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## THE ROLE OF BIG DATA AND DATA SCIENCE IN THE CONTEXT OF INFORMATION SECURITY AND CYBERSECURITY

## ABSTRACT

In the area of the fastest growing fields of ICT technology which determine the successive stages of progress in the field of online electronic banking, it is necessary to disseminate standards for conducting financial operations carried out in the so-called cloud as well as using the large data sets located in the so-called Big Data platforms. Current Big Data technology solutions are not only large data bases, data warehouses allowing for multi-aspect analysis of huge sets of quantitative data made for the purposes of reports submitted periodically to the managerial staff. Currently emerging trends in the development of technology based on Big Data dataset platforms usually allow to perform multidimensional calculations and reported results of analyzes in real time. The analyzes conducted on huge data sets allow for comprehensive, multi-aspect risk assessments at the level of the whole entity.

During the SARS-CoV-2 (Covid-19) coronavirus pandemic, there was an increase in the importance of analytics based on Big Data Analytics. During the pandemic, there was also an increase in the digitisation and internetisation of business processes. This also resulted in an increase in the scale of cybercrime development. The development of information technologies functioning on the Internet also involves the risk of loss or theft of information by unauthorized entities. The process of providing information via the Internet generates many threats related to identity theft, interception of classified data and cash embezzlement in Internet business systems. In response to these threats, particular entities are developing security systems for remote sharing of information and transactions conducted via the Internet.

**KEYWORDS:** *Big Data, Data Science, Internet, information security, cybersecurity, data processing, databases, information management, information society, Industry 4.0, Business Intelligence, Covid-19*

## INTRODUCTION

Artificial intelligence and machine learning could not exist without large data sets, called Big Data. These are large and diverse data sets that can be described in terms of data management challenges that – due to the increasing volume, speed and diversity of data – cannot be solved using traditional databases. Although there are many definitions of big data, most of them include the concept of the so-called *three Vs*: high volume – a large amount of data,

high variety – high diversity, includes data from many sources and formats (e.g. interactions in social media), news, e-commerce and online transactions, financial transactions, etc.) and high velocity – high speed of data processing that must be analyzed quickly and in the relatively shortest possible time. After some time, the model was supplemented with two additional components – the value of the data that we can obtain from them for the end user (value) and verification of the data we have (veracity).

According to Gartner, *big data is big data, information resources of high volume, high speed and/or diversity that require cost-effective, innovative forms of information processing that enable better insight, decision-making and process automation* (Gartner 2019).

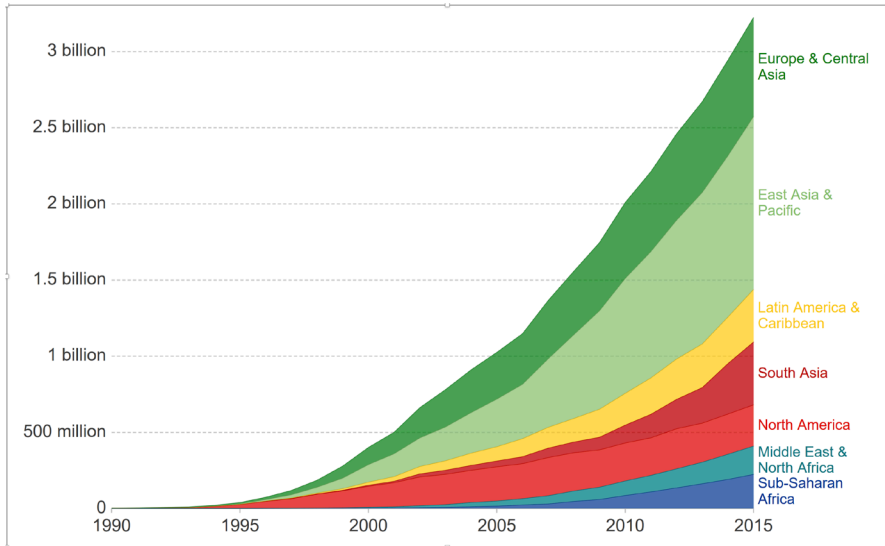
Marion Barraud told Harvard Business Review: *The term 'big data' is ubiquitous. Thanks to ecosystems of information flowing in broadband networks, companies compete with each other for the largest, most valuable data sets. And companies of all stripes – old and new, industrial and digital, large and small – are getting into the game* (Harvard Business Review 2016). Large amounts of data from various sources, such as social media, sales data, historical weather data, various government system registries, all of which can be used to correlate and extract valuable outputs, such as sales predictions, customer sentiment analysis and others (Such-Pyrgiel 2019, p.81-82).

The development of Big Data systems and cloud computing technologies is determined by the use of these analytical technologies in business management improvement processes. The aforementioned technologies of advanced data processing are increasingly involved in the processes of improving the management of various spheres of business entities. These technologies are increasingly being used to analyse the effectiveness of investment projects, assess the risks associated with the functioning of an enterprise, analyse the business effects of business ventures. The development of analytical techniques carried out with the use of analytical platforms Big Data Analytics and Business Intelligence is determined, among others, by the increase in the digitalisation of economic processes (Gołębiowska, Jakubczak, Prokopowicz, Jakubczak, 2021a, p. 857). One of the purposes of using Big Data analytical platforms to conduct analyses is to formulate recommendations for improving the process of financial management of an enterprise and a system of early

warning indicators in order to reduce the risk of losing financial liquidity in a situation of a significant downturn in the economy, a strong decline in sales of products or services caused by an economic crisis (*COVID-19 to plunge global economy into worst recession since World War*, 2020). On the other hand, computerised Big Data analytical platforms are also used in the processes of data analysis of cybercrime risk and improvement of cyber security systems.

The development of techniques for processing and sharing information via the Internet is determined by many facilities for beneficiaries, clients and people using information services of public sector institutions. In addition to it, there is the possibility of a significant reduction of transaction costs of financial operations and electronic data transfer for entities providing electronic information. Currently, the process of improving techniques ensuring a certain level of security Internet data transfer is being continued. Procedures for secure processing, storage and sharing of information in online banking systems are improved. Gradually, national legal regulations are being supplemented, taking into account new emerging technological innovations and technologies of electronic data transfer on the Internet. (Gwoździewicz, Prokopowicz, 2016c, p. 83). The dynamic development of the Internet and the environment for the development of ICT information technology is shown in the chart below.

