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# Cloud Computing in Hungary: Economic Impact Study

June 2024

# Foreword

The rapid and efficient adoption of cloud computing in business operations brings significant economic benefits not only to the company itself, but also to the national economy as a whole. This study provides further evidence of this by revealing that the annual revenue per employee of Hungarian companies using cloud services is nearly HUF 2.4 million higher than that of their competitors not using such services. Regarding macroeconomic impact, our calculations indicate that the further increase of cloud usage will contribute to Hungary's GDP by an average of 1.7-2.7% per year (compared to 2023), depending on whether the government's attitude towards cloud is neutral or supportive. The difference between the two values means a GDP surplus of approximately HUF 7,000 billion over 10 years.

We cannot let this surplus slip by. Therefore, we believe that coordinated, comprehensive measures are required. In the short term, this includes developing a national cloud strategy based on Cloud First policy, which outlines measures and programs which are aligned with relevant EU recommendations, prioritize competitiveness, while also respect national security interests. It is also time to change the mindset that data must be kept within national borders for data security reasons. If we continue with this practice, we will not be able to achieve an economically viable cloud, due to the size of our country. Another important lesson from our research is the amount of support smaller domestic companies need to adopt the technology. In addition to ensuring the availability of financial resources, we need to also focus on awareness and education to make a real, lasting impact.

As in the past, IVSZ will continue to play a proactive role in supporting the digital transition of the Hungarian economy as efficiently as possible by raising awareness among companies, sharing best practices, providing expert insights to decision-makers, participating in professional consultations, and providing in-depth economic impact studies such as the one you are about to read.

I trust that by the time you reach the end, there will be no doubt: addressing cloud adoption is essential.

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**dr. Balázs Vinnai, President**
IVSZ – ICT Association of Hungary

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# 01.

## Executive Summary

## Aim of the Study

**Cloud computing** is facilitating and **accelerating digital transformation** that no industry or government can afford to forego, and which is critical to **improving Hungary's competitiveness** in the economy and beyond. We believe that appropriate government regulations and investments can stimulate the adoption of cloud computing, and our aim is to propose government measures to promote the widespread use of the technology in Hungary.

## The Importance of Cloud Computing

Together, cloud computing, artificial intelligence (AI) and data capabilities have a transformative power that is not only reshaping the way organizations approach IT, but also the way companies and the public sector think and organize their processes, with positive spill-over effects across society and the economy. The benefits of cloud technologies contribute to **improving the economic performance** of companies. According to our own calculations, **Hungarian companies using cloud services have an annual revenue per employee of nearly HUF 2.4 million more** than their competitors not using such services.

Using this result, we have examined the macroeconomic impact of cloud adoption over the next 10 years: a further increase in cloud usage **over the next 10 years could add on average 1.7%-2.7% to Hungary's GDP annually** (as a % of the 2023 base), depending on whether the governments' attitude is neutral or supportive towards the cloud. The **difference** between the two end points of the range **amounts to HUF 7,000 billion** additional GDP over 10 years.

**2.4 million HUF**

**Average increase in revenue per capita of enterprises using cloud computing**

**7000+ billion HUF**

**GDP growth over a 10-year period given a supportive government attitude**

Widespread adoption and routine use of cloud computing is an indispensable condition for realizing the **economic benefits expected from artificial intelligence.** Although AI is technologically independent from the cloud, both innovations create economic and business conditions for the other that justify their coordinated development.

## Cloud Take-up in Hungary

According to the Digital Decade 2023 statistics[1], the EU cloud adoption rate for companies with 10+ employees is 45.2%, which Hungary approaches with 44.9%. However, our own calculations[2] do not support this: although some dimensions of cloud usage and other important digitalization factors show growth from time to time (in some cases significant), enterprise digital transformation and cloud adoption are fundamentally slow processes. When all the factors are considered together, the **pace of progress** appears to be **moderate** and not explosive.

**Use of cloud technology in Hungary[3] is proportional to the size of companies**: while only 34.9% of companies with 1-9 employees use cloud computing, the figure is 81.7% for companies with more than 250 employees. By sector, companies in the logistics and warehousing sector are the most likely to use cloud, while agriculture and mining are the least likely.

The most significant barriers to technology in this country are lack of skills, lack of understanding, security concerns, budgetary constraints, regulatory obstacles and contractual obligations.

1 Cloud computing services by size class of enterprise, [Link]

2 Based on BellResearch's ICT report and changes in other benchmark indices, the jump in the Eurostat report is difficult to explain, presumably for methodological and interpretative reasons. [Link]

3 Based on the dichotomous cloud variable trained by BellResearch, see chapter 4.3

## Regulatory Cornerstones, Data Security

**Government initiatives and procurement have significant impact on the spread of all new technologies, including the cloud**[4]. The **European Union**'s (EU) efforts and objectives in support of the cloud show that the European Commission and other EU organizations **have recognized the benefits of the best cloud solutions for European competitiveness.** In some cases, cloud-related measures are influenced by political ambitions (e.g. EUCS, the EU's cybersecurity certification scheme for cloud services), which hinder their use in Europe. The most advanced overseas service providers can – seemingly – affect European sovereignty if they manage valuable European data. However, it is worth narrowing the debate to specific data: removing administrative barriers for European companies and institutions could help them to choose the cloud services that will give them the biggest competitive advantage, thus improving the Continent's economic and institutional efficiency vis-à-vis all countries that are free to choose any technical platform in competition with Europe.

For a long time, cloud regulation was based on the assumption that the best way to protect data that is important to a country is to require in-country storage. **However, thanks to advances in data security technology, control over data is no longer primarily a geographical issue that can be secured by physical means. By focusing on the logical layers instead, the protection and the value extraction goals can be both achieved at the same time without** requiring storage in a specific geographical location. Removing location barriers becomes very relevant when considering that cloud computing requires a large scale of operation, which is incompatible with fragmentation of data across countries. Storing data outside the country is no longer a choice, but a necessary condition for realizing the full benefits of cloud – in line with appropriate data classification regulations.

In Hungary, there are also some progressive government initiatives using cloud technology (such as the NDÁP[5]). However, objectives and regulations regarding the use of cloud **still focus on managing data within Hungarian borders.** Data classification and OPEX-bound cost models are not sufficiently explored in public procurement.

## Recommendations for Promoting National Cloud Adoption[6]

The study outlines 3 groups of recommendations that can provide guidance to policymakers to support and accelerate cloud deployment:

1. **Develop a national cloud strategy in line with Cloud First policy**[7]**,** which foresees actions and programs that are in accordance with relevant EU recommendations, prioritize competitiveness and respect national security interests.
2. As part of a national cloud strategy, **government commitment and adequate regulatory environment** are of paramount importance. Within this, the key measures proposed are:
   - set up data classification,
   - review data localization provisions and assess the potential of confidential computing[8],
   - develop a cloud-friendly public procurement process.
3. Given that the cloud adoption of companies with less than 250 employees is well below that of large enterprises, **supporting cloud adoption in the SME sector** requires special attention. Within this, the key measures proposed are:
   - create a central online platform for information sharing on cloud,
   - host knowledge-sharing presentations and workshops,
   - provide resources and financial support,
   - develop cloud certification programs as part of digital upskilling courses or as stand-alone programs.

