Examining the impact of artificial intelligence on market competition and consumers

Study summarizing the results of the market analysis number AL/234/2024 of the Hungarian Competition Authority

HUNGARIAN COMPETITION AUTHORITY

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Content

1 Glossary

Data labelling: data in its initial raw form has no explicit tags other than its format (e.g., text, image, sound, etc.). Data labelling is the process of identifying raw data and adding one or more meaningful and informative labels to provide context so that a machine learning model can learn from it. Labelled data types:

- Labelled data: any data to which an attribute or category has been assigned.
- Unlabeled data: any data that does not have attributes defining its properties.

Foundation Model (FM): machine learning models trained on extremely large datasets with many different data types, which can be applied flexibly to a wide range of specific domains without prior fine-tuning. They have evolved due to the huge amount of content available on the Internet and to advances in machine learning methods and computational capabilities.

Algorithm: a set of defined instructions or rules that execute commands in a step-by-step procedure.

Application Programming Interface (API): a program that allows communication, data exchange and function invocation between separate systems. It facilitates the integration of different systems so that users can access the functionality of external applications without having to install them on their own systems. For example, an API is used to allow applications running on the phone to use the phone's features (such as the camera).

Plug-in: A software component that can be added to other applications to extend their functionality. A plug-in is a type of module that uses the existing structure of the application once installed in it. This allows users to easily install or remove plug-ins without changing the primary system functionality of their applications.

Chatbot: a program that simulates human conversation and can be used to complement other applications to enhance user experience. It has the ability to understand user questions and generate automated responses. Modern chatbots are mostly based on generative artificial intelligence models.

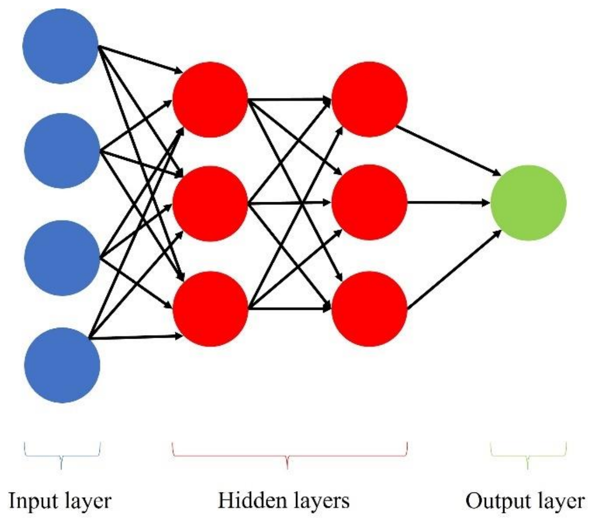
Deepfake: A technique using artificial intelligence (primarily deep learning, as the name implies) to impersonate people and create fictitious events by producing lifelike but fake audio, images and video. The content generated is most often used to spread false information or to promote economic fraud.

Generative Artificial Intelligence (GenAI): an AI technique that aims to generate synthetic data using pre-learned datasets. By using generative models, it is possible to generate semantically (and, where appropriate, grammatically) correct content, such as text, images, videos and audios, that requires creativity. One of the most common types is large language models. The content generated is based on probabilistic models, responding to user questions (prompts) as input. Consequently, the generated output data varies from user to user.

Machine Learning (ML): a subdomain of artificial intelligence within computer science. Just as the human brain learns in many cases through experience, ML models learn in a similar way. Machine learning models explore patterns on different data sets using the logic of human learning, analysis and information processing, while gradually optimizing their learning processes in a form of self-learning. There is a significant overlap with the field of statistics, as it applies a number of statistical methods and can be applied to similar tasks, such as forecasting.

Deep Learning (DL): refers to a neural network that consists of several hidden layers, i.e., the transformation of incoming data is done on a "deeper" structure (Figure 1). Each layer provides a different, increasingly abstract representation of the input data.

Figure 1. The structure of deep learning neural networks



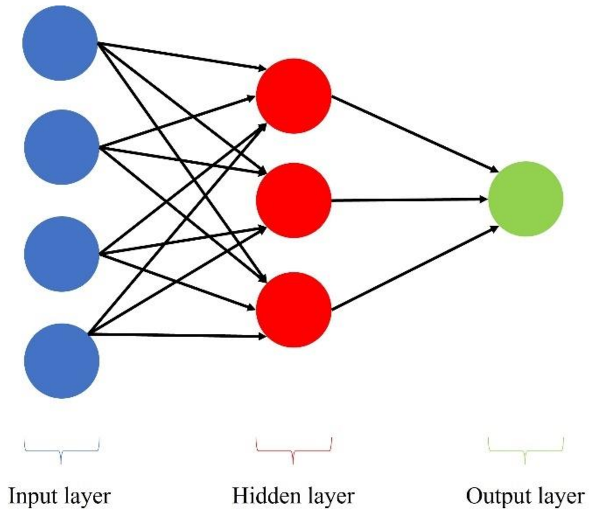
Artificial Intelligence (AI): a branch of computer science. It consists of systems that are capable of performing tasks that require cognitive skills. Currently, there is no clear consensus on the categorization of the different technologies, and therefore the question of whether some machine learning solutions can be considered as AI is a matter of debate.

Artificial Neural Network (ANN): one of the machine learning methods that models the network and operation of neurons for various prediction and data generation tasks, modelled on the structure and information processing of the human brain. Most artificial neural networks consist of hundreds or thousands of artificial neurons, called processing units, connected by nodes.

An ANN consists of several layers (Figure 2):

- from the input layer, which is the set of input data (this is the layer where the training of the model takes place);
- hidden layer, where the various calculations and estimations are made on the input data;
- output layer, which is the data generated from the predictions resulting from the model's calculations.

Figure 2. Layers of an ANN



Model parameter: a statistical indicator describing a measurable characteristic of the population under study. For machine learning, parameters are calculated on the input data during the training process of the models. The number of parameters of an ML model represents the amount of information needed to store the knowledge of the model, hence it gives a good approximation of the size of the model.

Large Language Models (LLMs): artificial neural networks that, after training on a large number of textual documents, are able to learn the statistical relationships inherent in them and thus perform various linguistic tasks. Examples of such tasks include text generation, processing, and classification.

Transfer learning models: a set of AI techniques that build on a basic model and involve further learning and training of the basic model, exploiting the information embedded in the basic model. An example of transfer learning is fine-tuning, which adapts the model to the developer's goals for a particular task.

Turing test: an experimental method to test whether a machine response is distinguishable from a human response. In the experiment, the experimenter asks two subjects, whom the experimenter cannot see or hear written questions via computer. One subject is a human, the other a computer. If the experimenter cannot decide in a given time which subject is the real person based on the answers, the computer passes the Turing test.

2 Overview and recommendations

2.1 Executive summary

Artificial Intelligence (AI) is one of the most promising technological developments of our time and is a major focus of attention in most countries. The market analysis carried out by the GVH aims to explore the impact of generative AI on market competition and consumer behavior. The analysis aims to provide knowledge base for the GVH's and future work and to identify areas where the GVH can and should intervene, make proposals to stimulate competition or protect consumers.

The development and deployment of AI-based technology can lead to many economic and social benefits, but it also entails significant risks. In sectors using AI, the rapid development and diffusion of technology can distort competition and make consumers more vulnerable.

The GVH's objective in this market analysis is therefore twofold. On the one hand, it aimed to examine the impact of AI-based technology on market competition . The development of this technology is extremely resource intensive and is currently typically only available to a small number of companies. As a consequence, the practical use of AI may become a privilege for a small number of companies, which could distort competition in many sectors in the future. On the other hand, it also aimed to review how the use of technology affects consumer behavior, data security and the extent to which consumer information is provided by the companies using the technology.

In order to provide a theoretical basis, the paper first introduces the conceptual framework, classification and evolutionary history of MI. This is followed by a desk research to explore international practices and experiences. In this section, studies by other competition authorities, national and EU AI strategies and existing regulations in the field and their background are presented in a comprehensive manner.

The GVH also sent out request for information documents (RFIs) to international technology companies and prominent generative AI model developers to obtain a comprehensive picture of their AI-related activities, the market structure, the existing competitive relationships and the respondents' consumer protection practices. In addition to international players, developers of Hungarian-language models in Hungary were also interviewed.

In order to identify domestic business practices, the GVH also surveyed domestic players in predefined sectors likely to use AI technology, in addition to developers. On the other hand, the GVH has also held several rounds of consultations with domestic research institutes, universities and public and non-profit organizations to obtain a more comprehensive picture of domestic regulation, developments and opportunities for companies.

The results of the analysis and the individual steps of the investigation are presented in the following chapters of the paper. On the basis of these results and relevant international experiences, the GVH has formulated a number of recommendations and guidelines.

2.2 Proposals

Based on the information collected in the market analysis, the GVH outlined four proposals for the further development of the domestic AI market and for the sake of its better use by the society.

1. **There is a need to promote the use of AI and generative AI in the domestic business sector, with a focus on small and medium-sized enterprises.**

   The results of the market analysis suggest that the integration of AI solutions into business processes and products could be a critical factor for the future productivity and competitiveness of companies (although, for the sake of completeness, there are doubts about this). This is confirmed by the MKIK-GVI survey,[1] which shows low adoption of AI among domestic enterprises. According to the survey, the smaller the enterprise, the less likely it is to use the technology or at least attempt to use it.

   In order to ensure that the productivity gap between large multinational companies and domestic companies, including small and medium-sized enterprises (SMEs), does not

[1] For details see chapter 11.1.

widen further in the future, AI-based technologies should be made more accessible to a significant part of the SME sector. This requires (inter alia, according to the Government Information Technology Development Agency[2]), in particular, basic factors such as the ongoing development and updating of SMEs' technological knowledge, the availability of adequate capital and the provision of competent staff, preferably through higher education training. It is also recommended to increase the share of access to supercomputing capacity for the SME sector, which currently stands at a maximum of 20%. Without widespread provision of these essential factors, the domestic business sector will not be able to move forward, despite the existence of public support programs that have now made critical development infrastructures, for example, available to SMEs.

At the same time, it is important that market players do not have unrealistic and inflated expectations of AI-based technologies. Among the market players contacted by the GVH, those that use AI or generative AI solutions did not uniformly report sweeping and fundamental changes or impacts, but rather reported smaller scale and non-critical advances. Some academic publications (e.g., Acemoglu, 2024) also lead to similar conclusions. Operators therefore need to be aware of what this technology can and cannot do at the current level of development and the human, machine, and data requirements. These should also be emphasized in the various programs and knowledge transfer.

2. **For businesses providing AI-powered services to consumers, the GVH suggests clear and easily understandable information (concise, concise, factual, and emphatic) to provide when presenting the service, and also before the consumers use it.**

   The information provided to consumers should address the fact that the service uses artificial intelligence and its essential characteristics, in particular:

   - what is the essence of the use, how, on what sources the service relies, what is the source of the information, the basic characteristics of the processing;
   - the risks and uncertainties of the results, the answers and the content produced in general;
   - for the reasons set out above whether there is a need for, and if so, what type of controls and reservations to have in terms of the service in general.

3. **We recommend that the government, when reviewing the national strategy for artificial intelligence, should address the development and support of domestic AI**

[2] For details see chapter 10.3.3.

training, especially given the lack of skilled professionals with relevant knowledge. In addition, greater emphasis should be placed on the rational integration and coordination of the currently fragmented research directions in AI and the government AI strategy.

In the renewal and implementation of the national strategy, it is particularly important to identify and remove bottlenecks. Adequate expertise and computational capacity are also essential for the implementation of the business support referred to in proposal 1. The Komondor supercomputer will significantly alleviate the computing capacity constraints, but it would be crucial for Hungary to develop an adequate IT infrastructure, including supercomputing capacities, as the current state of Komondor will soon be insufficient to serve new needs.

It is also important to build the value chain from models to business applications. Support the development of an ecosystem for AI development (data economy, technology application training, benchmark evaluation system, etc.).

4. **Taking into account the specificities of the Hungarian language, the expectations and needs of Hungarian consumers and users, in order to expand the range of available AI models on the Hungarian market, we propose the effective allocation of financial and strategic resources of public actors for the development, application and availability of Hungarian language models.**

Hungarian is one of the most difficult languages, spoken by relatively few people (13-15 million) in the world. This is compounded by the fact that only a fraction of the population speaks a foreign language. The quality of the AI models is determined not only by the computational capacity but also by the amount of data available in the language. While quality is high in global languages, we can all see that this is not the case for texts translated into Hungarian, for example in customer service applications: Hungarian users are often confronted with inaccurate or even grammatically challenged sentences that affect the content.

The OECD’s 2023 study and the information obtained by the GVH during the market analysis also support the direction set by the Artificial Intelligence Strategy years ago, namely that the development of Hungarian-language AI technology is not only appropriate, but also important. Hungarian language models contribute to the diversity of products available, and a wide range of products ultimately serves to ensure consumer welfare in the long term, as there are areas where the quality of the AI model depends on the understanding of the language, for which training in that language is essential (e.g., automated translations from or into Hungarian, text generation, customer services, education). Although it goes beyond competition policy, the fact that a country's identity is largely determined and shaped by its own language is not negligible; a common mother tongue is also a shared value with its own grammatical rules, expressions and cultural nuances, and the preservation of cultural traditions and knowledge, and of diversity, reflected in languages is also a public interest that needs to be protected. The OECD study refers to this challenge when it describes ongoing national initiatives, action plans and strategies for the development and use of language models.

On the other hand, looking at the relationship between the use of mother tongue and AI, the market analysis also revealed that not only the large language models are developed on English corpus, but that training materials are also generally available in English. This phenomenon is problematic because it can be a barrier to the uptake of AI technology if non-English speakers cannot access the relevant knowledge. It also further hampers their labor market prospects.

The above two issues can be seen as obstacles to the uptake of AI, even where there is an adequate team of experts and computing capacity. The development of proprietary language models - which is not really feasible without public support due to the significant resource requirements - can serve to broaden the range of products and ensure equal access to AI for users. It is therefore recommended to further support the development of the Hungarian language model and the production of training and educational materials in Hungarian to promote the use of AI technology.

The GVH undertakes to revise this market analysis study as necessary and to supplement it in the light of further market developments.

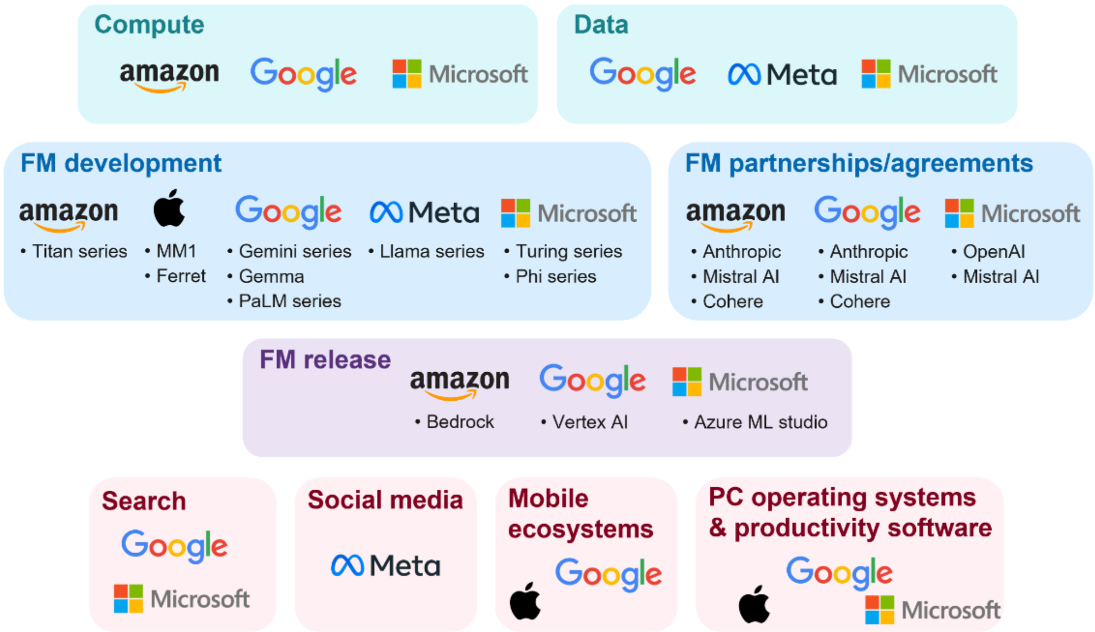
3 Reasons for initiating market analysis, relevance of the topic

Following the typically steady development of generative AI-based models in recent years, the recent emergence of generative AI-based models is seen by many as a kind of technological shock that could have a significant impact on a wide range of sectors and even the economy as a whole in the future. From intellectual property issues to labor market implications, the technology poses a number of challenges that require a thorough understanding of how AI and related markets work.