Therefore, the scale of dynamism of online banking development is mainly determined by the mentioned above positive aspects of conducting financial transactions conducted electronically, including via the Internet (Grzywacz, 2016, p. 49). In recent years, Poland has been continuing the process of developing electronic online banking and there is observed the growing interest of bank customers in using this form of settlements and payments. Consequently, it should be stated that online electronic banking is a particularly important determinant for current processes of new IT solutions to banking systems and hence the evolution of transaction platforms for financial operations (Dmowski, Prokopowicz, Sarnowski, 2008, p. 157). The dissemination of standards for financial operations in the so-called cloud as well as using the large data sets located in the Big Data platforms, belongs to the most dynamically developing fields of ICT technology which determine the successive stages of progress in the field of online electronic banking (Matosek, Prokopowicz, 2017, pp. 223-224).

**Chart 1.** *Internet users by World region.*

**Source:** *Internet Users by World Region.* Internet portal *OurWorldInData*, 25.06.2021 (in: H. Ritchie, M. Roser (2017) *Technology Adoption*, Published online at *OurWorldInData.org* (<https://ourworldindata.org/grapher/internet-users-by-world-region>), for: Science and Technology – World Bank, 2016, *International Telecommunication Union, World Telecommunication/ICT Development Report and database*, (<http://data.worldbank.org>).

The concept of Big Data has undergone the evolution of its definition in recent times. According to Douglas Laney from 2001, in the classic definition of identifying, Big Data means a huge amount of data that is collected at a fast pace (Laney, 2001). Currently, this definition has already been significantly expanded to further components symbolizing new characteristics of this problem of advanced technology of collecting and processing large data sets. According to this new approach of identifying, the Big Data database is built according to the formula 4V, that is in English volume, variety, velocity and value. Volume means the volume symbolizing the large amount of collected data. Variety, that is diversity means different types of information and quantitative data. Velocity means speed because the data collected in Big Data is characterized by high variability and dynamism of data modification. Value – concept symbolizing

conducted analyzes, verifications and assessments based on Big Data collected in datasets (*BI Analyzes*, 2017).

In recent years, the importance of sentiment analysis carried out on large data sets using Big Data Analytics has been growing, thanks to which it is possible to study the psychological aspects of phenomena of changes in trends of certain processes on product and service markets, factor markets and financial markets (Prokopowicz, Gołębiowska, 2021, p. 39; Wang et al., 2012; Saif, He, Alani, 2012). The development of the aforementioned analytics makes it possible to study the determinants of specific phenomena occurring in the markets caused by changes in consumer or investor preferences due to specific changes in the behaviour of consumers in the markets of products and services, entrepreneurs in the markets of production factors, or investors in the money and capital markets, including the markets of securities. The results of these analyses are used to forecast changes in the behaviour of consumers, entrepreneurs and investors that will occur in the following months and quarters.

## **DEVELOPMENT OF APPLICATIONS OF BIG DATA AND CLOUD COMPUTING TECHNOLOGIES IN BUSINESS**

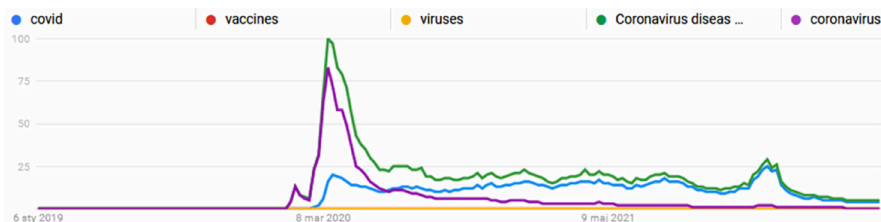
The development of Big Data and Data Science, Data Analytics and other ICT information technologies, multi-criteria technologies, advanced processing of large information sets and Industry 4.0 technologies increases the efficiency of the use of knowledge resources, including in the field of economics, finance and management of organizations (Mayer-Schonberger, 2015). In recent years, ICT information technologies, Industry 4.0, etc. are developing particularly rapidly and are being applied in knowledge-based economies. These technologies are used in scientific research and in business applications in commercially operating companies and in financial and public institutions. In view of the growing importance of this issue in knowledge-based economies, it is important to analyse the correlation between the development of Big Data technologies and analytics of Data Science, Data Analytics, Business Intelligence (Lim, Chen, Chen, 2013; Groot, 2012) and the effectiveness of using knowledge resources to solve key problems

of the development of civilisation. The application of Big Data technologies, Data Science analytics, Data Analytics, Business Intelligence and other ICT information technologies and advanced data processing Industry 4.0 in the processing of knowledge resources should contribute to increasing the efficiency of knowledge resources processing in knowledge-based economies, including economics and finance (Prokopowicz, Gołębiowska, 2021, p. 43).

In recent years, the range of applications of Big Data technologies and Data Science, Data Analytics in analytics and forecasting of various complex processes has been increasing. Consequently, the implementation of analytical instruments of advanced Big Data processing in enterprises, financial and public institutions, i.e. the construction of Big Data Analytics platforms for supporting the organisation's management processes in various aspects of activity, including the improvement of customer relations, is also growing in importance. In my opinion, conducted scientific research confirms the strong correlation occurring between the development of Big Data technologies, Data Science analytics, Data Analytics and the effectiveness of the use of knowledge resources (Matosek, Prokopowicz, Gołębiowska, 2021, p. 235; Gandomi, Haider, 2015). I believe that the development of Big Data and Data Science analytics, Data Analytics and other ICT information technologies, multi-criteria technology, advanced processing of large sets of information, Industry 4.0 technology increases the efficiency of the use of knowledge resources, including in the field of economics, finance and organizational management. In recent years, ICT information technologies, Industry 4.0, etc. have been developing particularly rapidly and are being applied in knowledge-based economies. In addition, the pandemic of the SARS-CoV-2 coronavirus (Covid-19) has accelerated the processes of digitalisation and internetisation of various aspects of the economic activity of companies and enterprises and the functioning of public institutions (Golczak, Golinowski, Kamycki, Lewandowski, Pająk, Płaczek, Prokopowicz, Wesołowski, 2021, p. 92; Boissay, Rungcharoenkitkul, 2022). The graph below shows the increase in Internet users' interest in coronavirus issues during the SARS-CoV-2 pandemic (Covid-19). The graph shows a graphical representation of search terms (covid, vaccines, viruses, Coronavirus disease 2019, coronavirus) on

the Internet search engine Google for the period from 1.01.2019 to 23.06.2022 in global terms using Google Trends analytics.

**Chart 2.** *Change in Internet users' interest in the issues of remote education and remote working. Graphical representation of search terms in the Internet search engine Google for the period from 1.01.2019 to 23.06.2022 in global terms (Google Trends). Search terms: covid, vaccines, viruses, Coronavirus disease 2019, coronavirus.*



**Source:** Google Trends analytics (<https://trends.google.com/trends/explore>) accessed 23.06.2022.

Current Big Data technology solutions (Gwoździewicz, Prokopowicz, 2016a, p. 228) are not only large data bases and data warehouses allowing for multidimensional analysis of huge sets of quantitative data made for the reports submitted periodically to the managerial staff. Currently emerging trends in the development of technology based on Big Data datasets allow for performing multidimensional calculations and reported results of analyzes usually in real time, and the analyzes conducted on huge data sets allow for comprehensive, multidimensional risk assessments at the level of the whole entity, ie. in the formula *firm-wide risk*.