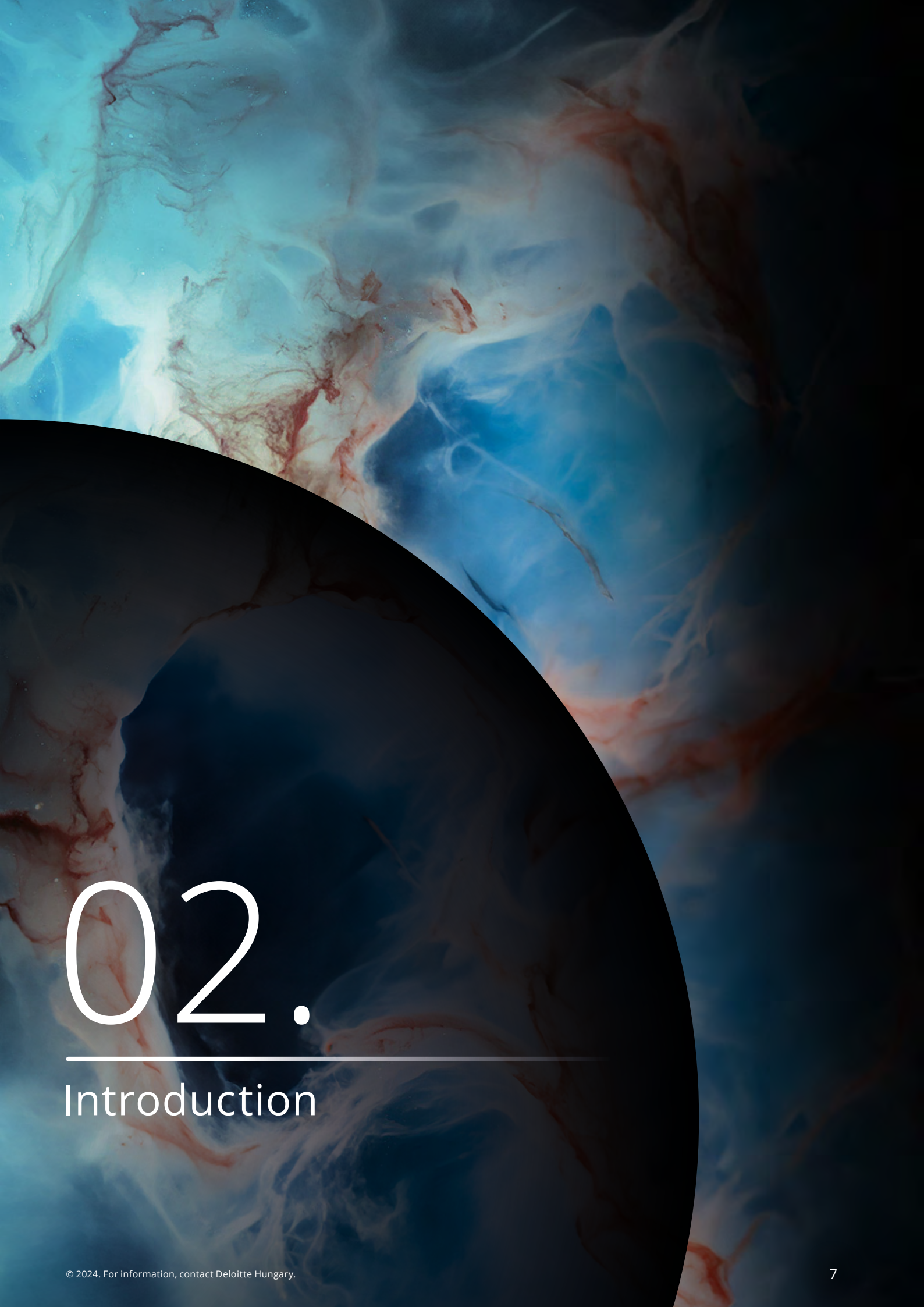
4 Stimulating digital innovation for growth and inclusiveness : The role of policies for the successful diffusion of ICT | OECD Digital Economy Papers | OECD iLibrary (oecd-ilibrary.org), [Link]

5 National Digital Citizenship Program

6 The list is not exhaustive. The full list of proposed measures can be found in Chapter 8.

7 Cloud First is a strategic policy that encourages or requires organizations to prioritize cloud solutions when developing and implementing IT systems and services.

8 Confidential computing is a technology that protects data during processing. Exclusive control of encryption keys enables end-to-end data security in the cloud. Read more: About – Confidential Computing Consortium, [Link]



# 02.

# Introduction

## 2.1. Motivation and Purpose of the Study

Nowadays, the key objective is to ensure that the IT platform follows the dynamic changes in the organization's goals and requirements – and cloud computing can meet this need more flexibly than previous technology solutions, both in the corporate and government sectors. In the course of writing this paper:

- we tested the hypothesis that the level of usage in Hungary is below the EU average, mainly limited to email and data storage,
- we reviewed the domestic status quo of cloud take-up,
- and we aimed to demonstrate the benefits and potential impacts of cloud computing through an economic impact assessment.

We believe that appropriate government measures and investments can stimulate the use of cloud computing, and our aim is to provide recommendations for government actions to boost the widespread use of cloud computing in Hungary. This analysis can contribute to the development of a technology-specific strategy and can also promote the idea of cloud adoption among a wider range of decision-makers.

The study is primarily targeted at potential users in small and medium-sized enterprises and government decision-makers who can influence enhanced adoption of cloud computing in the coming years.[9]

Among others, the study aims to:

- underline the importance of cloud computing,
- review the current state of play in Hungary,
- analyze the impact on productivity and growth of Hungarian enterprises, together with the spill-over macroeconomic effects of cloud computing investments,
- identify common misconceptions about cloud and the challenges to adoption,
- propose solutions for stimulating widespread use of cloud computing.

## 2.2. Our Methodology

The study was carried out by IVSZ in cooperation with Deloitte and BellResearch, based on three main types of analysis:

1. **Preliminary Research and Data Collection**: with the support of IVSZ, Deloitte conducted interviews with relevant market players and public institutions, using a comprehensive, semi-structured method to discuss the topics of the study.
2. **Secondary Research and Literature Review**: literature review on trends, challenges, and opportunities in the cloud computing market.
3. **Modelling and Analysis**:
   - **i.** Developing and applying quantitative models based on BellResearch's Hungarian ICT Report and other data sources to explore the relationship between cloud computing adoption and corporate financial performance.
   - **ii.** Application of an Input-Output (I-O) Model[10] to demonstrate the macroeconomic impact of cloud usage.

Interviews with cloud service providers, companies using cloud services, policymakers and institutions were conducted during the preparatory phase of the study.

9 In the case of large international companies, we assumed that it is primarily the parent company that takes the initiative to adopt cloud technologies.

10 I-O modelling is a methodology often used in economic impact assessments to quantify the spill-over, multiplier economic effects of events, large investments or policy changes.

# 03.

## About Cloud Computing

## 3.1. Introduction to Cloud Computing


To explain cloud computing, it is first important to clarify what exactly cloud is.

Unfortunately, there is no accepted and practical definition of cloud in the business context, but the engineering consensus accepts the definition of the American NIST (National Institute of Standards and Technology), which is also used by ENISA (European Union Agency for Cybersecurity). It defines a cloud computing as a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction. The service used must be dynamic and continuously responsive to current workload demands, and flexible to be released at any time with minimal management effort or service provider interaction.

According to NIST, there are five basic characteristics of the cloud:[11]

- **On-demand Self-Service**: a consumer can unilaterally provision computing capabilities, such as server time and network storage, as needed automatically without requiring human interaction with each service provider.
- **Broad Network Access**: capabilities are available over the network and accessed through standard mechanisms that promote use by heterogeneous thin or thick client platforms (e.g., mobile phones, tablets, laptops, and workstations).
- **Resource Pooling**: the provider's computing resources are pooled to serve multiple consumers using a multi-tenant model, with different physical and virtual resources dynamically assigned and reassigned according to consumer demand. There is a sense of location independence in that the customer generally has no control or knowledge over the exact location of the provided resources but may be able to specify location at a higher level of abstraction (e.g., country, state, or datacenter). Examples of resources include storage, processing, memory, and network bandwidth.
- **Rapid Elasticity**: capabilities can be elastically provisioned and released, in some cases automatically, to scale rapidly outward and inward commensurate with demand. To the consumer, the capabilities available for provisioning often appear to be unlimited and can be appropriated in any quantity at any time.
- **Measured Service**: cloud systems automatically control and optimize resource use by leveraging a metering capability1 at some level of abstraction appropriate to the type of service (e.g., storage, processing, bandwidth, and active user accounts). Resource usage can be monitored, controlled, and reported, providing transparency for both the provider and consumer of the utilized service.

The difficulties of applying the NIST definition in practice are discussed in Annex 9.1.

The cloud thus provides market and institutional players with a **flexible and data-driven platform** where they can focus on the question **'what do our customers need?'** instead of **'what can we achieve with our existing infrastructure?'** Companies and institutions no longer have to think in terms of the limitations of existing server capacity and geographical constraints, because new resources can be created in minutes. This kind of paradigm shift can encourage organizations to incorporate the cloud into their business strategy. A sluggish organization can gain advantage over its competitors by making this shift.

