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CONDITIONS AND MECHANISMS OF IMPLEMENTING AI IN THE FINANCIAL SECTOR

The research analyses the process of adapting artificial intelligence in the financial sector, highlighting the key mechanisms of its implementation. The mentioned process was presented from the perspective of the development of

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УМОВИ ТА МЕХАНІЗМИ ВПРОВАДЖЕННЯ ШІ У ФІНАНСОВОМУ СЕКТОРІ

Дослідження обґрунтовує процес адаптації штучного інтелекту у фінансовому секторі, висвітлюючи ключові механізми його впровадження. Зазначений процес представлено з погляду розвитку Індустрії 4.0.

Industry 4.0. The research presents an overview of the conditions for the implementation of artificial intelligence in the financial sector. It does not pretend to be a study that would exhaustively present the research problem undertaken. Each of the partial issues presented in the following paragraphs requires development based on more in-depth research. The aim of the research is to show the process of adapting artificial intelligence in the financial sector and to highlight the mechanisms of its implementation. Instead of hypotheses, the following research questions will be formulated in this study: What is the importance of AI in the development of digital economy? What is the role of AI in the development of financial sector? What are the experiences with implementing AI in the financial sector of different countries? What are the lessons learned from using AI and ML in the financial sector so far? The study is based on the analysis and evaluation of literature and sectoral reports presenting the issues of digital transformation of the economy, highlighting the importance and possibilities of using artificial intelligence and related modern technologies. The above-mentioned analysis was complemented by the use of deductive and inductive reasoning. The use of artificial intelligence is an integral element of the process of digitization of the economy. The financial sector has widely adopted solutions based on the use of artificial intelligence and machine learning. They have become an important factor in increasing the efficiency of this sector and the financial system and its elements, the quality of services provided by financial institutions and, consequently, their competitiveness on the market. The development of the digital economy has created new opportunities for financial institutions to use artificial intelligence and information technologies related to it. This applies to the use of technologies such as autonomous robots, Big Data, cloud computing, system integration, additive production, Industrial Internet of Things, augmented reality, simulations, and technologies supporting cybersecurity. These technologies create new opportunities for financial institutions to improve their efficiency and the quality of the products they offer.

Keywords: artificial intelligence, financial sector, Industry 4.0, digital transformation.

Розглянкуто умови впровадження штучного інтелекту у фінансовому секторі. Проте воно не претендує на вичерпне висвітлення досліджуваної проблеми. Кожне з питань, представлених у статті, потребує розробки на основі більш глибоких досліджень. Мета дослідження – показати процес адаптації штучного інтелекту у фінансовому секторі та визначити механізми його впровадження. У межах цього дослідження сформульовано такі дослідницькі питання (без висунення гіпотез): Яке значення має ШІ у розвитку цифрової економіки? Яка роль ШІ у розвитку фінансового сектору? Який досвід впровадження ШІ у фінансовому секторі мають різні країни? Які уроки використання ШІ та МН у фінансовому секторі винесені на сьогоднішній день? Дослідження базується на аналізі та оцінці наукової літератури та галузевих звітів, що висвітлюють питання цифрової трансформації економіки, підкреслюючи важливість та можливості використання штучного інтелекту та пов'язаних з ним сучасних технологій. Вищезазначений аналіз був доповнений застосуванням дедуктивного та індуктивного міркування. Використання штучного інтелекту є невід'ємним елементом процесу цифровізації економіки. Фінансовий сектор широко застосовує рішення, засновані на використанні штучного інтелекту та машинного навчання. Вони стали важливим фактором підвищення ефективності цього сектору та фінансової системи і її елементів, якості послуг, що надаються фінансовими установами і, як наслідок, їх конкурентоспроможності на ринку. Розвиток цифрової економіки створив нові можливості для фінансових установ використовувати штучний інтелект та пов'язані з ним інформаційні технології. Це стосується застосування таких технологій, як автономні роботи, великі дані, хмарні обчислення, системна інтеграція, адитивне виробництво, промисловий Інтернет речей, доповнена реальність, симуляції та технології, що підтримують кібербезпеку. Ці технології створюють нові можливості для фінансових установ щодо підвищення своєї ефективності та якості продуктів, які вони пропонують.

Ключові слова: штучний інтелект, фінансовий сектор, Індустрія 4.0, цифрова трансформація.

JEL Classification: G2, O3.

Introduction

The free flow of economic resources, the development of digital technologies and the growing importance of intangible assets as components of enterprise resources have become the driving forces for the emergence of the fourth industrial revolution. Its symbol is Industry 4.0, focused on the

digitization and mechatronization of production, and indicating a new approach to managing the efficiency of enterprises. The digital transformation taking place in the global economy is a factor stimulating the automation of business operations based on the use of artificial intelligence (AI). AI is the theory and practice of creating intelligent computer systems capable of supporting or replacing human mental work, as well as enabling a deeper understanding of human reasoning. This enables the processing of large amounts of data, which makes AI an important factor in increasing the efficiency of the financial sector and the financial system and its components.

This paper discusses the impact of the rapid adoption of artificial intelligence and machine learning (ML) in the financial sector. It highlights the benefits these technologies bring in terms of financial deepening and efficiency, while raising concerns about its potential in widening the digital divide between advanced and developing economies. The paper advances the discussion on the impact of this technology by distilling and categorizing the unique risks that it could pose to the integrity and stability of the financial system, policy challenges, and potential regulatory approaches. The evolving nature of this technology and its application in finance means that the full extent of its strengths and weaknesses is yet to be fully understood. Given the risk of unexpected pitfalls, countries will need to strengthen prudential oversight.

Therefore, the aim of the research is to show the process of adapting artificial intelligence in the financial sector and to highlight the mechanisms of its implementation. The implementation of this aim will be related to the exposure of the following partial research problems:

- artificial intelligence and the development of the digital economy;
- development and adaptation of artificial intelligence in the financial sector;
- good practices of the artificial intelligence implementation – perspectives of selected countries;
- analysis and evaluation of the artificial intelligence and machine learning in financial services.

1. Artificial intelligence and the development of the digital economy

The concept of the digital economy is intrinsically linked to the process of digital transformation of the economy (digitization of the economy) associated with the fourth industrial revolution exemplified by the concept known as Industry 4.0. This term originated in the German economy, where it is associated with the Federal Government's search for opportunities to mitigate the effects of the global financial crisis initiated in 2008 with the bankruptcy of Lehman Brothers. In 2011, the German government used the term Industrie 4.0 for the first time in a document indicating the high-tech

strategy formulated as part of the national development strategy for the German economy (Lucks, 2022). Industry 4.0 is oriented towards the digitalization and mechatronization of production and indicating a new approach to business performance management with the blurring of boundaries between the physical, digital and biological spheres of manufacturing processes (Mączyńska, & Okoń-Chorodyńska, 2020; Jaśko et al., 2022). The digital transformation taking place in the global economy is driving the automation of the manufacturing environment as well as the creation of digital value chains that enable multi-directional communication within the enterprise and between the enterprise and its environment (Ślusarczyk, 2019). The development and dissemination of the Industry 4.0 concept has also recently led to the demand for its transformation into the Industry 5.0 concept, which is dictated mainly by the need to reveal the human role in cyber-physical systems (Saniuk et al., 2022).

The possibility of emergence of the digital economy as a result of revolutionary changes in the functioning of economies and in the management mechanisms of organizations was preceded by significant transformations that, over the last decades (since the 1980s), have become the driving forces of the fourth industrial revolution. Among these transformations, the following have been of key importance:

- the processes of globalization and economic, political and social integration stimulating the facilitation of economic resource flows and access to new markets, but at the same time increasing competition and demands of consumers and investors in regional and local markets;
- the growing importance of intangible resources as components of an enterprise's potential, creating new opportunities for the creation and use of unique economic resources and increase in the company's effectiveness and competitiveness on the market. As a result, intellectual capital has become a key driver of effectiveness-oriented changes in an enterprise (Bugarčić & Slavković, 2023);
- the rapid development of information technologies, especially the spread of the Internet from the point of view of its accessibility and multidimensional use.

