. However, such solutions are not fully safe for at least a few reasons. Firstly, data in one specific location can be relatively easily manipulated by, for example, hacking the server on which it is located and modifying the content of the specific records in which it is stored. Secondly, the server on which the data is stored may simply fail or be disabled, and access to the data it contains may not be possible. Finally, obtaining information from such servers is performed by individual server requests, which of course requires appropriate permissions granted by the administrators of such servers. The architecture of the whole system, commonly known as "client-server", favours server administrators (so-called hosts), and at the same time places its ordinary users who want to gain access to information stored on such servers (so-called clients) in a subordinate position.

In recent years emerged a technology based on the so-called blockchain (i.e. blockchain technology), which works peer-to-peer and addresses all the above-mentioned problems. It can be used to create open and secure digital registers of various events taking place in the network. Unlike one central database located in one place, blockchain is the so-called distributed database system whose primary function is to store information about individual system nodes (so-called portfolios) and their respective private cryptographic keys in many different places (so-called nodes). This technology ensures secure storage of information and the same accessibility to it for authorised persons. Blockchain significantly facilitates the transfer of ownership rights to specific individuals, as well as the management of information related to various trading systems. This technology should be understood as a decentralised database which is accessible to everyone. Of course, only authorised persons with appropriate cryptographic keys have access to the sensitive data. The most important features of blockchain technology are as follows:

- open source character, so that everyone can use it for free and create technological solutions (applications, platforms) based on this technology,
- the transaction database is distributed, i.e. the information it contains is stored in multiple locations at the same time,
- it is a peer-to-peer solution, i.e. unlike the client-server architecture, it reflects a communication model that provides all parties with exactly the same permissions,
- distributed nature of the information that blockchain contains means that the operations performed (e.g. sending a cryptocurrency to someone else) are immediately visible to all network users at the same time. Similarly, all network users have full access to the most up-to-date and complete version of the information stored in the distributed database,
- all transactions recorded in the blockchain are arranged in chronological order and form a specific chain(hence the name of the blockchain technology),
- a time stamp is assigned to individual events (transactions) that are recorded in the blockchain,
- data stored in the blockchain cannot be manipulated as it is cryptographically signed and any attempt to manipulate such data would automatically break the chain.

The great advantage of blockchain is that it is decentralised since there is no superior authority that would exercise any control over it. This, in turn, makes this technology immune to any political or business malpractices. The blockchain underpins the functioning and security of digital currencies such as bitcoin and ethereum. The popularity of cryptocurrencies results largely from the fact that nobody other than their holders has the opportunity to decide about their ownership. A characteristic feature of cryptocurrencies is the irreversibility of the transactions carried out with their use. This means that once a transaction is approved, there is no possibility of reversing it.

Chart 10.1 *Bitcoin blockchain size*[89]



Source: Own elaboration (based on Statist data).

According to Marc Andreessen, the value of bitcoin as a digital currency is directly linked to the volume of transactions and the speed of transactions carried out in the blockchain system [351, pp. 58-61]. Unlike most fiduciary currencies, such as the dollar and the euro, the number of bitcoins in circulation does not depend in any way on central bank policies. This feature of cryptocurrencies has led to a significant increase in their values in recent years.

[89] Total size of all blocks and transactions headers. It does not contain database indexes.

Chart 10.2 *Bitcoin average market price across major bitcoin exchanges*

Source: Own elaboration (based on blockchain.info data).

Thanks to blockchain's unique features, one can expect that in the future it will disrupt the functioning of many existing business models. This may concern in particular the following areas and activities:

- financial and banking sectors,
- systems based on peer-to-peer technology,
- electronic signatures/identifications, and confirmations by electronic means of the validity,
- the conclusion of commercial agreements and contracts (without the participation of lawyers),
- voting systems,
- ownership, allocation, and exercise of rights,
- settlement of securities and equity transfers,
- obtaining patents,
- transactions on the real estate market,
- trafficking in works of art.

The interest in blockchain is growing practically every day. Initially, this technology was noticed only by a small group of enthusiasts, but over time it was also recognised by central banks, large financial institutions, and governments. Blockchain may completely revolutionize the law and the economy in the future [69].

Distributed autonomous organisations

The potential of the blockchain technology is enormous. Its possible applications include various implementations of the concept of smart contracts or the establishment of distributed autonomous organisations (DAOs). Blockchain is also likely to contribute in the future to a major revolution in the lawmaking process. Its widespread application for validating various operational data in many fields will significantly reduce the risks and costs of processing, storing and using such data [209].

In May 2016, **the first distributed autonomous organisation (The DAO) was successfully created and funded**. Such a decentralised organisation exists and operates exclusively on the Internet. This fact can be perceived as the beginning of an era of completely new economic models. The equivalent of 150 million dollars was collected in the form of ICO (i.e. initial coin offering). Unlike traditional companies, where control on behalf of shareholders is exercised by an elected board of directors, **autonomous distributed organisations do not have boards of directors at all, and management responsibilities and any agreements governing their activities are algorithmicised and recorded as transaction scripts in the blockchain**. This form of the functioning of companies and organisations has many advantages. Firstly, it protects them against various types of counterfeiting. Secondly, the fulfilment of certain conditions agreed by the shareholders of such a company results in an automatic execution of the relevant instructions (scripts) through the relevant system nodes. In this way, for example, all cash flows of such companies (organisations) may be generated or certain activities may be performed entailing specific legal effects. Thirdly, shareholders' rights and proposals with regard to the management of the DAO are also voted on the basis of the blockchain technology. If such a distributed autonomous organisation approves an execution of a smart contract by means of the network voting, it will automatically enter into such contract with the contractor, and the whole process of its execution will also be controlled by the blockchain technology. Such a contract may contain

appropriate algorithmic instructions according to which partial remuneration may be paid to the contractor following the implementation of a specific stage of the project. When DAO generates profits, they can also be distributed according to the instructions recorded in the blockchain, e.g. automatic transfers can be processed immediately when a specified condition has been met.

Blockchain based registry of things

As mentioned above, blockchain technology can be used to set up and keep a variety of different registries. In the future, almost every item will have its **unique digital footprint** and information about it will be stored within the blockchain database. Such a unique tag assigned to any asset will serve as its **digital authenticity certificate**. Recording it into the blockchain will allow for keeping records of events/transactions related to it and will provide digital confirmation of its life cycle.

Blockchain-based register of diamonds and artworks: The case of the Everledger company

An example of the application of blockchain technology in practice is the **digitalisation of diamonds and artworks** conducted by the company Everledger [204]. Each diamond that reaches this company receives an **individual cryptographic number**, which is associated with its unique characteristics. This number is then introduced into the decentralised (distributed) blockchain registry. This is intended to prevent the illicit diamonds' trafficking and to counteract other potential criminal activities that might be associated with such illicit trade.

Bike registry in the Dutch municipality of Groningen

Another example of the use of blockchain technology is the **pilot bicycle registration project undertaken by the Dutch municipality of Groningen**. The register, based on the blockchain's distributed ledger technology, makes it possible to track the history of all bike transactions and events recorded in the municipality, including the purchase and sale of bikes,

reporting of bike thefts, accidents involving bikes and the relationship of their owners with insurance companies, etc.

Vitalik Buterin's universal programmable blockchain: Ethereum

The same protocol that enabled the creation of bitcoin can be used to develop many web applications, which do not necessarily have to do anything with digital currencies. In other words, the future of the blockchain technology may lie in the blockchain 2.0 protocol (a.k.a. ethereum)[90]. Unlike the blockchain underpinning the bitcoin cryptocurrency, **ethereum technology allows for a relatively easy and scalable implementation of any type of blockchain-based smart contracts (transactions)**. Thanks to this technology it is possible now to create **dedicated cryptocoins (a.k.a. altcoins), smart contracts or even derivatives**. Ethereum can be used for crowdfunding, domain name exchange, financial exchange services, online voting, and even for managing a company or implementing various types of agreements. This universal blockchain can, therefore, be described as the bitcoin extended with additional functionalities.

Application of the blockchain technology in the public sector

Blockchain technologies could be implemented in the public sector in the future. For example, distributed registers would form the basis of tax systems. Such systems would make the fight against tax evaders much more effective. This is confirmed by the Government Office for Science (UK) 2016 report, according to which there are good reasons to believe that blockchain technology can support the government in achieving its tax goals. An important feature of this technology, which predestines it for such applications, is that it is based on a **cryptographically protected distributed ledger** and is characterised by a **standardised and uniform viewpoint**, i.e. it reflects true real-time occurrence data. This allows even persons/entities that do not trust each other to simultaneously have access to accurate information about certain events/information, which significantly facilitates their mutual cooperation. It is the distributed ledger that guarantees the veracity of the information (data)

[90] Ethereum was developed by Vitalik Buterin and is often referred to as blockchain 2.0.

stored in it. This solution makes it possible to unify the format and content of the stored information as well as to shorten the time needed to verify it. This enables companies and organisations to trade and operate more effectively with each other. All of this should not only make it easier for them to take various decisions in the future but can also lead to considerable savings.