## 3.2. Types of Clouds

Cloud solutions can be categorized by service and deployment type. The service model grouping separates cloud services based on how the service is provided by the provider to the user, with what level of responsibility and operational needs. The deployment model grouping divides the different solutions based on how the cloud is implemented.

Based on one dimension we define infrastructure, platform and software "as a service", and based on the other dimension we define public, private and hybrid cloud implementation/usage types - which can be combined according to business needs.

### 3.2.1. Public, Private and Hybrid Clouds (Classification by Deployment Model)

The cloud deployment model can be of three types:

- The **public cloud** provides services that are accessible to everyone over the internet. In this model, users are also given their own environment and their data cannot be accessed by others without their permission.
- The **private cloud** offers tighter control and security because it is only accessible and usable by a specific company or organization. These infrastructures are either self-hosted by companies within their own systems or hosted by a cloud service provider within the company, ensuring complete control of the data.

11 The NIST Definition of Cloud Computing | NIST, [Link]

- The **hybrid cloud** combines the advantages of private and public cloud. It allows you to use both types of infrastructure simultaneously, choosing between the two from an economic point of view. The choice can be made, for example, on the basis that some applications (e.g. email) are consumed from the cloud and others (e.g. CRM) from an on-premises system, but the two applications operate logically as a single entity, not separated from the user's perspective. Another common hybrid dimension is that the organization only deploys a certain amount of capacity in the local data center and when the workload exceeds this, the task automatically spills over to the public cloud. This increases adaptability to business needs, optimizing IT costs and increasing service flexibility.

The term public cloud is often misunderstood because we also use the term public to refer to access to data. However, the two concepts are not related: private data can be strictly protected in a public cloud, and data can be publicly accessible in a private cloud.

### 3.2.2. Infrastructure, Platform and Software as a Service (Classification by Service Model)

The most commonly used cloud service models are Infrastructure as a Service (IaaS), Platform as a Service (PaaS) and Software as a Service (SaaS), which provide different levels of abstraction and accountability to customers.

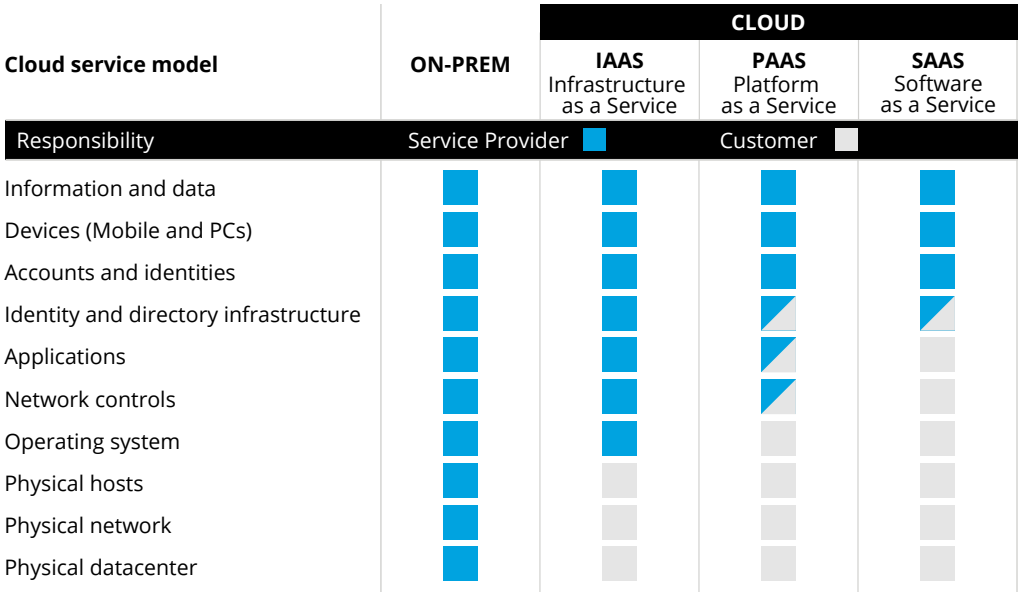
This triple division defines the scope of the cloud service provider. The more tasks the service provider is responsible for, the greater its scope for optimization. In this sense, it is reasonable to say that SaaS is more of a cloud than PaaS and PaaS is more of a cloud than IaaS. SaaS gives the service provider the greatest freedom to optimize the entire IT system and to organize hardware resources in a cost-effective way. As optimization and flexibility increase, the user's control decreases, with SaaS solutions only having access to data, devices and application tiers.

**SaaS** is the highest abstraction layer of the classification, allowing customers to use applications in the cloud without having to deal with application hosting or infrastructure. Customers simply access the applications through their browser and the cloud service provider is responsible for the operation and maintenance of the applications. Examples include Google's Workspace[12] collection of applications, Salesforce's CRM[13] or Slack's[14] productivity tool.

- **PaaS** is the next level, providing application infrastructure as a cloud service, including the runtime environment and application development time components, so developers only need to deal with the application. Examples of PaaS are AWS Elastic Beanstalk[15] , Azure App Service[16] , Google App Engine.
- **IaaS** is the lowest level of abstraction that enables the on-demand provision of computing resources and the associated storage and networking tools in a standardized and automated way, such as Amazon EC2, Azure VMs and Google Compute Engine.

It is also worth adding that when we talk about concepts not included in the above 'as a service' list, such as security, storage, Business Process as a Service (BPaaS) or other "XaaS" categories, these can also be classified under one of the above service models.

The figure below shows the characteristics of traditional (on-premises) IT and the three service models in terms of which component of the overall IT system is the responsibility of the service provider or the customer.




◄ ***Figure 1:*** ***Cloud service models (own ed. Microsoft Azure | Based on Shared responsibility in the cloud)***

12 Google Workspace | Apps and collaboration tools for businesses, [Link]
13 CRM software & Cloud business solutions – Salesforce, [Link]
14 Slack is your productivity platform | Slack, [Link]
15 Cloud Products (amazon.com), [Link]
16 Directory of Azure Cloud Services | Microsoft Azure, [Link]

### 3.2.3. Consumer and Enterprise Clouds (Classification by Target Group)

Two different types of cloud services can be distinguished by target group, as consumer and business customers have significantly different requirements and price sensitivities. Enterprise cloud also includes services for institutional users, as the requirements of these two types of customers are not significantly different, although the motivation for the requirements is different.

The distinction between the consumer and the enterprise/institutional target group is well manifested in the commitments of service providers, so it is by examining the commitments that these two types of cloud can be discussed in a more tangible way.

- **Consumer services** are targeted at users who use them for their own purposes (e.g. Apple iCloud or Gmail). These solutions are quick and easy to deploy, in many cases available from the cloud with just a few clicks. Typically, the cost level is more important to the target group than other features and service commitments, hence the prevalence of a business model funded by advertising revenue.
- In contrast, **enterprise-level solutions** deal with much more complex structures and processes. Examples include Amazon Web Services (AWS) EC2 and Lambda, Google Cloud Platform (GCP) Compute Engine and Cloud Storage, and Microsoft 365 in the SaaS space, which focus not only on the productivity of individual users, but on making all business processes more efficient. Integrations and data exchanges can be much more complex and often require configuration and consultancy intervention to implement. Given the difference between simplified marketing messages and expectations, it is important to have a comprehensive approach when implementing these types of solutions, tailored to the business needs.

The two different services targeting different user markets differ significantly in terms of data management. Generally speaking, the commitments to the protection of personal data are the same for both target groups, as the GDPR and other personal data protection requirements do not distinguish between individuals based on whether they or their employers have a contractual relationship with the cloud service provider. Data processing at the enterprise level should be understood in a different and more complex context than that of the consumer. The security requirements for data management are typically more stringent and often must comply with industry-specific regulations (e.g. HIPAA, MNB Cloud Recommendation). [17,18]

The enterprise cloud operates with significantly different availability commitments than the consumer cloud, which is reflected in the content of the Service Level Agreement (SLA).

| | CONSUMER | ENTERPRISE |
|---|---|---|
| **Economy of scale** | ✓ | ✓ |
| **Security** | ✓ | ✓ |
| **Compliance, audit** | ✗ | ✓ |
| **Business model input** | Data | Fee |
| **Service Level Agreement (SLA)** | ✗ | ✓ |
| **Commitment to store in EU** | ✗ | ✓ |

*Figure 2: Typical consumer and enterprise cloud commitments*

17 Cloud Data Security & Protection: Everything You Need to Know, [Link]

18 What is cloud data security? Benefits and solutions | Google Cloud, [Link]

### 3.2.4. Advanced Cloud Usage: Expressing Economic Impact

For this study, companies that use cloud services with a significant impact on their business processes or business performance are considered advanced cloud users.