Although the process of digital transformation is the result of the coincidental impact of the aforementioned revolutionary transformations, the emergence and spread of Internet use in the private and business spheres is of key importance here. This is because it has contributed to the following fundamental changes in the functioning of not only enterprises, but also other market actors:

- radical changes in terms of access to information and the speed of its flow, which has contributed, among other things, to an increase in the importance of information as an economic resource and market product and the emergence of information management as a business management concept;

- changes in the sphere of broadly understood communication – including the possibility to communicate online in real time using voice and video and using communication platforms such as Zoom, MS Teams and others;
- the use of the Internet as a channel for an enterprise to connect with its customers and distribute its products, in conjunction with both traditional business models and the creation of enterprises based solely on online sales of their products, resulting in new business models for enterprises based on the virtualization of their business;
- the use of the Internet in the field of education, enabling distance learning based on the use of real-time online communication platforms and professional learning platforms (e.g. Moodle);
- the emergence of technological solutions enabling digital authorization of documents through the use of an electronic signature, which has made it possible not only to facilitate the creation and transmission of formal and legal documentation, but also the provision of administrative services by public entities in the online system (e-governance);
- the emergence and spread of the use of information technologies in the medical services sector for issuing e-prescriptions and giving the physician online access to the patient's medical record and results of ordered tests, which has become an important factor stimulating the development of e-medicine with regard to the range of medical services that can be provided without the need for physical contact between the physician and the patient;
- the emergence of new ways of increasing the effectiveness of an enterprise and the quality of the products it offers and consequently increasing its competitiveness by reducing operating costs and the possibility of integrating dispersed economic resources with their sharing;
- the emergence and spread of hybrid products which, based on similar technological solutions, perform functions that were previously the domain of separate, unrelated products manufactured by separate economic entities, offered on separate markets and having their own, unrelated value chains – the hybridization of economic activity.

The emergence and implementation of technologies such as autonomous robots, Big Data, cloud computing, system integration, additive production, Industrial Internet of Things, augmented reality, simulations, and technologies supporting cybersecurity are associated with the development of the digital economy (Grabowska & Saniuk, 2022). In recent years, new areas for the use of artificial intelligence have been closely linked to the process of digitalization of the economy. The term "artificial intelligence" (AI) dates back as far as the mid-1950s, when it was defined by J. McCarthy and identified with the branch of computer science dealing with the construction of machines and algorithms, the operation of which has the hallmarks of intelligence (Winston, 1992). The connection of AI with the digital transformation of the economy, however, refers to its increasing implementation for business, economics, finance and management purposes. From the perspective of organization's operations, the utility of AI relates to the following three potential levels of its application (Korzynski et al., 2023):

strategic level – decision-making by managers based on the use of recommendations relating to specific decision-making problems, using of the organization's information resources for knowledge management purposes;

functional level – using for customer service, use for Human Resource Management;

administrative level – using to generate standard business documents and to automate and assist with various administrative tasks, such as scheduling appointments, booking travel arrangements, and managing calendars.

An important sector of the economy where technological solutions related to the use of AI have been used for many years is the financial sector. Research conducted in this area demonstrates not only the significant benefits generated from its use, but above all the very high potential relating to the future development of its applications for the growth of the activities of financial institutions. The financial sector is ranked third in the economy in this respect (after the information, communication and manufacturing sectors) (Fintech Poland, 2022). This is a natural consequence of the fact that this sector has been very quick to implement the achievements of digital transformation, the first stages of which were the provision of remote access to banking services for customers, followed by the creation of online banks based almost exclusively on the use of the Internet for the purpose of interacting with customers and their use of the services offered by the bank.

The research carried out demonstrates the feasibility and relevance of implementing AI-based technologies in the following areas of financial institutions' operations (Fintech Poland, 2022):

- functioning of the front office using machine learning, robotics, chatbots, biometrics and unique identity;
- functioning of the back office using text analytics tools, machine learning, robotics and chatbots;
- personalization of financial services using robotics and chatbots;
- risk management and compliance using text analytics tools, machine learning, biometrics and unique identity.

In the context presented, it becomes reasonable to present and exemplify the mechanisms for implementing AI in the financial sector, highlighting the determinants of its development and adaptation, presenting good practices applied in this field in different countries and carrying out an analysis and evaluation of the use of AI in the financial sector to date.

2. Development and adaptation of artificial intelligence in the financial sector

Artificial intelligence is the theory and practice of creating intelligent computer systems capable of supporting or replacing human mental work and enabling a deeper understanding of human reasoning. Machine learning, on the other hand, is the analysis of learning processes and the creation of systems that improve their performance based on past experience – through

the use of self-optimizing algorithms that stimulate the process of learning. In addition to their many practical applications, these technologies are increasingly used in the financial system. They are transforming the way financial market players make decisions on, among other things, transactions, capital allocation and lending. Therefore, there are many applications using artificial intelligence and machine learning technologies in the financial system. This is due to both supply-side factors (such as technological developments and the availability of data and infrastructure in the financial system) and demand-side factors (which may include issues of profitability, competition with other market players and regulatory requirements). These technologies are being used to assess the credit quality of business partners, price and sell insurance contracts, automate customer interactions, optimize capital utilization and commercial transactions as well as for risk management and fraud prevention, data quality assessment, regulatory compliance, among others.

With AI, machine learning and growing computing power, artificial intelligence is an increasingly effective mechanism to counter fraud. Financial institutions are using these solutions to detect payment fraud, credit fraud as well as social engineering fraud (phishing). Detection of inconsistencies or inaccuracies in payment, loan and application data is achieved through predictive analytics across multiple banking channels. By analyzing the data with a pre-trained algorithm, a transaction can be effectively assessed for fraud risk. Such a system can be extended to notify any deviations from the normal pattern by informing of different types of banking fraud vulnerability. Large-scale transaction verification is then performed in a matter of milliseconds, which reduces the risk of fraud in modern omnichannel banking.

The dynamic progress of artificial intelligence is fundamentally affecting the existing patterns operating in the financial sector. In the area of banking and insurance, AI is being used to automate processes, analyze complex data sets, detect fraud, personalize offers and create intelligent so-called robo-advisors. With AI, it becomes possible to gain a deeper understanding of customer preferences, enabling the delivery of better tailored products and services. Stock trading and investment are other areas where AI is playing an increasingly important role. AI-based models are able to analyze enormous amounts of data, predict trends in financial markets to aid investment decision-making. AI algorithms are also used for automated trading and identifying attractive investment opportunities. In the insurance sector, AI supports risk assessment, damage estimation, insurance portfolio management and the creation of personalized offers. AI-based chatbots are used for customer service and rapid response to queries.

The impetus for the use of AI and machine learning solutions in the automation of financial processes and in the replacement of human labor with algorithms was the deeply humanistic belief that human time, abilities and

intelligence can be used much more efficiently. It should also not be forgotten that AI systems do not get tired and therefore do not make potentially costly mistakes. Therefore, one can venture to say that full process automation would be the optimal solution for the financial sector. However, we will have to wait for such a scenario, mainly for legal reasons, although technology also imposes certain conditions in this case – such as that the automated process must be well defined and described.

At this point, it is worth mentioning that the financial sector and especially the financial markets have always been quick to adapt technological developments to their needs. This is no different with artificial intelligence solutions, especially with regard to deep learning. This type of data processing in the typical applications of financial institutions is far superior to other process automation methods. AI solutions are used, for example, in the preparation of stock market forecasts, in credit risk assessment or in the asset valuation process. However, it is worth remembering that the prospects opened up by the use of artificial intelligence in the financial sector are more promising. These include, among other things:

- automation of such complex processes as the planning and implementation of personalized and targeted marketing campaigns or complete strategies for both specific financial and banking products as well as entire brands;
- increasing transaction security, implemented while maintaining the flexibility of financial services and without compromising the usability of online tools or the quality of service in branch offices;
- preparation of complex demographic analyses in real time, without distracting customers from the financial operation being performed;
- analysis of customer behavior and the emotions they feel, based on their behavior in social networks;
- accurate real property valuation and optimized search for new locations for banking outlets.