Blockchain technology application to combat cyber-terrorism

One of the most important features of the blockchain is its decentralised nature, meaning that there are exactly the same copies of the registry on different nodes of the same distributed network. The Estonian government decided to use blockchain technology to create a Keyless Signature Infrastructure (KSI) [126]. In this way, the Estonians are trying to combat cyber-terrorism and prevent a repetition of the cyber-attacks that took place in this country a few years ago. Since the blockchain-based system remains distributed, it is virtually impossible that any successful hacker attack on a single system's element could lead to the disruption of the entire state-owned information system.

Blockchain-based solutions need to be implemented by the countries that want to prepare themselves adequately for cyberwar and cyber-terrorism.

Sealing up the tax system

The blockchain technology coupled with the digitisation of trade flows could effectively seal up the tax system. **Digital platforms based on the blockchain's distributed ledger can help to identify different forms of transactional exchange between parties**. Of course, in order to make such a concept a reality, the individual assets that may be the subject of such transfers, e.g. products, services, tangible assets, intangible assets, artworks, need to be digitised first. It is also important to ensure that appropriate legal instruments are put in place to oblige transaction parties to apply such a solution in all cases of ownership transfer.

Common and mandatory recording of transactions on a blockchain-based digital platform would improve the functioning of fiscal control mechanisms.

It would give the tax authorities a full insight into every type of transaction between different parties. In the case of sale and purchase transactions, tax administrations would also gain information on the selling price of the assets in question, which would make it much easier for them to determine the amount of tax due. The tax authorities would then also be in possession of information enabling them to identify the location of the taxpayers' assets in order to perform possible tax audits more quickly and efficiently.

11 SOCIAL INNOVATIONS

Crowdfunding is another area which has become popular thanks to the development of new technologies. Crowdfunding is a fundraising activity that involves popular social networking sites. As it turns out, many Internet users are more willing to participate in various projects and goals, e.g. business or charity, organised through crowdfunding portals[91].

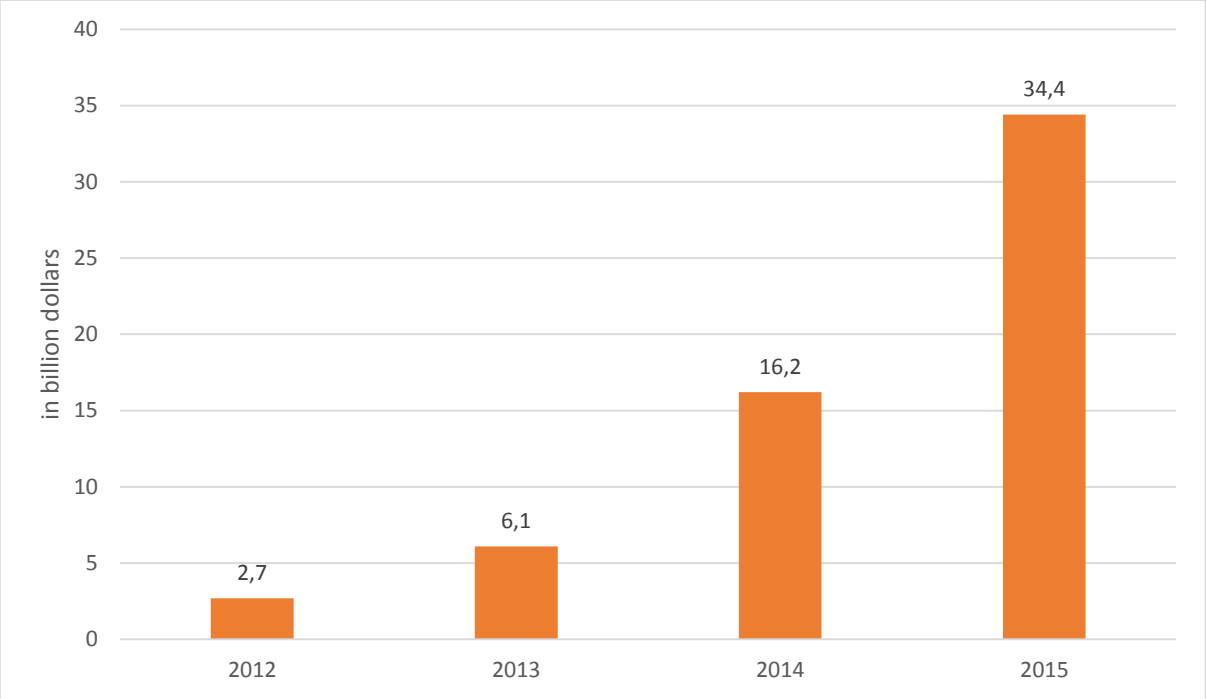
Illustration 11.1 *Crowdfunding types, Source: Wardyński & Partners Law Firm*

One example is the raising of one hundred thousand dollars through the Kickstarter portal on the development of a superhot computer game. In this particular case, the necessary funds were raised in less than 24 hours. According to the report published by Bruegel, a European think tank for economic affairs, the amount of money raised for various projects in the form of crowdfunding has been growing exponentially in recent years. In 2015, approximately $34.4 billion was raised in this way. Of course, the largest

[91] Crowd+funding, in other words, funding to provide masses; crowding means crowding, masses, a funding means funding. In practice, crowdfunding is carried out through a variety of online platforms.

amount of funds is raised in this way in America (about 60 percent), but Europe also does not lag far behind, reaching the level of 39 percent.

Chart 11.1 *Funds raised worldwide in the form of crowdfunding in the years 2012-2015*



Source: Own elaboration (based on Massolutions data).

Crowdfunding can be divided into four types: grant/charity - based on donations, pre-sale, debt/loan and equity. The Bruegel report also shows that the most forward-looking model is the equity model, as it enables companies to raise capital quickly and is much more efficient than, for example, issuing new shares on the stock exchange.

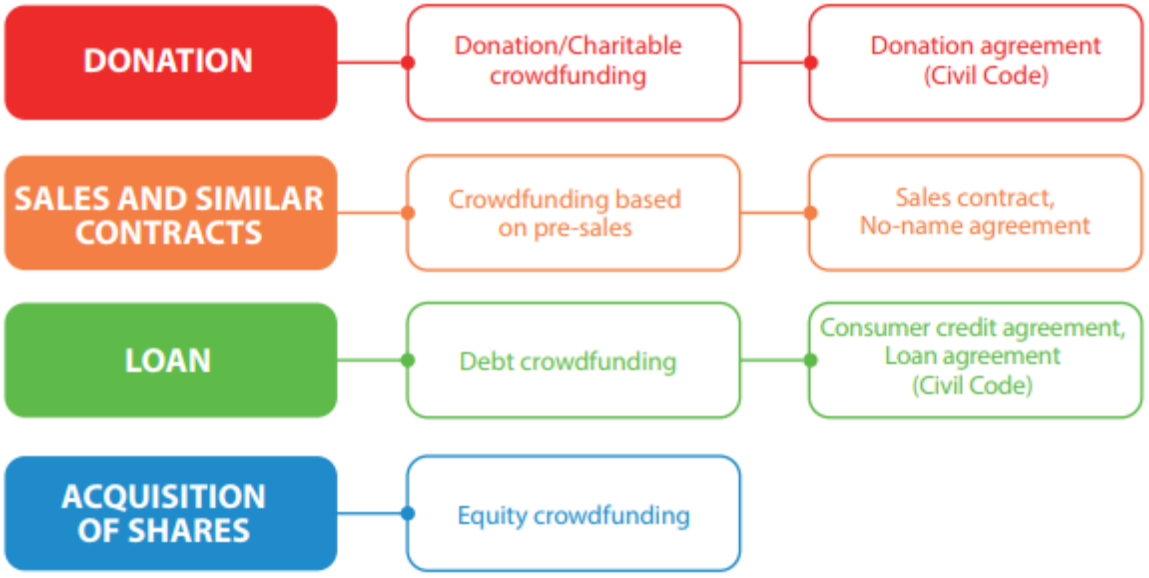


Illustration 11.2 *The most common constructions applied in the scope of crowdfunding legal relations, Source: The Law Firm Wardyński & partners*

Also, in the case of crowdfunding, there is no need to comply with the strict requirements that undoubtedly apply when it comes to arranging financing through the capital markets. On the other hand, it should be remembered that crowdfunding is not as secure as the issuance of shares through financial markets. Moreover, there are no appropriate legal regulations to keep up with the development of new technological advancements, including those concerning crowdfunding.