Identifying advanced cloud usage is not easy for individual organizations. As a practical criterion, the DESI (Digital Economy and Society Index), following Eurostat, defines a cloud services cluster, of which organizations using at least one service are considered sophisticated or intermediate cloud adopters. This service set does not yet consider AI applications in April 2024.

For the purposes of our study, we consider companies as advanced cloud users if they use the following from the Eurostat-defined set of sophisticated or intermediate services[19]:

- financial and accounting software, or
- ERP (Enterprise Resource Planning), or
- CRM (Customer Relationship Management System), or
- security software, or
- database hosting, or
- computing capacity as a service for the development

According to our study, advanced cloud usage can take place in SaaS, PaaS or IaaS models.

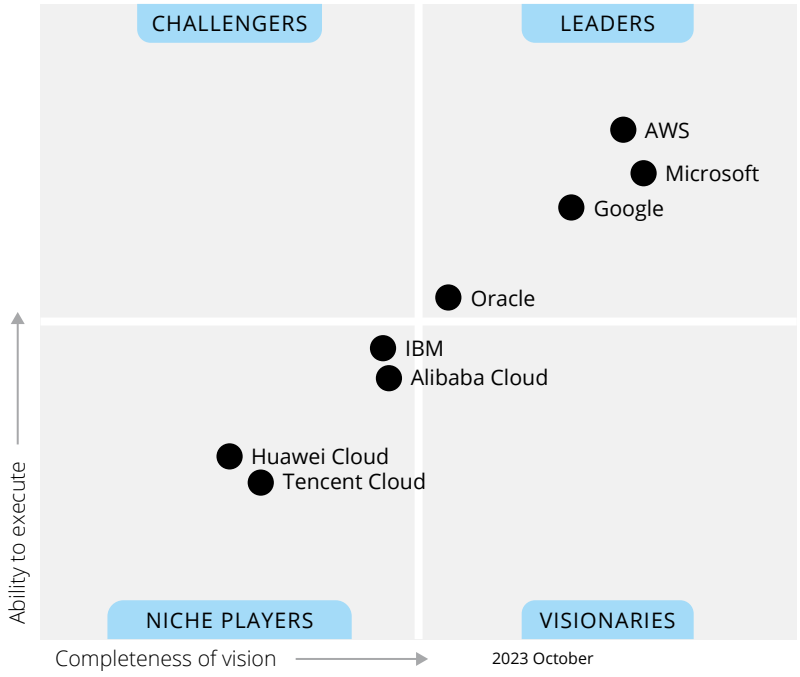
An example of a non-advanced usage in a SaaS model could be the simple use of email from an office service package. However, if the organization also uses artificial intelligence functions from the same service bundle to support its office workflow (e.g. Qatalog, CoPilot, or Duet AI), it can be considered advanced. Also advanced is document-based workflow management (e.g. UiPath, or Microsoft Power Automate), of which email may be an essential, but not the only component.

In an IaaS model, if the service provider requires a multi-year commitment to request a certain type of resource, or if the provisioning of that resource requires human intervention, it is not considered advanced usage, and the latter cannot be considered cloud according to the NIST definition.

## 3.3. Cloud Service Providers

Let us begin with an overview of the most prominent cloud service providers, based on Gartner's study on strategic cloud service providers[20]. We found this analysis relevant to the advanced cloud usage that we will examine later. Eight of the so-called strategic cloud service providers were included in the Gartner Magic Quadrant. This analysis divides cloud infrastructure and platform providers into four sections based on the completeness of their vision and their ability to execute. The providers are US-based Amazon Web Services, Microsoft Azure, Google Cloud Platform, IBM Cloud, Oracle Cloud, and China-based Alibaba Cloud, Tencent Cloud and Huawei.

***Figure 3:** Magic Quadrant ▶*
***(based on** Gartner Magic Quadrant for Strategic Cloud Platform Services**)***




19 Cloud computing – statistics on the use by enterprises – Statisics Explained (europa.eu), [Link]
20 Critical Capabilities for Strategic Cloud Platform Services (gartner.com), [Link]

The three largest and best known of these are Amazon Web Services (AWS), Microsoft Azure (Azure) and the Google Cloud Platform (GCP), which cover around 65% of the total cloud services market. These three providers are the market leaders and therefore have the broadest range of services. It is common to refer to the three largest cloud service providers as „hyperscalers".[21]

- **Azure** is widely successful across all use cases, especially for organizations that rely on Microsoft products and follow a hybrid cloud strategy.[22]
- **AWS** has the broadest portfolio of over 200 full-value services for enterprise customers.[23]
- **GCP** offers the most complete range of generative AI (GenAI) solutions and is the market leader in cloud AI development, according to Gartner research.[24,25]

The following figure shows the location of the existing or planned data centers of these strategic cloud service providers. The 'big three' have the largest number of data centers in Europe, most of which are located in locations and hubs in Western Europe. US-based companies are in a leading position in this market compared to the Chinese, which are present in only 5 countries in Europe.