These are just a few of the many new and not-so-obvious possibilities offered to financial institutions by artificial intelligence (Report, 2020).

Intelligent solutions can therefore be used in the financial sector in many aspects and areas of business. Robotization and automation of operational processes, mainly in the back-office area, are already an increasingly popular way to reduce costs and improve efficiency. AI is doing well in the case of handling large amounts of data, in automatic decision-making, where we are able to program a solution with the help of an algorithm. However, there are tasks where humans have the advantage. Decision-making there requires a comprehensive view of the problem, such as in the case of investment appraisal, which often requires talking to experts and drawing logical conclusions based on the data provided. However, the true potential will only become apparent when AI e starts to support human capabilities and cooperate with humans. A contemporary example here is Morgan Stanley which has supported the work of its 16 000 financial

advisers with AI agents. An intelligent algorithm analyses customer data and supports advisers in finding investment options. The role of the adviser, who remains in contact with the customer, is to make an offer at the right time. With such a large number of customers and such a comprehensive portfolio of banks, it would not be physically possible for financial advisers to keep track of investment options for each individual customer. Through machine-human cooperation, additional possibilities have therefore been unlocked (Reworking the Revolution, 2019).

The aforementioned processes, however, require significant data sets that are subject to machine analysis. Of course, data has been collected by companies for years, but as a rule it was an unstructured collection, often in analogue form, collected unsystematically and without a clear purpose. Now, thanks to powerful computers and machine learning, systems are better able to read data sets and see regularities in them. Operations that currently take seconds would require several years of work by analysts. Big data therefore makes it possible to better advise customers on financial products, better manage risk and carry out a variety of projects that were not possible previously. It is no wonder that so many banks have created central credit registers for each customer and Data Science departments. Financial institutions know what their customers spend their money on, their habits and their needs. They can make predictions about future spending and create segmentations and personalized offers.

Current research on AI also focuses on reinforcement learning. This is a machine learning technique in which an AI model learns to make decisions by interacting with the environment and receiving feedback (reward or punishment) depending on the actions taken. Such AI model takes actions in a given environment and learns to improve its decisions based on the feedback it receives. In parallel, the development of large language models and learning from human interaction is noticeable. Nevertheless, there are still many obstacles in the way of AI freely "learning" and increasing its similarity to humans.

Taking all the aforementioned content into account, it is important to realize that artificial intelligence is no longer a distant future. It is being used today, often even without our knowledge. Sometimes we are confronted with the effects of AI without realizing that somewhere in the process concerning us an element of intelligent algorithm has been used. Various bots and algorithms are already assisting employees in the banking or insurance sector. Therefore, the financial sector should not be asking itself "should we implement?". The most important question now is "how to implement?", so as to catch up with competitors and not fall behind in the race of the digital revolution. The increasingly fierce competition caused by the low barrier to entry will make the progress of artificial intelligence solutions ever faster. Companies in the financial sector that underestimate the importance of AI will experience losses and their position on the market will be challenged.

For many companies in the financial sector, it is important that the implementation of AI involves a change in strategic approach or business model. AI is not only profitable if the aim is to cut costs. AI is a benefit on many levels at the same time (e.g. reducing costs or increasing customer and employee satisfaction). This is why it is important to take a holistic view of the implementation of solutions, also taking into account the impact on the organization and its customers. It is for this reason that any implementation should be preceded by idea testing. Already at this stage, it is necessary to measure success and potential profit and to determine whether the solution will bring the expected business value. It is also at this point that an organization should select the available technology options. How the implementation of artificial intelligence and the changes brought about by it are managed is also not without influence. This process should take into account the ethical approach to AI development and the organization's values.

In summary, to maximize the benefits of AI implementation, organizations in the financial sector should (Fintech Poland, 2022):

1. Move beyond simple automation, serving mainly to increase efficiency or reduce costs.
2. Focus on real, holistic growth.
3. Redefine the boundaries of the ecosystem in which the organization and its customers exist.
4. Propose and verify ideas (proof-of-concept) for AI that provide real, measurable business value and define a basic framework for building AI (e.g. it is important to identify activators, i. e. factors that will facilitate the development of AI in the organization).
5. Define the AI governance framework.

As for the specific benefits arising directly from the various applications of AI, these can be divided into the following categories:

Efficiency. Performing routine tasks thanks to well-defined rules, procedures and criteria.

Knowledge. Supporting the decision-making process will be facilitated by enhanced analytical capabilities.

Effectiveness. Activities performed by a personal assistant or agent will enhance human capabilities.

Innovation. Increasing creativity by identifying alternative possibilities and advising on optimal decisions.

The financial sector is therefore one of the key beneficiaries of advances in AI, which also translates into increased effectiveness, better customer service and more purposeful decision-making. However, the introduction of AI in the financial industry brings challenges such as liability, data security and regulatory issues. Therefore, it is important to maintain a balance between innovation and the protection of customer interests and the stability of the financial system.

It is natural that new technologies raise certain concerns. However, it is worth remembering that innovation has always helped to develop our skills. Calculators have not made us unable to count, but have made the process of calculation easier. Automated spell-checking has not replaced our ability to write, but aids its correctness. AI and automation aim to make work easier and more efficient and to extend our capabilities, not to replace humans. Nowadays, artificial intelligence that supports automation is becoming an important element influencing the ways in which both physical and mental work is done. The development of AI technology allows machines to take over routine and repetitive tasks, which initiates changes in the nature of work and reduces the direct involvement of humans in the stages of work that they have always complained about.

What aspects should the financial sector consider when preparing for AI implementation? First of all, AI should not be expected to replace employees. Artificial intelligence should be gradually improved, extended to then lead to automation. Over time, the proportion and nature of employee roles will change and there will be an increase in new roles related to AI training, explaining and maintaining AI-based solutions. It is also important to focus on identifying the areas of AI implementation that will have the most positive impact on driving business growth and increasing operational efficiency. It will be particularly important here to understand that the effect of AI implementation is the opportunities that will develop between human and machine. It is therefore important to give this a chance, rather than replacing humans with machines, as this will not deliver the expected benefits. From an organization-building perspective, it may be necessary to create an operational model that ensures ethical governance from the ground up as well as to acquire AI skills within the entire organization. Ethical and regulatory compliant governance must be integral to AI development. Also, cooperation with regulators, including by signaling loopholes or phenomena that require the creation of missing regulations, will ensure the success of AI implementation in the financial sector (Boost Tour AIQ, 2018).

In conclusion, it is worth noting that technological advances have helped to accelerate the integration of artificial intelligence and machine learning models with a growing number of processes in the financial sector. Today, financial institutions that do not exploit the potential of AI risk falling behind competitors who make strategic decisions using analytical systems. Intelligent algorithms learn from examples derived from historical data and are then used to discover patterns that are difficult for humans to identify. The use of machine learning in the financial sector is not new. In practice, this technology has been used for decades by banks and institutions offering financial services. It involves basic statistical methods and techniques, such as linear and logistic regression or rule-based modelling. Such traditional methods are relatively simple, easy to understand, explain and interpret. However, the price of their use tends to be lower efficiency compared to the possibilities offered by more advanced machine learning techniques.

With the increase in computing power of computers in recent years, analytical methods such as neural networks, decision tree-based algorithms and others have become increasingly popular. These methods tend to have higher efficiency compared to classical statistical methods, but the way they work is more complex and the influence of individual input variables on the final result is more difficult to interpret.