12 THREATS ACCOMPANYING THE FOURTH INDUSTRIAL REVOLUTION

With the development of digital technology, cybercrime has become one of the greatest threats and challenges faced by companies, corporations, public institutions and state institutions. The global economy loses around 450 billion dollars a year due to cybercrime[92]. Heads of the world's largest companies point to hacker attacks as one of the greatest contemporary and global threats[93]. There is also a growing awareness among entrepreneurs, who are beginning to realize the asymmetry of the risk of hacker attacks. This means that while the mere probability of experiencing such an attack can be considered relatively low, once it has taken place, the losses resulting from it may be unimaginable. Therefore, companies' expenditures on activities related to the security of their IT systems are starting to be treated as investments rather than as costs. Increasingly, companies and governments are hiring hackers themselves to check whether they are adequately protected in the event of a cyber-attack. One such institution is, for example, the Pentagon. In Poland, such awareness of threats is very low. Market research conducted by *ARC Rynek i Opinia* shows that only 26 percent of Polish entrepreneurs from the SME sector are afraid of a hacker attack.

Today, widespread Internet connectivity enables us to monitor the situation in our homes, companies and public institutions almost continuously. These places are vulnerable to attacks by cybercriminals whose motivations vary. Sometimes it's only a matter of competing between the hackers themselves, namely who is the first to make a more spectacular cyber-attack, for example on NASA, PENTAGON, the big banks, or even on a strategically important facility that is part of a country's critical infrastructure. More often, however, hackers specialise in industrial espionage, gaining control over production systems, stealing sensitive data and blackmailing wealthy companies or even governments.

Sometimes even the victims of such cyber-attacks become political parties. This was the case in the United States in 2016. The hackers broke into the servers of the Democrats and stole their sensitive data, which they then used to manipulate the results of democratic elections. A similar situation also occurred before the second round of the presidential

[92] According to the *Center for Strategic and International Studies (CSIS)*.
[93] According to a study carried out at the World Economic Forum.

elections in France in 2017. What is more, entire countries are also behind the cyber-attacks, testing the effectiveness of warfare in cyberspace. Their aim is to obtain information that would give them economic, political or military advantages, e.g. scientific research results, technological or military plans.

Cybersecurity issues pose a major challenge to the political and economic world, as they relate to maintaining the stability of social cohesion and governance, which is now very easy to disrupt by spreading misinformation and hoaxes in the global network. Such actions may even lead to social unrest.

Cyber defence, or so-called cyber security, is a matter not only for IT specialists, but also for politicians and managers, who should develop, implement and update appropriate security policies.

It is worth noting that cybercriminals are now using increasingly sophisticated methods to steal from ordinary internet users. An example is the distribution of viruses which by themselves or in combination with other circumstances download materials with child pornography to randomly selected computers. Then the owners of these computers are subjected to moral blackmail. The criminals impersonate police officers in an attempt to extort specific sums of money for refraining from the initiation of independent investigation and prosecution of the alleged "perpetrators". Another proven method of cyber criminals is to infect private computers with appropriate viruses (i.e. so-called bots), which then serve as tools to further send spam, hack into computers to block and take over "computer websites". There are tens of millions of different varieties of such bots. They all represent a huge network of botnets[94], generating millions of dollars in profits for cyber criminals. For one of the most spectacular cybercrimes the perpetrators used the DNSCharger botnet of four million connected computers. As a result, they managed to extort more than 14 million dollars from Internet users.

[94] Botnets are networks of infected computers spread across the world.

In Poland, CERT[95], a team of cybernetics experts at NASK[96], is fighting against similar crimes. Very active in the fight against cybercriminals is also the European Union which led the European Parliament to change the law, e.g. by introducing high penalties for committing cybercrimes.

In 2016, sensitive personal data of one billion Yahoo users were stolen by cybercriminals [62]. In the following years we will probably be dealing with more and more sophisticated hackers feats on a large scale. We should take into account that hackers will be interested in devices and smart gadgets (wearables) forming the Internet of Things. Considering that the number of such devices will reach even hundreds of billions within a dozen or so years, it will generate very serious threats to cyber security.

An important and real threat is also the possibility of hackers attacking industrial robots[97]. Technological progress makes this type of machines more and more technologically advanced and more widely available. According to the estimates of the International Federation of Robotics about 1.3 million industrial robots will be in use worldwide already in 2018 [208, p. 4]. Thanks to their enhanced communication capabilities, it is already relatively easy to establish a remote connection with them, e.g. by means of HTTP[98] requests and APIs[99]. The growing number of such robots in service and their increasing communication capabilities significantly increase the likelihood of being attacked by cyber-terrorists. To access and control them, hackers take advantage of vulnerabilities in operating systems and additional software.

In May 2007, Estonian critical infrastructure was paralysed by attacks carried out simultaneously from multiple computers located in different locations around the world (the so-called DDoS[100]). As a result, the servers and websites of Estonian government agencies, banks and the media suffered, and the Estonians themselves lost the possibility of withdrawing money from ATMs for a certain period of time [349]. Many sources indicated at the time that the hackers who had carried out this cyber-attacks were linked to the Kremlin.

[95] CERT (Computer Emergency Response Team) is an institution established to respond to events that violate the security of Internet users.
[96] Research and Academic Computer Network.
[97] This is what Trend Micro & Politecnico di Milano's report shows.
[98] HTTP is a hypertext transfer protocol that allows communicating with a network service server.
[99] API is an application programming interface that enables applications to communicate with each other, e.g. software with the operating system of another computer.
[100] DDoS is the so-called distributed denial of the service.

DDoS is a well-organised, large-scale attack on a computer system or network service carried out from multiple computers around the world. DDoSes are intended to flood servers with bogus traffic in order to use up their available internet bandwidth or their CPU and RAM resources thus prevent them from operating. DDoSes are usually primitive types of cyber-attacks that do not rely on data theft, but on making it impossible for others to use the network service.

The aim of DDoS attacks is most often to prevent the use of IT infrastructure or to immobilize the GSM network and systems important for the functioning of the state, such as energy, banking or communications.

An example of paralysing activities was the use in 2010 of a threatening virus known as Stuxnet by Israeli and American intelligence[101], for spying and reprogramming of industrial installations. It was used to destroy Iran's uranium enrichment centrifuges and to delay by several months the date of commissioning of the Buszer nuclear power plant. Another example is the jamming of Ukrainian GSM networks by Russians during the occupation of Crimea and during military attacks (by "little green men") in eastern Ukraine.

Stuxnet is considered to be a very dangerous computer worm created by an Israeli intelligence service which has been used for spying and reprogramming nuclear installations in Iran, among other things. According to the information available the principle of operation of the virus was to interfere with Siemens's SCADA system which is used to control industrial processes.

It is impossible not to notice that cyber-attacks and informational-propaganda activities are increasingly becoming a domain and part of the hybrid war being waged by states. Some even say that we are currently facing another world war that is taking place unnoticed in cyberspace. The Internet itself has become a battlefield. We have to admit that in this case

[101] Disputes about who really stood behind the creation of Stuxnet are still continuing to this day. The most reliable version seems to be that of German IT specialists, who presented a lot of evidence showing that Stuxnet could have its origin in Israel. Forbes journalists, on the other hand, presented their evidence that the creation of Stuxnet was supported by the Chinese and Finns, and the New York Times claimed that it was the result of cooperation between the United States and Israel.

the size of the state is insignificant in order to be successful on this battlefield, as exemplified, for example, by the actions of the Syrian Electronic Army (SEA).

Hybrid war is a new form of conflict between states conducted with the use of unconventional means, definitely going beyond the concept of a classic war based on the Clausewitz theory. One of its key elements is hostile activity in cyberspace.

Governments are aware of the threats and are therefore preparing for cyber warfare. The importance of the situation can be seen in the words of Gerhard Schindler, head of German counter-intelligence, who revealed that strategic state institutions in his country had been attacked by foreign hackers at least five times in a single day. Moreover, in the majority of cases, the attackers were Chinese. In order to fight cybercriminals, the Germans even set up a special counter-intelligence unit, the only task of which is to prevent attacks on government servers. The German BND[102] is recruiting large numbers of new intelligence officers, who are specialists in cyber security. The intelligent services are keen to attract the most prominent cyber-security specialists possible and spare no money for this purpose.

The Japanese government also fight against potential attackers and has commissioned Fujitsu to develop a special virus (software) to combat computer systems responsible for attacking government servers. This virus is able to find both sources of DDoS attacks, as well as other machines acting as intermediaries. The Japanese have also invested considerable sums of money in setting up a special system for monitoring and analysing cyber-attacks[103]. Of course, such examples can be multiplied. It is also well known that all great powers, including China and the US, already have cyber weapons at their disposal.

Year after year cyber-attacks are becoming more severe. In June 2017 a powerful cyber-attack destabilised almost the whole of Ukraine. Malicious software NotPetya seriously hindered the activities of many Ukrainian companies and institutions. Hackers attacked the country's critical infrastructure: government websites, airports, telecommunications and banking systems, and even power installations. According to experts from the NATO

[102] BND (Bundesnachrichtendienst) is the foreign intelligence agency of Germany, directly subordinated to the Chancellor's Office.