Recognizing this, the GVH launched a market analysis to investigate the MI value chain, which, in line with its competence, was primarily determined by competition and consumer protection considerations. In the case of AI and in particular generative AI models, two main types of competition problems may arise.

Since AI and generative AI-based solutions can have a significant impact on economic growth and can have a meaningful impact on the future development path of economies, it is essential to develop these models and make them as widely available as possible. However, competition in the developer market is essential. The more these models can do, and the more they are available to more companies, the greater the economic and social added value they will bring. This, in turn, requires more intense competition in the developer market. It is therefore important to take action as soon as possible to avoid the significant concentration that occurs in other digital markets (e.g., social media, search services), and to create a market environment and regulatory framework that helps to maintain competition and counteract concentration. In addition, the markets for AI and generative AI are subject to concentration, as economies of scale are important. Moreover, incumbents in digital markets (Microsoft, Google, Meta, Amazon, etc.) own many critical inputs (e.g., computing power, data) (Figure 3) that make it difficult for companies independent of them to enter the market. This is why more and more competition authorities are interested in the developer market. A short summary of the results of their analyses is also presented in this paper.

Figure 3. Big tech companies at different levels of the AI value chain



Source: CMA (2024): AI Foundation Models. Technical update report. Competition and Markets Authority, London. Figure 6.

On the other hand, the economic growth and welfare potential of AI and generative AI-based services can be maximized if they are adopted by more businesses. Moreover, if these technological innovations are able to make a real contribution to business productivity growth, companies that do not adopt them may be left behind and even fall out of the market over time. Moreover, the SME sector could be severely affected by this process. This could lead to increased market concentration in a significant part of product markets, resulting in higher prices, lower product and service quality and less choice for consumers. As a competition authority, the GVH cannot influence the technological solutions adopted by a company, but it can identify the barriers to the adoption of different technologies by companies and, on this basis, make competition policy recommendations to help remove or overcome these barriers.

Moreover, these two competition problems can be linked, amplifying each other's negative effects. If the pricing of AI solutions is high or their availability is limited, this may lead to higher prices for end-consumers, as the deployer (enterprise) level incorporates the additional costs of developers into its own pricing. On the other hand, there is also a risk that the user base will continue to shrink, with even fewer companies being able to access the technology, leading to increased concentration and reduced consumer welfare.

However, in addition to the many concerns, it should be stressed that the evolution of technology is very dynamic, so the balance of power in the value chain and the business policies of the players are not yet firmly established. It is therefore worthwhile for competition authorities to pay continuous and close attention to the markets affected by AI.

4 Legal background of the market analysis process

Pursuant to Article 43/C of the Act LVII of 1996 on the Prohibition of Unfair and Restrictive Market Practices (hereinafter: Competition Act) with a view to discharging its statutory responsibilities more effectively and efficiently, the GVH may conduct market analyses, in the framework of which it surveys and analyses the operation of particular markets, the market processes and the development of market trends as well as particular market practices, as well as the effects thereof on competition and trading parties, in particular ultimate trading parties, relying on information in the public domain and data collected on a voluntary response basis.

The GVH shall announce on its website the initiation of a market analysis, the specific markets, market practices and issues covered, as well as the proposed timeframe.

On the conclusion of a market analysis, the GVH shall prepare a report presenting the issues investigated, the facts discovered and the findings, any further measure that needs to be taken and the methodology employed, and it shall publish this report on its website.

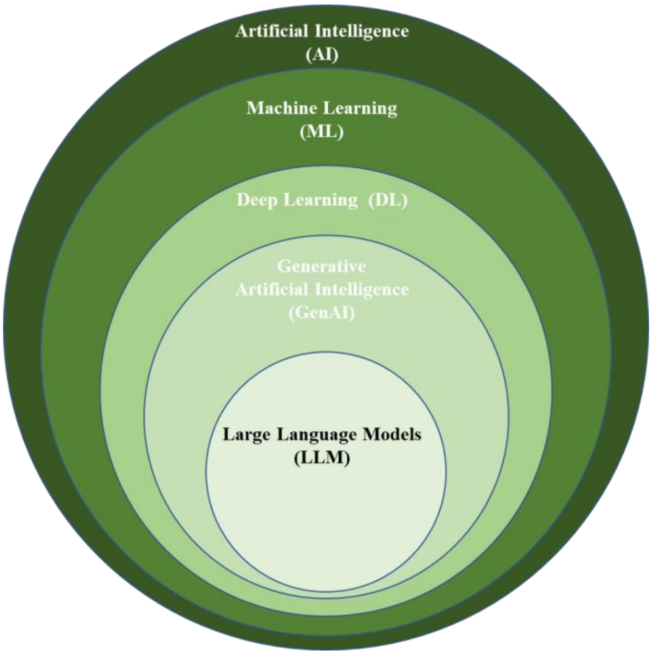
Pursuant to Article 43/F of the Competition Act, if a market analysis detects a market failure which cannot be remedied in full or in part by competition supervision proceedings, the GVH

- shall inform the competent committee of the Parliament, or the competent minister or authority;
- may publish non-binding public recommendations; or
- may initiate, if deemed necessary, the enactment or amendment of legislation.

5 Evolution of artificial intelligence-based technologies: from concept to practical applications

Various forms of AI-based technologies and solutions have been on the market for decades. They are used, for example, for filtering emails, recommending content and text translation tasks. The latest wave of AI-based applications is considered to be generative artificial intelligence (Figure 4**Hiba! A hivatkozási forrás nem található.**), which has spread much faster and more widely among consumers than before. For the regulatory side, this pace of technology diffusion and development raises a number of questions.

Figure 4. Subgroups of MI models



The field of artificial intelligence has seen continuous, and in many cases dynamic, development, although there have been some setbacks in the early stages, most notably in the field of practical applications.

However, to understand the evolution of the system, it is worth clarifying a few concepts beforehand. Among other things, MI systems are usually grouped according to their depth and breadth. In this context, a distinction is made between Artificial *Narrow* Intelligence (ANI) and Artificial *General* Intelligence (AGI).[3]

Currently, even the most complex AI models use only "artificial narrow intelligence." These systems are goal-oriented, so this form of intelligence can be applied to tasks that AI algorithms have already encountered.

5.1 The birth of the AI concept

After the development of the programmable digital computer (1946), Alan Turing outlined the Turing test in 1950, which laid the foundations for the concept of machine intelligence. Turing also contributed to the development of modern computational theory and algorithm theory, which formed the basis for the development of the field. Artificial intelligence was declared a field in its own right at the Dartmouth Conference in 1956.

[3] More on the classification aspects of MI will be discussed later.

5.2 The era before deep learning

The first decade of the field saw practical applications such as the Mark I Perceptron artificial neural network (1957), which was able to recognize visual patterns in a rudimentary way (it was able to group cards with different labels, as the application was called). The first chatbot that passed the Turing test (ELIZA, 1966) was also born by this time.

Despite the initial optimism, the field's development stalled in the 1970s and 1980s due to challenges in various modelling and capacity constraints. The potential of the technology was more theoretical. From this stagnation, the advance of machine learning methods pushed artificial intelligence research forward.

Machine learning models can learn adaptively and improve their performance over time, making them very useful for cognitive tasks such as pattern recognition and classification under the right learning conditions. One of the cornerstones of machine learning has been the concept of artificial neural networks. In its early days, this field manifested itself in practice in the form of artificial perceptrons. Perceptrons, which are simplified models of biological neurons, can be seen as the initial forms of more sophisticated artificial neural networks (ANNs). ANNs are now composed of networks of several interconnected neurons. The "backpropagation" learning algorithm, created in 1969, laid the foundations for the concept of multilayer ANNs, which later paved the way for the development of deep neural networks.

After the 1980s, the necessary technological infrastructure to develop ANNs was available, and the scope of models trained on large data sets was broadened. By 1989, for example, the use of Convolutional Neural Networks (CNNs) made it possible to identify handwritten characters.

5.3 The age of deep learning

Since the 2000s, deep learning models based on multilayer neural networks have become the best performing models in most applied fields, including image classification, natural language processing and speech recognition. Their development, and the development of any AI-based solution in general, has been greatly facilitated by the continuous growth of infrastructural capabilities such as improved computational capacity and the increase in the amount of data available for learning models.

From the mid-2010s, AI applications based on **generative models** began to spread, where users are able to communicate with AI-based systems through prompts. For example, in 2011, Apple introduced Siri, a voice-activated virtual assistant that could provide voice responses to users’ verbal prompts and perform tasks (such as generating calendar entries) within Apple products. Compared to earlier chatbots and other solutions, these systems no longer generated built-in template sentences for a narrow topic, but were based on intensive learning and fine-tuning phases. This development is illustrated by the fact that, until the 2010s, no machine was able to reliably recognise language or images at human level, but nowadays they outperform humans in controlled tests in all these areas.

In 2014, developments such as the variational autoencoder and the generative adversarial network created the first practical **deep neural networks** that could train generative models on complex data such as images. Taking images as an example, these deep generative models were the first to not only identify and cluster images, but also to create complete image files.

Behind instruction-based AI applications are the so-called **transformer-based deep learning models**, which first appeared in a theory developed by Google researchers in 2017. Transformers represent another paradigm shift in deep learning, introducing the attention mechanism as a fundamental component of sequence modelling tasks. At the core of the transformer architecture is the self-attention mechanism, which allows the model to consider the weight of different input elements when making predictions, thus capturing more effectively the dependencies and context between different texts and words. Consequently, for example in text generation tasks, semantically and grammatically correct outputs can be produced. The concept of transformers has inspired the development of applications based on large language models designed to understand and generate human language, and thus interact with humans. Large language models have also become capable of interpreting unlabeled textual data, so transformer-based deep neural networks have facilitated the widespread adoption of instruction-based AI applications.

In 2018, OpenAI introduced the **first generative pre-trained transformer** (GPT-1**) model**, followed by GPT-2 in 2019, acting as a kind of foundation model. The concept of a foundation model was introduced by the Standford Institute in 2021. By this time, models developed on huge amounts of data and a wide variety of data types had become a new milestone in the field of artificial intelligence, with their adaptive nature, providing a basis for different, even very specific applications after a very expensive learning phase. Previously, for example, in order for a chatbot to provide the right answer in a given domain, it had to learn on a large amount of specific labelled data sets. In the case of a foundation model, however, it is sufficient to use even a small amount of unlabelled data during the fine-tuning phase to achieve a similar result. In practice, the model first labels the unlabeled data (e.g., it identifies an input image file as having a cat and a “happy” mood) and then uses the labeled data for fine-tuning.

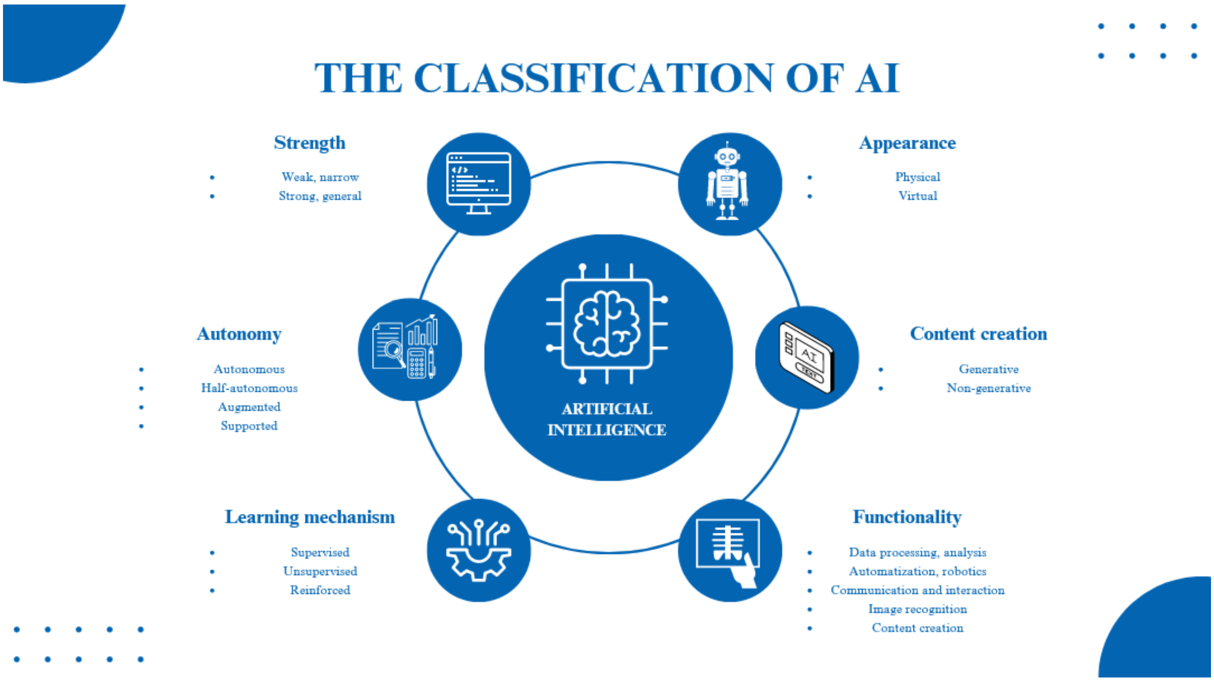
Overall, this generation of models is flexible enough to be used for a wide range of tasks, unlike previous technologies, which in most use cases required models to be developed from scratch.

Among digital applications, ChatGPT, the chatbot also launched by OpenAI in 2022, was the fastest to reach 100 million users. The underlying large language models GPT-3.5 and the latest version, the multimodal GPT-4, are the most powerful base models ever trained on a large amount of data (175 billion parameters and 96 hidden layers).

6 Classifications of artificial intelligence

Classification of AI is a key factor in understanding and sorting the broad range of the field. This categorization will help us to review the different types, functionalities and applications of AI. AI can be classified according to different aspects, including, but not limited to, functionality, capabilities, autonomy, learning capabilities, physical appearance, temporal characteristics and content production capabilities (Figure 5).

Figure 5. The classification of AI



One possible aspect of the classification of MI, which has been mentioned earlier, is the strength of the system in technical terms. In this context, we distinguish between **weak and general (strong) MI**:

- **Weak (narrow) AI** refers to systems that can only perform a specific task or set of tasks and lack general intelligence. For example, virtual assistants like Siri or Alexa can only perform specific tasks, such as following voice commands, providing weather forecasts or playing music.
- **General or strong** AI represents a more universally understood intelligence with comprehensive knowledge and learning abilities. This type includes AI systems that function in a similar way to human intelligence, with the ability to solve different tasks, learn new information and apply this knowledge to other situations. Truly general AI does not yet exist, and some experts believe it will never exist (Fjelland, 2020).