3. Good practices of the artificial intelligence implementation – perspectives of selected countries

Artificial intelligence may be one of the driving forces Polish economy. But in order for that to happen, we have to be right for it prepared now. The effective implementation of artificial intelligence is a challenge not only for entrepreneurs, but also for the broadly understood state.

A challenge not only of a strategic, technical or business nature, but also ethical and legal. AI solutions must be created because carefully, responsibly and ethically both at the level of the legal framework and processes in each organization using this technology. That is why in our paper we have devoted special attention to ethics in AI. We also reviewed national strategies in the field of AI so that the strategy finally implemented by Poland turns out to be effective. Entering the era of artificial intelligence must be an act not only conscious for all parties involved, but also systemic, because it is supported by an appropriate state strategy.

Polish financial institutions thanks to their technological advancement and the potential to use the huge amounts of data at their disposal, may be a critical part of the Polish artificial intelligence sector. At the same time, financial institutions have a special responsibility due to the scope of data they have and process and their role as an institution of public trust. It is estimated that the banks that will invest in AI and related solutions, may increase theirs in 2020–2025 revenue by more than 37%. And in the opinion of bankers, AI technology will be the one that will have the greatest impact on banking in the next couple of years.

The global race for position leader in the field of artificial intelligence is not limited only to leading companies. More and more countries are starting recognize the role of AI in development (Fintech Poland, 2022).

Governments are realizing how many changes driving their economy can be brought about by artificial intelligence. The Tech Vision trend report, prepared periodically by Accenture based on the opinions of key managers managing global companies, has been systematically showing for several years that that artificial intelligence is of interest to the most important players.

Those who do not adapt to the new conditions may pay a high price. That is why more and more countries recognize this and decide to create their own national AI strategy. The first such coherent and comprehensive strategy was presented by Canada in 2017. Also, in the international space, arrangements for cooperation between entities, countries, regions and

metropolises are being prepared. An example of the latter can be London, which in its strategy positions itself as a hub for the development of artificial intelligence. Also, in Poland, the dynamic development of innovative products based on AI was noticed, and the Ministry of Digital Affairs published assumptions for the AI strategy.

Such great interest from government, regional and local entities indicates the importance of artificial intelligence. They began to realize that maximizing the benefits of AI will only take place if we manage to strengthen cooperation between business, education and the public sector.

This ecosystem must have access to data and appropriate legal regulations must be ensured. Therefore, it is worth analyzing the approach of leaders to the subject of artificial intelligence. The UK, US, China, France and the EU are already in the midst of this transition.

Each strategy addresses issues such as:

- research and development;
- education;
- access to the data;
- financing;
- ethics and law;
- infrastructure.

These strategies also adjust the above issues to local realities. An interesting case is also the strategy of India, which – in addition to economic growth – is to take into account social problems.

There are some countries which have presented and already published a national strategy on AI: USA, Canada, Mexico, Tunisia, Kenya, United Arab Emirates, India, China, Taiwan, Japan, Australia, Great Britain, Italy, France, Denmark, Sweden, Finland, Lithuania, Germany. International strategies are also visible for the European Union, for Nordic-Baltic countries, for some countries of the UN, and a special agreement between United Arab Emirates and India (Fintech Poland, 2022).

The institutions of the European Union have been actively dealing with the subject of AI since 2016. In April 2018, the European Commission published a Communication Artificial Intelligence for Europe. This document describes the main goal for Europe: to become a global leader, providing state-of-the-art, ethical and safe human-centric AI solutions. The entire document emphasizes the anthropocentrism of the approach (Communication Artificial Intelligence for Europe, 2018).

The human being is to be at the center of the solution, despite the fact that development is associated with the development of artificial intelligence, i. e. algorithms, innovations and machines. This positions artificial intelligence and its role as ancillary to humans and its surroundings.

The European Union has the potential to develop artificial intelligence and recognizes the challenges it brings. The advantage of the European Union is undoubtedly its academic background in the form of scientists, research

and laboratories. Many AI startups are thriving in the EU and new ones are still being created.

Artificial intelligence solutions are already working well in many countries. For example, in Denmark there is a system that helps emergency services diagnose heart attacks based on the caller's voice. In Austria, on the other hand, X-ray images are analyzed to detect tumors by instantaneous comparison of medical data with X-ray images.

The great advantage of the Union is the Digital Single Market. This market is characterized by common rules, e.g. regarding data protection and flow, as well as security. The uniformity of these rules makes it easier for business and cooperation between entrepreneurs who, operating in other Member States, are subject to the same guidelines and regulations.

The European Union already has access to huge amounts of data on various industrial sectors, including the public sector. Access to this data and its processing may turn out to be crucial in the development of artificial intelligence.

The European Commission proposes a three-pronged approach to the development of artificial intelligence. Success is guaranteed here:

- increasing investment in AI in both the public and private sectors;
- preparation for socio-economic changes caused by AI;
- providing an ethical and legal framework.

The EU approach – in addition to investments – also analyzes changes in the human environment. AI causes and can cause further socio-economic changes that should be paid attention to. Not only the disappearance of entire professions, but also profound changes in the way they are performed can cause social tensions. They can only be mitigated by the coordinated policies of the Member States. For example, the introduction of the Uber application brought a wave of protests by taxi drivers. This will probably also be the case when fully driverless taxis are launched. That is why it is so important to introduce legal solutions on an ongoing basis that leave no room for doubt and over-interpretation. However, it will certainly be difficult, as most of the innovations introduced by enterprises are ahead of legal regulations.

In addition, the European Commission, together with the Member States, prepared and published in December 2018 a coordinated plan for AI (European Coordinated Plan on Artificial Intelligence, 2018, December 7). The plan provides for a number of actions to support the development and use of AI in Europe, including by:

- maximizing investment through public-private partnerships, increased funding for AI start-ups and small and medium-sized enterprises;
- creating and connecting digital innovation hubs that can help in the application of AI in small and medium-sized enterprises;
- adaptation of training programs and systems;
- creating European data spaces regulated by the GDPR (General Data Protection Regulation);
- ensuring that AI solutions are ethical and trustworthy.

The European Union's policy on artificial intelligence is also supported by a budget prepared for these purposes. The European Commission has so far planned significant sums of investment in AI in 2014–2020, including under two dedicated programs: Horizon and Digital Europe.

- Approximately EUR 1.1 billion is the budget allocated in 2014–2017 to areas related to artificial intelligence (robotics, big data, health, transport, new technologies) under the Horizon programme.
- As much as EUR 2.3 billion has been allocated – through the Structural Funds – to the development of digital skills (http://ec.europa.eu/newsroom/dae/document.cfm?doc_id=51610).
- Investments planned for the period 2018–2020 amount to EUR 1.5 billion for research and innovation.
- After 2020, as much as EUR 1 billion of expenditure per year was planned from the Horizon and Digital Europe programmes.

These amounts illustrate the importance of spending related to artificial intelligence in the Community budget.

On April 10, 2018, 24 member states, together with Norway, signed a declaration on cooperation in the field of artificial intelligence. This declaration aims to create a unified European approach to AI. As part of the declaration, all Member States committed themselves to develop their own national strategies by mid-2019, defining the approach to AI and the level of investment (European Comission, 2018, December 7).

The EU plans to monitor the implementation of the strategy in individual countries, introducing indicators necessary to analyze and evaluate the implementation of this initiative. Monitoring information will be published on the AI Watch portal (A hub for the JRC's scientific research on Artificial Intelligence).

Despite the anticipated benefits, AI also poses many risks. Therefore, the European Union places great emphasis on making AI solutions credible and ethical. The key here is to create an ethical and legal framework in which the EU's position as a leader in the implementation of innovative solutions in the field of artificial intelligence should be built. For this purpose, the European Commission's group of experts developed the Ethics Guidelines for Trustworthy AI[2]. The document was published on 2019, April 8. and is a set of guidelines for building and implementing AI systems. The addressees of these guidelines are enterprises, organizations, public administration bodies, academia, individuals or other entities involved in the creation, implementation and use of AI in practice.