[103] It cost the Japanese Government 178.5 million yen to develop this virus and the system for monitoring and analysing cyber-attacks.

Cooperative Cyber Defence Centre of Excellence (CCDCoE) the attack was of an external nature and was most likely launched by another country. If this information is true then we have confirmation that modern war is not just about dropping bombs and firing bullets but that warfare is increasingly also taking place over the Internet in cyberspace. In Ukraine, for example, dozens of government institutions and private companies operating in that country have been affected by the cyber-attack. Due to cyber-attacks Ukrainian banks had to temporarily reduce their activities. All major Ukrainian strategic facilities, such as Kiev Airport and the Kiev Metro struggled with difficulties. The hackers tried to paralyse even the Ukrainian media. Both the Ukrainian cyberpolice and politicians indicated the Russian Federation as the initiator of these massive attacks.

Malware like ransomware (e.g. WannaCry, Petya) used recently by cybercriminals has proven to be very effective. It completely paralyses access to a computer and encrypts all the files available on its disk, and cybercriminals later charge the owners of these computers several hundred dollars in bitcoins in exchange for restoring a specific device back to working conditions. It cannot be ruled out that these viruses are merely a smokescreen for the real purpose of a future attack which may be to paralyse the government institutions of a country by blocking computers, servers and other electronic devices.

In May 2017 unknown hackers attacked thousands of organisations in at least 99 countries around the world [64]. They used the malware WannaCry which blocked the computer screens and demanded a ransom[104]. They attacked many manufacturing companies (e.g. Renault), telecommunications companies (e.g. Spanish Telefónica and Russian MegaFon), transport companies (e.g. FedEx, Deutsche Bahn), as well as state institutions (e.g. the Russian Ministry of the Interior). Cybercriminals did not even save hospitals [215]. The situation was most dramatic in London where hackers managed to paralyse the work of five large hospitals. At some point, in order to ensure the safety of all patients an emergency plan had to be implemented which consisted of cancelling part of the scheduled treatments and transporting some of the patients to other facilities. CERT Polska analysis shows that the malicious WannaCry virus infected also over 1200 devices in Poland[105].

[104] The ransom demanded by cybercriminals oscillated between $300 and $600 and was to be paid in bitcoins. In just five days from the date of the massive attacks, cybercriminals managed to raise nearly $100,000.
[105] CERT Polska is Computer Emergency Response Team which operates within the structures of Naukowa i Akademicka Sieć Komputerowa (Research and Academic Computer Network).

WannaCry is a ransomware encryption Trojan that infects computers and other devices around the world, blocks them, and then demands a ransom from their users. In May 2017 the WannaCry virus paralysed the information systems of many important institutions all over the world. The victim of the WannaCra attack was over 300 thousand computers in 99 countries.

Many of these attacks were attributed to Russians, Chinese and North Korean hackers. It is commonly known that for years they have been attempting to penetrate governmental institutions of other countries. For this purpose they create and engage special hacker teams called "The Dukes" which are well-organised cyber-spying groups commissioned by states to collect sensitive information on foreign policy and defence [192][79]. The activity of these groups is an important element of the information war. The Dukes started their activity in 2008 and continue it until today. Their attacks were directed mainly at NATO countries, including Poland which found itself on their target after the American administration announced plans to place an anti-missile shield in our country. During the 10-year period of the Dukes activity the victims of their attacks were government institutions, ministries, parliaments, embassies, military companies and strategic think tanks. Apart from Poland, the Dukes conducted their operations in Ukraine, the Czech Republic, Hungary, Georgia, Belgium, Spain, Uzbekistan, Azerbaijan, Kazakhstan, Uzbekistan and Kyrgyzstan, as well as in the USA. According to the Russian Underground 101 report published by Trend Micro access to illegal hacking services is extremely simple today. On the Internet you can find a full catalogue of such services together with their detailed price list. Most of them are carried out as commissioned activities by hackers from the above mentioned countries (sometimes cooperating with each other). They are extremely active and they can be approached through special discussion groups. For unauthorised entry to someone's Facebook account hackers want $130, for stealing passwords to their email accounts $160, and for a one-day blockade of access to a web site from $50 to $70. Simpler and cheaper activities are blocking mailboxes or mobile phones with spam messages. In hackers' underground you can also easily get viruses and malware which can be used to make life of the Internet users more difficult.

Industrial espionage

Cyber espionage is increasingly used for surveillance of decision-makers and theft of data from their personal computers. **Today, waging an information and cyber war is much cheaper and faster than training soldiers**. Contrary to appearances, there are no such antivirus systems that can always protect us from the most malicious software.

In the case of planned attacks on strategically important cyber targets criminals spare no resources and forces to create appropriate, dedicated software, the so-called exploits, which are based on the exploitation of previously unknown security gaps in computer systems. Sometimes even such cybercriminals join forces with hackers from other countries to maximise the effectiveness of their attacks.

In June 2017 cybercriminals who were most likely linked to the GRU Russian military intelligence and the Kremlin broke into the network of nuclear power plants in the United States. Although the attack itself concerned only the administrative and business part of the infrastructure of U.S. energy companies (mainly personnel) and did not seriously disrupt the operation of the IT systems of the power plants themselves, it cannot be ruled out that it was only a reconnaissance before a major cyber-attack planned in the future.

Consciousness manipulation systems

Today, the Internet is increasingly used to manipulate mass consciousness. An example is the Russian authorities which for the purpose of conducting an effective information war in the media established a special operating unit, the so-called "Ministry of Truth", dealing with practicing an active propaganda war on the Internet. From the leaks of people directly involved in this project it is known that the headquarters of this "centre of propaganda" was initially Olgino near St. Petersburg[106]. In 2014 it was transferred to St. Petersburg[107].

[106] Among others, one of the Radio Svoboda journalists managed to reach the former "employee" of the so-called "ministry of truth".
[107] to the building located at 55 Sawuszkina Street in St. Petersburg.

Illustration 12.1 *The building at 55 Savushkina Street in St. Petersburg, where the Internet "troll factory" is located, Source: The Guardian*

The St. Petersburg "troll factory" employs over 400 people who spend hours writing flattering comments on Vladimir Putin's policy, ridicule the Russian opposition and are critical of such countries as the United States, Ukraine and Poland. According to official information, the building at 55 Savushkina Street in St. Petersburg houses the Internet Research Agency (IRA). Its founder is police colonel Mikhail Bystro, but the project was financed by Concord Holding, headed by Vladimir Putin's close friend, billionaire Yevgeny Prigozin.

Illustration 12.2 *In the photo Vladimir Putin together with Yevgeny Prigozin who finances the "troll factory", Source: NEO New Eastern Outlook*

The intelligence services of the Russian Federation implemented even a special system that manipulates mass awareness through social media. This system is known as the Storm-12 and is a very useful tool used by the authorities in the Kremlin to wage a propaganda and information war. It monitors content on the Internet (mainly blogosphere, discussion groups and internet forums) for the purpose of disseminating convenient information on social networks as well as for the purpose of posting on the Internet information that serves intelligence services in some way.

A similar tool is used by the Polish military for offensive activities in cyberspace. The military virus code-named ID29, used by the Polish Army, is used to wage an information war and paralyse the enemy's infrastructure. ID29 performs the following functions:

- carrying out DoS and DDoS attacks,
- taking control of network and mobile devices,
- deactivation of systems and devices,
- listening to and capturing data transmission.

The activity of Internet users is today a matter of interest for the services of most countries. For example, it is known that the US National Security Agency (NSA) had for a long

time regularly monitored the phone calls of 35 foreign leaders and carried out total surveillance of the Internet. This was revealed by Edward Snowden in 2013, when the world became aware of several hundred thousand confidential, secret and top secret documents from the U.S. National Security Agency. According to Snowden, the American intelligence services used the intelligent PRISM software, which allowed them to listen to Internet calls in bulk, browse e-mails and learn from chats, video chats and social networking sites. What is more, American companies, such as Microsoft, Google, Yahoo or Facebook, were also to participate in this procedure.

Another example is the Romanian hacker Marcel Lazar Leher, known as "Guccifer", who contributed to revealing the e-mail scandal of the presidential candidate Hillary Clinton during the U.S. presidential campaign. Although it is unofficially said that the Russians dipped their fingers in revealing this correspondence.

There are also defaced attacks[108] in cyberspace aimed at replacing the content of websites displayed to users with hackers' content, such as an important political message or graphics. An example is the Syrian Electronic Army (SEA), which has many such feats on its account, e.g. replacing the official website of the American Army or breaking into Barack Obama's Twitter profile and changing the link in one of his posts.