Another important classification criterion is the autonomy of the system. We distinguish between **autonomous, semi-autonomous, extended and supported systems**:

- **Autonomous AI systems** require minimal or no human intervention and are able to operate and make decisions autonomously. These systems include, for example, automated production lines that can operate autonomously without human intervention.
- **Semi-autonomous AI systems** are capable of a certain level of autonomy, but still require human supervision and intervention, especially when dealing with more complex decisions or new situations. Examples include driver assistance systems, which are capable of lane-keeping and braking, but require continuous human supervision during use.
- **Augmented artificial intelligence** means that systems work in collaboration with humans, making users more efficient in performing tasks and making decisions. These AI systems often use machine learning and data analytics to improve user experience and efficiency. Examples include predictive tools used in financial decisions to help choose the right investment, or systems that help in medicine to make the right diagnosis and choose the right treatment.
- **Augmented** AI is different from augmented systems in that while augmented AI works with humans to harness their skills and improve their decision-making processes, augmented AI typically acts as a tool or assistant to humans. Examples of assisted AI are the virtual assistants mentioned above.

MI can also be classified according to learning methods, such as **supervised learning, unsupervised learning and reinforcement learning**:

- In supervised learning, AI systems perform tasks for which tagged data is available during the learning process. An example of this method is the spam filtering system.
- In the case of **unsupervised learning,** AI systems autonomously discover patterns and structures in the data, without the need for human intervention. An example of unsupervised learning systems is a system that classifies consumers into clusters (groups of consumers with homogeneous characteristics) based on their prior choices and then recommends products based on these clusters.
- **Reinforcement learning** is a technique in which the AI system interacts with the environment and receives feedback from users on the effects of its actions. Algorithms learn from this feedback and optimize their decisions and behavior based on fine-tuned rewards and punishments. Examples of such systems include the artificial intelligence of some self-driving cars.

Artificial intelligence can also be classified **as physical or virtual** based on its appearance:

- **Robotics** refers to AI systems that are embedded in a physical body and are able to interact with their environment. Examples of such systems include manufacturing robots, self-driving cars and medical robots.
- **Virtual agents** are AI entities that exist in a digital environment or as software. Examples of this category are virtual assistants, chatbots or video game characters.

Among AI systems, we distinguish **between generative and non-generative** AI systems, the main characteristics of which are:

- **Generative AI systems** -are artificial intelligence algorithms and -models that can generate new data, content or information. These systems are usually able to learn from patterns and data and then create new, unprecedented data based on them. Generative AI applications include -generative models based on text-, image-, sound and video recognition, which are able to create new, realistic text, images, sounds, videos based on learned patterns.
- **Non-generative AI systems,** on the other hand, do not generate new data or content, but perform predefined tasks during the processing and analysis of the data received. These systems tend to be more limited in creativity and in generating new information, but can be effective in performing specific tasks. Examples of non-generative AI systems include machine translators, which generate specific outputs for given inputs based on learned data.

Finally, AI systems can be divided into several **functional classes** according to the tasks they perform:

- The field of data processing and -analysis, where AI systems can process large amounts of data and perform analytical tasks. These systems often use machine learning models to discover patterns or make decisions based on data. In the field of financial analytics, for example, these AI systems offer significant opportunities.
- The field of automation and robotics, which includes AI systems capable of automating physical or digital tasks.
- **The field of communication and interaction**, where AI systems allow people to interact with AI in an intuitive way. Examples include virtual assistants, chatbots and speech recognition systems that help people access information faster or complete tasks. This is an area that is becoming more and more common in online commerce and customer service.
- **The field of image recognition and perception**, in which AI systems are able to recognize and interpret visual information such as faces, medical lesions. These systems can be used, for example, for personal identification or medical diagnostics.
- **The area of content generation**, where AI systems are able to create content such as written text, images, videos or audio, based on properly prepared data and models. Examples of AI systems capable of generating written texts are GPT-based language models capable of generating human-like texts (as an example, see Figure 6). These systems learn from large amounts of text data to generate new, authentic-looking texts based on the learned patterns and styles. This allows, for example, the automated creation of articles, blog posts, marketing materials or literary works. In the field of image creation, generative AI models such as GAN (Generative Adversarial Network) systems can create new, realistic images (as an example, see Figure 7). Such systems can be used, for example, for image recognition or style translation tasks, but also for the creation of new images in different painting styles.

Figure 6. Example of a mathematical problem solved by GPT

Derivate f(x)=x/2 + 2 dx

To find the derivative of the function $f(x) = \frac{x}{2} + 2$ with respect to x, you can differentiate each term individually.

1. The derivative of $\frac{x}{2}$ is $\frac{1}{2}$.
2. The derivative of the constant 2 is 0 since the derivative of any constant is zero.

Therefore, the derivative of $f(x)$ is:

$$f'(x) = \frac{1}{2}$$

Figure 7. Image generation based on song lyrics using generative AI

Based on the lyrics of the song Riders on the Storm by The Doors, could you create a picture that describes in a diagram what happened in the song, the mood and the message of the song?

Here is the visual representation based on the song "Riders on the Storm" by The Doors. The image captures the mood, message, and storyline of the song with stormy clouds, a winding highway, and an ominous figure on the side of the road, evoking the sense of mystery, danger, and isolation. Let me know if you'd like any changes or additions!

It is important to note that the classification of MI is not only important in a theoretical sense, but also has a significant impact in practical applications. For example, when developing autonomous or fully automated AI systems, designers need to take into account **the potential risks and ethical issues** of systems operating without human supervision, especially when they concern the life and safety of sentient beings or affect fundamental human rights. Classification of AI can also help to regulate and guide the development and deployment of AI systems. The different classification categories allow regulators and legislators to define precise rules and standards for specific AI systems, which can contribute to making the technology safer and more ethical (Martinez, 2019).

However, the classification of AI also has challenges and limitations. Due to the rapid evolution and variability of AI systems, categories must also keep pace with the emergence and evolution of new technologies. In addition, classification categories often overlap and a given AI system can be classified into several different categories, which can make clear classification difficult.

7 The history of regulation of artificial intelligence

7.1 Preparation of the regulatory processes in the European Union

European initiatives to regulate artificial intelligence date back to 2018. The European Commission's Communication[4] on the creation of a **common European data space**, published in spring 2018, was the first ever EU strategy document to announce a joint action in the field of AI, addressing the strengthening of technological and industrial capacities, and aiming to anticipate the socio-economic changes that AI will bring and to ensure an appropriate ethical and legal framework. This document was closely followed by **a coordinated plan**,[5] as a result of cooperation between Member States, the European Commission, Norway and Switzerland, to provide a common framework for national AI strategies in each Member State, to support private investments and to foster cooperation between different European research centers. The European Commission's independent expert group also set out **ethical requirements**[6] during the year, setting three expectations for AI: it must be *legal*, i.e., comply with existing legislation; it must be *ethical*, i.e., ensure compliance with moral principles and values; and it must *be stable*, so that it does no harm, either technically or socially.

[4] SWD(2018) 237; https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52018DC0237
[5] COM(2018) 795; https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52018DC0795
[6] https://op.europa.eu/en/publication-detail/-/publication/d3988569-0434-11ea-8c1f-01aa75ed71a1/language-en

As a continuation of this process, the European Commission published its **White Paper on Artificial Intelligence** in early 2020,[7] which aims to outline policy options in the field of AI that promote reliable and safe AI development while respecting the values and rights of users. At the same time, the Commission has summarized the impact of digital technology developments on existing regulatory frameworks in three areas – AI, Internet of Things (IoT), and robotics – **in a report**.[8] The document states that clear and predictable regulation is needed to make Europe a world leader in these areas.

In the same year, 2020, the European Parliament published **its recommendations in** three areas concerning artificial intelligence, calling on the Commission to create new rules on the ethical aspects of artificial intelligence rules,[9] on liability,[10] and on intellectual property aspects.[11] At the same time, the European Parliament set up **a special committee on** artificial intelligence,[12] which concluded in its 2022 report[13] that the European Union was lagging behind in the global race to research, develop and invest in artificial intelligence.

7.2 Other international regulatory history and recommendations

The strategic importance of this area is demonstrated by the fact that, in addition to EU organizations, several global players have started to address the issue of AI regulation. In 2019, the Organization for Economic Co-operation and Development (OECD) Council adopted **a Recommendation on AI**[14] which calls on all relevant actors to comply with the key principles set out in the document (e.g., anthropocentricism, transparency, security, accountability). The ethical aspects of AI were also addressed in the first **global recommendation** adopted by the UN Educational, Scientific and Cultural Organization (UNESCO) General Assembly in 2021,[15] which aims to identify the benefits of AI for society while reducing the risks that come with it.

Alongside global organizations, the United States has also started to regulate the field: in 2022, it published **the AI Bill of Rights**,[16] to promote the use of AI for the benefit of citizens. To this end, the document sets out the principles to be respected, focusing on practice. One year

[7] COM(2020) 65; https://commission.europa.eu/system/files/2020-02/commission-white-paper-artificial-intelligence-feb2020_en.pdf
[8] COM(2020) 64; https://eur-lex.europa.eu/legal-content/HU/TXT/HTML/?uri=CELEX:52020DC0064
[9] 2020/2012(INL); https://www.europarl.europa.eu/doceo/document/TA-9-2020-0275_EN.html#title1
[10] 2020/2014(INL); https://www.europarl.europa.eu/doceo/document/TA-9-2020-0276_EN.html#title1
[11] 2020/2015(INL); https://www.europarl.europa.eu/doceo/document/TA-9-2020-0277_EN.html
[12] Artificial Intelligence in a Digital Age; AIDA
[13] 2020/2266(INI); https://www.europarl.europa.eu/cmsdata/246872/A9-0088_2022_EN.pdf
[14] OECD/LEGAL/0449; https://legalinstruments.oecd.org/en/instruments/OECD-LEGAL-0449#mainText
[15] https://unesdoc.unesco.org/ark:/48223/pf0000381137/PDF/381137eng.pdf.multi
[16] https://www.whitehouse.gov/ostp/ai-bill-of-rights/

after the non-binding guidelines, in the autumn of 2023, the United States has now regulated the development and use of AI in a normative way, by **an Executive Order**.[17]

7.3 History on the regulation of artificial intelligence in Hungary

The **Artificial Intelligence Strategy**[18] published in May 2020, could be seen as the start of the domestic regulation of AI. The strategy is based on the European coordinated plan's objective for national strategies. The Hungarian Government considers the AI strategy important because it is a technology that affects everyone, transforms the labor market, contributes to efficiency gains and economic growth, while the development is in a competitive global environment and it is raising a number of questions. In general, to address the weaknesses identified by the strategy, attention needs to be paid towards opening up the data assets, strengthening the start-up ecosystem, and fostering a culture of experimentation. The document also warns that the fundamentally profit-driven market (the international technology companies), given that a Hungarian language model would be attractive for a relatively narrower user base (e.g., people who speak Hungarian), is not interested in producing high-quality Hungarian language processing on the market, which may weaken the usage of Hungarian and the quality of services available in Hungarian or using Hungarian in the digital age. The document aims to prepare society to manage and benefit from the changes brought about by AI through the so-called *"foundational pillars,"* also to improve the efficiency of the economy *in its sectoral and technological focus areas* and sets out overarching objectives through long-term *transformative programs.*

The public parliamentary background analysis *"Artificial Intelligence, Regulatory Trends"*[19] published in autumn 2023, provided a comprehensive, accessible and up-to-date summary of the concept, types and areas of development, benefits and threats of artificial intelligence, as well as the EU and international regulatory situation.

[17] E.O. 14110; https://www.whitehouse.gov/briefing-room/presidential-actions/2023/10/30/executive-order-on-the-safe-secure-and-trustworthy-development-and-use-of-artificial-intelligence/
[18] https://digitalisjoletprogram.hu/files/2f/32/2f32f239878a4559b6541e46277d6e88.pdf (in Hungarian only)
[19] www.parlament.hu/documents/d/guest/mesterseges-intelligencia (in Hungarian only)

8 Normative regulation affecting the field of artificial intelligence in Hungary

8.1 EU legislation to facilitate the development and regulation of data space for artificial intelligence

In 2020, the European Commission presented **a European strategy for data**[20] in parallel with the White Paper, which aims to help the EU utilize the potential of the data economy. The document notes that the bulk of the world's data is owned by a few technology giants, which could hold back the emergence, growth and innovation of data-driven businesses in the EU. To overcome this, the Commission has set out a five-year plan for a range of policy actions and investments, the earliest pillar of which is the **European Data Governance Act** adopted in May 2022.[21] This regulation aims to increase trust in data sharing and overcome barriers to data-driven innovation by creating European data spaces between Member States in strategic areas such as health, environment, transport, agriculture and public administration. The data governance legislation will apply from September 2023, after a 15-month grace period.

The European Data Act,[22] adopted at the end of 2023, builds on the data governance regulation and aims to make it easier for businesses to access and use industrial data in large volumes for development purposes, in particular from the IoT, and to make it clear to consumers who can use these data and under what conditions. The new regulation will thus contribute to innovation in artificial intelligence, where huge amounts of data are needed to train algorithms. The data sharing legislation came into force in January 2024, but will only become applicable after 20 months, i.e., from September 2025.

[20] COM(2020) 66; https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52020DC0066&from=EN

[21] Regulation (EC) No 2022/868 of the European Parliament and of the Council on European data governance and amending Regulation (EU) 2018/1724

[22] Regulation (EC) No 2023/2854 of the European Parliament and of the Council on harmonized rules for fair access to and use of data and amending Regulation (EU) 2017/2394 and Directive 2020/1828

8.2 EU consumer protection legislation and GDPR provisions on automated decision-making and profiling

The European Union's **Consumer Protection Directive**[23] and thus the domestic legislation[24] also require consumers to be informed when a business applies personalized pricing based on automated decision-making (e.g., based on purchase/browsing/search history or other factors). Providing this information counts as a pre-contractual informative element, failure to provide it constitutes as an infringement.

The EU **General Data Protection Regulation**[25] has regulated the processing of personal data in the Member States since 2018. According to the parts of the Regulation dealing with automated decision-making and profiling, natural persons have the right, on the basis of the data, not to be subject to a decision based solely on automated processing which would produce legal effects concerning them. In the case of decisions based on artificial intelligence which have legal effects (e.g., a contract offer), data controllers operating an automated decision-making mechanism based on artificial intelligence (e.g., e-commerce platforms using personalized pricing) cannot (while respecting trade secrets and intellectual property rights, in particular copyrights protecting their software) completely hide the way their algorithm works, as they must inform the data subject of the logic used and its relevance and consequences for them before the processing starts. And if the customer decides to consent to the processing of his personal data, with having the abovementioned information, he should also be given the possibility to opt-out from the personalized pricing scheme.

8.3 Specific sectoral rules concerning the use of artificial intelligence

The **General Product Safety Regulation**,[26] adopted in 2023 and applicable from December 2024, includes the assessment of cybersecurity features and any continuously evolving, self-

[23] Directive 2011/83/EU of the European Parliament and of the Council on consumer rights, amending Council Directive 93/13/EEC and Directive 1999/44/EC of the European Parliament and of the Council and repealing Council Directive 85/577/EEC and Directive 97/7/EC of the European Parliament and of the Council; Article 6 ea)

[24] 45/2014 (II. 26.) of the Government Decree on the detailed rules of contracts between consumers and businesses; § 11 (1) q)

[25] Regulation (EU) No 2016/679 of the European Parliament and of the Council on the protection of natural persons with regard to the processing of personal data and on the free movement of such data, and repealing Regulation (EC) No 95/46/EC

[26] Regulation (EC) No 2023/988 of the European Parliament and of the Council on general product safety, amending Regulation (EU) No 1025/2012 of the European Parliament and of the Council and Directive (EU) 2020/1828 of the European Parliament and of the Council and repealing Directive 2001/95/EC of the European Parliament and of the Council and Council Directive 87/357/EEC

learning and predictive functions of the product among the mandatory pre-market security risk assessments for manufacturers or distributors of products.