[2] Within the advisory bodies of the European Commission, a group of 52 high-level experts on artificial intelligence in the European Commission was established, consisting of academics, lawyers, politicians and business practitioners (High-level expert group on artificial intelligence)

As part of the "trustworthy AI" concept, the EC emphasizes that artificial intelligence should be used in compliance with applicable regulations and basic principles and values, and should be technically reliable. Reliable AI is defined by three determinants:

- should comply with applicable regulations;
- should respect basic ethical principles and values;
- it should be reliable – technically reliable while taking into account the social environment, so that it cannot cause even unintentional damage.

The guidelines are organized according to three levels of abstraction, from the most abstract (providing ethical AI) to the most practical (Assessing the AI's credibility). The document contains guidelines divided into 3 groups:

- ensuring ethical AI;
- implementing reliable AI;
- AI credibility assessment.

The first part is about ensuring the ethical purpose of AI by establishing the fundamental rights, principles and values necessary for AI solutions. The implementation, development and use of artificial intelligence systems should comply with ethical principles such as: respect for human autonomy, harmlessness, justice and responsibility.

Based on ethical principles, the second part outlines the seven principles necessary to achieve trustworthy AI (both in terms of ethical purpose and technical integrity):

Human leadership and oversight – supporting the development of a democratic and just society by strengthening human leadership and supporting fundamental rights.

Stability and security – creating safe and technically reliable solutions, resistant and preventing potential damage.

Privacy and data protection – providing citizens with access and appropriate control over their own data. The data used should be checked for appropriate quality and integrity.

Transparency – ensuring the traceability of AI systems.

Diversity, non-discrimination and fairness – ensuring diversity and equal and fair treatment.

Social and environmental well-being – enhancing positive social change, supporting sustainable development and ecological responsibility.

Accountability – ensuring accountability mechanisms for artificial intelligence systems and their results.

Artificial intelligence solutions are constantly changing, evolving in a dynamic environment, therefore they require appropriate assessment methods that can be used at every stage of their life cycle. The very process of their assessment should be a continuous process. In order to assess and verify the implementation of ethical AI requirements, methods were proposed and divided into technical and non-technical (*Figure 1*).

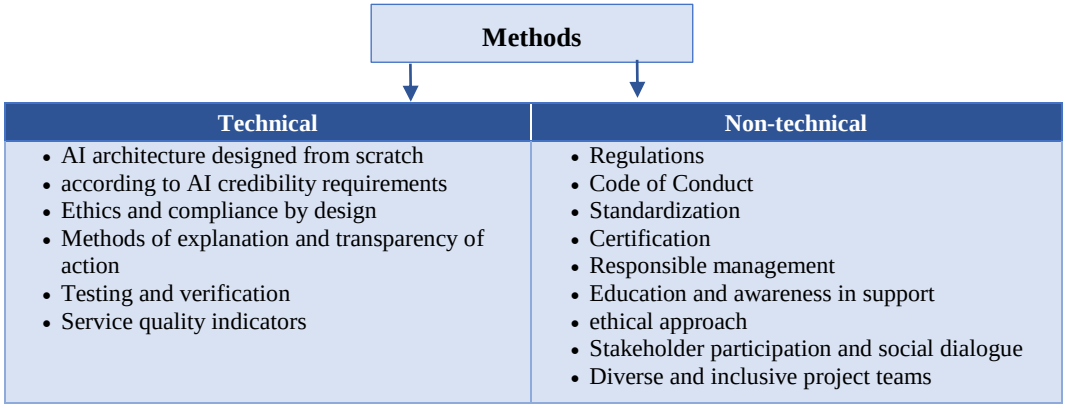

Figure 1. AI evaluation methods

Source: ethics guidelines for trustworthy AI (2019).

The proposed set of methods resembles project methodologies, probably known to many managers.

The third part focuses on verifying each of the key AI credibility requirements using a checklist. This list should be flexible and tailored to specific cases. this summer it is planned to launch a pilot phase aimed at collecting opinions on the prepared checklist[3]. After taking into account the collected comments, an updated checklist was proposed at the beginning of 2020.

The last part of the report presents examples of beneficial uses and risks associated with artificial intelligence. Many countries are already using practical solutions that support socially important areas, e.g. health or education. Positive examples are presented in *Figure 2*.

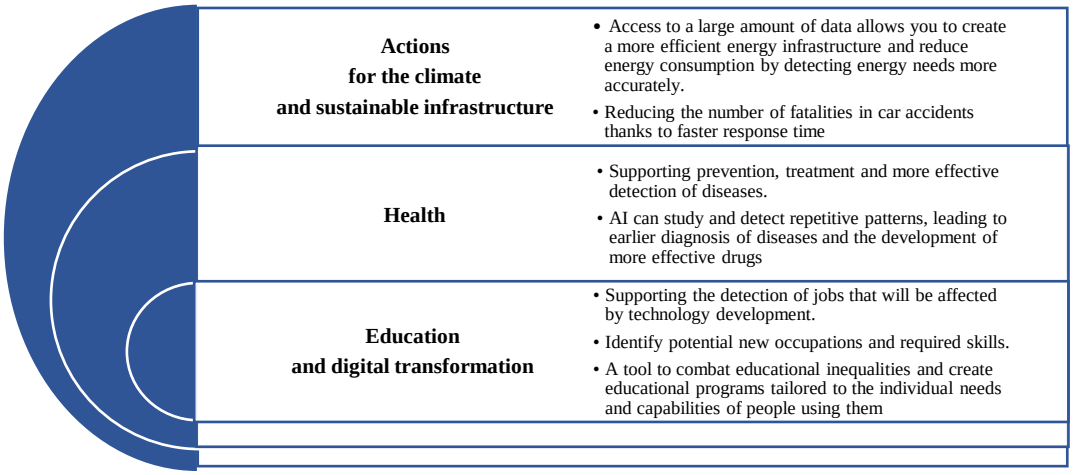

Figure 2. Practical solutions that support socially important areas

Source: ethics guidelines for trustworthy AI (2019).

[3] It is also planned to expand the EU's cooperation with other countries, such as Japan, Canada and Singapore, and to participate in international discussions and initiatives, including under the G-7 and G-20. The pilot phase will also cover companies from other countries and international organizations.

The document of the European Commission also indicates many areas that require discussion, and often legal regulations. Trust in artificial intelligence may be synonymous with the need to give up the rights of a citizen. It is very important to decide which values are more important, e.g. whether it is possible to limit a citizen's freedom while increasing his security.

The risks are listed in *Figure 3*, presented below.

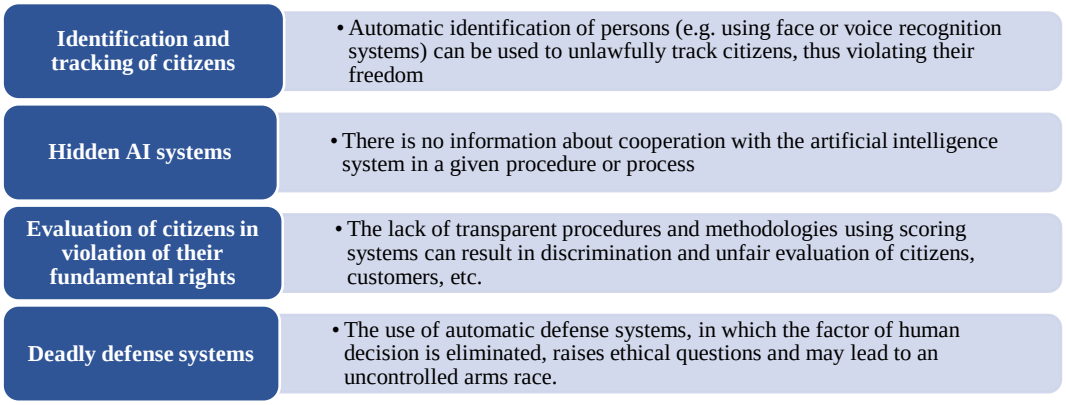

Figure 3. Risks and limits for a citizen's freedom

Source: ethics guidelines for trustworthy AI (2019).