The results of this type of analysis provide information to the banks' management on the bank's exposure to a given risk category and the required level of securities for given parameters of transactions. Thanks to the Big Data technology operating in integration with cloud computing platforms, financial institutions have already had the possibility to conduct complex risk analyzes in real time, taking into account many criteria and obtaining a precise result according to multidimensional parameters (Blagov, Rytsarev, Strelkov, Khotilin, 2022).



In addition, the analytical results may also concern the verification of the current exposure of an enterprise or bank to various risk categories, including liquidity, profitability and credit risk in connection with the valuation of financial instruments, behavioral studies of customer behavior both seasonal and cyclical changes in demand for individual financial products (Libuda, 2016, p. 95).

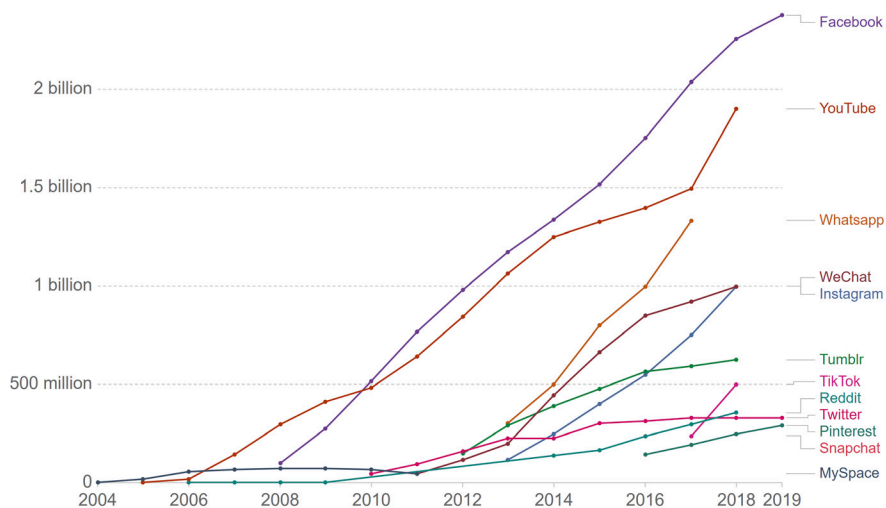
The so-called clouds mean cloud computing. This is a service that enables storing, archiving and using the data collected in this way, which is accessed via the Internet through computers located in another location. Usually, this technology means the possibility of using the Internet with high computing power and memory drives. Therefore, limiting the expenditure on own IT equipment (eg operational memory) (Szpor, ed., 2013, p. 38). Using this technology so-called clouds are also characterized by other positive aspects that can be described as increasing convenience for the user. Well, you can access the data stored in the cloud from any Internet-connected device, and therefore not only a computer, also from a tablet, a smartphone or other device connected online with Internet access (Dmowski, Prokopowicz, 2010, pp. 324).

Therefore, the amount of stored data in the cloud on external servers has been growing dynamically in recent years. It is usually available for free; these are parts of what is more and more commonly referred to as big data. Institutions and companies estimate that by 2020 the amount of component data in this way on external servers will increase many times. Their effective operation is currently based on the Cloud and Big Data technologies mentioned above. It will mean an increase in the capacity of data storage devices, including large disks, which combined in the cloud with servers enabling communication via the Internet will create a kind of external data warehouses. They are currently referred to as Big Data (Gwoździewicz, Prokopowicz, 2016a, p. 228; Banafa, 2015).

Conducting financial operations in the so-called cloud as well as using the large data sets located in the so-called Big Data platforms are only some areas of cyberspace, whose dynamic development determines the need for analogous progress in the field of improvement of security instruments for transfer and storage of nonpublic data (Liderman, 2008, p. 73). In recent years the scale of cash fraud has been growing in Poland on the basis of personal data stolen in IT systems, i.e., identity theft. Data from the 26th edition of the InfoDOK Report prepared by the Polish Bank Association, show that in the second quarter of

this year there was an attempt of extorting 81.8 million PLN. Data from this report show that more than 1.5 thousand cases of using stolen identity in the process of funds extortion were detected (*InfoDOK, Report on documents ...*, 2016). An effective solution significantly limiting this criminal practice was the creation of a system to reserve documents by people who lost them under the *Restricted Documents* program and to disseminate this possibility in social media information campaigns conducted in various fields (*InfoDOK: Almost PLN 900,000 per day ...*, 2016). The scale of growth in people's use of social media globally from 2004 to 2029 is shown in the chart below.

**Chart 3.** *Number of people using social media platforms in years 2004 to 2019. Estimates correspond to monthly active users (MAUs). Facebook, for example, measures MAUs as users that have logged in during the past 30 days.*



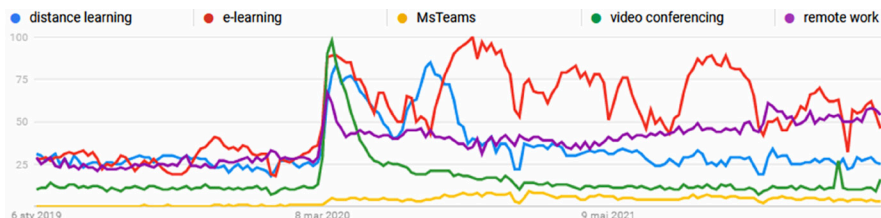
**Source:** M. Roser, H. Ritchie (2017). *Monthly active users* (in: *Technology Progress*, Internet portal *OurWorldInData*, Published online at *OurWorldInData.org*, 25.06.2021 (<https://ourworldindata.org/technological-progress>), for: Statista and The Next Web 2019. (Statista: <https://www.statista.com>; and TNW: <https://thenextweb.com/tech/2019/06/11/most-popular-social-media-networks-year-animated>).

Technological developments in ICT are having an increasingly positive impact on the performance of small and medium-sized enterprises. New ICT information technologies, but also internet technologies and Industry 4.0 are usually first

implemented into specific business processes and sometimes also to improve management processes, logistics, marketing, business analytics etc. in large companies, corporations, financial institutions (Gołębiowska, Prokopowicz, p. 139, 2021a). Some new technologies and technological standards were developed in the laboratories of large companies. However, after some time within the development of a certain technology, within the life cycle of a technology there is its dissemination, reduction of transaction prices in the situation of a technology sale transaction, certain technological solutions become more available to other, also smaller companies and more and more economic entities representing the SME sector acquire and implement certain technologies into their economic processes. The implementation of specific ICT, Internet and Industry 4.0 information technologies improves the economic efficiency of business processes, which are modernized by increasing the scale of automation and the weaponization of work in manufacturing processes (*The Internet of Everything, The age of Internet ubiquity has arrived*, 2014).