The **directive about machines** and its Member State implementations will be replaced by a direct regulation from 2027,[27] which will now include so-called "self-evolving" systems using artificial intelligence as a priority risk for the equipment covered by this directive, due to their characteristics such as data dependency, black box effect, autonomy and interconnectivity. All these can significantly increase the probability and severity of failure. It therefore expects businesses to have an independent, third-party assessment of the adequacy of the security features of these machines.

8.4 DSA risk mitigation provisions for large platforms

Although the EU product safety regulation does not apply to services, the **digital services legislation**[28] (applicable to giant platforms and search engines since summer 2023 and generally since early 2024) imposes similar risk assessment and mitigation obligations on operators of the largest digital platforms and search engines, which reach at least 45 million monthly active users, which is one tenth of European consumers. These services use artificial intelligence in a number of ways, e.g., to personalize content for social media and multimedia streaming platforms, or to rank search results and display ads for search engines and online marketplaces. Usually, content moderation is also automated on these platforms. This carries significant risks, such as biased or discriminatory content targeting, or addictive behavior that can be detrimental to maximize their screentime. Giant service providers should therefore analyze and assess annually the systematic risks arising from their algorithmic systems (with particular emphasis on, for example, actual or foreseeable negative impacts on electoral processes and public safety) and implement reasonable, proportionate, and effective mitigation measures to mitigate them. The regulation also imposes transparency requirements, such as the inclusion of information on algorithmic content moderation, the logic of their recommendation systems in the platform's terms and conditions.

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[27] Regulation (EC) No 2023/1230 of the European Parliament and of the Council on machinery and repealing Directive 2006/42/EC of the European Parliament and of the Council and Council Directive 73/361/EEC

[28] Regulation 2022/2065 of the European Parliament and of the Council on the single market for digital services and amending Directive 2000/31/EC

8.5 *Regulation on artificial intelligence*

On 13 March 2023, the European Parliament adopted the **Regulation on Artificial Intelligence (AI Act)**,[29] the world's first comprehensive framework for artificial intelligence. The aim of the regulation is to provide clear requirements and obligations for developers and users of artificial intelligence without imposing unnecessary burdens on the risk-free use of AI systems (which account for the majority of AI systems). To this end, it takes a risk-based approach, i.e., classifying different AI systems according to the risk they pose to users, and imposes different levels of obligations of different levels of strength.

- It completely bans systems with the highest unacceptable risks, such as artificial intelligences that pose a direct threat to human security or (with certain public purpose exceptions) artificial intelligences that use real-time facial recognition for mass surveillance.
- High-risk cases (e.g., devices used in transport and other systems used in critically important sectors, such as surgical robots, law enforcement systems, etc.) are subject to strict requirements such as appropriate risk assessment and -mitigation, high quality of input data, continuous logging of activities or human supervision.
- Limited risk systems (e.g., chatbots) are subject to transparency obligations. For example, users must be adequately informed that they are interacting with a machine so that they can make an informed decision whether to continue or withdraw.
- And for minimal risk systems (e.g., spam filters), the proposal does not impose any obligations at all. The vast majority of AI systems currently in use in the EU fall into this category.

In view of the explosion of generative artificial intelligences (such as ChatGPT), the Regulation specifically regulates the category of so-called general purpose artificial intelligence[30]. This category is also subject to transparency requirements (e.g., labelling of the works of authorship used for the generated content), similar to those for limited risk systems. AIs that pose a potential systematic risk, in particular those with a computational capacity of more than 10^{25} FLOPS, must undergo a thorough evaluation process.

[29] Regulation (EC) No 2024/1689 of the European Parliament and of the Council laying down harmonized rules for artificial intelligence and amending Regulations (EC) No 300/2008, (EU) No 167/2013, (EU) No 168/2013, (EU) 2018/858, (EU) 2018/1139, (EU) 2019/2144 and Directives 2014/90/EU, (EU) 2016/797 and (EU) 2020/1828

[30] GPAI

The Regulation entered into force on 1 August 2024 and will apply in stages: the prohibitions will apply 6 months after entry into force, the obligations for general purpose MI models 12 months, while the provisions of the regulation will apply generally from August 2026.

8.6 Organizational set-up for implementing the AI Act in Hungary

Under the AI Act, each Member State will designate its independent and impartial authorities to oversee the relevant markets and monitor the functioning of conformity assessment bodies operating in the field of AI. To this end, the Hungarian Government has decided **to set up a new governmental body**[31], under the supervision of the Minister of National Economy, which will operate, in addition to the above monitoring activities, the domestic AI regulatory sandbox to be established by August 2026. The Government also established the Hungarian Artificial Intelligence Council, which will be entitled to issue guidelines and resolutions related to the implementation of the AI Act, with delegates from the National Media and Infocommunications Authority, the Central Bank of Hungary, the GVH, the Hungarian National Authority for Data Protection and Freedom of Information, the Supervisory Authority for Regulated Activities, and the Digital Hungary Agency. The Government has entrusted the Minister of National Economy with the tasks of preparing the necessary legislation.

8.7 Draft directive on the liability of artificial intelligence

The **Directive on the liability of artificial intelligence**[32] is currently a draft regulatory proposal.[33] The drafting of this proposal has been initiated following the 2020 White Paper, in which the European Commission undertook to address the risks associated with certain uses of AI. The risks of AI systems can rationally cause harm, but their specific characteristics - such as their complexity, autonomy and opacity - can make it difficult or prohibitively expensive for victims to identify those responsible and prove claims. To counterbalance this, the proposed legislation aims to establish uniform rules on certain aspects of civil liability for artificial intelligence systems.

The proposal for a directive was presented by the European Commission in autumn 2022. The legislation will enter into force after the examination and negotiation phases in the

[31] 1301/2024 (30.IX.) on the measures necessary for the implementation of the Regulation of the European Parliament and of the Council on artificial intelligence
[32] Artificial Intelligence Liability Directive; AILD
[33] SEC(2022) 344 - SWD(2022) 318 - SWD(2022) 319 - SWD(2022) 320; https://eur-lex.europa.eu/legal-content/HU/TXT/HTML/?uri=CELEX:52022PC0496

European Parliament and the Council, with an obligation for Member States to transpose it within the timeframe set out in the Directive (expected to be 1 or 2 years).

8.8 EuroHPC

In 2021, the European Union decided to set up a **European High Performance Computing** (**EuroHPC**) joint undertaking under the European Union's current research and innovation program Horizon Europe. With the amendment of the Regulation establishing the EuroHPC on 9 July 2024[34], the creation of so-called Artificial Intelligence Factories (AI factories) has become possible. These will be composed of certain supercomputers needed for machine learning, in particular for training general-purpose AI models, and will aim to support start-ups and developers to achieve common European leadership in AI. The factories are expected to be in place by 2025.

9 Research on the impact of artificial intelligence on competition and consumer decision-making

9.1 Study by the UK Competition and Markets Authority (CMA)[35]

The UK competition authority's study provides a comprehensive overview of the product paths for applications/services using the different foundation models. The upstream level of the vertical is defined as the developers of the models, while the downstream market is defined as the application level (the integration of models into user-facing applications).

The models presented are mostly large language models, used to run chatbots, create code writing assistants, generate images and search tasks, for example, and are basically built into various software applications to help users while using the software. Consumers interact with these models in a direct and active way, as opposed to classical machine learning tools (e.g., regression analysis, classification, cluster analysis, factor analysis).

In principle, models can on the one hand improve existing products and increase the productivity of the companies producing them (e.g., chatbots can replace/add to human resources in customer service). This can give smaller market participants the opportunity to become more efficient and thus increase competition in the market, while at the same time it can be able to reinforce the already strong positions of larger players.

[34] Council Regulation (EU) No 2024/1732 amending Regulation (EU) No 2021/1173 as regards the EuroHPC initiative to strengthen European leadership in trusted artificial intelligence for start-ups
[35] https://www.gov.uk/cma-cases/ai-foundation-models-initial-review

The models can also be used to produce new products. While this may strengthen the position of the larger players in related markets, it may also create substitutes (for example, regarding search engines, services such as ChatGPT may weaken Google's position).

Respondents to the study included model developers, businesses using models, consumer and industry organizations, and academics.

9.1.1 Developers (upstream level)

Model development is the overall process of training and fine-tuning models. These processes require the following critical input factors, the possession of which can be considered a significant barrier to entry and expansion:

- **Computing capacities**: most models are developed on hundreds or thousands of gigabytes of data, so supercomputers with specialized chips or cloud-based solutions are needed to meet the computing needs.
- **Data assets**: the performance of models is enhanced by the amount and quality of the data used in their development and the feedback data generated during their use by consumers, which is also computationally intensive to collect, organize and clean.
- **Technical expertise**: highly skilled workers are needed to develop and operate competitive models.
- **Capital**: the existence of the factors above implies significant investments and costs, for which the necessary financial resources must be available.

9.1.2 AI-based services, applications (downstream level)

Downstream businesses do not need to develop their own models. Indeed, there are many ways to integrate models from the upstream market into the services of downstream players:

- by directly installing models,
- by accessing an external closed source via an application programming interface or
- using modules in contact with the models.

9.1.3 Theoretical scenarios of the development of competition

The study presents two theoretical scenarios for competitive relations. A positive, idealistic one and a negative one.

In the idealistic case, there is an effective competition between developers, ensuring a wide and high-quality range of models for the downstream market. This would be possible if all upstream firms were able to access the necessary inputs, allowing for continuous improvement of models.

In the negative scenario, access to inputs is limited, with only a few firms able to create and operate high-performing models. As a result, some developers could build up a strong position that could enable and incentivize them to provide only closed source models with unfair prices and constraints.

9.1.4 Competition problems, experiences

The study found that currently **a significant proportion of upstream market sales are attributable to vertically integrated players.** Integrated players are able to develop models in-house and subsequently integrate them into their services.

In addition, currently the upstream market is highly concentrated in terms of critical model inputs, with vertically integrated big tech players typically having the quantity and quality of data needed to develop good performing models.

The study found that only a few actors are capable of developing quality models, hence access to good models (openness), which can take different forms, is crucial for the competitive levels of both the application and the development markets. For other upstream actors (in order to be able to further develop their own models), the availability of data, estimators, programming scripts used in benchmark models is important, while from a downstream perspective, the availability of models for their own use is essential.

The following two extreme cases of model availability were presented:

- **Open-source model**s: freely available to other developers and available for use by downstream actors.
- **Closed-source models**: their availability is more controlled, and their use is permitted under license agreements that include, for example, significant clauses (for example, restricting third parties from using the models for commercial purposes).

An example of a fully closed source and vertically integrated case is Bloomberg, which uses its model BloombergGPT exclusively in its own financial services software Bloomberg Terminal and does not offer a license to other companies to use the model.

An example of a partially closed-source case is the practice of OpenAI, which provides access to its GPT-3 model to the downstream market through an application programming interface, but the model is typically not published in detail to other developers.

Currently, different variations of open- and closed-source models typically compete with each other. This has made it realistic for many companies to invest in model development, and this is already evident in the growing number of services where AI models are gaining ground.

It is clear that access to appropriate inputs and to good performing models are considered critical factors for competitiveness. Other market characteristics may also play a role. For example, economies of scale, as the initial significant costs of model development are likely to be recovered only if a large number of customers are established. Also, the feedback loop effect, which is the use of real-time data generated by consumers during the use of applications, may be a key factor, and may be of particular importance for both users and developers to improve their performance. In general, the greater the feedback effect, the greater the rate at which an application can be improved.

9.1.5 Potential theories of harm

The CMA outlines several potential theories of harm in the generative AI and foundation model markets based on current market conditions.

1. **Input foreclosure in the development market**: to strengthen the position of their own development business, vertically integrated players with critical inputs are able to foreclose inputs from rival development firms.
2. **Input foreclosure in the downstream market**: in order to strengthen the position of their own downstream business, vertically integrated players with well performing models are able to foreclose their models to rival adopter firms.
3. **Consumer foreclosure in the downstream market**: in order to strengthen the position of their own upstream business, downstream firms of significant size are able to foreclose other rival developers (self-preferencing).

The level of switching costs **can** also **reduce the intensity of competition**:

- Downstream market: if an application is only compatible with the model they are currently using or with one that is used for the first time, firms that are using it are prone to stick to a particular ecosystem, as it is only possible to switch models or multihoming for their applications at a cost.
- End users: where there is no possibility to migrate consumer data between applications, creating the right user experience can be time-consuming, as the application models for new users have not yet met user feedback. This could be

addressed, for example, if a model behind a virtual assistant could learn in advance from users' search and mail history.

The existence of competition is beneficial for consumers, besides to the general benefits, because it means that both **developers and users are under constant pressure to improve the reliability and accuracy of the content they generate.** For example, in search, while chatbots may reduce the time consumers spend interpreting searched content with their summaries, the results of applications may not be reliable if the underlying models are of low quality.

9.1.6 Regulatory proposals

The CMA also made a number of regulatory, albeit relatively general, recommendations and guidelines at the end of its study:

- ensuring continued and universal **access to critical inputs** (such as computing capacity) for upstream market participants;
- facilitating **the availability of models** (open and closed source, and variations thereof) for smaller upstream developers and downstream participants;
- enabling access for downstream actors to **multihoming** by creating interoperability between different upstream and downstream systems (the proposal is essentially aimed at reducing the switching costs at the downstream level);
- **increasing transparency**, requiring developers to inform their users about the limitations of AI-based content.

9.2 Study by the Portuguese Competition Authority (AdC)[36]

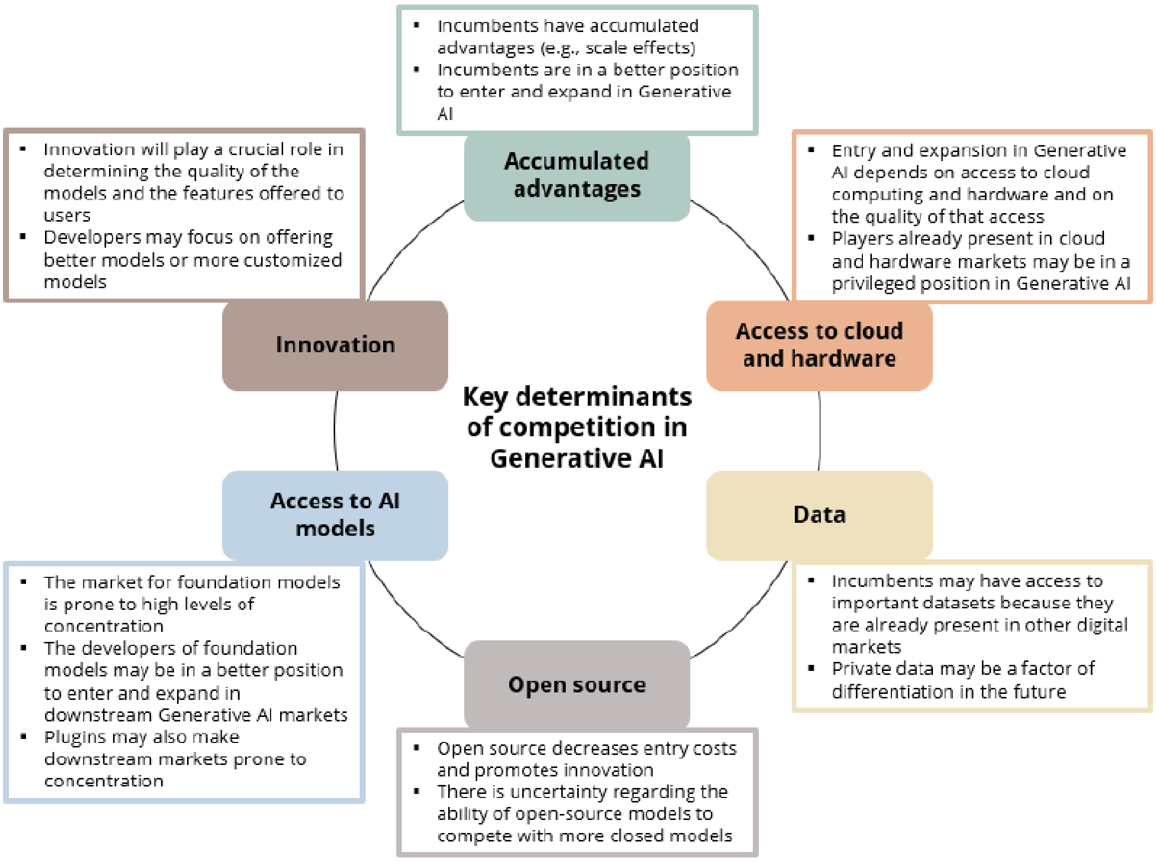
The Portuguese Competition Authority's study aimed to identify the main factors affecting competition **in the digital sector** and to anticipate the risks to competition **in the market for generative artificial intelligence**.