Gateway for hackers

For example, an out-of-date, vulnerable software or an open printer port can be used to access data stored on a computer. It's often the case that virus-infected Word or PDF documents that sent in e-mails as attachments are sufficient to infect entire computer systems. To avoid raising suspicions they are usually related to current social and political events. When the addressee of such an e-mail opens the attached file (tries to download it to his/her own computer), spyware will be installed on his/her computer which will allow cybercriminals to break into the infected system and steal relevant sensitive data from it. In the hacking slang such a manner of action is called "smash-and-grab".

[108] Website defacement is an attack on a website that changes the visual appearance of a website or a web page.

In addition to accessing the data on the victim's hard disk, cybercriminals can also record the keys they press, listen to their communications, or watch them on a webcam.

It is also worth knowing that antivirus software is usually not a shield for devices such as printers or other peripherals. Hackers very often use these devices as a kind of bridge, thanks to which they can easily get to the victim's computer. In February 2017, a hacker named Stackoverflowin used a proprietary script to search for open printer ports to break into thousands of different computers in homes and offices around the world. Victims of Stackoverflowin's attacks could find in their printers prints with the message: “Hacker god has returned to his throne, and your printer belongs to him”. Fortunately, the goal of this hacker was not to cause any harm to anyone, but only to make people aware of the dangers resulting from gaps in security of their devices.

Hackers also take advantage of imperfections in the programming languages (PostScript and PJL) that printers use to execute commands. In this way, they intercept communication between the printer and the computer and then make the printer execute their own commands. Listening to the data transmission between the printer and the computer very often allows them to intercept important (from a business perspective) information concerning various offers, contracts or projects, or even sensitive data such as bank account numbers. By taking control over such a printer you can easily change account numbers, names of important persons (e.g. beneficiaries of transfers or invoice details) to whom specific money transfers are to be sent. It is not difficult to guess that in such a situation the money instead of going to the entitled persons is credited to the accounts of hackers or persons (companies) related to them. Of course, there is a whole catalogue of various cybercrimes, including hacking into someone's account, data theft, industrial espionage and even tarnishing someone's image as well as state cyber-terrorism.

Remote-controlled Boeing

In the near future there will be passenger planes in operation that will no longer require the presence of pilots on board. This competence will be entirely entrusted to artificial intelligence. Boeing is currently working on the development of such technology and wants to carry out the first experimental tests of such machines as early as 2018. Automation of remote control's work is not only dictated by the development of artificial intelligence and the

tendency for even greater automation (to automate everything). In part, this process is being forced upon the aviation industry itself which is ordering more and more new airplanes while at the same time facing a serious shortage of pilots on the labour market. According to estimates by the International Air Transport Association (IATA), there will be approximately 40,000 new airplanes in the world in the next 20 years. With approximately 29,000 commercial machines worldwide today, this means that the current global fleet will be more than doubled. At the same time, it seems impossible for the number of experienced pilots to increase enough to keep up with the growing number of airplanes.

The risks involved cannot be ignored. Fully autonomous aircrafts will pose an additional risk (air transportation risk) as they could potentially become the targets of cyber-attacks which could expose passengers to loss of life. This is a major challenge for individuals, companies and organisations responsible for cyber security in airspace.

How dangerous can an intelligent home be?

Technologies are entering our daily lives relatively quickly, although we do not really know yet whether they are safe or not.

In the age of the Internet of Things, intelligent fridges, washing machines, vacuum cleaners and microwaves are no longer impressive. These devices are designed to make our lives easier, but in reality they very often expose us to the risk of losing valuable data. This is due to the fact that they receive, store and send our data on the basis of a global network to which everyone has access. Unfortunately, hackers only wait for the information flowing through the Internet, and thanks to appropriate modern methods they are now able to hack even the most complicated security systems and watch or listen to almost everyone.

The problem is that if hackers are able to break the security features of such intelligent devices (hardware), they usually immediately gain access to a wireless network (Wi-Fi) which opens the way for them to intercept electronic communications such as passwords to e-mails and bank accounts. They also gain practically the ability to control the entire house. Cybercriminals are perfectly aware when their victims are at home or away from home, e.g. by having access to electricity meters or to webcams on their laptops, TVs or integrated security systems. Unfortunately, most of us do not even suspect that we may be watched or eavesdropped on. Meanwhile, reality can be more surprising than you can imagine. Today,

there are often cases where someone is watched and then even blackmailed by embarrassing recordings that are recorded (in the privacy of your own home) by cybercriminals. In the United States, much attention was given to the case of Cassidy Wolf, Miss Teen USA in 2013, who was a victim of a cybercriminal who hacked her webcam and took intimate pictures of her and then used them for blackmail. In times of frequent use of devices equipped with such mini-cameras, it is worth to make sure that we are not accidentally watched by someone.

In 2015, Pen Test Partners security specialists discovered serious security gaps in Samsung's smart fridges. The errors were related to the implementation of the TLS protocol[109]. The equipment used SSL protocol[110], however, it did not verify the validity of the certificates themselves. Software gaps expose users of such refrigerators to the risk of hacking attacks and theft of their data. Potential cybercriminals could easily steal their passwords and tokens from the refrigerator system and then use them to hack their home wireless network (Wi-Fi) and finally intercept the right login and password for Google services and gain unhindered access to the computer of an unaware victim[111]. Devices such as smart fridges and washing machines are very often attacked by hackers only to be later used as "bots" to create a network of such machines (i.e. botnets) for even larger Internet attacks.

There is also a serious possibility that drivers may be on the hacker's sight. Today, most modern cars are vulnerable to cyber-attacks (they are not adequately protected against such attacks). An example is the new Nissan Leaf in which the Japanese manufacturer neglected to properly protect computer systems, thus leaving the hacker the door open to take control of this electric car. In 2015, Charlie Miller and Chris Valask, two researchers who deal with car safety issues on a daily basis, managed to take control over Jeep Cherokee's electronic system from a distance of 30 km [89]. They took advantage of the gap in the vehicle's electronic system and were able to control its steering system, transmission, air conditioning, radio and wipers via a laptop. They also managed to switch off the brakes in this car and make it fall off the road and find itself in the proverbial "ditch". In the upcoming years the risk of taking over control of moving cars will be systematically increasing. This is due to the fact that modern cars are increasingly equipped with systems that enable them to be controlled via the Internet.

[109] TLS (Transport Layer Security) is an encryption protocol that ensures confidentiality and integrity of data transmission.
[110] SSL (Secure Socket Layer) is a protocol for encrypting data transmitted over the Internet.
[111] Using the man-in-the-middle hacking method, which involves listening to the data transmission and then modifying the content of the message sent between two parties.

The example of Jeep Cherokee (manufactured by FCA Group) shows that the systems and software in such cars are susceptible to attacks from the outside and therefore leave a lot to be desired.

Hackers also have the potential to interfere with many medical devices. In 2016, Johnson & Johnson warned its customers against the possibility of hacking one of its diabetic insulin pumps[112] [286]. Although the risk of such an event has been identified as low, if it were to occur, its users could even be seriously endangered. This could result in an overdose of the insulin hormone. Cyber-terrorists could remotely control such pumps.

Unfortunately, most of the intelligent devices we use on a daily basis do not have very strong security features. Their problem is that they can be remotely controlled and the data can be downloaded from them via the Internet. Most often, they do not combine different security features, such as chip cards and fingerprint readers or iris scans (the so-called double authorisation or multilevel security). Biometrics, our individual body features, appear to be one of the most effective forms of protection against cybercriminals today. However, even this technology does not provide 100 percent protection against hackers. It should be remembered that many companies do not modify the software installed in their devices after they had been introduced to the market, and that these devices are ageing very fast and not all of the companies can afford to replace them with new ones, for example, every six months.

The more devices are connected to each other in the future the greater the potential of the hackers themselves will be. In the future, more and more elements will be automated and in addition to intelligent homes entire intelligent metropolises, cities, towns and even villages will be created. Of course, we will also not avoid security gaps and software designers' mistakes which will be immediately exploited by cybercriminals (hackers). This, of course, should change the optics of looking at network security. Cybercriminals will be able to attack not only individual users or companies but also entire cities. It is possible that in the near future we will also have to deal with such a phenomenon as “cyber murder”.

[112] It was a OneTouch Ping pump model that was sold in the USA and Canada.

13 SUMMARY (GENERAL OVERVIEW)

Digital technologies have completely changed the lives of millions of people. Both at work and in everyday life, we are increasingly surrounded by new technological solutions and intelligent objects. Examples include smart shoes that communicate our physical activity data to the smartphone, a refrigerator that can order shopping on its own, remote check-in at the airport, autonomous driving technologies, electric cars, 3D implants, and 3D houses, bionic prostheses, biological computers, artificial muscles, self-cleaning clothes or facades of buildings, nano-medicines which enable targeted therapies for cancer treatment, virtual reality goggles, cryptocurrencies, drones, new kinds of alternative energies and thousands of other technical solutions. It seems, however, that the most interesting is yet to come. Progress in many areas has reached such a point that the limits of further technological development can ultimately be bounded only by human imagination. However, most of the technological innovations that are emerging in the fourth industrial revolution have one thing in common: they all **benefit from the ubiquitous power of digital and information technologies**. For example, gene sequencing would not have been possible at all without adequate progress in computing power and data analysis. Similarly, advanced robots would not have been possible without artificial intelligence, which itself benefits greatly from the massive computing power of computers. The same can be said about 3D printing, nanotechnologies, biotechnologies, autonomous-driving technology, virtual and augmented reality, energy-related technologies or space technologies. They all need massive computing power, and that is the key element that underpins their development.