In May 2018, the General Data Protection Regulation (GDPR) entered into force, which has a significant impact on the development of artificial intelligence (driven by, among others, data sets). Their processing provides huge amounts of information and can have an impact on AI solutions. It is necessary to apply the provisions of the GDPR already in the design phase, when building and implementing AI elements. Experts are already asking questions about whether the GDPR will not limit the technological revolution and raise doubts related to the interpretation of the current regulations.

Some initial information on the case studies strategies for selected countries are presented in *Table 1*.

Table 1

AI implementing experiences – case studies for selected countries

Country	Key actions connecting the AI implementation
France	The France Intelligence Artificially report was published, and the introduction of both documents was intensively promoted as the #FranceAI initiative
	Report "For a meaningful artificial intelligence. Towards a French and European strategy" analyzes the current situation in France and describes in detail what development directions to take to become a leader in the field of AI
	To achieve the leading position, the French government planned to invest EUR 1.5 billion in the development of artificial intelligence by 2022. Of this amount, 700 million will be allocated to research. Investments in AI are expected to double the number of students working in this area
	France emphasizes the possibilities offered by AI in terms of ecological impact on the environment, e.g. by understanding ecosystem dynamics and optimizing resource management (including energy). Artificial intelligence can help reduce energy consumption. It can be used in environmental protection (e.g. using drones for afforestation or mapping living species using image recognition technology). In a green economy powered by AI, access to data is essential. It is crucial to ensure access to open data sets, e.g. on weather, agriculture, transport, energy consumption, climate
	The report proposes the creation of an AI ethics committee, responsible for the public debate, which will deal with topics related to the ethics of artificial intelligence. Another proposal is to automate administrative procedures so that citizens better understand administrative rules and how they affect them

End of Table 1

Country	Key actions connecting the AI implementation
Great Britain	The UK published its Artificial Intelligence Action Plan in April 2018 (Industrial Strategy. Artificial Intelligence Sector Deal). The advantage of Great Britain is its academic background (including universities in Oxford, Cambridge and Leeds)
	The UK strategy itself is coherent, full of specific assumptions supported by specific numbers. It is based on 5 pillars (see Ideas, People, Infrastructure, Business environment, Places): I. Ideas/concepts
	The main objective of the strategy is to make the UK the most innovative economy in the world. This will be made possible by investments and increased spending in the area of research and development (R&D). Expenses are expected to increase to 2.4% of GDP by 2027
	Education ecosystem is conducive to development in the field of science and technology. Cooperation with universities is to be a base that will provide a highly qualified staff of scientists and employees in the field of AI
	Infrastructure support is provided primarily in the area of data. It is not only about improving the current data infrastructure, but also increasing the amount and availability of high-quality public data
	The UK has ambitions to become the best economic ecosystem to start and develop an AI-based business. The ecosystem also means access to capital, which is why the British Business Bank has created a fund for targeted investments with capital of GBP 2.5 billion (the activities of the fund, together with the private sector, will enable financing projects at the level of GBP 7.5 billion)
	The creation of a national strategy is to mobilize regions to create their own AI strategies (which will use local assets). Particularly important is the issue of transport between regions and cities, which will be incubators for the business of the future. Therefore, it is assumed that the new fund (called the Transforming Cities Fund) will provide GBP 1.7 billion to finance projects to improve transport connections in metropolitan regions
USA	The USA is one of the world leaders in the field of artificial intelligence. It is here that the biggest players – GAFAM (Google, Amazon, Facebook, Apple, Microsoft) have their headquarters. These companies are undoubtedly associated with technological innovations, access to data and extensive infrastructure. They are an inspiration for many startups and create a massive ecosystem, because according to data, 40% of all global AI startups start their operations in the USA
	The US ecosystem also includes strong research regions (San Francisco Bay Area, New York, Boston) and academic units at the highest level (including MIT, Stanford). Qualified staff is about 850.000 specialists in the field of artificial intelligence. Research and investments in AI are supported by an appropriate funding system
	October 2016, the Executive Office of the President of the United States issued a report, preparing for the Future of Artificial Intelligence, describing actions that the government should take to increase the economic and social benefits of AI
	A separate plan was created, covering only issues related to R&D and the provision of qualified staff (National Artificial Intelligence Research and Development Strategic Plan). The plan was issued by the Networking and Information Technology Research and Development Subcommittee (NITRD)
	The US sees the role of public policy in providing education and training and the appropriate transformation of workers, which is necessary to develop relevant skills and, if necessary, re-industry workers. AI solutions should be governable, transparent and understandable to be able to effectively cooperate with humans. Attention is also drawn to the ethical dimension for practitioners, students, researchers and decision-makers responsible for artificial intelligence
	The US is meticulous about ethics, it has included priorities in its strategy that are considered ethically controversial. For example, the US government aims to develop AI in weapons systems. There is an international discussion about the potential of AI-controlled weapons
China	China's plan assumes that by 2030 it will become the world leader in AI, and the Chinese business based on artificial intelligence will be worth USD 150 billion. International players such as Baidu, Alibaba, Tencent and Xiaomi (BATX for short) are already active in the Asian region – well-known enterprises originating from China. These companies have their own huge research facilities and dynamically implement artificial intelligence in their services
	Artificial intelligence was already one of the 10 strategic sectors/areas of development listed (the others include new information technologies, aviation equipment, modern ships, energy saving, agricultural machinery, new materials, medical devices). China wants to stop copying technological solutions and start creating them based on its own innovations
	The detailed AI strategy was announced on July 20, 2017 in the Next Generation Artificial Intelligence Development Plan published by The State Council of China. So, the goal is to become the world leader in artificial intelligence – is implemented in 3 stages: *Stage I*: 2017–2020. The goal is to equalize technological levels. By 2020, China wants to catch up with AI pioneers, such as the US. They estimate that their market will then reach USD 23 billion. *Stage II*: 2020–2025. The second stage is to lead China to specialization and leadership in selected fields of artificial intelligence in 2025. These fields are primarily medicine, agriculture, national defense and smart cities. *Stage III*: 2025–2030. The goal of the third stage, scheduled for 2030, is for China to become the world leader in AI. It is advanced research and implementation in business and society that will make China number one

Source: authors' elaboration based on (European Judicial Systems – CEPEJ Evaluation Report, 2024).

4. Analysis and evaluation of the artificial intelligence and machine learning in financial services

Artificial intelligence and machine learning are being rapidly adopted for a range of applications in the financial services industry. As such, it is important to begin considering the financial stability implications of such uses. Because uses of this technology in finance are in a nascent and rapidly evolving phase, and data on usage are largely unavailable, any analysis must be necessarily preliminary, and developments in this area should be monitored closely.

Many applications, or "use cases", of AI and machine learning already exist. The adoption of these use cases has been driven by both supply factors, such as technological advances and the availability of financial sector data and infrastructure, and by demand factors, such as profitability needs, competition with other firms, and the demands of financial regulation. Some of the current and potential use cases of AI and machine learning include:

• Financial institutions and vendors are using AI and machine learning methods to assess credit quality, to price and market insurance contracts, and to automate client interaction.

• Institutions are optimizing scarce capital with AI and machine learning techniques, as well as back-testing models and analyzing the market impact of trading large positions.

• Hedge funds, broker-dealers, and other firms are using AI and machine learning to find signals for higher (and uncorrelated) returns and optimize trading execution.

• Both public and private sector institutions may use these technologies for regulatory compliance, surveillance, data quality assessment, and fraud detection.