The paper **addresses competition law issues in the field of generative artificial intelligence**. It analyses the requirements for the development and deployment of generative AI services and examines competition between developers of foundation models and competition in downstream markets for generative AI. In addition, it has identified the competitive risks associated with the development and deployment of generative AI. Finally, it

[36] https://www.concorrencia.pt/index.php/en/articles/adc-warns-competition-risks-generative-artificial-intelligence-sector

mapped some of the determinants of the degree of competition in the field. Figure 8 presents the key points and results of the study.

Figure 8. Main aspects determining competition in the generative AI market, based on the analysis of the Portuguese competition authority



Source: https://www.concorrencia.pt/index.php/en/articles/adc-warns-competition-risks-generative-artificial-intelligence-sector

9.2.1 Benefits of incumbents firms in the digital sector

Generally speaking, **the digital sector** is characterized by strong economies of scale, which make it prone to **high levels of concentration**. These characteristics encourage incumbents to create an economic environment in which they have a competitive advantage over new entrants.

The characteristics of generative AI create an environment where **incumbent companies have a strong accumulated advantage.** These firms are also better positioned to enter and expand in the various markets for generative AI, thereby strengthening their position in the sector.

9.2.2 Access to cloud computing services and specialized hardware

Entry and expansion into the generative AI markets depends on the access to and the quality of computing capacity. Companies can access computing capacity in two ways:

- by **cloud** computing services,
- by building **their own infrastructure** and purchasing specialized hardware such as CPUs and GPUs.

This access depends on the incumbents of the cloud computing and specialized hardware markets, which in turn may be in a privileged position to enter and expand in the generative AI markets.

The promotion of competition in the generative MI markets is closely linked to the promotion of competition in these upstream markets. More competitive upstream markets will ensure easier access to inputs for the development and application of generative AI, thus allowing more players to enter these markets. Increased competition will also lead to more competitive prices and better tailored services in the generative AI market. This in turn can lead to products benefiting consumers even more.

9.2.3 Data

Incumbent firms can benefit from their **access to data**. Data is one of the cornerstones of generative AI competition, and both the quantity and quality of data can have a decisive impact on the performance of services and their competitiveness in the market. The accumulated advantages of incumbents in relation to data derive from their access to existing data sets and their ability to generate new data. One source of data-related benefits is the large user base, as users can be monitored and can produce content as part of these services. This information can later be transformed into the data needed for models. Furthermore, the more users generate data for the incumbent, the better performing AI the company can develop, and hence network effects can occur.

It is possible that in the future, private data will become increasingly important and a key factor in differentiating services. Many of the currently available generative AI models rely on publicly available data sets. However, this trend may change in the future, after the initial expansion of services.

9.2.4 The role of open source in generative AI

Some generative AI models are open source, allowing third-party developers to offer services based on these models. Access to open-format models gives third parties the flexibility to use, adapt and extend generative AI-based models, reducing the cost of entry and fostering innovation.

However, the role of open source in stimulating competition remains uncertain. On the one hand, the open-source format may not provide sufficient incentive or basis for the development of models that can compete with closed models. On the other hand, these models will require some form of monetization, as the computing capacity, human resources and other costs involved in their development have to be covered, raising questions about the feasibility and viability of open-source models. Moreover, the use of open-source models may be subject to conditions that restrict commercial use by third parties. Furthermore, this format does not necessarily eliminate potential competition concerns, as such a model can be used to strengthen the market power of a developer in a related market (tying).

9.2.5 Access to artificial intelligence models

Due to the generalized nature of foundation models, their market may be prone to concentration, which may also affect downstream levels. Foundation models are the input for the developers of generative AI services/applications. Therefore, a higher concentration of this market will result in a reduction of bargaining power of generative AI developers. Developers of foundation models are also in a privileged position to enter and expand into the downstream markets of generative AI services, which may also have an impact on the conditions to access to their models for downstream competitors.

In the downstream market, **plugins may generate network effects** (the more users, the more plugins and vice versa) and make the market for transfer learning models more prone to concentration. Therefore, the same concerns and competition dynamics apply for plugins' access to transfer learning models. Developers of these models are also in a privileged position to enter the plugin market.

9.2.6 Innovation

Innovation will be a key element in the generative AI sector. **Innovation can come through new products and services or through improvements of existing ones.** Two ways of improving existing products and services are presented in the paper:

- upstream firms can produce better products and services than their competitors (due to vertical differentiation),
- models can be adapted to the specific needs and preferences of users (horizontal differentiation).

The generalizability of generative AI indicates a significant potential for innovation. Competition as a driver of innovation is key to fully exploiting this potential.

In summary, the cornerstones of the competition in AI are:

- access to data,
- access to cloud computing or specialized hardware, and
- access to foundation models of generative artificial intelligence.

9.3 Market study on the generative AI sector by the French Competition Authority (AdlC)[37]

It makes similar findings to the UK, Portuguese or OECD studies on the value chains of AI models, the market participants at each level, the resource requirements for AI development and competitive barriers, and refers repeatedly to its market study on the cloud services market (2023).[38]

High barriers to entry and access to computing capacity are critical factors in the generative AI market. The development of foundation models requires significant computing power and large amounts of data, which can only be provided by large digital participants and a few companies with large proprietary data centers. Developers can only access the computing power, AI-specific infrastructure and platform services required for model building through cloud services. The cloud is also necessary for the further distribution of models on marketplaces. There is a trend towards platformization in terms of model developers reaching consumers or enterprises through platforms. Barriers to entry are generally high for new entrants. Access to the computing capacity needed to train AI models is limited and currently only cloud-based providers or public supercomputers can provide it.

Limited access to data can also be problematic. Large amounts of data are needed to train AI models. It is questionable whether the amount of publicly available data will be sufficient or reduced in the future, while the protection of proprietary data or individual data will become an increasingly important topic - legal uncertainties (IP and privacy) may be an obstacle to accessing data.

The French competition authority is calling for **greater transparency** on minority shareholdings of innovative companies (Article 14 of the DMA could provide a guide for this),

[37] https://www.autoritedelaconcurrence.fr/en/opinion/competitive-functioning-generative-artificial-intelligence-sector

[38] https://www.autoritedelaconcurrence.fr/en/article/autorite-de-la-concurrence-issues-its-market-study-competition-cloud-sector

to require designated companies to provide information on their acquisition operations. More transparency is also needed in general for investments by partnerships and digital giants in this area.

The generative artificial intelligence sector is currently taking shape, with a number of market participants (e.g., start-ups) emerging less than two years after the launch of ChatGPT. In France alone, more than 130 start-ups have been created in areas such as design, productivity, customer relations, sales, healthcare, cybersecurity, and knowledge management.

The French government launched its national AI strategy in 2018. In March 2024, the Commission on AI made a number of recommendations (e.g., promoting access to quality data, setting up a high-performance machine, supporting high-level research). The implementation of the strategy is divided into stages, e.g., the program *"Accelerating the economic application of generative AI,"* which focuses on the downstream part of the value chain and encourages the development of integrated generative AI solutions with advanced functionality, was open for applications until 2 July 2024. The government aims to support 500 SMEs and medium-sized establishments in the deployment and use of AI solutions by 2025.

Regarding access to computing power, the study **proposes the development of public supercomputers**. These supercomputers could be an alternative to cloud providers and provide scientific actors with access to computing power in the spirit of contributing to open science. It proposes that they should be opened to private providers under certain conditions and for a fee. The CentraleSupélec research team was able to train the CroissantLLM model on the French supercomputer Jean Zay. The EuroHPC joint initiative is working to develop such supercomputers across Europe and plans to deploy a new supercomputer in France by 2025.

Technical or organizational improvements and certain public policies can help limit barriers to entry the market.

On the question of the need to develop regional or national models of major languages**, it stresses that the development of major language models can be particularly important at regional and national level**. This is important because models tailored to local languages and cultures can serve local user needs more effectively. Local models can better understand language specificities, cultural context and local customs.

On the consumer protection side, the study mentions the following issues:

- Transparency: the transparency of the operation of AI models and the availability of information to consumers is essential to build trust. The AI Act imposes transparency obligations on providers of generative AI models.

- Data protection: the protection of users' personal data and the privacy compliance of the content generated by AI models are of paramount importance.
- Ethical issues: the use of AI models must respect intellectual property rights and prevent the dissemination of false information, and basic consumer protection guidelines and regulations must be developed.

9.4 Analysis of the impact of generative AI on consumers by the Norwegian Consumer Council (Forbrukerrådet)[39]

The Norwegian Consumer Council, a member organization of BEUC**, is calling for immediate action and safeguards** from legislators, enforcers, developers and market actors to prevent and remedy consumer harm caused by generative AI. The report, published on 20 June 2023, sounds alarm bells in a number of areas (e.g., security vulnerabilities, fraud and deception, environmental harm, labor exploitation and intellectual property damage), showing the consumer harms that could result from the proliferation of generative AI. Consumers are constantly interacting with AI, for example through personalized social media, content generation, email filtering, or music or video streaming recommendations. There is already much debate about how to ensure the safety, reliability, and fairness of generative AI, but this is all in vain if it is not followed by action. The controversies and abuses that have arisen in the development and use of generative AI (e.g., data breaches, creation of fake and disinformation content) also show that we cannot wait any longer, and that **immediate action is needed to protect consumers' interests and human rights**. The study draws attention to the fact that there are already several consumer protection laws and action mechanisms in place that would allow law enforcement to carry out their tasks much more effectively.

AI is essentially in the hands of big tech companies, which means that these huge profit-oriented companies currently have a decisive influence over the directions of AI development or the training of algorithms that defines AI. AI has been developed from the digital commons, "everyone's data,' but the economic power that comes from this has been in the hands of the big tech firms, and this is set to grow stronger due to the specificities of digital markets (e.g., network effects) at the expense of other participants. The dominant firms, with their existing consumer base behind them, can further strengthen their market positions with their generative AI services. To take consumer searches as an example, while a search on a search page will

[39] https://storage02.forbrukerradet.no/media/2023/06/generative-ai-rapport-2023.pdf

bring several results to the consumer at the same time, a search with generative AI will return a single answer, thus narrowing the results significantly.

To increase consumer engagement, service providers are offering a wider range of services on their platforms, which also makes it more difficult for consumers to switch to another provider and has a serious anti-competitive impact on competitors of the big online platforms and thus on the whole market. The report stresses **the need for accountability and transparency**, as opaque systems can exacerbate consumer harm and hinder legal enforcement of consumers. Although some companies have set up AI ethics groups and promote ethical principles, their effectiveness is questionable if ethical issues conflict with corporate profit objectives.

There are serious dangers associated with deepfake content: generative AI can produce misleading or deceptive content, either intentionally or simply because of poor data quality, which can still appear convincing to users. However, incorrectly generated information can lead to harmful consequences (e.g., health advice obtained through bad AI). If users become comfortable with the chatbot, they are more likely to be unaware that the information they receive is false or incorrect. The more misinformation there is in the digital environment, the harder it will be to detect. By 2026, it is expected that 90% of online content will be AI-generated content, and much of this could be illegal content (e.g., sexual abuse). Unfortunately, there is no good, flawless technology to prevent and identify deepfakes, and they are not tackled by watermarks or other markings. The proliferation of deepfake could lead to a significant erosion of trust in AI.

A chatbot has the ability to influence people's feelings and opinions, as AI can react in a similar way to real people during interactions with humans, and based on the content provided, it has become virtually indistinguishable whether it comes from a real person or a robot. As generative AI spreads, manipulation is expected to increase.

Further **consumer harm may result from biases in the training data and models**. Generative AI can lead to biased or discriminatory results, so it matters how businesses and people use models. Content moderation gives the system's owner considerable power to decide what is harmful and what is permissible, unless legislators make this clear.

Generative AI is trained on personal data (facial images, texts, dialogues). Therefore, data protection concerns need to be addressed, and there are already tools available for this, such as the GDPR. It is important to protect the interests of vulnerable groups who are particularly exposed to the risks posed by AI. There is also a need to ensure that human review is also available in the case of automated decision-making. Unfortunately, practice shows that it is not always possible for a user to reach a real human for feedback.

By placing generative MI in a broader socio-cultural dimension, the study emphasizes the impact of MI on the environment. It is an undeniable fact that environmental pollution is inherent to the AI industry, and although it promises a cure for the climate crisis, the energy requirements (e.g., water consumption, carbon emissions) for developing an AI are staggering. Generative AI companies should therefore be required to disclose their energy requirements and the carbon emissions of a model over its entire life cycle.

In addition to environmental protection, the study also highlights the labor rights dimension of AI and calls for awareness of the working conditions of invisible workers involved, for example in content management in Asia.

The study makes a number of recommendations to regulators and practitioners:

- emphasis on consumer rights is necessary for safe and responsible AI;
- law enforcers should be equipped with the necessary tools for law enforcement (e.g., technological expertise);
- encouragement of international, cross-border investigations;
- international AI research centers and institutes should be established;
- politicians to take a stronger stance against the market lobby on the above principles; adopt a critical and cautious approach;
- transparency and accountability should be expected throughout the life cycle of a model;
- it should always be clear to the consumer when they are interacting with a generative AI model or when faced with artificial text;
- it has to be clearly communicated if commercial objectives influence the developer;
- require AI developers and AI users to publish their energy and water use and carbon emissions data;
- effective means of consumer rights enforcement should also be introduced in the field of AI, such as claims for damages and litigations of public interest.

9.5 OECD analyses

According to an OECD study from 2023, several countries are developing their own LLM[40] with the aim of having a well-functioning, high-quality LLM model in their own - possibly less widely used - languages. The uses of these models include, for example, improving the accuracy of automated translation services (e.g., different dialects in Finland, Norway, Israel, India), sentiment analysis, better answering of text questions, or even improving speech-to-text and text-to-speech transformation. Consumers, linguistic communities and businesses also benefit from such a model, as this way they have easier access to AI systems. On the other hand, by allowing the development of proprietary LLMs to feed in data sets that are only available in the language, the accuracy of the output of the AI systems can be significantly improved. This may also have an impact on the quality of the tasks performed by the AI systems. In turn, the outputs of the systems have an impact on the quality of work (e.g., sales, customer service).

The OECD's analysis, "Artificial Intelligence, Data and Competition" from 2024, after the technology's description, takes a look at whether concerns about the future of competition are justified and, if so, what can or should be done. Does AI really pose new challenges for competition policy, or are the approaches taken so far sufficient, given the constantly evolving nature of the technology and the lack of clear evidence of its impact on productivity (there are areas where there is already evidence of such impact, such as customer services or software programming tasks)?

The analysis focuses primarily on generative MI, dividing its life cycle into several, sometimes overlapping, stages that are not necessarily distinct from each other, given that identifying the stages helps to understand what is needed to deliver MI systems and to identify potential competitive concerns. These stages are:

- planning;
- data collection and processing;
- developing the model;
- testing, evaluation, verification and validation of the model;
- the use of the AI system;
- operation and supervision;
- withdrawal from the market.