Also in recent years, more and more companies in the SME sector have been acquiring specific ICT, Internet and Industry 4.0 information technologies in order to improve production processes, services provided, management processes, logistics, marketing, etc. Thanks to the implementation of ICT and Internet information technologies, more and more companies are improving their marketing by increasing the scale of Internet marketing and providing services by contacting customers directly remotely via the Internet (Gołębiowska, Prokopowicz, p. 324, 2021b). The following graph shows the increase in Internet users' interest in the issues of remote education and remote work during the SARS-CoV-2 coronavirus pandemic causing Covid-19 disease. The graph shows a graphical representation of the searched keywords (distance learning, e-learning, MsTeams, video conferencing, remote work) in the Internet search engine Google for the period from 1.01.2019 to 23.06.2022 in global terms using Google Trends analytics.

**Chart 4.** *Change in Internet users' interest in the issues of remote education and remote working. Graphical representation of search terms in the Google search engine for the period from 1.01.2019 to 23.06.2022 in global terms (Google Trends). Search terms: distance learning, e-learning, MsTeams, video conferencing, remote work.*



**Source:** Google Trends analytics (<https://trends.google.com/trends/explore>) accessed 23.06.2022.

In connection with the development of the SARS-CoV-2 (Covid-19) pandemic, the scale of implementation of ICT and Internet technologies for remote, via the Internet, execution of specific processes necessary for effective business operations is currently increasing rapidly. In addition, more and more companies, including companies from the SME sector for the purpose of improving management processes for economic and financial analysis processes implement Industry 4.0 technologies such as cloud computing, Big Data Analytics, Business Intelligence, machine learning (Golczak, Golinowski, Kamycki, Lewandowski, Pająk, Płaczek, Prokopowicz, Wesołowski, p. 97, 2021; Jonung, Roeger, 2020). In this way, companies increase the efficiency of certain processes carried out as part of their business activities. Of course, there are not only positive aspects associated with the implementation of these technologies into the conducted business activity (Alberola, Arslan, Cheng, Moessner, 2020). A negative factor is the increase in operational risk of the applied ICT and the risk of cybercrime and data transfer on the Internet when the scope of applications of Internet technologies increases significantly. However, despite the increasing expenditures on the improvement of cyber security systems, the scale of the generated increase in the profitability of technologically improved business processes is usually much higher. Therefore, the processes of implementation of ICT, Internet and Industry 4.0 information technologies are constantly increasing, and in recent months, in connection with the SARS-CoV-2 coronavirus pandemic, the aforementioned processes

of computerisation and Internetisation of specific areas of economic activity are accelerating (Jakubczak, Gołębiowska, Prokopowicz, p. 176, 2021).

In 2020, the pandemic of the coronavirus SARS-CoV-2 (Covid-19) caused an acceleration of digitisation and internetisation of remote communication processes, economic and other processes. This growth has occurred mainly through the implementation of ICT information technologies and Industry 4.0, including Big Data Analytics, Internet of Things technologies, cloud computing, machine learning, etc. into economic processes (Gołębiowska, Prokopowicz, p. 136, 2021a; Sun, 2016). New business, technological, logistic, etc. innovations are created due to the increasing financial expenditures on the development of the mentioned ICT and Industry 4.0 information technologies and their implementation into economic processes. For example, many companies are currently investing in the development of computerised platforms in order to generate on these platforms so-called digital twins, which are the digital equivalents of the business, logistics, production and other processes taking place in the economic entity that creates these innovative solutions. Solutions based on digital twins enable the creation of computerised, multi-criteria simulation models. As a result, innovative instruments are created to support predictive analyses of economic processes and thus additional instruments to support company management processes.

The acceleration of the growth in the scale of investment in new technologies Industry 4.0 in enterprises in Poland that occurred during the SARS-CoV-2 (Covid-19) coronavirus pandemic is confirmed by the results of a report conducted in 2021 by the research company Autodesk.

The aforementioned report is based on a survey conducted in January 2021 on a group of 211 Polish enterprises. This study presents the issue of the development of digitisation of companies and enterprises operating in Poland with regard to the then ongoing pandemic. The results from this survey confirmed the thesis according to which there is a growing awareness of Industry 4.0 solutions in business entities operating in Poland. Taking into account the investment activity of economic entities, associations with the concept of Industry 4.0 had 59.5% of surveyed entrepreneurs in 2020 and 85.3% in 2021. Therefore, in the period from 2020 to 2021, i.e. during the development of the pandemic, there was a 42 per cent increase in the awareness

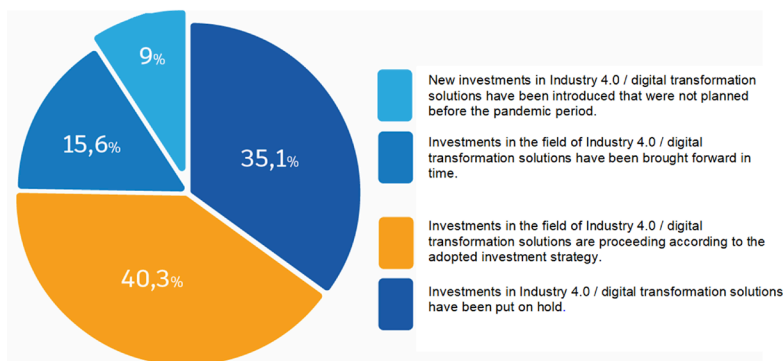
of entrepreneurs regarding issues related to Industry 4.0 technology. In 2020, more than half of the surveyed entrepreneurs admitted that they did not know what Industry 4.0 meant. The same was also true, for example, of the concept of digital twins. Before the pandemic, few companies and enterprises made investments aimed at building multi-criteria, computerised simulation models representing complex processes taking place within the framework of business activity. As part of this type of modelling, digital twins of processes such as production logistics processes, procurement, distribution, operation of production machinery and equipment, etc. can be built. Besides, before the pandemic, most entrepreneurs in Poland did not know what the notion of digital twins meant. On the other hand, already during the 2nd wave of the pandemic in the autumn of 2020, a significant part of enterprises from the production sectors had already implemented or planned in the near future to implement an investment consisting in the construction of multi-criteria, computerised simulation models according to the digital twins formula.

The above-mentioned study also demonstrated the large impact of the pandemic on the financial situation and the implementation of new technologies in companies and enterprises operating in Poland. Despite the high level of uncertainty generated in the context of business by the SARS-CoV-2 coronavirus pandemic (Covid-19), almost 56 percent of businesses continued and possibly also accelerated their investment processes in digitisation. 9 percent of companies made completely new investments in the implementation of Industry 4.0 technologies, which were not planned before the pandemic period.