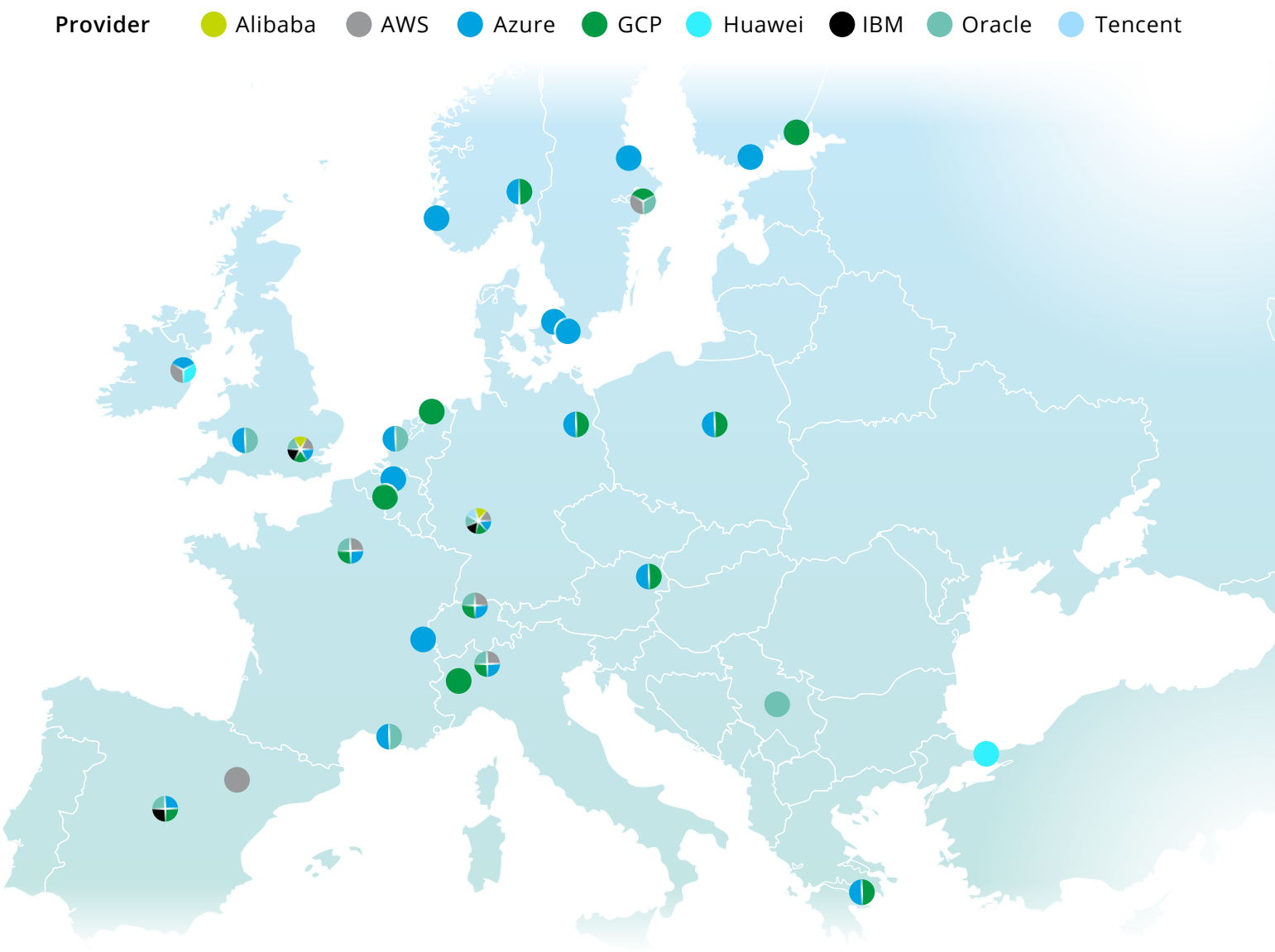



***Figure 4:** Public cloud data centers in Europe (source: https://www.cloudinfrastructuremap.com/)*

21 Cloud infrastructure services vendor share 2023 | Statista, [Link]
22 Microsoft Learn, [Link]
23 Cloud Computing Services – Amazon Web Services (AWS), [Link]
24 Generative AI Cloud Platforms: AWS, Azure, or Google? – The New Stack, [Link]
25 Magic Quadrant for Cloud AI Developer Services (gartner.com), [Link]

In addition to the cloud service providers identified as strategic by Gartner, it is also worth paying attention to regional and local players in the cloud services market, given the EU's ambition for digital sovereignty.[26] Regional competitors are led in market share by Deutsche Telekom (Germany), followed by OVHCloud (France), SAP (Germany) and Orange (France).[27] In the Hungary, although not as functional as their regional or global counterparts, there are for example Magyar Telekom, Invitech and Wigner Datacenter, and the declaration of intent between 4iG and Huawei to create a joint cloud services platform.[28] At institutional level, NISZ Zrt. can also be considered as a major data center operator (and thus a potential provider of private cloud services).

## 3.4. Cloud Computing and Artificial Intelligence

AI is now a dominant technology, so it is particularly important to address the relationship between cloud and AI solutions. AI leverages machine learning, which requires two fundamental factors:

- a high-quality, large data set on which to 'train' the AI
- and a sufficiently large computational capacity to perform machine learning on the dataset and – in the case of generative AI – to generate responses.

The larger the data set on which the AI is trained, and the more sophisticated the algorithm, the better the AI solution will work.

The synergistic relationship between the cloud and AI can be viewed from several perspectives:

1. on one hand, the efficiency of development and maintenance of AI models (in particular large language models and other generative AI solutions),
2. the integration of AI capabilities into cloud services (AI-enabled cloud adoption).

### *Effective Development and Maintenance of AI Models*

If we plan to train the AI model needed to run a chatbot or other generative AI solution on our own enterprise data, we will need significant computing power. Since 2010, when deep learning was first introduced, the growth in the computing power used by AI models has skyrocketed, currently doubling every 6 months or so, compared to the 21 months previously.[29]

**Machine learning combined with cloud computing enables rapid and large-scale innovation** for organizations. Using AI in the cloud can benefit an organization in many ways, of which we would like to highlight the following:

- Optimizing investment costs
- Optimizing operating costs
- Functionality offered
- Availability of hardware resources

In terms of **investment cost optimization**, the cost of an average AI computing time requirement for an on-premises infrastructure investment is much higher than renting the same computing time in the cloud. To compare cloud and on-premises AI costs, we have taken Google's pricing of graphics processing time and NVIDIA's current pricing of GPUs as examples. On average, the GPU (Graphical Processing Unit, also known as video card) used for AI calculations runs 1-2 days per month, roughly 1 month in a year, which is 730 hours.

- For the cloud: if you want to run this computation on a 16 (80GB) GPU system and you need the computation immediately, it costs $35-45,000 per year, if you can wait, it costs $15-20,000.
- For on-premises use: if you need to buy your own hardware, an NVIDIA A100 (80GB) card costs between $15-20,000, of which 16 would be needed to achieve the same capacity. The total cost of purchasing your own hardware is between $240-300,000 – excluding software and other support, which costs an additional $100,000.

Since the hardware investment is not made for a year, it is worth considering that to remain competitive and to keep up with new technologies coming to the market, a company will use the video cards it has purchased for about 3-4 years. Projected over four years of cloud-based capacity rental, a usage-based operating cost of up to $180,000 compares to an investment of $340,000 to $400,000.

The cloud also offers good solutions for **optimizing operational costs**. When installed in an on-premises data center, the direct and indirect power consumption of GPUs is additional cost element. When used as a cloud service, these energy costs are already included in the service provider's fees. This cost optimization can be achieved by cloud service providers procuring energy at a significantly lower cost level than is typically available to Hungarian companies. Indirect energy demand is also generally lower in the cloud, as expressed by the PUE (Power Use Effectiveness) value.

26 Digital sovereignty for Europe (europa.eu), [Link]

27 European Cloud Providers Double in Size but Lose Market Share | Synergy Research Group (srgresearch.com), [Link]

28 4iG-Huawei Memorandum of Understanding on joint cloud services platform – ITBUSINESS, [Link]

29 [2202.05924] Compute Trends Across Three Eras of Machine Learning (arxiv.org), [Link]

The different pricing models provide value for money. Demand-based costing allows payment by usage, ideal for short-term or seasonal loads; reservation-based costing offers discounts for long-term, steady workloads; while 'spot' (or immediate) costing offers huge discounts for variable capacity availability.[30]

From a **functionality** perspective, the cloud also offers AI services such as pre-built models, frameworks and general purpose algorithms for developers. Furthermore, the cloud can also provide large-scale data repositories and computing capacity that can ingest, process and store the data arriving at high-speed and real-time (or in batches) that the AI process needs.

In terms of **availability of hardware resources**, cloud service providers together with AI developers are at the forefront of advancing AI. Thanks to large financial investments and partnerships, public clouds enable users to adopt new AI technologies much sooner.

### *Integration of AI Capabilities into Cloud Services*

According to a study by United IT Consultants[31], artificial intelligence-enabled cloud services:

- can reduce IT spending by 15-25%,
- can increase IT productivity by 25-40%,
- are most widely used in the healthcare, financial, retail and manufacturing sectors,
- 89% of companies reported a significant acceleration in revenue growth.

In addition to the benefits, an important aspect of the uptake of AI is the corresponding increase in carbon dioxide (CO2) emissions.[32] CO2 emissions during the installation and development process of AI depend on the quality and quantity of the energy source used and a number of other factors. For example, cloud providers often use renewable energy sources[33,34], so their CO2 emission is typically lower for the same amount of processing. Other important factors related to carbon emissions are the geographical location of data centers, their specific efficiency and the efficiency of the hardware they operate. The carbon emissions of the energy used by AI can differ significantly for the reasons mentioned above. From a Hungarian perspective, benefits of sourcing AI from data centers located in other countries include:

- if sourced from a country with a higher share of renewable energy, the carbon footprint can be reduced,
- the carbon dioxide emission is accounted for in the country hosting the data center.

In conclusion, although the use of the cloud is not theoretically a prerequisite for the development of AI, it can be said that the **combined development and operation of the so-called transformative digital capabilities (AI, Cloud, Data) is necessary to create and sustain effective innovation and technological competitiveness.**[35]

30 Turbonomic Blog Mastering Cloud Cost Optimization: Cloud Cost Models & Discounts Overview, [Link]
31 AI in Cloud Computing: Explore the Synergy Between AI and Cloud Technology, [Link]
32 International Scientific Report on the Safety of Advanced AI – Interim Report (publishing.service.gov.uk), [Link]
33 Sustainable AI: Environmental Implications, Challenges and Opportunities (mlsys.org), [Link]
34 The Carbon Footprint of Machine Learning Training Will Plateau, Then Shrink | IEEE Journals & Magazine | IEEE Xplore, [Link]
35 Computational Power and AI – AI Now Institute, [Link]

# 04.

# Cloud Computing: Current State of Play in Hungary

## 4.1. Cloud Adoption in Hungary

According to Statista's Hungarian dataset[36], the gross revenue of the domestic public cloud market is forecast to reach USD 665.30 million in 2024, with SaaS solutions leading the cloud services market with a forecast market volume of USD 331.7 million. Gross revenue is projected to grow at a CAGR of 9.47% from 2024 to 2028, resulting in a projected market volume of USD 955.4 million by 2028.