[40] Among the OECD member states, Denmark, Estonia, Finland, Germany, the Baltic countries, Japan, South Korea, Turkey, Slovenia, Norway, while among the non-OECD member states, Brazil, Egypt, India, Qatar, Vietnam, Thailand, etc. are mentioned.

Very simply put, generative **AI systems can basically be divided into three main phases: 1) building the foundation models; 2) fine-tuning; 3) deployment**.

The analysis identifies and delimits the people involved in the value chain of AI systems based on their participation in the development and use of AI systems, the main purpose of which is to identify how responsible business conduct and the principle of accountability can be held accountable within a given group. Accordingly, the three groups are:

- people with the knowledge and resources for AI: those with IT expertise, those involved in providing the financial, logistical, administrative and hardware inputs needed to support the development of the system, e.g., investors, digital infrastructure providers and semiconductor manufacturers);
- people involved in the design, development, implementation and operation of the AI systems: businesses, service providers, research institutions, who are involved in the different stages of the life cycle of the AI systems;
- the users of the AI systems: those who use the AI systems in their operations, products and services (manufacturers, traders, etc.)

At each level of the value chain, some actors are vertically integrated or operate in adjacent markets and several partnerships have been established (e.g., OpenAI).

In the context of generative AI, first the foundation models are needed, and then the foundation models provide the generic capabilities (e.g., natural language processing) that are necessary for a generative AI system or AI application to work. According to a Stanford University survey, 149 models entered the market in 2023 alone, indicating that this is a dynamically evolving market and product. The analysis refers to the CMA's 2023 study in connection with the competitive assessment of the market for foundation models. The OECD analysis highlights that the development of foundation models requires a huge amount of data, much of it from public sources, but that the costs of development are very high. In the development process, it is not the same whether open or closed source models are created, and the distinction between open and closed source models has an impact on the extent to which the models can be used for further development and by developers. Concerns have been raised about the recent increase in the number of proprietary developments, presumably as businesses seek to cover the costs their increasing investments. Of the 149 foundation models released in 2023, 98 were open source.

It refers to CMA's market study for a description of the inputs (data, computational capacity, other relevant factors such as expertise, know-how and financial resources) needed to develop the foundation models. On computing capacity, the OECD stresses the need for and the significant costs of high-capacity hardware and that the increased demand for GPUs has further increased costs (the supplier market is highly concentrated, with essentially 80 % of the market being supplied by one supplier).

Generative AI becomes useful with the user application. The AI provider can satisfy consumer needs either on its own servers, network or through a cloud service provider. The users are distinguished between individuals and organizations (e.g., businesses, government agencies, research institutes that have some kind of infrastructure and want to use AI to perform tasks within their system). There are two main options for organizations to deploy AI solutions: i) they can license a foundation model (or a fine-tuned version of it) and integrate it into their system; ii) they can purchase the AI model. Other configurations could be, for example, that in the organization the model is hosted by an AI provider, which provides access to the model via an application programming interface, or that the provider can tailor its services to user needs, for example by developing fine-tuned models.

AI as a service can be purchased on its own or in conjunction with other IT services, for example, AI can be offered as part of a software package as a service or in conjunction with other software applications or packages.

An interface for each user to access the AI service must be provided. It could be installed on their own, through a website, program or application; or integrated into existing services or packages.

Close interaction between AI applications and other digital services, such as digital platforms, is possible. Such ecosystems could be a route to market for AI, for example through applications running on existing operating systems or even websites.

In addition to the Americas and Europe, the development of foundation models is also developing strongly in Asia, including India, Japan, Korea, and China. A distinctive feature of these generative AI models is their optimization in local languages, i.e., the region is placing a strong emphasis on creating highly localized AI solutions.

Regarding competition concerns, some competition authorities are concerned about the evolution of the market position and power of some digital firms (e.g., because of winner-take-all or tipping effects), while others argue that the market is competitive, there are many active firms, intervention would be premature and would have a negative impact on innovation. **The OECD sees the following factors as potential risks to competition:**

- structural factors: economies of scale, first mover advantage, mergers and "killer acquisitions," the creation of partnerships;

- access to data (at the development stage of foundation models and at the fine-tuning and deployment stage);
- access to computing capacity, including competition concerns identified in the cloud services market in the neighboring markets, because although there are many potential cloud providers, the market is basically dominated by three large companies (see the French competition authority's[41] and the UK Ofcom's[42] 2023 reports);
- possible bundling, tying, lock-in effects of certain ecosystems, high switching costs;
- access to other key factors such as expertise and foundation models.

The OECD analysis points out that competition authorities are challenged by the technical complexity and dynamism of the market and therefore see their primary task as understanding technology and the market and gathering information on the area, for example by contacting market participants, involving stakeholders, conducting market studies. It is also an important signal from the competition authorities to market participants that they are listening and will, if necessary, take action if anti-competitive behavior is detected (e.g., abuse of dominant position or, in the case of associations, the investigation of whether they fall under the Block Exemption Regulation). It is also useful for government bodies and legislators to be aware of the views of the competition authorities. There is also the tool of merger control. The paper also mentions the international nature of AI, emphasizing the role of international rather than national action.

The analysis **covers the effects of AI on competition in the market, taking into account the potential disadvantages and benefits**.

There is a negative consequence if AI is used for pricing or product offers to consumers. In the latter context, for example, there may also be risks if generative AI is used by consumers to choose between products, as this may create an incentive for companies using or developing AI solutions to distort the information provided in order to favor their own products. It is difficult to judge whether this is feasible, although the risk may be increased if consumers do not fully understand how the services work because they are too complex and technical.

There may also be concerns about the extent to which organizations rely on AI to make decisions, especially in sectors with dynamic pricing or huge amounts of data. There are also

[41] https://www.autoritedelaconcurrence.fr/en/press-release/cloud-computing-autorite-de-la-concurrence-issues-its-market-study-competition-cloud

[42] https://www.ofcom.org.uk/siteassets/resources/documents/consultations/category-3-4-weeks/244808-cloud-services-market-study/associated-documents/cloud-services-market-study-final-report.pdf

questions about how to find responsibility for an infringement following an AI-driven decision (e.g., whether the business using the AI or the service provider is responsible). Transparency problems may arise in understanding what the AI has done and why. The situation is complicated by the trade-offs that may be required between the explanatory power and effectiveness of models, and accountability may also be difficult in the context of complex AI value chains. The analysis lists a number of consumer protection concerns, such as false consumer reviews, the production of realistic fake advertising material, and the deception of consumers through unfair commercial means.

The analysis mentions the benefits of AI for the market, such as increased productivity and innovation. But AI can also support competition authorities, for example, in obtaining information, processing data or carrying out routine daily tasks.

10 Development of artificial intelligence in Hungary and abroad

10.1 International developments

In the course of the investigation, the GVH sent requests for information to several **companies developing** AI-based **models in** order to assess the scope of their activities and the way in which they operate in the field of generative AI. Three model developers responded to the requests for information. Two of them are of global relevance (although they started as start-ups), while one is currently a regional player.

Among the respondents, global players offer a broad product portfolio. Their models are typically used in free and premium-featured paid versions of chatbots, virtual assistants and image-generating applications, and are also made available in some form to enterprise users' applications and other developers through an API. For example, their customers can fine-tune the models available in the pre-learned API using their own data to be able to execute specific tasks.

The regional player uses AI in a narrower field (customer relationship management, CRM). It complements its own software solutions with generative models.

Overall, the respondents' models can be used to automate routine tasks, manage interactions with users, and support and complement client applications.

10.1.1 Development of artificial intelligence-based models

Similar factors were cited by respondents as essential resources for model development, and similar factors were highlighted as being indispensable for deploying and distributing models in applications, in addition to development.

Such factors include the large and varied amount of data needed to train the models, the appropriate computing capacities (hardware and software resources such as graphics processing units or cloud capacities), the highly and specifically skilled workforce, and overall the financial resources needed to finance them.

Some respondents noted that the availability of workforce with specific skills is a critical factor, but that it is not necessary to be available in large numbers for a given company. They cite the example of small start-up companies where a small but skilled team of engineers and data scientists have been able to create very competitive models and related services.

When resources are available, market players highlighted the following phases of model development:

1. prepare the data set needed for training;
2. the "pre-learning" phase of models, during which the model learns relationships and patterns from the large amount of data (this is an iterative process, so it is possible to continuously refine the model's capabilities), and as a result the model is able to produce content similar to what it has learned;
3. a fine-tuning phase, which aims to train models to solve dedicated tasks (defined by the application or domain to be supported) by training the pre-trained model on a specific data set.

In addition to the above, respondents stressed the need to fine-tune models to human values and preferences.

In their development, respondents collaborate with external partners to varying degrees and in different ways. These differences are reflected in the different stages of development. The differences are typically determined by the way in which developers provide their services to their clients.

For example, some operators use cloud computing partners to perform the calculations needed to develop their models. One actor, for example, performs the fine-tuning process in a relatively specific way, using human subjects provided by partner companies to write the sample responses expected to be delivered by the models for different commands, and then these subjects evaluate the responses given by the model that were trained using the sample responses.

Due to the fact that their models are on-premise developments, some operators do not have any relationship with partners other than their customers. Furthermore, in addition to industry, respondents also cooperate to some extent with a number of other actors, such as non-governmental organizations, governmental organizations and higher education institutions.

10.1.2 Competitors and barriers to entry

Depending on their size, respondents identified different companies as significant competitors in the developer market. Respondent with a regional, more "focused" service mentioned competitors operating in the same segment, while global players listed global, typically big tech competitors. There seems to be a consensus among respondents that it is not easy to provide a comprehensive list of significant players at this stage, as the competitive landscape is incredibly dynamic and therefore the market has yet to mature to clarify the balance of power and to identify the relevant players.

The availability of pre-trained models is also a critical factor in the development market. Indeed, compared to proprietary systems, **open-source models** make it much easier to enter the market, for example for start-ups with limited resources, as they can save a lot of development time and costs. This was confirmed by respondents, who also pointed out that open-source systems are and will continue to be effective competitors to proprietary models, as they provide a more flexible development environment and, with the right resources, can even compete with larger proprietary models. It is described as a common practice for many developers to build their own models based on open-source models, although in many cases the models developed in this way have been made proprietary by the developers.

The main **barriers to entry and expansion** cited by respondents were the availability of essential inputs for model development, their high cost and scarcity (mostly of skilled labor). According to the global players interviewed, access to adequate computational capacity and data sources is not currently a problem, although this may change in the future, for example due to poorly implemented regulations or if input owners restrict access to data through exclusionary behavior. **Overall, barriers to entry and expansion are already significant due to the funding required** but could become more significant in the future depending on the availability of essential inputs.

10.1.3 Benefits of vertical integration and its presence in the market

Looking at the value chain as a whole, several vertically integrated companies can be identified, and the GVH also questioned developers about the existence of vertical integration and the benefits of vertical integration.

One of the most important **benefits of** the development processes **identified** by the respondents **is vertical integration, as if a company can control the whole value chain, it can better coordinate activities between levels**, minimize lead times, reduce costs, and thus increase supply chain efficiency through better exploited synergies. Vertically integrated players can thus respond more quickly to market changes and offer more innovative solutions to their customers. This is particularly important in the field of artificial intelligence, where development cycles are fast and market competition is intense.

The phenomenon therefore has many advantages, and according to the respondents it is a dominant trend in the market, especially among companies with significant resources and technological capabilities.

At the same time, respondents also see aspects of concern from a competitive point of view. Indeed, integrated players may have incentives to engage in various input and customer foreclosure practices that could put rival non-integrated firms at a significant competitive disadvantage.

10.1.4 Areas of use of services and monitoring of use

Global players indicate that the uses of their models are as wide and varied (analytical, scientific, even philanthropic) as the people and companies that use them, so there is no single area for which they can be used. For example, chatbots can save teachers time and effort in tasks such as lesson planning and feedback, allowing them to focus on other aspects of teaching, such as engaging with students and developing interactive lessons. The regional operator's solutions are used to support a specific area, customer relationship management.

Developers monitor in different ways the use of their models by customers, i.e., the use of models integrated into services provided to consumers.

All data traffic is handled through the regional respondent's own system (due to the fact that its models are installed on-premise), so no third-party monitoring or reporting systems are used for this purpose. The services provided by its customers generally consist of customer support and customer contact in the form of voice, chat, or email. These are monitored in all cases.

Global players typically use internal classification systems to control, for example, traffic from clients through the API. These systems cannot be turned off by clients without the specific approval and compensating control of the developers, and their basic function and purpose is to filter unethical or offending content. Their models are essentially trained to reject certain types of commands, for example, not to respond to requests to assist in illegal activities.

10.1.5 Services provided and sales models in Hungary

Global respondents do not offer dedicated products for their Hungarian customers. They typically offer the same product range as in other target markets, although the nature of the product range can be strongly determined by the regulatory environment in the target market. While the regional operator lists specific services provided in Hungary, there is no indication that these are only available to Hungarian customers.

In terms of future developments, similar to the current product portfolio, global and regional players do not plan to introduce additional products specifically for the Hungarian market. In the future, they will uniformly target the EU market for the launch of a new development.

In terms of selling services, developers typically have different practices based on their size. The regional respondent sells its products directly to its customers. In addition to custom development, they also offer consultancy services. Global players offer paid services on a subscription basis. Customers need to register with an online account, and corporate customers can request services by signing an order form. The operators do not currently work with intermediaries, but one of them plans to make its services available in the future through various authorized resellers or partners.

According to global respondents, it is not easy to define their customer base by activity and size. According to them, companies worldwide use and require AI solutions in all sectors, from large multinational corporations to individuals and small businesses. They point out that specific elements of their product portfolio are typically used by specific customer segments for different purposes. In principle, the regional respondent sells or could potentially sell to all companies that communicate in digital form. However, companies with a turnover of more than HUF 100 million and at least five employees are preferred.

In general, respondents do not see significant technological and financial conditions necessary to use their services. They believe that they can be used by anyone with a simple computer having internet access or a mobile phone having internet access. It is understood that in using them, users must accept and comply with the business and user policies of the model developer.

10.1.6 Services offered to consumers

The services of the regional respondent are not available to natural persons, while the various virtual assistants, chatbots, model APIs, etc. of the global players are available to individuals free of charge or by subscription.

The question for consumers is how their data is used by developers and what information is provided. The two global players collect or process as much personal data as necessary to provide, manage, protect, and improve their services. They do not therefore use users' personal data for secondary purposes, such as profiling users, which could be used for example for advertising purposes. The models behind the chatbots are improved based on the conversations between the users and the chatbot, but users are informed about this, and they have the possibility to opt-out of this form of data collection.

10.1.7 Risk assessments by developers and their practices

As before, the size of the respondents determines the practice of risk analysis.

For the regional operator, the **assessment and management of model risks is left to the customers** (taking into account their own internal policies and risk management practices). Therefore, no specific analysis is carried out for vulnerable customers (e.g., children, elderly people). The frequency of risk analysis is determined by their customers, based on their internal processes and risk management policies.

Global players **are working to manage model risks** in different ways and on **an ongoing basis**. On the one hand, as a form of information, they publish public reports describing the capabilities and limitations of models, as well as areas of recommended and inappropriate use. On the other hand, potential risks to users are identified and mitigated through the following measures:

- processes for dealing with inaccuracies in model outputs;
- measures to reduce the risk of prejudice;
- incorporating assessments and other feedback mechanisms into product development processes;
- using feedback from the real world and user feedback to improve the accuracy of the models.

These measures and their principles are often incorporated in a kind of "constitution," which is regularly reviewed and, where necessary, amended to make their models as safe and reliable as possible.

10.2 International platforms

In the course of the market investigation, the GVH also contacted several companies that provide a wide range of digital services to consumers, businesses or both. These companies are therefore not only and often not primarily active in the development phase of AI models and AI-based solutions (as opposed to the companies contacted in the previous sub-chapter), but have a much broader spectrum.