The results of the study also indicated numerous benefits for companies and enterprises resulting from the implementation, deployment and development of the Industry 4.0 technology in the context of their business activities. In industrial business entities operating in Poland in 2021 the process of implementation of innovations is above all a way to increase the effectiveness and flexibility of enterprises' production (89.1%), a possibility to increase competitiveness (87.7%) and a necessary issue to maintain and possibly also strengthen a good position on the market (79.1%) . The issue of increased investment in the implementation of new ICT and Industry 4.0 during the pandemic implies a high level of adaptation of companies in the production sectors to the difficult macroeconomic conditions of the pandemic. These

difficulties were associated with a significant downturn in the economy in 2020, including the occurrence of more than 8% recession in the second quarter of 2020, i.e. during the development of wave 1 of the pandemic and the occurrence of the highest level of uncertainty in the context of business activity at that time. This is illustrated in the chart below.

**Chart 5.** *The impact of the pandemic on the financial situation and the implementation of new technologies in companies operating in Poland in 2021.*



**Source:** J. Kontkiewicz – Studzińska, R. Cieślak, *Digitalizacja polskich firm przemysłowych w dobie pandemii, Raport 2021*, Autodesk Publishing House, May 2021, ([www.autodesk.pl/Przemysl2021](http://www.autodesk.pl/Przemysl2021)).

**Chart 6.** *Change in the rate of economic growth (in percent), the level of Gross Domestic Product in Poland (y/y) in the period: January 1996 – September 2022.*



**Source:** Internet financial portal [bankier.pl](http://bankier.pl) (accessed 3.02.2023).

## **INTERNET DATA TRANSFER SECURITY AND BUSINESS DEVELOPMENT IN THE CONTEXT OF THE SARS-CoV-2 CORONAVIRUS PANDEMIC CAUSING COVID-19 DISEASE**

Predictive analysis processes of specific multifaceted, complex economic and social processes are carried out in recent years more and more often on Big Data Analytics platforms after collecting a large amount of market data and other factors shaping specific situations in selected, researched markets, branches and sectors of the economy, etc. (Grzegorek, Prokopowicz, Gwoździewicz, p. 126, 2021). In connection with the development of the SARS-CoV-2 coronavirus pandemic causing Covid-19 disease and the implementation of anti-pandemic and sanitary security principles into economic processes, we are currently observing a strong acceleration of the development of the digitalization of the economy in many countries. The processes of implementation of ICT, Internet and Industry 4.0 information technologies into various spheres of economic activity, into companies, enterprises, institutions, etc. representing various sectors and branches of the economy have been taking place for many years. In view of this, in connection with the development of the SARS-CoV-2 coronavirus pandemic, the processes of digitalization of the economy have accelerated (Golczak, Golinowski, Kamycki, Lewandowski, Pająk, Płaczek, Prokopowicz, Wesolowski, p. 97, 2021).

For several years, in many industries and sectors, more and more companies have been developing their activities via the Internet, remotely providing their services and selling their products via e-commerce. Many companies that previously did not do so are now switching to remote operations, conducted electronically via the Internet. The importance of Internet marketing, including viral marketing, Real-Time marketing conducted on social media portals is increasing (Gwoździewicz, Prokopowicz, p. 68, 2021). There is also an increase in the development of electronic banking, including online and mobile banking. The share of payments made electronically, cashless via the Internet and when paying with electronic bank cards is increasing. An increasing number of citizens do not use cash to pay in shops, but make payments using contactless payments. In some countries the limits for all



contactless payments with bank cards have just been increased (Prokopowicz, Gwoździewicz, Grzegorek, p. 104, 2020).

Therefore, the cashless system has already existed since the 1990s, but in the past it was only a certain part of the overall payments, financial system, etc., and gradually increased and went through successive stages of technological revolution. However, currently, due to the development of the SARS-CoV-2 coronavirus pandemic, this development, i.e. the development of the electronic economy, online and mobile banking, e-commerce, etc., has strongly accelerated (Jakubczak, Gołębiowska, Prokopowicz, p. 179, 2021). Currently, it can be concluded that the development of e-commerce is also likely to accelerate significantly in the coming years. However, due to the high level of dynamics of many current determinants shaping both the development of the current pandemic and changing anti-crisis socio-economic policies and certain suggested standards of anti-pandemic and sanitary safety, so the processes of prediction of e-commerce development for the next years are subject to a high level of analytical error. The SARS-CoV-2 coronavirus pandemic further accelerated the processes of digitalization and Internetization of various aspects of business activities of companies and enterprises presented above (Prokopowicz, Komorowski, p. 97, 2021).

Therefore, in recent years new categories of Internet risk of ICT systems have been created as a derivative of dynamically developing and constantly expanding large collections of nonpublic data created by companies offering specific products or services to Internet users (Gwoździewicz, Prokopowicz, p. 127, 2020). For several years, this type of data warehouses have increasingly been functioning as information sets known as Big Data and in the so-called computing clouds. The companies that currently own the largest such data sets about Internet users are mainly Google, Facebook, Twitter, Instagram, YouTube and others (Prokopowicz, 2012, pp. 41-42).

Because each of these commercial entities creates their own databases about Internet users, so sensitive data about users are being currently stored in many places of the global network (Górka, ed., 2014, p. 93). Globally operating Internet corporations offering Internet users free use of the services, including social networking platforms (Gwoździewicz, Prokopowicz, 2016c, pp. 82-83) create special programs called robots. Thanks to them, they conduct

an analysis of information available on the Internet about individual users and they collect personal data for the purposes of marketing activities. Probably a small part of Internet users knows how far this commercialized surveillance conducted by Internet companies has already taken place. The activities of these entities increase the potential scale of risk associated with a possible decrease in the security of nonpublic information collected in electronic databases and transferred via ICT systems connected to the Internet (Domańska-Szaruga, Prokopowicz, 2016, pp. 122-136).

In the economic systems of highly developed and developing countries, both economic entities as well as public sector institutions play a particularly important role in satisfying the needs of society and indirectly the entire economy. After over 25 years of development of the Polish economy in market conditions and adjustment processes to the system standards of the European Union, also in Poland one of the areas of public services offered is satisfying the information needs of citizens (Domańska-Szaruga, 2014, p. 23). Decision-making processes in enterprises and public sector institutions concerning financial management indirectly influence on the pace of socio-economic development of the country (Muchacki, 2014, p. 27).