**Public Cloud market size**
**665.3 million USD**
gross revenue (2024)

**Most popular solution**
**331.7 million USD**
Software as a Service (SaaS)

**Annual growth rate**
**9.47 %**
CAGR 2024-2028

**Market volume**
**955.4 million USD**
by 2028

Gartner's forecast for Hungary in the IaaS solutions market is shown in the chart below. Total spending in Hungary of HUF 92,896 million in 2023 is expected to grow steadily and significantly at an average annual rate of 22.92%, increasing nearly three and a half times by 2029, according to the research.

**Gartner: in Hungary, IaaS spending is growing at an average annual rate of 22.92%**

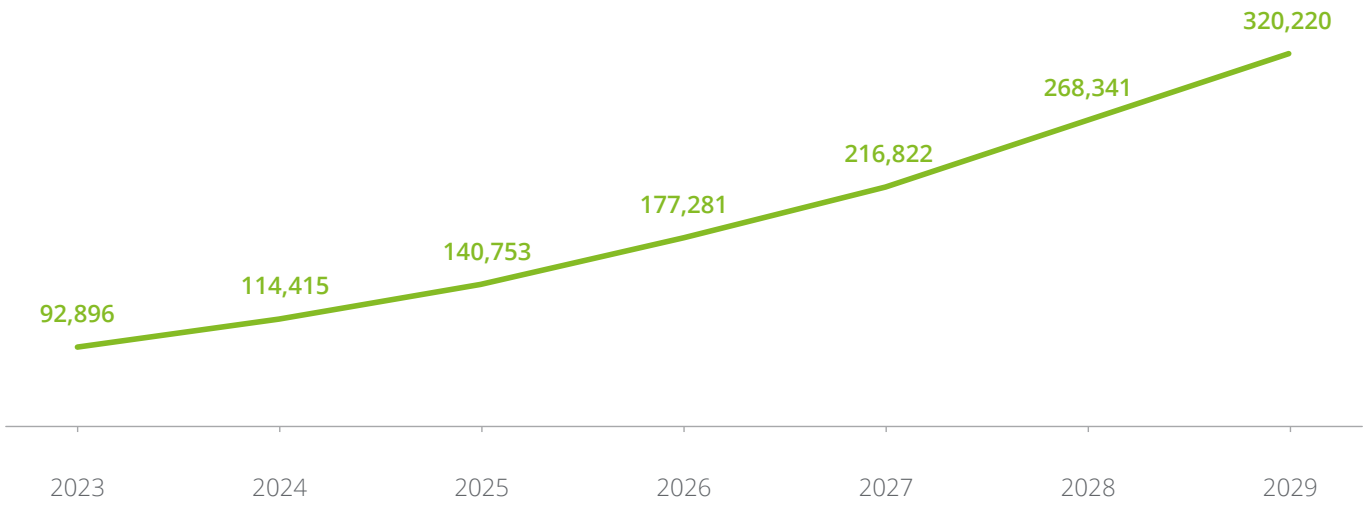



***Figure 5:** IaaS spending in Hungary (HUF million), Gartner Market Databook, 1Q24*

DESI and Digital Decade present the cloud usage of the enterprises with 10 or more employees based on the *EU* survey *on ICT usage and e-commerce in enterprises*[37]. According to the Digital Decade 2023 statistics, the overall (basic + intermediate + sophisticated) usage rate for enterprises with 10+ employees in the EU (27 countries, from 2020) is 45.2%, which is closely followed by Hungary with 44.9% (i.e. this percentage of enterprises use a cloud service as defined[38]).

36 Public Cloud – Hungary | Statista Market Forecast, [Link]
37 EU survey on ICT usage and e-commerce in enterprises, [Link]
38 Cloud computing services by size class of enterprise, [Link]

**DESI: Cloud usage in the region seems to have grown by leaps and bounds in recent years**

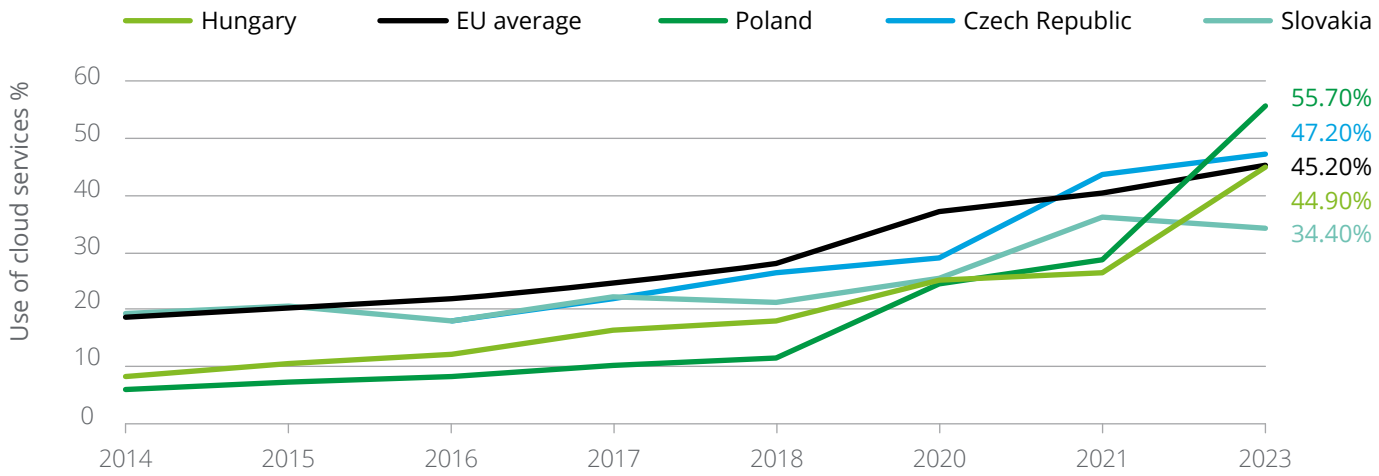



*Figure 6: ESTAT 2023: Use of cloud computing capacity, 10 or more employees, 2014-2023*

**It should be stressed that the +18.5 percentage point change in the Hungarian figure since 2021 is an outlier and questionable given the pace of change so far, so we consider it important to further examine the background and justification for this change.**

The DESI data for Hungary seem to suggest that the change is essentially due to a leap in sophisticated use: the indicator has increased by +16.2 percentage points in 2 years, from 16.7% to 32.9%, compared to an EU average of 34% (we nuance this conclusion below). This "jump" seems to be similar in all domestic size segments according to the DESI[39].

The Eurostat survey series mentioned above is based on standard methodologies, the questionnaire including cloud usage and the methodology has not changed for the period 2021-2023. The Hungarian data processed by DESI is collected by the Hungarian Central Statistical Office (KSH) in the OSAP 1840 questionnaire, on the Elektra online self-completion platform, on a sample of ~7,100 out of a ~33.5 thousand enterprise population of 10+ persons, with a 91% completion rate. The questionnaire asks for the assistance of an IT specialist, but no information is available on the control or actual implementation of this.

Furthermore, time-series data from BellResearch's annual research series, the Hungarian ICT Report, show that although some dimensions of cloud usage and other important digitalization factors show growth from time to time (in some cases significant growth), corporate digital transformation and cloud adoption are fundamentally slow processes. Even when there is a spectacular increase in one dimension (e.g. Microsoft 365 penetration suddenly increases), it is typically supply-side and administrative, not structural. **With all factors considered, the pace of development appears to be moderate rather than explosive**, as the DESI report would suggest. This is especially true for services (such as an ERP system) that assume advanced, complex usage patterns, and are not trivial.