Five of the platforms surveyed provided substantive responses. One of them is currently in the planning stage of AI development, while another one does not market its own AI solutions on its own, but only adds them to the products it sells. A third player describes itself as an actor that has been active in the development and application of AI and machine learning in the field of internal processes and customer relationship management for more than 20 years. Four of the respondents can be described as a so-called big tech company, while the fifth can be described as a prominent player in a particular software industry segment, CRM.

As a basic principle, one of the respondents considers it important to stress that generative AI is not a product or service, but rather a technology that can be used to improve other applications, processes and services, or to enhance their functionality.

10.2.1 Development of AI-based models

Big tech respondents have a broad but diverse product portfolio. Some focus on developing smaller, more cost-effective models for specific tasks, such as ***vision* models for image recognition and classification, or a family of specialized small language models for predicting the "next word" or for focused research purposes**. The latter can be used in tasks such as reasoning from user-supplied data, text comprehension, mathematical problem solving and text summarization. Others, similarly to the global developers presented earlier, are adding models to their existing applications (e.g., voice-based case manager) or making their models available to third parties through an API. They even use their models in business activities that were not previously closely linked to digitalization or artificial intelligence. Given their size, these players are aiming to cover the entire vertical chain. Some players are building new business lines within their business, for example to provide access to computing capacity, and are thus entering the cloud computing service provider space as new players.

The smaller player active in the CRM field, in addition to **integrating** various predictive and generative AI models from other developers **into its own products, is also** active **in developing its own models**, specifically adapted to the company's business. The company's customers typically use its AI-based functions to edit emails, generate summaries of sales, service and marketing calls, summarize customer service interactions, and generate product descriptions.

The development of models requires **a range of resources.** In particular, respondents highlight the computational capacity and data resources needed to develop models as essential factors. The current state of availability of these resources and their future development is generally seen positively by the major players. In addition to the above, the availability of open-source models and the availability of a skilled workforce (with an emphasis on knowledge of benchmark metrics for benchmarking models) are also considered important by the smaller players.

Respondents mentioned a number of different public data sources for the data needed. For example, public sources from government agencies and research institutions, open-source datasets and licensed data (available on the data market). Data needs are considered to be most significant in the pre-learning phase, where large amounts of publicly available data are generally used, while data for fine-tuning is either synthetic or generated in-house or from specialist data providers such as Scale AI, Prolific, Surge AI, Super Annotate, or Dataloop.

As with developers, **the importance of hardware and software resources and cloud capacity are highlighted in relation to computing resources.** Again, they note that there are currently a number of different options available to developers. In addition to the often mentioned on-premise solutions (computers with accelerator chips, which are currently the most commonly used solution) and those provided by cloud providers, the importance of hybrid solutions combining these options is also highlighted.

The process of model development is described in a similar way by respondents, with several distinct stages. Firstly, the design and development phases are mentioned, typically carried out by dedicated product (designer) and engineering teams. The resulting pre-trained models are evaluated on the basis of their outputs by so-called security teams, according to legal, ethical and privacy aspects. The testing is followed by in-house testing and then beta testing of the fine-tuned models adapted to the specific application. Finally, the final product is published as AI-based applications.

The development process is characterized by many collaborations. These are most often with computing capacity providers and data providers. **For example,** respondents use computing capacity provided by **third parties**, including NVIDIA, CoreWeave and Oracle, **to train their models.** They also have a number of non-exclusive agreements with data providers. These partners undergo extensive legal, security and privacy checks beforehand. In addition, it is common for some respondents to involve their customers at the earliest stages of the development process to ensure that their models are as well suited as possible to specific user problems.

10.2.2 The main competitors of the platforms

Similar to developers, the responses of platforms are also determined by the size differences. The larger players describe the developer market as essentially a dynamic and differentiated market, with **the number of platform developers growing exponentially**. In addition to developers of these models, there is an increasing number of smaller developers offering more application-specific generative solutions. The rapid pace of model development is facilitated by Hugging Face and similar public archives where developers can query or download open-source models. Overall, respondents commented that innovations are coming not only from large technology companies such as Google, Meta, Apple, NVIDIA and Alibaba, but also from start-ups such as Adept, Anthropic, Cohere, Deci, Mistral, Nixtla, OpenAI, Stability AI and xAI OpenAI, as well as from non-profit organizations such as the Allen Institute for AI and government-funded research institutes such as the Technology Innovation Institute. These players typically offer both proprietary and open-source licensed models.

The smaller player surveyed does not consider itself to be a direct competitor of the companies listed above. It considers its main competitors to be companies developing CRM and related solutions, including those integrating AI services in this segment. These include SAP, Adobe, Oracle, ServiceNow, HubSpot and Shopify.

10.2.3 Areas of use of services and monitoring of use

The products of the larger players are mostly used to support innovation and efficiency processes. Such an efficiency-enhancing process is, for example, the automation of routine and administrative tasks for employees. The products of larger players are also used for data-driven decision-making tasks, such as supporting financial analysis and forecasting or market research projects. In addition, cyber defense is also a common application.

The products of the **smaller player** are most often used in organizational areas such as identifying **sales opportunities**, coordinating **marketing** projects or **customer relations**. For example, its top revenue-generating software is mainly used by the business intelligence and analytics departments of companies.

Respondents did not mention that they directly monitor their clients' use of the model. They do, however, set specific standards and guidelines for ethical and responsible use for their customers, and oblige them to do so through the terms and conditions of use of their products. However, some operators have also mentioned more direct measures to combat dishonest practices, such as filters on the input data of models.

10.2.4 Relations with Hungarian economic actors

For their Hungarian customers, respondents typically offer the same range of products as in other markets. They did not mention any products or services that would typically be available only to their Hungarian customers, or that their Hungarian customers would use to a greater extent than other customers.

As with the development of their current product range, **respondents do not plan to introduce additional products specifically for the Hungarian market in the future**. In other areas, such as training in AI, a more regional approach can be observed. For example, some actors have made a dedicated commitment to developing AI skills in the EU, and thus in Hungary, through various programs, in the form of training courses for different skill levels and a wide range of jobs.

When selling to domestic players, larger platforms typically follow an **indirect sales model.** This means that in Hungary, products are mainly sold through their partners (distributors, resellers). The smaller player, on the other hand, sells primarily directly through its own sales team, although some products are also available in self-service online format.

Respondents typically do not differentiate between their customers by size or activity. They serve both large enterprises and SMEs. Many of their clients are active in sectors such as finance and insurance, retail, manufacturing, or even the public sector such as education and healthcare.

In some cases, platforms also offer solutions tailored to the specific business needs. They also work with technology partners, systems integrators, and independent software vendors to provide their customers with the most tailored AI solutions.

In general, respondents do not see any significant technological and financial conditions that their potential customers would need to meet in order to use their services. Overall, compliance with user policies and codes of conduct applied by companies is considered to be such a condition.

10.2.5 Services offered to consumers

For natural persons, the smaller respondent does not offer any products, while **the larger players' various virtual assistants, chatbots, model APIs** can be purchased through online portals or reseller partners, or to some extents are available for free. They are, by definition, integrated or compatible with the products of other operators' applications.

Only two of the major respondents provided meaningful responses on the use of data collected from consumers. These operators use such data for development purposes and provide consumers with detailed information in their privacy statements and policies, including information on what data is collected and processed when using their tools and for what purposes. One respondent's privacy statement is available to users in all official languages of the European Union before they use its services. This respondent also provides a concise overview of how it uses users' personal data in a separate *"How we use personal data"* section. A special section is dedicated to the protection of the privacy of young people.

10.2.6 Risk analyses carried out by the platforms and their practices

As with the use of consumer data, **only two** of the respondents **gave meaningful responses on risk analysis practices** before and after the introduction of the services. They said that they are dedicated to continuously working to ensure that their AI-based services are safe and reliable for consumers. For example, **they provide guidance in** the form of initiatives to identify, assess and mitigate risks associated with AI services. They also require teams within the company developing or offering AI services to carry out an impact assessment (so-called *red-teaming*) and to manage and mitigate any risks identified. These impact assessments need to be updated and reviewed at least annually.

In addition, one respondent has also created an internal document that sets out the basic expectations for each of the different services and what is needed to create a safer online experience. This document requires **a risk analysis for** all their consumer services to **identify risks to children or other vulnerable users**, and a risk analysis specifically tailored to children for services that children are likely to use. All risk assessments are aligned with the EU Digital Services Act.

10.3 Domestic developments

Increasing domestic supercomputing capacity and developing Hungarian large language models are essential for several reasons. The first is the issue of (data) sovereignty. Global development companies typically do not publish their training datasets, so essentially their models act as a black box for the external user. As a consequence, there are rigid limits to their application and customization.

The second aspect is data security. This is another argument in favor of local model development, as there are areas where the storage and processing of sensitive data in the cloud is not allowed.

The third aspect is the question of cultural identity. The corpus used for training inevitably reflects the cultural traditions, knowledge, and values of the community by which it is generated. Therefore, it is not sufficient for the corpus to contain a predominantly English-language text, with a generally negligible amount of Hungarian text. The system may produce grammatically well-formed sentences, but it will not be culturally adequate for the Hungarian community.

Taking these aspects into account, it is welcome that two large language models are being developed in Hungary currently.[43]

10.3.1 Hungarian Research Centre for Linguistics

The Hungarian Research Centre for Linguistics has started to develop a large language model in Hungarian that can be used in practice. Their developments are basic and prompt-based models, which are developed using external open-source systems that are further trained in Hungarian. For the PULI family of models, the LLAMA architecture introduced by Meta is used by the Hungarian Research Centre for Linguistics.

They typically work with their customers on a framework contract basis, whereby customers license or lease pre-trained models and computing capacity (supercomputing infrastructure), as well as customized development services. The models are typically used to support **administrative and customer support tasks.**

In terms of **sales, they see** a strong **domestic interest**, although this is essentially only on the market side, although they also see great potential in the areas of public administration and government work (where (foreign) cloud services are not a realistic option due to data security requirements). At the same time, they stress that it is not yet clear how well Hungarian large language models can meet market needs. As regards the use of large language models in

[43] "Applications based on language models have already appeared in both public education and higher education. Their skillful and conscious use is a prerequisite for the future and success of both individuals and society. A well-functioning Hungarian language model is also a matter of welfare, as it increases the number of Hungarian beneficiaries of artificial intelligence," said Ferenc Dietz, Head of the Artificial Intelligence Coalition's Education and Awareness Working Group (https://infovilag.hu/tokeletesre-csiszoljak-a-mesterseges-intelligencia-magyartudasat/, in Hungarian only).

Hungary, no industrial-scale application is known so far. Interested companies are rather in a preparatory phase.

To run and train their models, they require significant computing capacity. In their view, **Hungary** is currently far **from having the capacity to produce large language models on an industrial scale**. The pace of investment in capacity expansion and development is lagging behind global trends, although few players worldwide are able to compete with global developers. For Hungarian players, the realistic goal is to adapt cutting-edge technologies to the Hungarian language. In addition to supercomputing capacities, this requires carefully compiled data sets and language technology expertise that takes into account the specificities of the Hungarian language, which is, of course, only available in Hungary.

The main **constraint** for the development of Hungarian models is **the lack of state funding** (since the abolition of the Ministry of Informatics and Technology), the lack of updating the **central strategy** (in line with professional changes and the current technological environment) and the lack of computing capacity (the Komondor supercomputer has limited capabilities).

At the same time, **Hungary's competitive position in the development of large language models is currently very good** compared to the EU average. Large language models developed in national languages are a rarity in the EU as a whole, and these constraints are present in most EU countries. Among the cooperation initiatives of the EU, joining the Alliance for Language Technology European Digital Infrastructure Consortium (ALT-EDIC), whose mission is to support the development of a common European large language model through pan-European cooperation, was a particularly important event.

10.3.2 OTP Group

Within the OTP Group, Monicomp Zrt. is developing a GPT-3 language model. Within this framework, the company (in collaboration with another external company) has built a system with a large computing capacity, which has made it possible to train large language models.

In addition, Monicomp Zrt. collects the necessary data, on the basis of which monolingual (Hungarian) and multilingual (Hungarian, English) models are trained and research is conducted. Among linguistic models, they also develop GPT architecture models, one of which is a Llama2 model adapted to Hungarian and trained with seven billion parameters, which has already been completed. The company also develops application methods for which it occasionally fine-tunes the models.

The company's partners are ELTE – Digital Heritage Laboratory and Sambanova Systems. The former aims to develop an inter-institutional collaboration to process Hungarian cultural heritage on the basis of artificial intelligence and to work out the market-based exploitation of the methodologies and tools developed during the process. Examples include the development of language-processing algorithms optimized for the Hungarian language, the collection of web resources relevant to research and innovation from the Hungarian community in the homeland and beyond its borders, and the archiving and publication of *born digital* materials. Sambanova Systems is a California-based company that is a supplier of high computing power technology. It offers a service to produce a pre-learned language model on proprietary hardware devices by writing custom software.

The company intends to use the language models for a variety of tasks. One is to create knowledge-based systems that can extract relevant information from large text files based on questions, thanks to their text understanding, thus making workflows more productive. It will also be applied to synthetic data and general tasks where text generation capability is important.

In addition, OTP will also make public the model it has developed, as a condition of the state support it has received, making it available to domestic market players. Discussions are currently under way on how and in what form this publication will be made.

10.3.3 Governmental Information-Technology Development Agency

The Governmental Information-Technology Development Agency (KIFÜ) has been providing supercomputing (HPC) services to higher education institutions and research centers since 2001. At present, the Komondor supercomputer, which is fully operational as of 1 August 2023, is available to users, together with the necessary software support and full user support.

In 2020, KIFÜ established the **HPC Competence Centre**, which aims to promote and support the most efficient and effective use of supercomputing infrastructure. This includes HPC-related education, user support, community building and networking at Hungary and abroad.

HPC is used by Hungarian academic and higher education institutions, small and medium-sized enterprises, companies, and governmental actors. In order to enable HPC researchers in a given discipline and students who are potential users of HPC to work more effectively, KIFÜ has concluded cooperation agreements with a number of higher education institutions to provide additional professional support. In this context, KIFÜ provides guidance, expert advice and HPC use to its partners.

In addition, another main activity of the HPC Competence Centre is user support. The organization and provision of user support is justified because supercomputers are very complex technical systems, the effective use of which requires a lot of specialized knowledge and is not a trivial task, and a significant proportion of users are not IT specialists but specialists in other fields.

Although the HPC service is available to all SMEs in Hungary, certain conditions must be met in order to benefit from it, such as the activity of the SME, the market situation to be addressed or the quality and type of service to be developed, the maturity of the company's IT systems. Based on the response of KIFÜ, these criteria **suggest that the use of HPC** is most appropriate **for innovative, research and development oriented SMEs and start-ups**. In order to use the Komondor supercomputer, applicants must submit a project proposal, which will be evaluated by experts from the KIFÜ HPC Competence Centre and, if positive, a cooperation agreement will be concluded.

Currently, KIFÜ is working with 46 SMEs, 27 of which have already launched a pilot or live run on Komondor. The HPC Competence Centre is available not only for initial development but also for ongoing support, providing funding, but the completed products remain the property of the companies, which are responsible for their further development, including through repeated use of HPC.

Small and medium-sized enterprises can use HPC beyond the development phase, especially for computationally intensive tasks such as training and fine-tuning AI models. HPC can support model operation only in specific cases or not at all.

The HPC Competence Centre has been in contact with more than 600 users, running more than 200 projects on Komondor. Nearly half a hundred SMEs and start-ups have reached the cooperation agreement and a total of 27 SMEs and start-ups have been selected, typically from the information and communication technologies (ICT), health, data, engineering, and environmental sectors.