Unfortunately, in Polish conditions, there are very few verified and confirmed quantitative data by specific institutions in the scope of effective hacking attacks on IT systems of other entities via the Internet. Wróbel says that the issue of the right responsibility related to the security of information systems and information resources contained in them has already been significantly described by American researchers. In Poland, on the other hand, this issue is still undertaken in research to a small extent. It involves a limited amount of analytical data (Wróbel, 2014, pp. 186-187).

On the basis of research conducted in the Western countries, a relatively high level of *leakage* in teleinformation systems was demonstrated. According to a Websense Research report from 2011 based on a survey of 2,000 different types of business entities and institutions operating in the US, Canada, Great Britain and Australia employing a minimum of 250 computer users over a period of one year, there were many disturbing events that could suggest the existence of many gaps in security systems and wrongly developed procedures. In 37% of the surveyed entities, the employee contributed to the loss of certain nonpublic

information and data, which could have led or led to events unfavorable for the functioning of a given entity (D. Wociór, ed., 2016, p. 48). In 20% of the surveyed organizations, nonpublic information was intentionally copied and hijacked by employees in an unauthorized way. Besides, They were stolen from internal IT systems of companies and institutions. Also in 20% of the surveyed entities, nonpublic data went to social networking sites. In addition to it, Trojan horses, malicious malware or other types of viruses appeared in 35% of the surveyed entities in their internal IT systems (*Websense Research Report*, 2011).

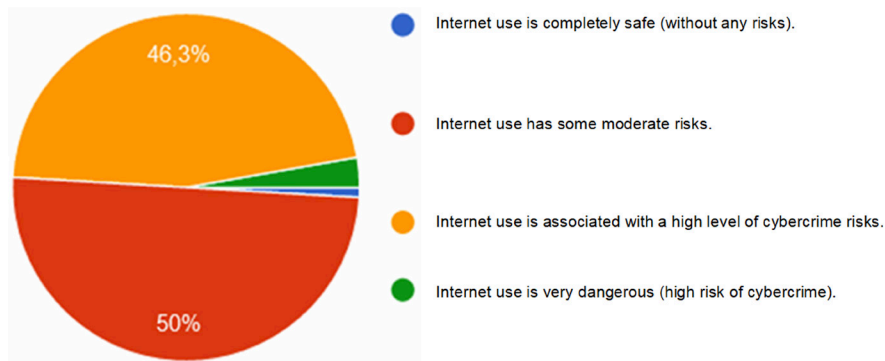
The dynamic development of Internet services has accelerated the globalization information process (Gwoździewicz, Prokopowicz, 2016b, p. 65), but also created a wider field for hackers and terrorist organizations. Every day in global terms, many new viruses are created, which are often able to attack IT systems of many companies, public institutions, banks and home users' computers. On the other hand, new securities for attacked information systems are created every day. This type of competition does not always take the form of a zero-score game. Currently, it has been assumed that legal norms functioning in the European Union are not fully adequate to the prevailing standards of digitization offices and enterprises and the infrastructure of sensitive branches in the national economy created by these entities. Energy, transport, crisis management centers, offices and the financial system are types of branches in the economy particularly threatened with the attack from the cyberterrorists (Suchorzewska, 2010, pp. 19-20).

In 2021, the authors of this article conducted a survey by sending out survey forms to over 2,000 respondents, who were students at several universities in Warsaw. The survey addressed, among other things, the issue of the impact of the SARS-CoV-2 coronavirus pandemic (Covid-19) on various aspects of the digitisation of the economy, the use of the Internet by citizens and the issue of cybercrime and cyber security. The results of the survey on the issue of safe use of Internet resources are presented in the chart below. The chart below shows the results of the answers to the question: How would you rate the issue of the safety of using Internet information resources?

The study found that half of the participating students in the survey indicated that Internet use is associated with certain moderate risks. Of the remainder of the student group surveyed, 46.3 per cent responded that Internet

use is associated with a high level of risks associated with cybercriminal activity. The survey found that awareness of potential incidents described as cybercriminal is high among students.

**Chart 7.** Results of responses to the question: How would you rate the safety of using Internet information resources?



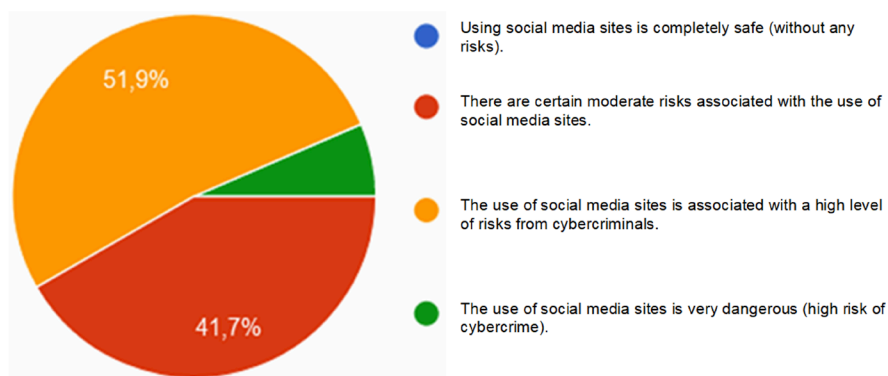
**Source:** Own elaboration based on a questionnaire survey.

It is widely accepted that according to the needs of the majority of Internet users, personal data protection is an area of human existence in the present era of the digital revolution. It should be also ensured by companies operating on the Internet. In accordance with the Basic Law, ie the Constitution, the protection of personal data is one of the elementary rights of every citizen and therefore also of the Internet user. The dynamic technological progress in the range of Internet services offered to Internet users resulted in a partial erosion of the real operation of this right (Grzegorek, Prokopowicz, 2017, pp. 222-237). This is because either Internet users are not fully aware of the built avatars in the data warehouses of Internet corporations or new ICT technologies no longer allow for the complete privacy of citizens functioning in information societies. The internet corporations mentioned above such as Google, Facebook, Twitter, Instagram, YouTube, collect other data about their social networking sites users every day (Gwoździewicz, Prokopowicz, 2016c, pp. 84-85). They are constantly expanding information avatars already existing, i.e., electronic equivalents of individual citizens and internet users.

Unfortunately, Internet users do not know how and when these data will be used in addition to the current advertising activity of these corporations (Libuda, 2016, p. 95). They cannot know it even if these companies, internet corporations owning social networks also do not know how these constantly expanded information collected in data warehouses will be used in 10 years.

As part of the 2021 survey mentioned above, the authors of this article also investigated the issue of safety in the use of social media sites. The results of the survey on the issue of safety in the use of social media sites are presented in the chart below. The chart below shows the results of the responses to the question: How do you assess the issue of safety in the use of social media sites?