In order to rule out data source bias, BellResearch also examined the results of an additional source, Digiméter (researcher: Róbert Pintér, BCE). The index, which aims to quantify the degree of digitization of SMEs, is one shade more pessimistic in its results than the ICT Report, with no growth over the last two years. On the basis of the above, **we do not consider it realistic to assume that advanced cloud usage in Hungary has suddenly increased by an order of magnitude, but rather a moderate growth is likely.**

The large variation in Eurostat's cloud usage statistics is assumed to be due to the interpretation uncertainties of the online survey. Indeed, two categories allow for a broader interpretation of cloud services:

- Among **financial accounting applications**, for example, online billing systems (szamlazz.hu, billingo.hu) are widely used, which can be used at entry level without any special cloud commitment.
- **Anti-virus software**, which is commonly used by domestic businesses, can also be considered as cloud-based applications by respondents because of its strong online component (updating, sending data) - although the security solutions related to real cloud-based network solutions are far more complex and sophisticated, and their target group is much narrower.

Returning to the analysis of Eurostat's cloud service usage statistics, the highest domestic penetration rate of cloud services is seen in the security software applications category, where 59.2% of Hungarian respondents use the technology, while the lowest usage level is observed in the CRM software applications category, with a value of 19.5%.

39 Small enterprises with 10-49 employees: 15.9 percentage points; medium-sized enterprises with 50-249 employees: 17.8 percentage points; large enterprises with 250+ employees: 19.8 percentage points

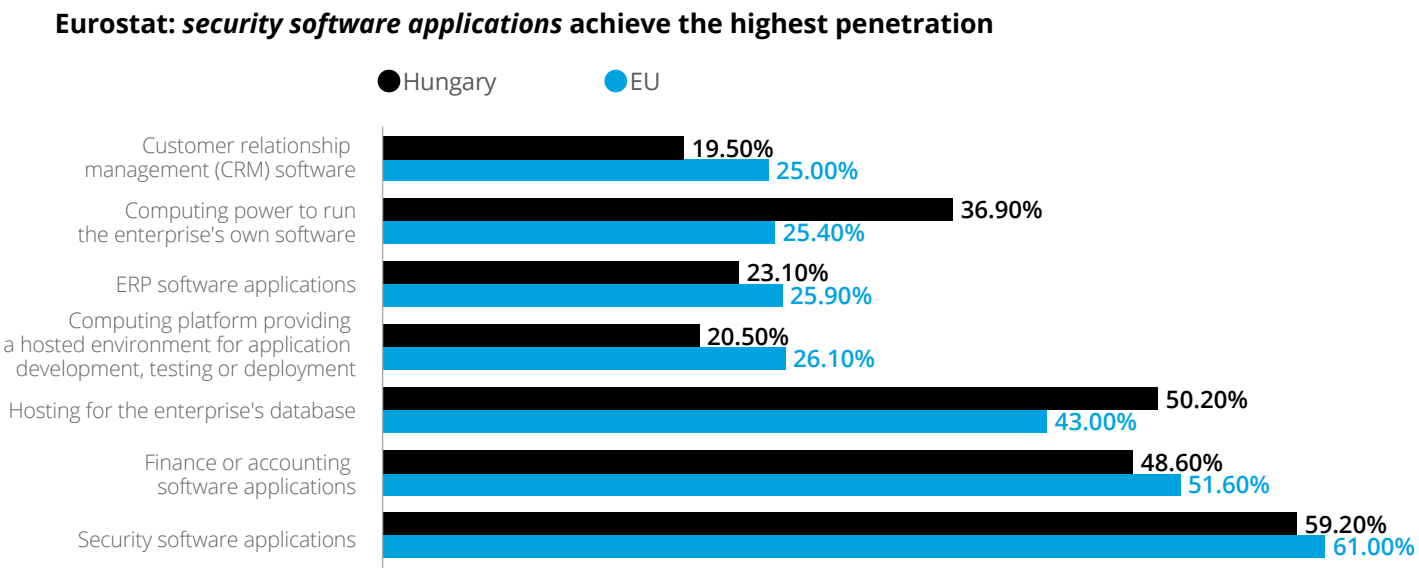



***Figure 7:** Eurostat 2023: Cloud usage by application type*

## 4.2. Key policies and regulations

The summary of the Hungarian policy and regulatory environment includes an overview of EU and government efforts and highlights some of the relevant regulations. These regulations, strategies, plans and constraints **will provide the basis for our recommendations**.

### 4.2.1. European Union

The largest cloud service providers (AWS, GCP, Azure) are non-European, which poses a complex situation for the European Union. Most economic actors, including SMEs, which are particularly in the focus of public policies, prefer unlimited availability of cloud services in Europe without administrative restrictions. On the other hand, companies that offer or could offer cloud services have an interest in making it difficult or at least costly for their non-EU competitors to enter the European market. The EU institutions are trying to balance these two conflicting interests.

The European Union's efforts to promote the cloud are clearly visible. The DESI and the Digital Decade survey measure cloud usage specifically, and the declared aim is to increase it. The Trade and Technology Council (TTC) is the most important forum for intensive trade and regulatory discussions with the US, aimed at breaking down barriers to economic cooperation. One factor in this is the free flow of data and the use of each other's IT services. The EU-US Data Protection Framework is a good example of TTC's achievements.

The next part of the chapter briefly reviews the policies and legislation that are most relevant to the study.

#### *Digital Decade 2030 Policy Programme*

The European Union' strategic plans touch the topic of cloud computing several times: the Digital Decade 2030 policy programme sets specific targets for EU Member States to achieve in order to facilitate their digital transformation. The program states that the EU should develop its own cloud infrastructure, encouraging structured cooperation between Member States and EU bodies, and sets out how to monitor progress towards the targets. The EU's target for business cloud use reads as follows:

***"Tech up-take: 75% of EU companies using Cloud, AI, or Big Data[40]"***

This goal may sound ambitious, but it does not actually specify the nature of cloud services, so it can in fact be met by using basic services that are not at the advanced level defined in the study. Several international projects have been launched to achieve the objectives of this specific program, such as the "Important Project of Common European Interest on Next Generation Cloud Infrastructures and Services".[41] The target set for Hungary is to achieve a 60% usage rate by 2030.[42]

40 Digital Decade 2030: [Link]

41 Important Project of Common European Interest on Next Generation Cloud Infrastructures and Services [IPCEI-CIS], [Link]

42 Hungary's National Strategic Plan to achieve the targets of the Digital Decade Policy Program 2030, as set out in Decision (EU) 2022/2481 of the European Parliament and the Council (14 December 2022), [Link]

#### *EU Cybersecurity Regulation (CSA) and EUCS*

The EU Cybersecurity Act (CSA[43]) mandated the European Union Agency for Cybersecurity (ENISA) to develop EU-wide voluntary cybersecurity certification schemes to regulate cloud service providers and to align the security and interoperability of cloud services with EU regulations, international standards and industry best practices. This is how the development of the EUCS, the European Cybersecurity Certification Scheme for Cloud Services, was launched.

The EUCS aims to improve and rationalize cybersecurity guarantees for cloud services at three levels of assurance (basic, substantial, high) across all types of cloud services (IaaS, PaaS, SaaS) across the EU.[44]

The EUCS is still in development and has been the subject of significant sovereignty disputes over the past 3 years due to concerns about potential US access to data stored in the cloud. An earlier draft of the text included so-called sovereignty requirements that would have made it significantly more difficult to use the services of overseas cloud service providers on high assurance levels (which would have been used in procurement procedures). In addition to EU data localization requirements, firms seeking the highest level of cybersecurity certification would have needed to be based in the EU, have a majority of board members be EU citizens and store and process their customer data on EU territory.[45]

Following immense pushback by several countries and organizations, these requirements were finally removed from the draft EUCS on 22 March 2024 and moved to the International Company Profile Attestation (ICPA), which is required to achieve the highest assurance level. Under the ICPA, cloud service providers are required to declare where their customer data is stored and processed, and which jurisdiction(s)' laws apply to them. With this amendment, the possibility to enforce sovereignty requirements has been transferred from the EU's discretion to the Member States.

It is important to add that the draft EUCS mentioned above is still being challenged at the time of writing in May 2024, mainly by France, which has recently pointed out the contradiction between the idea of standardization at EU level and the decisions left to the member states, so the final content of the EUCS is still in question.