Therefore, let me try to highlight the most important conclusions that you can draw from reading this book, which will indicate the most important changes, consequences and challenges that the fourth industrial revolution brings with it:

- **The digital revolution is accelerating the pace of technological changes**. This means that further significant technological changes (new inventions) will occur more and more often. According to the famous British astrophysicist Stephen Hawking, thanks to the development of artificial intelligence we will soon reach the limit of technological singularity. Under the concept created by Vernor Vinge back in the 80s

of the last century, the singularity is the **moment when technological progress becomes so advanced that all human predictions will cease to matter** [356][178]. People will simply not be able to keep up with algorithms and artificial intelligence. Actually it is not a breakthrough discovery. It has been known for a long time that the world is not developing linearly. Kevin Kelly [151][176], who in his book *What technology wants* tries to answer the question of what is the significance of technology in our lives, points out the fact of permanent technological acceleration. We must admit, that it changes our everyday life more than we are able to realise - starting from the personal level of each one of us, and finishing on the place of man in the universe. The acceleration of technological processes is relatively easy to illustrate using the example of the Human Genome Project. At the beginning of the 1990s, it was assumed that the project would be implemented within 15 years (i.e. until 2005). The U.S. Department of Energy and the U.S. National Institute of Health (NIH) allocated $3 billion for this purpose [61]. After 10 years of research, only a small part of the entire human genome has been known. This is where the nature of exponential growth lies, namely that certain processes accelerate only when they reach a certain point in their development. In the case of the human genome, most of the gene sequences were known only in the last few years of the development work on this project. It took 14 years to sequence HIV and in the case of SARS lasted only 31 days [179].

- **The digital world becomes connected to the physical and biological worlds**. The different environments intertwine and the differences between them fade away. One could say that in the age of the fourth industrial revolution, these three worlds are merging. The fourth industrial revolution is also unique in that it leads to increasing harmonisation and integration of various areas of life [301, p. 15]. Real innovations which are more frequently taking place are the result of synergies between different technologies. Digital technologies more and more often interact with the physical and biological worlds. Some designers are already integrating computational design, additive manufacturing technology[113], material engineering and synthetic biology [301]. They do this to create systems based on the interaction between the microorganisms, the human body, the products we consume and even the buildings in

[113] Another name for 3D printing technology.

which we live. In this way, they create products (objects) that are constantly transformed and modified. The fourth industrial revolution will bring together a variety of technologies, often from completely different industries, but which are mutually supportive. Examples are for instance:

- **combining 3D printing technologies with editing and modifying human genes, known as bioprinting**, which can perceived as a fusion of technologies from the physical and biological world. This technological hybrid allows the production of living tissues, which can replace old cells requiring regeneration. Thanks to this technology, artificial skin, vascular tissues or even some human organs such as the heart can be created. It cannot be excluded that in the future such a technological hybrid will allow the creation of liver cells and other organs for transplantation purposes;
- **laboratory production of animal-free leather and meat** (production of artificial food), which is a solution combining the physical and biological worlds (this technology is used, among others, by Modern Meadow). This solution involves the use of a 3D printer and bioinks containing cells previously taken from animal bodies. Small pieces of tissue are collected from the animals, replicated and used as bioinks for the production of pieces of meat;
- **augmented reality**, which allows for designing an effective interface ensuring human communication with the digital machine [140, p. 634]. However, the augmented reality does not change the real image that exists in our environment, but only imposes additional information on it (presented in digital form), which enriches the real image and allow for its better interpretation. **This technology is the link between the physical world and the digital world**. AR is applied in many areas of life. For example it is increasingly used in the automotive and military sectors. A lot of additional information from the external environment is displayed in an unusual way thanks to this technology, namely by means of special HMD goggles (head/helmet mounted display) or on vehicles' windscreens by means of *head-up displays*;
- some recent medical developments linking the biological world to the physical and digital worlds. The possibility of editing and modifying genes, artificial muscles made of carbon nanotubes - 30 times more resistant than human’s,

bionical body, bionical prostheses controlled solely by the power of will - are just some of the examples. Progress in gene sequencing, activation and editing has led to the potential to "create" perfect children without unwanted genes. So it is highly probable that in the future parents will decide about various genetic attributes of their offspring. Over time, the cost of sequencing the human genome will fall to a few dollars, and genetic therapy will be used to treat many serious diseases. **Over the next decade or two, biotechnology will become a tool to read and process information from our biology**. In this way, we will begin to perceive and interpret our lives (the structure of the human body and its behaviour) through the prism of information processing [368]. **By the middle of the third decade of the 21st century, we will probably be able to successfully "program" and "reprogram" our biology as part of a broader information process that will be integrated with the digital world**. For example, it will be possible to silence some of the genes that cause diseases, such as cancer or coronary heart disease, and to add others that will delay the ageing process and prolong life itself. According to Ray Kurzweil, with time, progress in replacing ageing cells and replenishing organs will become so rapid that with each subsequent year, we will be able to extend human live by more than one year [372].

- **Large companies initiate projects in various areas**, sometimes in areas with which they had no previous experience. Open thinking and the ability to connect the dots have become pivotal traits of modern managers. Here are some examples:
  - Google, which has entered into numerous medical projects, including the Baseline project, which aims to collect, process and analyse millions of medical data in order to later develop a model of the ideal state of human health.;
  - Apple, which working on the technology of an electric car called Titan;
  - Sony Corporation, which is involved in the insurance industry;
  - Facebook, which has started spreading wireless and free Internet;
  - Amazon, which has entered the space industry.

- **No one knows where and when, yet another amazing start-up will emerge which will change the world in a flash just like Google, Apple or Tesla did.** Other examples of similar companies that are rapidly transforming their industries are:
    - Uber, which has changed the approach to transport and mobility. The company was founded in 2007 and yet in 2015 it was valued at 60 billion dollars. Uber is also strongly involved in the development of autonomous driving technology;
    - Amazon, which has revolutionised e-commerce. The founder of Amazon, Jeff Bezos, is currently the second richest man on earth;
    - Netflix, which has changed the film and series industry;
    - Spotify, which has revolutionised the way music is accessed;
    - Alibaba, which disrupted the traditional retail industry and affected e-commerce industry;
    - Airbnb, which has changed the approach of clients to using the accommodation base.

  Some companies, which based their business models on new advanced technologies, did not need much capital to establish themselves and prosper. Examples are companies such as Instagram, WhatsApp or Snapchat. It is therefore worth emphasising that **in the era of industrial revolution 4.0 the role of capital and economies of scale is significantly changing**.
- **More and more dynamic changes make science fiction film scripts a reality.** Examples are:
    - **Google's autonomous driving technology**, which was completely unknown 10 years ago and for the first time the company announced its plans for this technology in 2010 [41]. When Google presented the concept of its first fully autonomous car, no one expected that all of its autonomous vehicles would rack up nearly 4 million miles in just six years. Today, the technology developed by the giant from Mountain View is so advanced that the number of interventions made by drivers testing Google’s stand-alone vehicles has fallen to just two for every 10,000 miles covered. Without doubt, self-driving cars will soon become a common reality on our roads;

- **Tesla electric cars**, which travel about 540 km on a single charge. The company was founded in 2003 and back then it may have seemed improbable to launch such a car on the market;
- **smartphones**. The first smartphone (iPhone) was presented to consumers in 2007. Ten years ago, none of us had a smartphone yet. But by the end of 2015, there were already about 2 billion such devices in use around the world. Today, it is practically difficult to imagine life without them. Over the past decade, they have changed both the world of digital technology and people's social behaviour and communication;
- **technological solutions in the area of telemedicine and tele-surgery**. The increase in the speed of data transmission on the Internet and the development of artificial intelligence and virtual reality technologies already allow for remote surgical operations;
- **development of biological computers**. Today the first model of such a biological computer is able to solve simple mathematical problems, such as checking the sum of subtotals in a set of numbers. However, biological computers are one of those technologies which, about which a few years ago we could at most read in fantasy science books, and now step by step they are becoming a reality. According to experts, whereas in the long run quantum computers may prove to be much more efficient than biological ones, protein machines are more likely to be widely used in the short term. An example is a biological computer, called a molecular transducer, developed by the Technion - Israel Institute of Technology, which performs complex calculations and can modify the genetic code based on the results [336]. In contrast to the electronic computers we know today, a biological machine can perform many operations simultaneously, which may prove very useful in the future, e.g. when modelling connections between neurons of our brain [249]. Meanwhile, in order to achieve multi-tasking in ordinary computers, the number of microprocessors needs to be increased;
- **nano-drugs**. The dynamic development of nanotechnology has made it possible to create solutions based on targeted therapy, i.e. drugs that can reach and destroy only diseased cells, e.g. cancer cells. Such nano-drugs were

developed, among others, by the team of Prof. Tomasz Ciach from the Warsaw University of Technology. These drugs are cytostatic-filled polysaccharide nanoparticles which act as self-stimulating missiles when they reach their targets. Polysaccharide nanoparticles have a transport function, i.e. they reach the tumour cell target. Solutions of this kind, which until a few years ago could only have been dreamed of, may soon lead to a real revolution in the treatment of diseases that were previously considered incurable;