As far as large language models are concerned, to the best of the KIFÜ's knowledge, ELTE, BME and the National Laboratory for Artificial Intelligence are involved in the development of Hungarian large language models in academia. According to the data provided by the KIFÜ, the performance of Komondor GPU and AI is suitable for running large language models. The supercomputing capacity is available primarily for academic users, but 20% of the capacity per year can also be used by domestic SMEs. The Komondor supercomputer also has significant storage capacity, which is necessary to store the data used to train large language models.

According to KIFÜ, **the Hungarian large language models could be used for automation, personalized services and efficiency improvements**. In these areas, the models can help to increase competitiveness and exploit new market opportunities. However, in practice, there are no known areas where Hungarian high-level language models have been successfully applied so far.

At the same time, they add that in general, the possibilities of using AI (not only for Hungarian-language models) are becoming more and more accessible to everyone, including Hungarian SMEs, thanks to open-source development frameworks. According to KIFÜ, Hungarian SMEs are increasingly recognizing the potential of AI, but further user support and education, as mentioned above, is needed for its widespread use.

In their opinion, **the main obstacles to the development of** Hungarian large **language models** are the lack of data sources, limited computational resources (e.g., Komondor in its current state will soon be insufficient to serve new needs), lack of financial support, language differences, lack of technological infrastructure, lack of expertise and training, ethical and legal issues, and market interest. Access to learning data (data liberalization) and improving data quality are also important to support AI developments, but are currently hampered by a lack of legal regulations and practical solutions. KIFÜ believes that the digitization of SMEs and a change of mindset are also necessary to promote AI developments.

It can also be pointed out that Hungary's lagging behind in the field of AI is also due to the lack of skilled labor, as there is currently no training available to learn how to use AI development tools, which, according to KIFÜ, would mean that despite strong development tools, adequate development infrastructure, clean and high-quality data, Hungary would not be able to move forward.

Regarding the impact of the AI Act on Hungary, KIFÜ draws attention to the increasing administrative burdens and costs that may discourage AI developments. At the same time, the requirements for security and reliability could help the market to develop in the long term.

11 Artificial intelligence-based applications used in the focus sectors in Hungary

Based on the experience of the face-to-face consultations conducted at the beginning of the market analysis, the Hungarian Competition Authority contacted companies likely to use artificial intelligence regarding requests for information and further questions. The main focus areas of the GVH were the **banking services, mechanical engineering, business consulting**

and telecommunications sectors, taking into account that these sectors and market segments are the ones in Hungary today where AI is likely to be known and applied and operate on a market basis. Although sectors of medical health care or public administration could have been included in the GVH's analysis, as AI deployment also appears in these sectors and this may have a huge impact in the future, but the examination of competitive and consumer protection issues in these areas is not primarily relevant for the GVH.

The queries of the Authority focused on four issues:

1. the deployment of artificial intelligence,
2. the development of artificial intelligence,
3. business partners, and
4. experiences and achievements in artificial intelligence.

However, the companies involved in engineering and business consultancy sectors either did not respond to the GVH's (voluntary) information requests, or their responses indicated that they do not use AI-based solutions in addition to the widely available general AI services (e.g., Microsoft Copilot, ChatGPT), so we will not go into details on these sectors.

11.1 Use of AI-based services in Hungarian companies

In this section, **we present the main results of the** survey conducted by the Hungarian Chamber of Commerce and Industry Economic and Enterprise Research Institute (MKIK-GVI) between 1 and 11 July 2024[44].Within the framework of the survey, a total of 350 Hungarian companies employing at least 20 people were asked whether and for what purposes they use AI-based tools, and whether they assessed what obstacles they see to such new technologies. It is clear that the findings of the MKIK-GVI confirm the GVH's information from other sources regarding the low penetration of AI and the lack of knowledge and experts on AI.

11.1.1 Personal management and in-company application of AI-based technologies

According to the analysis of MKIK-GVI, only 12% of managers of Hungarian enterprises employing at least 20 people use AI-based tools in their work. Among managers of companies operating in the field of economic services, this proportion is higher, reaching 19%, compared to only 8% in construction and manufacturing and only 5% in the commercial sector. Managers in managerial positions are more likely to use AI, but for owners, chief accountants and office managers, the figure is only 2-5%.

[44] https://gvi.hu/files/researches/742/nkonj_243_mesterseges-intelligencia_240808.pdf (in Hungarian only)

Hungarian companies use AI-based tools at a low rate similar to CEOs, the vast majority of them, 66%, do not use AI and do not plan to implement it, and only 22% plan to develop it in this direction. Managers' personal use of technology reflects the company's approach to AI: 77% of companies where leaders personally use AI, already adopted or plan to adopt AI.

11.1.2 The use of AI by key company characteristics

The size of a company has a significant impact on the use of AI, while 21% of large companies with 250 or more employees already use AI and a further 44% plan to adopt it, 70% of smaller companies, especially those with 20-49 employees, do not even plan to use smart technologies.

At sectoral level, AI is most prevalent in economic services, where 20% of companies already use it and another 24% plan to implement it, while in the commercial sector, a higher proportion (32%) of companies plan to adopt the technology. In the construction sector, on the other hand, only 20% of businesses use or plan to use these technologies.

11.1.3 Corporate goals for the use of AI-based technologies

AI companies primarily use the technology for marketing (49%) and process automation (45%), but they also rely on AI for data analysis, content generation and product development. In cybersecurity, a quarter of companies use AI, whereas 20% of the requested companies use AI for financial forecasting. The least common application areas are inventory management and logistics, as well as the operation of chatbots, where only a 13% application rate appears.

11.1.4 Barriers to the use of AI-based technologies

The biggest barrier to AI adoption is that 53% of companies believe that these technologies cannot be integrated into their operations, while a significant problem is also the lack of knowledge of the technology (46%) and competent expertise (48%). 35% of companies cited security risks and 33% cited excessive costs when asked about barriers to deploy AI.

When summarizing responses based on business size, skills shortages (84%) and security risks (66%) are the biggest problems for large companies, while small and medium-sized businesses cite technology as the most common barrier they consider AI technology to fit into their operations (53%).

Looking at the issue from a sectoral perspective, MKIK-GVI concluded that the lack of suitable technological solutions in the construction and manufacturing industries is a significant obstacle (30-40%), while in the commercial sector the lack of AI expertise hinders the spread of technology the most.

An important finding of the analysis of MKIK-GVI is that export activity and ownership structure do not have a significant impact on companies' perceptions of obstacles.

11.2 Telecommunications

The reply was voluntary, and 10 of 15 requested **telecommunications companies sent their replies** to the GVH. Seven of the latter **companies** indicated to the GVH that:

1. does not use AI in its activities,
2. does not use artificial intelligence solutions, or
3. does not cooperate with business partners in relation to its AI application, and
4. has no experience with artificial intelligence.

That said, some companies indicated that their employees regularly use OpenAI or get acquainted with

- OpenAI's Assistant service, which allows them to manage knowledge for colleagues from own corporate documents, or
- with solutions based on machine learning.

Another phenomenon in the case of companies not using AI technology is that

- key people in the company participate in targeted AI trainings and provide orientation trainings to a wider range of employees;
- According to the company's information and vision, AI applicability is primarily seen in the following areas:
  - automation of customer service,
  - churn management,
  - accounting, bookkeeping,
  - error detection during technical troubleshooting, error analyses,
  - development and improvement of internal processes.

It is therefore important to underline that the practices presented below are not representative.

The following is a summary of the relevant replies received by telecommunication companies along the above mentioned four issues. However, given that the existence and use of certain AI solutions are strategic information of economic interest that is not publicly available, if revealed, conclusions could be drawn about companies' future AI strategies and harm or endanger the legitimate economic, financial and market interests of companies, the whole of the below listed answers is subject to trade secrets.

Notwithstanding, without prejudice to trade secrets, it can be said that artificial intelligence should be applied in these particular areas:

1. in the customer service area, using individual virtual assistants, or in connection with transcribing and analyzing customer service calls;
2. there is an example of an internal training platform which can be filled with content by the user areas of the undertaking and then train their own colleagues with it, this application works in the field of retail and customer service;
3. There are also solutions used in the field of quality management, fraud prevention (identification of abuses) and more efficient sales (customer value management, support of sales processes) and more efficient work organization.

The main criteria (or practices applied or intended) to select AI solutions and developers:

- consideration of price, functions available for a given price;
- duration of use of the solution – in the absence of a long-term commitment;
- defining what needs/functions need to be fulfilled along the company’s own needs (the area concerned) and then sorting out the available options, products, suppliers and selecting the best offer/solution in terms of quality, cost and reliability;
- take into account publicly available information in addition to its own previous experience and, where appropriate, request a public offer, and always take care to preserve the fairness of competition when tendering. As undertakings are under intense competitive pressure in all markets in which they operate, it is of paramount importance to remain efficient that they select the best offers for such purchases in order to cope with intense competition;
- One of the respondents plans to use an additional, AI-specific questionnaire with external IT development companies in the future to ensure legal compliance.

In general, the integration of AI solutions consists of the following stages:

1. Design –> Approval –> Development –> Putting into operation –> Service –> Disconnection

   or

2. Assessment and specification of business and customer needs, preparation of feasibility study –> development of AI models and solutions –> Putting into operation –> Application of customer pilot

At each stage, resources may be required in the following areas of the company: internal project management, architect (department responsible for designing and leading the implementation of AI systems), law, compliance, regulation. In addition to internal resources, there may be a need for external developer resources.

At present, he respective company does not have any in-depth experience with regard to AI. In general, however, it can be stated that if external developers/consultants are involved, the company would limit their task to the development period if possible, and would strive to perform the operation in-house.

Some companies have internal training courses on AI.

According to the statement of one of the telecommunication service providers, in connection with internal developments (sales efficiency, customer value management, fraud detection, prevention of abuses), it was necessary to prepare employees using the given software for the functional use of the software.

In addition, a general educational material is being developed, on the basis of which the company plans to hold a training course on the dangers of using artificial intelligence in the coming months. The main topics planned in this tutorial are:

- limiting the data that can be included in AI software, in particular personal data and trade secrets;
- drawing attention to the dangers and possible prohibitions of the use of AI software publicly available on the Internet;
- the use of AI-generated output;
- the obligation to report discrepancies in the operation of AI software within the company’s organization without delay.

According to the reply of one telecom service provider, the use of AI solutions is mostly on a daily basis or with varying frequency as needed.

The results of each AI solution can be assessed on the basis of the following indicators in different areas:

- sales efficiency (financial effectiveness, increasing customer value, effectiveness of campaign activities, customer experience);
- detection of malpractice (financial effectiveness, efficiency of financial planning);
- prevention of malpractice (reduction of abuse rate, reduction of bad debt);
- support of sales processes (sales performance);

- quality management (resource efficiency, wider application of quality assurance, increase customer experience by extending quality assurance, sales support);
- increasing work efficiency (increasing resource efficiency, increasing agent satisfaction, increasing sales numbers, increasing customer reach).

Overall, based on only one company's response, the effectiveness of AI solutions varies.

11.3 Banking sector

In the course of the market analysis, the GVH contacted **a total of 21** banks operating in Hungary and certain other financial institutions (not classified as banks but providing services to a wide range of domestic consumers) in the banking focus sector. Nine companies in the sector **sent their replies** to the GVH.

Four of the respondents **indicated that they use some kind of artificial intelligence-based solution** in their domestic corporate activities, while **the same number (4) of companies indicated that they do not use** such devices. A company requested indicated that although AI-based solutions exist at group level, its services to Hungarian customers are provided by a member of a group of companies registered in another EU Member State, so its bank registered as a branch in Hungary does not yet carry out activities subject to regulatory scrutiny.

Based on the answers, it can be stated that **larger commercial banks** typically **use some kind of artificial intelligence-based solution**, and some of the companies dealing with personal lending also use AI. It should be noted that among those who answered no, there was also a company that indicated that although its Hungarian subsidiary (branch) does not use such solutions, its parent company uses artificial intelligence-based services. Another company indicated that its parent company uses such solutions on a wider scale than the narrower scope of application in Hungary, which do not manifest themselves directly in domestic banking operations.

Based on the responses received, some players of the domestic banking sector only **use artificial intelligence to support internal, technical background operations** (e.g., text digitization, translation, filing and mail system, targeting communication campaigns). However, AI solutions for many businesses are also reflected **at the level of services available to customers**. Among the latter, chatbots performing written customer service tasks and virtual (digital) assistants assisting telephone or net banking services can be highlighted. Of the respondents**,** three banks operated chatbots **and two operated virtual assistant** applications. The latter provide a different range of assistance: while some solutions help to find customer contact routes (e.g., information and options of the telephone menu system) more easily, others also allow for wider banking service options (e.g., bank card security operations). AI use to customers includes **other service solutions**, such as the development of personalized financial offers. Among the background processes, **AI-based automatisms facilitating the** mitigation of risks of bank transactions and the filtering out of abuses are worth mentioning.

Service providers consider deployment of AI **to be a major contributor to automating and making their operations more efficient (thus reducing costs), reducing banking risks and improving the customer experience.** Based on the signals, AI will help operators develop and deploy new banking products and services, which can boost competition between market participants. In certain areas, the application of artificial intelligence **can represent a particularly significant improvement** compared to traditional methods: for example, in preventing abusive, fraudulent banking operations, where, due to the legal obligation of instant transfers, an extremely short time frame of only one-tenth of a second is available for analyzing transactions.

Businesses that use AI-based solutions were unanimously described as **essential but not critical** to operations. Some service providers indicated that certain critical processes (e.g., translation of documents of particular financial importance) continue to take place without artificial intelligence, and in all application cases it is possible to perform (override) the processes concerned manually.

Based on their data reports, Hungarian companies typically introduced their **AI-based solutions through their own (or coordinated by their parent company) internal developments**, if necessary, with the involvement of external partners or consultants. At the same time, service providers typically use certain services (e.g., cloud storage) that support the operation and running of AI solutions as external resources. For AI-based solutions of some providers, international tech giants offering big data analytics services and an AI platform provide the development environment. Also mentioned were third-party and operational applications that already have AI-supported functions built in, such as the currently most common general office application package (word processing, spreadsheet, etc.).

When selecting developers of artificial intelligence solutions, the most frequently mentioned aspect by banking service providers was the **expertise and professional experience of** the developer. The selection criteria of the companies also included, among others, the ethical and social awareness of the development company, project-specific knowledge, the fulfillment of information security requirements, as well as the cost-effectiveness and group-wide feasibility of the development. Based on the reporting data, developers are typically selected by the parent company or taking into account group-level experience in banking market participants with foreign parent companies.

Based on data services, service providers **all monitor the effects and outcomes of AI-based solutions.** The performance of AI solutions is measured, inter alia, by the degree of autonomy of automated customer service systems (response rate), response time and accuracy without the need for human intervention, while the effectiveness of misuse filtering automatisms is measured through the ratio of false positives to false negatives. The general methodology includes benchmarking indicators of an operation performed manually, i.e., with a non-AI solution, as a reference, based on criteria defined according to the given objective (e.g., error rate, speed, cost, safety).

Several providers indicated that they do not yet have metrically meaningful feedback on some of the results of AI solutions (e.g., return on investment). However, based on data services, in areas where metrics on AI solutions are already available (e.g., duration and accuracy of customer service responses), results **generally met or even exceeded expectations**.

All banking and financial enterprises using AI solutions **pay attention to the development of employee competences and knowledge related to AI**, so they are conducting or are in the process of developing an internal training program for this purpose. In addition to training programs, those practices include, inter alia, internal communication on the use of AI, encouraging continuous learning or providing practical experience on the use of AI. Some responses underline that preparing employees to use AI solutions means not only transferring the necessary technological knowledge, but **also increasing employee confidence**.

Banking and financial service providers using AI tend to view AI solutions **as long-term investments**. Service providers typically expect a return on their investment in AI within a period of one to three years. Some service providers calculate with a slightly longer profitability period (3-5 years) for developments that do not support internal processes, but external banking services (e.g., chatbots).

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