**Chart 8.** Results of the responses to the question: How would you rate the safety of using social media sites?



**Source:** Own elaboration based on the conducted questionnaire survey.

The survey found that according to almost 52 per cent of participating students in the survey, the use of social media sites is associated with a high level of risk from cybercriminals. In the rest of the surveyed group of students, 41.7 per cent responded that the use of social media sites is associated with certain moderate risks. The results of the survey indicate a high level of awareness among citizens using social media sites of the potential high risk of cybercrime and the need to improve cyber security systems and instruments for data and information posted on these sites.

## SECURITY OF DATA TRANSFER ON THE INTERNET

In recent months, further cases of cybercriminal attacks using ransomware viruses have emerged (Górka, ed. p. 32, 2014). These viruses encrypt access to data on disks preventing the use of this data. The encryption is done using encryption algorithms that are difficult to break. Once data access is encrypted, cybercriminals send a ransom demand to the companies that fall victim to their cybercrime attack. Once the ransom is paid, they hand over the decryption key (Prokopowicz, p. 107, 2017a). Research on this issue has been conducted by the authors of this article for several years. This research shows that, unfortunately, it is still the case that cyber-attacks using ransomware viruses also affect large companies and can lead to serious economic problems and, in the short term, can also cause a noticeable impact on capital markets. There have been recent cases of this kind of cybercriminal activity targeting, among others, also large companies in the energy sector. The energy sector is an economically strategic one, so when news of this reached the media it caused a noticeable change in the behaviour of investors in the capital markets.

By maximising cyber security systems and their use we also agree to increase the scope of interference by institutions providing certain cyber security instruments installed in the operating systems we use, in devices connected to the Internet (Prokopowicz, p. 259, 2007). Next, we set up further profiles on subsequent Internet portals and websites of companies offering specific information services on the Internet. We provide some data, including e-mail addresses for the companies, which then send us advertisements of their product and service offers and we receive a discount, price reduction after using these offers. However, this increases the number of companies and institutions to which our contact details, including e-mail addresses, are sent. We then receive unnecessary e-mails, as well as e-mails with unreliable offers and fake e-mails created by cyber criminals who want to collect more personal data in this way, install malicious software on our laptops and smartphones in order to take control over our accounts and profiles created on Internet portals, including social networks and Internet banking accounts. This creates a kind of vicious circle of perpetual cybercrime risk and constant, necessary improvement of cyber security techniques and principles (Liderman, p. 83, 2008).

During the SARS-CoV-2 coronavirus pandemic (Covid-19), the number of dangerous cybercrime attacks using ransomware viruses and malware increased. In 2020 and 2021, there have been spectacular successful cyber-attacks on large companies operating in other countries (e.g. a corporation that manages a gasoline pipeline, a large meat products company, a technology company that produces computer games, local and central government institutions, etc.). This raises the question: are companies and public institutions investing too little in implementing state-of-the-art cyber security solutions and instruments into their IT systems? Already a few years ago, publications appeared in the literature warning of a growing risk of cyber-attacks using ransomware viruses and malware. However, during the pandemic also in Poland there were successful cybercriminal attacks on some large companies and firms, local government public institutions and some central state administration institutions, including on the e-mail boxes of people working in these institutions (Jakubczak, Gołębiowska, Prokopowicz, p. 173, 2021).

There is a particularly high risk of cybercrime when users of online social networking sites post information on their social networking profiles that may allow cybercriminals to obtain login details for email, other profiles and indirectly for online banking. This further stage of obtaining data that enables cybercriminals to obtain login data for online banking profiles, including mobile banking is by sending out hidden malicious programs in fake emails that collect login data from the Internet user's laptop or smartphone or by using phishing (Mórawski, p. 51, 2015).

Cybercriminal attacks involving taking control of email inboxes, social network profiles through cyber phishing techniques, sending fake emails, etc. to steal data from public institutions and government, stealing funds from online banking accounts, stealing personal data of customers of companies and institutions, blocking access to data on disks through the use of ransomware viruses and extorting ransoms, etc. are a growing problem in recent years. Despite constantly improved cyber security systems in public institutions, financial institutions, online banks, etc., there are still spectacular successful cyber criminal attacks on public institutions, government institutions and online banking systems operated by customers on laptops and smartphones with Internet access. Cyber-security systems are constantly improved, however, still the weakest

link of the cyber-security issue are the clients of public or financial institutions and employees of companies and institutions who forget about the basic rules of cyber-security, set access passwords to operated systems that are too easy to crack, do not change access passwords, etc. as a result of which cyber-criminals using socio-technical instruments can easily get access to secret data and sensitive information (Domańska-Szaruga, Prokopowicz, p. 128, 2016).

Cybercrime and the improvement of cybersecurity techniques and cybercrime risk management are realized in the field of commercially operating business entities and financial institutions as well as this issue concerns public institutions. Cybercrime attacks on public institutions, including government institutions, are becoming a new form of data acquisition by security services between politically rival states. The growing risk of cybercrime may lead to increased international destabilisation and economic and financial crises, etc. Cooperation should be developed on the technological advances taking place in the field of ICT (Matosek, Prokopowicz, p. 225, 2017).

Within the framework of the aforementioned survey conducted in 2021, the authors of this article also examined the issue of security of the use of social media portals, including the security of posted personal data, sensitive data on these portals. The survey was conducted by sending out survey forms to over 2,000 respondents, who were students of several universities in Warsaw. The survey addressed issues such as the impact of the SARS-CoV-2 coronavirus pandemic (Covid-19) on various aspects of the digitisation of the economy, citizens' use of the Internet, and issues of cybercrime and cyber security. The results of the survey on the issue of security of the use of social media sites, including the security of personal data posted, sensitive data on these sites are presented in the chart below. The chart below shows the results of the responses to the question: Is the sensitive data, personal data posted on private social media accounts safe there, i.e. is there a high risk of it being stolen, intercepted by unauthorised persons (by hackers, cybercriminals)?

The survey found that more than 83 percent of participating students indicate a high risk of theft of personal (sensitive, private) data.

It is estimated that the cases of effective hacker attacks on IT systems of financial institutions described in the literature are only a small part of the real scale of this criminal activity (Dmowski, Prokopowicz, 2006, pp. 78-79).



This is because companies, banks and offices do not boast that they have been attacked and have been victim of financial embezzlement or have been robbed of personal data of clients or employees. Personal data is increasingly being stolen from social networks (Gwoździewicz, Prokopowicz, s. 127, 2020).

**Chart 9.** Results of responses to the question: *Is the sensitive data, personal data posted on private social media accounts safe there, i.e. is there a high risk of it being stolen, intercepted by unauthorised persons (by hackers, cybercriminals)?*



**Source:** Own elaboration based on the conducted questionnaire survey.

After filtering among the data of these entities information referring to people representing the management of a given company or department in a specific institution, it is easier for hackers to make a more sophisticated break into the IT system of a given entity and take control of some of its functions (Dolecki, 2016, p. 51). In recent years, the most popular method of attacks on IT systems of financial institutions has been fishing. This is substitution of websites and theft of personal data through applications installed in web browsers or using Trojan horses launched after opening a fake e-mail that apparently contains relevant, interesting and reliable information (Król, 2016, p. 48).