- **houses printed in 3D technology**. An example is the Chinese construction company WinSun, which made the first five-storey block of flats fully printed with 3D spatial printing technology, the tallest building in the world, which was created as a 3D printout using a giant printer measuring 150 metres in length and almost 7 metres in height;
- **Hyperloop vacuum train technology**. Elon Musk presented details of this technology in a White Paper (i.e. Hyperloop Alpha), which he published in August 2013 [245], and already in 2017 the construction works of the first Hyperploop test tracks were commenced in two different cities (in Quay Valley, Calif. and Nevada) [134]. In the first quarter of 2017, the construction of the first Hyperloop capsule started at the Airbus Defence and Space laboratory in Toulouse, France [155].
- **holographic singer Hatsune Miku**. A few years ago it would be hard to believe that a holographic character, physically non-existent, would attract thousands of fans to the concerts. Such a character, "created" by the Japanese, is a virtual singer Hatsune Miku, whose concerts are attended by thousands of people, and who has a lot of fans in Japan;
- **the Internet of Things**. There are many examples in the IoT area that would have seemed unlikely until a few years ago, such as connected cars that communicate themselves, smart footwear or the TracoVino platform (in the Moselle Valley), which can control wine-growing and manage vineyards (by controlling, among other things, the amount of water available in the soil, the temperature of the air and other factors that determine wine-growing);
- **virtual and augmented reality**. Everything related to VR has been developed over the last few years. Thanks to the VR goggles, we can already move to the

world of virtual reality and see everything around us almost as in the natural world. An example that went far beyond all imaginations is the VR Coca-Cola action, which during the World Cup in Brazil in 2014 allowed football fans to move from the changing room directly to the stadium where the hosts played their game. All this happened in virtual reality with the help of special VR goggles. Nevertheless, the world of virtual reality itself and everything that those who took part in the action saw with the help of VR goggles was almost the same as in the natural world;

- **fast-growing space tourism sector.** Tourist flights to space are no longer science fiction, but a real future, which many of us will witness while we are still alive;
- **development of carbon-fibre fuselage and spacecraft engines to help realise interstellar flights in the future**. These technologies make it possible to accelerate a small mass to a speed corresponding to about 10-15 per cent of the speed of light. It is quite likely that thanks to this technological solution we will be able to get to know better the whole universe;
- **emergence of technologies for space-mining**. Companies such as Planetary Resources and DSI have already achieved successes in this area [139, p. 26];
- **development of blockchain technologies**, i.e. distributed database networks (a.k.a. blockchain distributed ledger). The secure protocol that underpins this technology allows for common (collective) verification of various transactions over a network of computers before they are validated and saved. The technology on which blockchain is based builds trust between each of the parties to the transaction (contract), without the need for the assistance of a trustee or notary. Blockchain is a common, programmable and cryptographically secure registry that cannot be manipulated by any individual and can be checked at any time by anyone involved. So far, the best known use of this technology is bitcoin, but the possibilities of its application are practically countless. **While today blockchain allows financial transactions to be recorded, in the future it will be used as a registrar for birth and death certificates, property titles, marriage certificates, academic and professional qualifications, degrees, insurance claims, vote counting, etc**. We will use this

technology in all types of transaction agreements. Some countries are already trying to exploit the potential of blockchain. For example, Honduras wants to use this technology to trade property titles and in the Isle of Man it is being tested for registering companies;

- **development of the Internet with very high speeds and low delays, i.e. the so-called 5G standard.** The 5G network is becoming a reality. Thanks to this technology it will be possible to develop further inventions and completely new business models, which so far have not been possible to develop due to significant technological barriers, e.g. delays in data transmissions reaching tens of microseconds. Examples of technologies whose further development depends on the full implementation of the 5G standard (anywhere in the world) include:
  - Internet of Things (IoT);
  - autonomous driving technology;
  - telesurgery and telemedicine;
  - mutual communication between vehicles (V2V);
  - merged reality technologies;
  - technologies (devices) for the delivery of live VR transmissions, e.g. Intel True VR.
- **artificial intelligence**, which is becoming more and more visible in our everyday lives. The dynamic development of this technology makes the attempt to compare man to machine pointless. Machines are gaining an advantage over us in more and more areas expertise. Here are some examples:
  - deepMind's AlphaGo computer program, which defeated the world's top-ranked Go-player Lee Sedol 4:1 (in March 2016);
  - self-driving cars. Progress in the development of autonomous driving technology has led to the expectation that transport will soon become another fully 'digitalised' domain. Robotised vehicles, driven by machines, will start to appear on the roads. This will eliminate a significant number of road accidents and reduce the number of traffic jams;
  - virtual assistants (chatbots), e.g. SIRI, an iPhone application that can communicate in a natural language. Other examples of virtual assistants

include those created by Amazon (Echo), Microsoft (Cortan) and by Google (Google Now);

- robo-soldiers created by Boston Dynamics. If the future battlefields are dominated by robo-soldiers (similar to those produced by Boston Dynamics), they will certainly not need to be given orders several times and will execute them immediately.

- **As a result of the Industrial Revolution 4.0, the role of capital and economies of scale is changing**:
  - thanks to digital methods of reaching customers worldwide, **marginal costs are decreasing and the economies of scale are very high**;
  - digitisation means that production is becoming increasingly automated, which in practice means that **businesses are not exposed to decreasing economies of scale**. The fact that much fewer workers are needed to produce a single unit of wealth today than yet a decade ago is due to the fact that digital businesses have a declining marginal cost which is decreasing and approaching zero;
  - the digital revolution is an opportunity to **increase production efficiency**;
  - thanks to digital platforms, **selling the same service to another customer does not require any additional costs**. The reality of the digital age makes it possible to offer services that entail practically no costs for storing, delivering or reproducing the service or goods offered;
  - **Some highly developed countries, such as Germany, are already relocating their production from countries such as China to their own countries**. This is the result of the fourth industrial revolution, which is **making labour costs meaningless**. **As a result, countries that have so far competed on the basis of low labour costs and have built their competitive advantage on this premise may soon face serious competitiveness problems**. This could ultimately lead to an even greater concentration of wealth and the formation of a bipolar world. The richer countries will become even richer and the poorer countries even poorer. There will also be many social problems, such as an **increase in terrorism**, caused by increased frustration on the part of excluded people, who will come from regions threatened by poverty and high unemployment. It is

worth emphasising that **social inequalities are becoming an element of systemic change**[114].

- **Legal changes do not keep pace with the dynamics of technological changes.** Here are some examples are:
  - the lack of adequate regulation of autonomous driving technology in most countries;
  - the lack of adequate legal regulations to keep up with the pace of crowd funding development and capital raising for various projects;
  - technological solutions that escape the standards, e.g. the owner of the first Tesla electric car in Poland had a problem with the registration of his car due to the fact that his title did not include an entry on the engine capacity [229].
- **Development of digital technologies entails an increase in energy demand**. Without additional, cheap energy to meet the rapidly growing demand, the development of digital technologies will not be as fast as you would expect. **The pace of the fourth industrial revolution will therefore depend to a large extent on the development of alternative energy technology and increased energy efficiency**. There is great hope for research into unconventional energy sources. The most promising solutions include floating nuclear power plants, low-energy fusion, reactions in thermonuclear reactors and wireless transmission of energy from space. It is very possible that in the future tokamaks or stellerators will provide us with abundant and inexhaustible sources of clean energy. It is also worth highlighting the great progress that has been made in recent years in the field of renewable energy sources, which is due to increasingly better and more advanced technologies. The first photovoltaic roads have already been built in various parts of the world and they act as solar power plants supplying road lighting systems with electricity. For the time being, these are only pilot projects involving small road sections, but it is very likely that these technologies will become widespread in the near future and will be implemented on a much wider scale.