In order to be able to analyze and evaluate the use of AI and machine learning in financial services, several important hypotheses must be articulated:

• The more efficient processing of information, for example in credit decisions, financial markets, insurance contracts, and customer interaction, may contribute to a more efficient financial system. Applications of AI and machine learning can help improve regulatory compliance and increase supervisory effectiveness.

• At the same time, network effects and scalability of new technologies may in the future give rise to third-party dependencies. This could in turn lead to the emergence of new systemically important players that could fall outside the regulatory perimeter.

• Applications of AI and machine learning could result in new and unexpected forms of interconnectedness between financial markets and institutions, for instance based on the use by various institutions of previously unrelated data sources.

• The lack of interpretability or "auditability" of AI and machine learning methods could become a macro-level risk. Similarly, a widespread use of opaque models may result in unintended consequences.

• As with any new product or service, there are important issues around appropriate risk management and oversight. It will be important to assess uses of AI and machine learning in view of their risks, including adherence to relevant protocols on data privacy, conduct risks, and cybersecurity. Adequate testing and "training" of tools with unbiased data and feedback mechanisms is important to ensure applications do what they are intended to do.

Overall, AI and machine learning applications show substantial promise if their specific risks are properly managed.

This paper defines AI as the theory and development of computer systems able to perform tasks that traditionally have required human intelligence. AI is a broad field, of which "machine learning" is a sub-category[4]. Machine learning may be defined as a method of designing a sequence of actions to solve a problem, known as algorithms, which optimize automatically through experience and with limited or no human intervenetion[5]. These techniques can be used to find patterns in large amounts of data (big data analytics) from increasingly diverse and innovative sources.

Many machine learning tools build on statistical methods that are familiar to most researchers. These include extending linear regression models to deal with potentially millions of inputs, or using statistical techniques to summarize a large dataset for easy visualization. Yet machine learning frameworks are inherently more flexible; patterns detected by machine learning algorithms are not constrained to the linear relationships that tend to dominate economic and financial analysis. In general, machine learning deals with (automated) optimization, prediction, and categorization, not with causal inference[6]. In other words, classifying whether the debt of a company will be investment grade or high yield one year from now could be done with machine learning. However, determining what factors have driven the level of bond yields would likely not be done using machine learning.

A variety of factors that have spurred adoption of AI and machine learning in financial services. On the supply side, financial market participants have benefitted from the availability of AI and machine learning tools developed for applications in other fields. These include availability of computing power owing to faster processor speeds, lower hardware costs, and better access to computing power via cloud services.

As more firms adopt these tools, the financial incentives to access new or additional data and to develop faster and more accurate AI and machine

[4] Examples of AI applications that are not machine learning include the computer science fields of ontology management, or the formal naming and defining of terms and relationships by computers, as well as inductive and deductive logic and knowledge representation. In this paper, for completeness, we often refer to "AI and machine learning", with the understanding that many of the important recent advances are in the machine learning space.

[5] An algorithm may be defined as a set of steps to be performed or rules to be followed to solve a mathematical problem. More recently, the term has been adopted to refer to a process to be followed, often by a computer. See: Samuel (1959), Mitchell (1997), Jordan & Mitchell (2015).

[6] Here, prediction is understood as identifying something as likely before the event based on experience. Causal inference and forecasting are done from a scientific perspective on the basis of analysis of the past.

learning tools may increase. In turn, such adoption and development of tools may affect incentives for yet other firms.

A variety of technological developments in the financial sector have contributed to the creation of infrastructure and data sets. The proliferation of electronic trading platforms has been accompanied by an increase in the availability of high-quality market data in structured formats. In some countries, such as the United States, market regulators allow publicly traded firms to use social media for public announcements. In addition to making digitized financial data available for machine learning, the computerization of markets has made it possible for AI algorithms to interact directly with markets, putting in real-time complex buy and sell orders based on sophisticated decision-making, in many cases with minimal human intervenetion. Meanwhile, retail credit scoring systems have become more common since the 1980s, and news has become machine readable since the 1990s. With the growth of data in financial markets as well as datasets – such as online search trends, viewership patterns and social media that contain financial information about markets and consumers – there are even more data sources that can be explored and mined in the financial sector.

On the demand side, financial institutions have incentives to use AI and machine learning for business needs. Opportunities for cost reduction, risk management gains, and productivity improvements have encouraged adoption, as they all can contribute to greater profitability. In a recent study, industry sources described priorities for using AI and machine learning as follows: optimizing processes on behalf of clients; working to create interactions between systems and staff applying AI to enhance decision-making; and developing new products and services to offer to clients. In many cases these factors may also drive "arms races" in which market participants increasingly find it necessary to keep up with their competitors' adoption of AI and machine learning, including for reputational reasons (*Figure 4*).

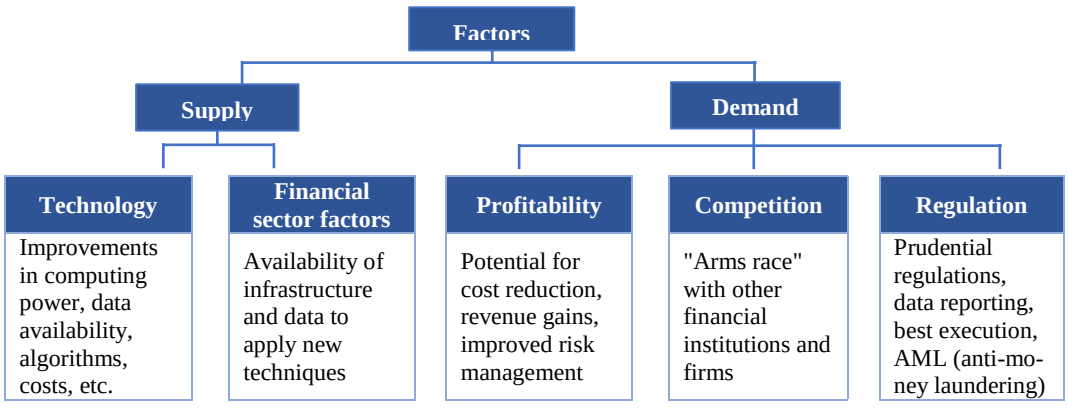

Figure 4. Supply and demand factors of financial adoption of AI and machine learning

Source: authors' study based on: Artificial intelligence and machine learning in financial services (2017).

A number of developments could impact future adoption of a broad range of financial applications of AI and machine learning. These developments include continued growth in the number of data sources and the timeliness of access to data; growth in data repositories, data granularity, variety of data types; and efforts to enhance data quality. Continued improvement in hardware, as well as AI and machine learning software as a service, including open-source libraries, will also impact continued innovation. Development in hardware includes processing chips and quantum computing that enable faster and more powerful AI. These developments could enable cheaper and broader access to AI and machine learning tools that are increasingly powerful. They could make more sophisticated real-time insights possible on larger datasets, such as real-time databases of online user behavior or internet-of-things (IoT) sensors located around the world.

At the same time, sophisticated software services are becoming more widely available. Some of the software services are open source libraries made available in the past few years that provide researchers with off-the-shelf-tools for machine learning. There are also a growing variety of vendors that provide machine learning for financial market participants, including some firms that scrape news and/or metadata and enable users to identify the specific features (webpages viewed, etc.) that correlate with the events they are interested in predicting. As services emerge to provide, clean, organize, and analyze these data for financial insights, the cost to users of incorporating sophisticated insights may fall significantly. Thus, at the same time, risks related to multiple users of the same information and techniques across the financial sector could grow.

The legal framework for relevant data will likely also impact the adoption of AI and machine learning tools. Breaches of personal data or uses of data that are not in the interests of consumers may be expected to lead to added data protection legislation. In addition, the development of new data standards, new data reporting requirements, or other institutional changes in financial services can impact the adoption of AI and machine learning in specific markets.

Financial stability implications depend critically on the uses of AI and machine learning. To assess these implications, questions to be considered would include which AI and machine learning tools are being used to make which types of decisions, on what time scales, to address which financial functions, and where and at what level human involvement is being integrated.