According to Dariusz Wojtas, Project Manager dealing with applications offered by IMPAQ Sp. z o.o. for commercial banks, the development of Big Data technology is determined by the process of monitoring on-line financial transactions and collecting large information related to customers and products. The main determinant of the development of Big Data (Power, 2013) is

not only the storage of terabytes of data obtained from Internet resources and supported clients, which are given specific financial products, information, advisory, communication and other services; for example part of the social networking sites offer.

The function of effective use of Big Data technology is the issue of the quality of isolating necessary and appropriately processed information from information databases. According to this concept, Big Data is growing out of the data warehouse developed in the 90s in which there started to use the current development of collected information and their analysis based on the inquiries. (Olszak, 2014, p. 35). For several years corporations and financial institutions have combined these technological solutions with remote access via the Internet and verification of market data contained in the resources of the global network. Currently, entities based on the construction of a portfolio of sold products or services provided to a large group of customers are interested in using Big Data in the range of identification, characteristics and analysis of customer profiles (Mórawski, 2015, p. 51).

Precise definition of the cross-section of dominant customer profiles and their current update conducted on the basis of a permanent analysis of the market environment and available Internet resources will increasingly determine the market success of the company and it will become one of the factors of competitive struggle. Financial institutions belong to those entities that have already noted the large marketing and strategic potential of Big Data technology solutions (Gwoździewicz, Prokopowicz, 2016a, p. 229).

Technology solutions based on a Big Data are a new category of information source, whose multi-criteria analysis can significantly improve and increase the efficiency of corporate management. It is based on making more accurate decisions referring to both strategies and more current and operational issues (Złoch, 2013, p. 58-59). A positive aspect of the implementation and development of Big Data-based solutions is the ability of significant reduction of the information scale asymmetry in the field of marketing activities directed towards existing and new banking clients. Marketing asymmetry of information is often a source of annoying situations on the side of bank customers who receive calls and e-mails with offers of subsequent financial service several or more times a year (Prokopowicz, 2017a, pp. 95-96).

It refers to both offers presented by the bank with which the beneficiary of these advertisements has been cooperating for years as well as offers of other companies and financial institutions with whom no cooperation has not been previously concluded before. The problem is increasing because specialized marketing companies build databases of potential customers of various products and services and then resell these databases to various companies and financial institutions (Matosek, 2015, p. 117). For existing bank customers, the most annoying situations include those in which these customers repeatedly receive telephone and e-mail offers of further loans and insurance. Implementation of technological solutions based on Big Data would allow to diagnose customer needs more precisely and prevent the loyal customer from being offered completely unnecessary financial services several times (Warren, Marz, 2016). The aim of significantly reducing this marketing asymmetry of information and eliminating this type of annoying situation is necessary to implement the so-called multi-channeling on the plane of communication channels of customer access to services and developing solutions based on Big Data.

## SUMMARY

Current Big Data technology solutions are not only large data bases, data warehouses allowing for multi-aspect analysis of huge sets of quantitative data made for the purposes of reports submitted periodically to the managerial staff. Currently emerging trends in the development of technology based on Big Data datasets allow for performing multithreaded calculations and reporting results of analyzes usually in real time. These analyzes conducted on huge data sets allow for comprehensive, multifaceted risk assessments at the level of the entire entity, ie in the form of *firm-wide risk* (Libuda, 2016, p. 95).

The development of online banking is mainly determined by the positive aspects of conducting financial transactions carried out electronically, including via the Internet (Dmowski, Prokopowicz, 2010, p. 324). In recent years, Poland has been continuing the process of developing electronic online banking and the growing interest of bank customers in using this form of

settlements and payments. The dissemination of standards for conducting financial operations in the so-called cloud as well as using the large data sets located in the so-called Big Data platforms and Business Intelligence (Prokopowicz, 2007, pp. 258 – 259) analytics are the most dynamically developing fields of ICT, which determine the next stages of progress in the field of online electronic banking.

In recent years, data processing technology in the cloud has been also dynamically developing. Using this technology so-called clouds is also characterized by other positive aspects that can be described as increasing convenience for the user. Well, you can access the data stored in the cloud from any Internet-connected device. Therefore, it is possible not only from a computer but also from a tablet, smartphone or other device connected with the Internet (Grzywacz, 2016, p. 49).

Consequently, the amount of stored data in the cloud grows on external servers. It is usually provided free of charge with specific disk capacities, i.e. parts of what is increasingly commonly defined as a big data. Performing data processing in the cloud as well as using the large data sets located in the so-called Big Data platforms are only some areas of cyberspace, whose dynamic development determines the need for analogous progress in the field of improvement of security instruments for transfer and storage of secret data (Liderman, 2008, p. 73).

In the future, the use of Industry 4.0 and subsequent generations of these technologies will grow in predictive analysis and in interdisciplinary research processes and branches and sectors of the economy. The aim of predictive analysis is to develop forecasts for the development of complex, multifaceted processes concerning various fields of science, industry, economy or other spheres of human activity. Predictive analysis can also be applied to objectively realised processes, such as natural phenomena, climatic, geological and cosmic changes. In the predictive analysis, Big Data Analytics and Business Intelligence (*BI analysis*, 2017) as well as other innovative information technologies typical for the current fourth technological revolution defined as Industry 4.0 can be applied. The technological revolution currently taking place, defined as Industry 4.0, is motivated by the development of the following factors: Big Data database technologies, cloud computing, machine learning, Internet of Things, artificial intelligence, Business Intelligence and

other technologies of advanced data processing Data Mining. On the basis of the development of the above-mentioned new technological solutions, in recent years there has been a dynamic development of, among others, processes of innovatively organised analyses of large sets of information collected in database and analytical systems Big Data Analytics and information processing in the cloud computing for the purposes of applications in such fields as: machine learning, Internet of things, artificial intelligence, Business Intelligence (Grzegorek, Prokopowicz, Goździewicz, p. 125, 2021).

*The progress by which humanity accumulates, stores and begins use available information is huge, and our focus on extracting the greatest possible value from their analysis is worth emphasizing. And it is this trend that, in my opinion, determines the need to state that today society is becoming digital and no longer just informational or network. Of course, it doesn't matter what name we choose, it is more important to constantly observe the world around us and try to understand it and draw conclusions for the future. Yes, so that we do not lose our humanity in this technological race, so that technologies serve us in creating new, better ones values* (Such-Pyrgiel 2019, p.309).

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