  The authors of the book *The Second Machine Age: Work, Progress, and Prosperity in a Time of Brilliant Technologies* - Prof. E. Brynjolfsson and A. McAfee even claim that **computers are already so highly efficient that it is impossible to predict**

[114] A systemic change means a change that affects the system.

what else they will be used for in a few or a dozen years [41]. The huge progress in the field of artificial intelligence (AI) is largely due to **the increasing availability of vast data resources**, which we ourselves create as consumers of many technologies, for example by making videos available on YouTube. AI is used for research on new medicines. Algorithms are also able to predict our interest in culture. Artificial intelligence learns from the small 'footprints and fingerprints' we leave ourselves in the digital world. This results in new forms of machine learning and discoveries in the field of automation that make intelligent robots and computers capable of self-programming and finding optimal solutions in many areas of life. An example of this is the super machine Watson described earlier, created by IBM[115], which on the basis of the results of scientific studies, medical examinations and the cards of millions of patients, is able to make its own diagnoses and thus provide the doctors with help. The great popularity of Apple's Siri smart app shows that technologies like "intelligent assistants" which are based on artificial intelligence, have a bright future ahead of them. Voice recognition and artificial intelligence are technologies that are developing so fast that talking to a computer or a smartphone is now available practically everywhere. Personal robo-assistants are already able to answer most user questions. Intelligent devices, which we use more and more often, every year will have an increasing share in our life and will even constitute entire ecosystems of various functionalities, making it easier for us to carry out many activities. They will listen to us, they will anticipate our needs and, finally, they will relieve us of many of our daily activities, whenever we need them and even if we do not ask for them ourselves.

Technologies for virtual and augmented reality are also on the verge of major breakthroughs. **They form a bridge between the digital world and the real world.** The augmented reality connects the world of vivid images with the digital world of computer graphics. It allows us to impose digitally generated effects on the real world. However, with further rapid development of these technologies, they could prove to be a serious competitor or even a threat to the real world. This, of course, may be of some concern. The possibilities of using VR and AR technology are enormous. This will primarily benefit areas such as video games, medical science, industrial engineering,

[115] This case is described in the chapter on Artificial Intelligence.

real estate, entertainment, marketing, military and education. Even today, VR goggles are used by surgeons to prepare for procedures/surgeries or to perform virtual endoscopic tests. VR technologies already allow us to watch selected sports, music and entertainment events without leaving home. One of the greatest achievements in this field is Intel True VR technology based on spherical cameras. The sales industry is also looking forward to VR and AR technologies. One of the biggest beneficiaries in this area may be shops with interior furnishings and building materials. Thanks to the VR goggles customers of these shops can actually see (as if they were actually there) how the furnishings might look in a room and how they fit. The only difference is that they see them in virtual reality and not in real world. It can also be expected that the experiences and feelings related to the virtual reality will be additionally supported by other technologies. In the future when someone speaks to us in a foreign language thanks to the augmented reality we will have immediate access to the translation of his or her speech (in a simultaneous form). With special AR glasses or even, as Ray Kurzweil says, with special contact lenses, the images and information we need will appear directly in our field of view. It is highly probable that in the future, apart from the person we are going to talk to, we will also see (in augmented reality) information about him/herself. If this technology is actually developed, it will very likely change the lives of all of us, giving us access to a variety of texts, speeches, translations, real-time charts, maps and much more valuable information at any time and any place. This will probably disrupt many areas of live and change the functioning of many professions. Thanks to the AR, we will be able to access information from the Internet practically anytime, anywhere.

Another important area that is driving the fourth industrial revolution is the space industry. Some scientists are even convinced that it is only by conquering space that we can ensure humanity's survival. According to Stephen Hawking, we will survive on Earth for at least 1000 more years. That is why we should start thinking now about establishing self-sufficient colonies beyond the Earth. Elon Musk expects that by 2060 a million people fully self-sufficient colony could be created on Mars. This is certainly one of the most difficult challenges we will have to face in the upcoming years. Anyway, today it is difficult to predict whether this challenge will eventually be sustained in the long run. It's not just about escaping from the Earth alone. The

resources that could potentially be exploited in space in the future could significantly change the nature of modern economics. **Breaking with the basic economic principle of scarce resources in relation to people's unlimited needs could result in unimaginable changes in global markets** (i.e. disrupt and destabilise them). Technological progress makes the prospect of mining of various raw materials from asteroid quite real [304, p. 44]. It should also be remembered that space exploration is driving the development of many technologies that are not directly related to the construction of rockets or space shuttles and their propulsion systems. Nor can we underestimate the significant impact of space exploration and the entire space industry on overall technological progress and on the development of many areas of our lives. We must remember that many technological solutions coming from the space industry are also relatively quickly applied in other ordinary areas of human life. **Therefore, the impact of this sector on the development of the world and on the fourth industrial revolution is no less important than in the case of other technologies and entire industries**.

The fourth industrial revolution may bring us many benefits but it will probably also be the cause of many challenges. Particular concerns relate to the expected increase in social inequalities. However, **the challenges that will accompany the growing social inequalities are difficult to predict as most of us are both consumers and producers**. Innovation as well as the shocks that the Industrial Revolution 4.0 will cause will affect our standard of living and our well-being. Of course, consumers should benefit most from the changes that await us. Thanks to the industrial revolution 4.0 consumers get completely new products and services. Technological progress allows us to do many things remotely, e.g. order a taxi, book a flight, buy certain products online, make a payment, listen to music or watch a movie. The benefits of digital technologies for consumers are undeniable. The Internet, smartphones and thousands of applications make our lives simpler and more productive. On the other hand, the challenges of the fourth industrial revolution appear to be mainly on the supply side, i.e. in the world of manufacturing and the labour market. Over the last few years, most developed and fast developing countries (such as China) have seen their labour-to-GDP ratio falling significantly. Half of this decline is due to a change in relative prices for capital goods as a result of **progress in innovation, forcing companies to replace**

labour with capital. As a consequence, **the biggest beneficiaries of the fourth industrial revolution are those who provide both intellectual and physical capital, i.e. innovators, investors and shareholders**. This justifies the growing gap in wealth between those who live from work and those who have their own capital (i.e. venture capitalists). This also explains the disappointment of many ordinary workers, who remain convinced that their real income is unlikely to change throughout their entire lives. Many of them even believe that their children will have no better life than themselves. **The concentration of benefits and values in the hands of a small percentage of people is also partly a result of the so-called digital platform effect**. Digital managed enterprises use a global network to maximise their customer base and thus achieve significant economies of scale [299, p. 17]. As a result, several such giant companies using digital technologies can control almost the entire market in their industries (e.g. Amazon). This phenomenon will benefit consumers in the first place. Compared to traditional businesses, companies operating online provide their customers with additional value of delivered products and services, e.g. lower costs, time savings, convenience, comfort of using the services, etc. On the other hand, it also involves a social risk. To prevent capital and power concentration, we need to find a way to balance the benefits and risks of digital business. One way to reduce potential risks is to ensure the widest possible access to innovation for all stakeholders, e.g. through collaborative projects. Another idea could be to impose a special 'robot tax' on companies using smart machines in their operations, or to introduce an unconditional basic income, which would be a form of compensation for the fact that the work is largely carried out by machines. **The negative social effects of automation should be combated by means of systemic solutions, and the role of states and governments, which must actively participate in the fight against social inequality, should be crucial in this matter**. On the other hand, no one should be discouraged or even prevented from using automation because apart from the social costs, as consumers we are all beneficiaries of new technologies.

The challenges outlined above have a significant impact on the entire economic, social and political system and have far-reaching consequences which are in principle already irreversible. The important question that should be asked by entrepreneurs and representatives of particular industries is this: will my company or

my industry be disrupted? If there is a breakthrough technology, what form will it take and how will it affect my business?

The omnipresence of technologies and digital devices, the dizzying pace of computerisation and automation, will result in the emergence of many more and more new threats. One of the most serious of them is of course the issue of cyber security. Hacker attacks into strategically important facilities that are part of the critical infrastructure of the state, industrial espionage, taking control over production systems, stealing sensitive data and blackmailing rich companies or even governments of nation states, the possibility of surveillance or even taking control over buildings or even entire cities are just some of the exemplary threats. Many of the devices that we use every day and that may be the target of a possible attack are typically low-capacity systems, making it difficult for them to resist cyber-attacks. If in the future cars, home furnishings, TV sets, refrigerators, washing machines and even clothes are to be plugged into the network, this will obviously pose a number of significant risks to our security. After all, the cybercriminals who would gain access to them would not only be able to steal us but in extreme cases would also expose us to health or even life risks. An attempt to identify the perpetrators of such crimes could also be a problem.

However, the expected inevitability of many of the social changes and threats brought about by the fourth industrial revolution does not necessarily mean that we are completely powerless to face them. It is our responsibility to ensure that we set the right common values so that the choices we make and the changes we bring about make this revolution an opportunity for all.

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LIST OF TABLES

LIST OF ILLUSTRATIONS

LIST OF CHARTS