AI and machine learning are being adopted for a number of purposes across the financial system. Examples include:

- Sentiment indicators: Social media data analytics companies use AI and machine learning techniques to provide "sentiment indicators" to a number of financial services players. Investor sentiment indicators are being developed and sold to banks, hedge funds, high-frequency trading traders, and social trading and investment platforms.
- Trading signals: Machine learning can help firms to increase productivity and to reduce costs by quickly scanning and making decisions based on more sources of information than a human can. Therein also lies a limitation of machine

learning technology: by identifying and relying on patterns that were predictive of outcomes in the past, these tools are susceptible to false information. For example, there were market moves across equities, bonds, foreign exchange, and commodities in April 2013 after trading algorithms reacted toa fraudulent news Tweet announcing two explosions at the White House. These types of issues may be exacerbated with more widespread use of machine learning.

- AML/CFT (anti-money laundering and combating the financing of terrorism) and fraud detection: Seeking to increase productivity and simultaneously reduce costs and risks, while complying with regulations, some firms use AI for AML/CFT and fraud detection at financial institutions (van Liebergen, 2017). Firms can also use machine learning for credit monitoring and risk mitigation purposes.

Micro- and macro-financial perspectives of the application of AI/ML are presented in *Table 2*.

Table 2

Micro- and macro-financial perspectives of the application of AI/ML in the financial system

Areas of application	Perspectives
Micro-financial	
Financial markets	Since AI and machine learning have the potential to substantially enhance the efficiency of information processing, thereby reducing information asymmetries, applications of AI and machine learning have the potential to strengthen the information function of the financial system (AI and machine learning may enable certain market participants to collect and analyze information on a greater scale; AI and machine learning may lower market participants' trading costs)
Financial institutions	AI and machine learning have the potential to enhance the efficiency and profitability of financial institutions, while reducing their costs and risks, through various channels. Greater profitability could aid the build-up of buffers and ultimately benefit system-wide stability (AI and machine learning may enhance machine-based processing of various operations in financial institutions, thus increasing revenues and reducing costs; AI and machine learning can be used for risk management through earlier and more accurate estimation of risks; the data intensity and open-source character of research in AI and machine learning may encourage collaboration between financial institutions and other industries, such as e-commerce and sharing economy businesses)
Consumers and investors	If AI and machine learning reduce the costs and enhance the efficiency of financial services, consumers could obtain a number of benefits (Consumers and investors could enjoy lower fees and borrowing costs if AI and machine learning reduce the costs for various financial services; Consumers and investors could have wider access to financial services. For example, applications of AI for robo-advice might facilitate people's use of various asset markets for their investments; AI and machine learning could facilitate more "customized" and "personalized" financial services through big data analytics)
Macro-financial	
Enhancing the efficiency of financial services	More efficient risk management of individual banks' loan portfolio and insurers" liabilities may benefit the aggregate system. AI and machine learning could help process information on the fundamental value of assets, thus allocating funds to investors and projects more effectively. Moreover, if AI and machine learning increase the speed and reduce the costs of payment and settlement transactions, for example by executing trades at times when there are available counterparties with corresponding demand, this may stimulate transactions for real activities
Facilitating collaboration and realizing new "economies of scope"	Were AI and machine learning to facilitate collaboration between financial services and various industries, such as e-commerce and "sharing economy" industries, this could realize new economies of scope and foster greater economic growth. For example, customer analysis based on transaction data attached to payment and settlement activities (for example, "who buys what, when, and where?") would encourage cooperation between e-commerce and financial services
Stimulating investments in AI and machine learning related areas	Many firms, including non-financial businesses, appear eager to apply AI and machine learning to their business. The growth in investments in AI and machine learning-related R&D can directly contribute to economy-wide investment and thus stimulate economic growth

Source: authors' elaboration based on (Merton, & Bodie, 2005).

The use of AI and machine learning technology is changing the provision of some financial services. While data on the extent of adoption in various markets is quite limited, dialogue with market participants suggests that some segments of the financial system are actively employing AI and machine learning. These applications are thus currently more widely used than other key innovations, such as distributed ledger technology or smart contracts. In particular, fraud detection, capital optimization, and portfolio management applications appear to be growing rapidly. Most market participants expect that AI and machine learning will be adopted further. Because of this, it is important to start thinking about the financial stability implications now rather than after the potential implications have been realized. The analysis is necessarily partial and will benefit from greater understanding of use cases over time. Moreover, the changes will not result in a material change to financial stability and hence fall outside the scope of this paper.

The use of AI and machine learning in financial services may bring key benefits for financial stability in the form of efficiencies in the provision of financial services and regulatory and systemic risk surveillance. The more efficient processing of information on credit risks and lower-cost customer interaction may contribute to a more efficient financial system. The internal (back-office) applications of AI and machine learning could improve risk management, fraud detection, and compliance with regulatory requirements, potentially at lower cost. In portfolio management, the more efficient processing of information from AI and machine learning applications could help to boost the efficiency and resilience of financial markets – reducing price misalignments earlier and (under benign assumptions) reducing crowded trades. Finally, with use cases by regulators and supervisors, there is potential to increase supervisory effectiveness and perform better risk analysis in financial markets.

Many current providers of AI and machine learning tools in financial services may fall outside the regulatory perimeter or may not be familiar with applicable law and regulation. Where financial institutions rely on third-party providers of AI and machine learning services for critical functions, and rules on outsourcing may not be in place or not be understood, these services and providers may not be subject to supervision and oversight. Similarly, if providers of such tools begin providing financial services to institutional or retail clients, this could entail financial activities taking place outside of the regulatory perimeter.

The uses of AI and machine learning should continue to be monitored. As the underlying technologies develop further, there is potential for more widespread use, beyond the use cases discussed in this paper. It will be important to continue monitoring these innovations and to update this assessment in the future.

Conclusions

The deployment of artificial intelligence and machine learning systems in the financial sector will continue to accelerate. This trend is driven by rapid increases in computational powers, data storage capacity, and big

data, as well as by significant progress in modeling and use-case adaptations. The COVID-19 pandemic is accelerating the shift toward a more contactless environment and increasingly digital financial services, which will further strengthen the appeal of AI/ML systems to providers of financial services. Use of AI/ML will bring important benefits but will also raise significant financial policy challenges. AI/ML systems offer financial institutions the potential for significant cost savings and efficiency gains, new markets, and better risk management; bring customers new experiences, products, and lower costs; and offer powerful tools for regulatory compliance and prudential oversight. However, these systems also bring about ethical questions and new unique risks to the financial system's integrity and safety, of which the full extent is yet to be assessed. The task facing financial sector policymakers is further complicated by the fact that these innovations are still evolving and morphing as new technologies come into play. These developments call for improvements in oversight monitoring frameworks and active engagement with stakeholders to identify possible risks and remedial regulatory actions.

Regulators should broadly welcome the advancements of AI/ML in finance and undertake the preparations to capture its potential benefits and mitigate its risks. This includes the timely strengthening of institutional capacity, recruiting relevant expertise, building up knowledge, improving external communication with stakeholders, and expanding consumer education. Deployment of AI/ML systems in the financial sector has proven to be most effective when there are national AI strategies in place that involve all relevant public and private bodies. Cooperation and knowledge sharing at the regional and international level is becoming increasingly important. This would allow for the coordination of actions to support the safe deployment of AI/ML systems and the sharing of experiences and knowledge. Cooperation will be particularly important to ensure that less-developed economies have access to knowledge related to techniques and methods, use cases, and regulatory and supervisory approaches. Finally, the evolving nature of the AI/ML technology and its applications in finance mean that neither the users, the technology providers and developers, nor the regulators understand, currently, the full extent of the strengths and weaknesses of the technology. Hence, there may be many unexpected pitfalls that are yet to materialize, and countries will need to strengthen their monitoring and prudential oversight.

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