The significance of the EUCS is that, although the certification scheme will be voluntary under the CSA, it may still be effectively mandatory for a number of highly critical organizations (such as energy or finance) under the NIS2 (an EU directive that aims to achieve a high common level of cybersecurity across the EU).[46]

#### *White Paper – How to Manage Europe's Infrastructure Needs*

The White Paper - How to Master Europe's Infrastructure Needs[47], published for consultation by the European Commission in February 2024, may envisage a paradigm shift, proposing to enhance the regulation of cloud computing along the lines of the draft future regulation of the telecoms sector.

### 4.2.2. Hungary

The Hungarian strategic documents and legislation highlighted for the cloud are:

#### *National Digitization Strategy (NDS)*

The use of the cloud is included in the National Digitalization Strategy (NDS) 2022-2030, one of the objectives of which is:

> ***"Hungary should be self-sufficient in the provision of state services and the storage of the necessary data in the cloud (at least two thirds of these services should be provided from local infrastructure)"*** [48]

While this effort supports cloud adoption by proposing infrastructure deployed in Hungary, it also restricts the usage of public cloud provided by non-Hungarian operators.

#### *Act L of 2013 on the Electronic Information Security of State and Local Government Bodies*

The Ibtv. (*Act L of 2013 on the Electronic Information Security of State and Local Government Bodies*), which is of great importance from a Hungarian regulatory point of view, contains strong geographical restrictions, stating that data forming part of the national data assets may be managed in electronic information systems operated and stored in Hungary, as well as in closed electronic information systems used for defense and diplomatic information purposes.[49] While there is an exception handling mechanism whereby data can be stored within the EEA territory instead of Hungary, granting approval is not a general practice. The strict regulation is further strengthened by the *Act CI of 2023 on the System of Utilization of National Data Assets and on Certain Services*. Article 94 of this law sets out enhanced protection of certain state records belonging to the national data assets, according to which data processing operations may be carried out by data processors exclusively on the territory of Hungary[50].

43 Cybersecurity Act, [Link]
44 Cybersecurity Score – European Cybersecurity Certification Scheme For Cloud Services (EUCS), [Link]
45 EU drops sovereignty requirements in cybersecurity certification scheme, document shows, [Link]
46 Cybersecurity Score – European Cybersecurity Certification Scheme For Cloud Services (EUCS), [Link]
47 White Paper - How to master Europe's digital infrastructure needs? | European Commission, [Link]
48 Government of Hungary – National Digitization Strategy (2022-2030) (kormany.hu), [Link]
49 Act L of 2013 on the Electronic Information Security of State and Local Government Bodies, [Link]
50 Act CI of 2023 on the System of Utilization of National Data Assets and on Certain Services, [Link]

### *National Digital Citizenship Program*

Among the progressive measures, the National Digital Citizenship Program (NDÁP), adopted to achieve the goals of the EU's Digital Decade 2030, foresaw the need to introduce a national cloud for public administrations to support digital developments and reduce rising infrastructure costs.[51] The NDÁP also analyses how to maximize the potential of the technology, so that while critical data would be managed in its own modernized data center, it proposes the use of international cloud service providers to take full advantage of cloud computing and accelerate development. However, this proposal does not appear in the respective legislation – Act CIII of 2023.

### *The MNB's Cloud Recommendation for the Financial Sector*

Among the sectoral rules, it is worth highlighting the MNB's cloud recommendation for the financial industry,[52] which approves the use of the cloud if it can be supported by a proper risk analysis. One of the legislative objectives of the Recommendation is to safeguard the stability of the Hungarian financial system by requiring industry players wishing to support their operations with cloud computing to take careful preparatory steps. One of the drivers is that the risk to the national financial system from the failure of even a few players is too high, so it is of paramount importance to have a well prepared and guaranteed continuity of service.

### *Other Government Programs and Grants*

According to the Ministry for National Economy (NGM), government and EU programs and resources have been available so far (especially the Modern Enterprises Program) and will continue to be available (mainly through the DIMOP Plus schemes and EDIHs) to shape the digital mindset of SMEs, to encourage and support companies, to raise their level of digitalization and to expand their access to ICT tools and solutions. An example of a government measure specifically targeting cloud computing is the SME Technology Plus Loan Program (KKV Technológia Plusz Hitelprogram, GINOP Plus 1.4.3-24), which contributes to the development of micro, small and medium-sized enterprises in Hungary by supporting organizational renewal. The program requires the use of cloud-based IT solutions for the purchase (or implementation) of IT systems and solutions, thus opening up the possibility for companies to obtain loans not only for capital investment but also for operating costs.

Overall, there are some progressive governmental measures and ideas on cloud usage in Hungary, but there is still a strong focus on the management of national data within the borders of Hungary. Adequate public procurement frameworks that would allow to account for IT infrastructure costs as operating expense (OPEX) are missing. These frameworks, along with data classification have proven in several countries to rationalize the scope of data to be stored within national borders.

## 4.3. Cloud Usage of Enterprises

The source of the data used in this chapter is the BellResearch Hungarian ICT Report 2023. By the secondary analysis of the data, BellResearch created a binary cloud variable, which clearly distinguishes between respondents using the cloud and those who do not use it. Companies were classified as cloud users if they used at least one of the following three services:

- Microsoft 365 service
- any IaaS service
- any PaaS service

The survey results show that in the size classes surveyed, larger companies tend to use cloud computing more than smaller companies. **63% of the total surveyed population do not use cloud computing**, which can be explained by the fact that the majority of companies surveyed are in the 1-9 employee category. The vast majority of companies with 1-9 employees do not use cloud: only 34.9% use cloud computing. In contrast, the vast majority of companies with more than 250 employees (81.7%) can be considered cloud users.

51 National Digital Citizenship Program, [Link]

52 Recommendation No. 4/2019 (IV.1.) of the Hungarian National Bank on the use of community and public cloud services, [Link]

**Cloud is typically used by large enterprises in Hungary**

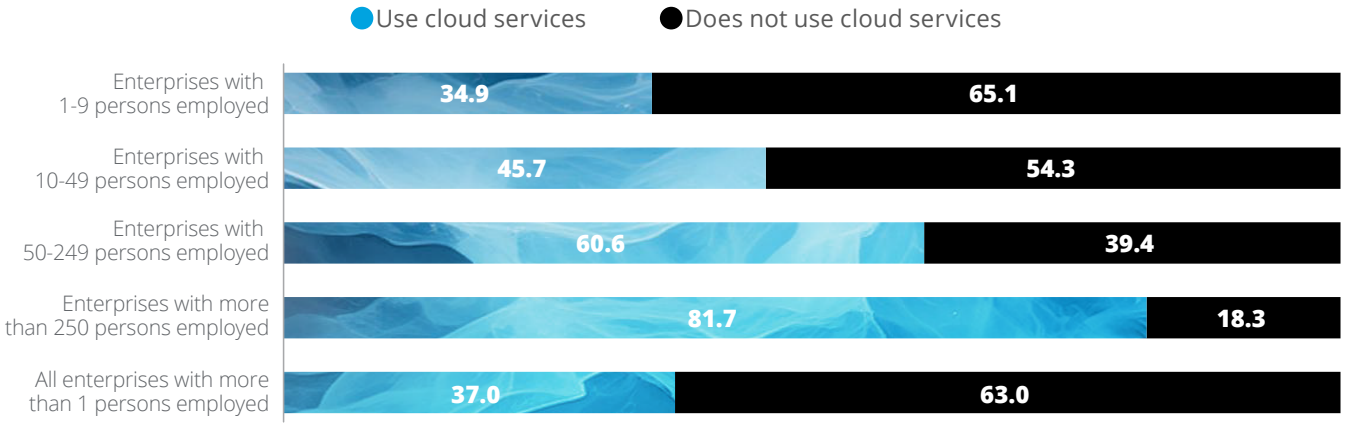



***Figure 8:** Cloud adoption by enterprise size class (%)*

Based on the survey responses, companies in different industry segments surveyed typically have a mixed use of cloud. In this breakdown, one sector, *Finance and services*, has the largest effect on the population (37.78% of respondents belong to this sector). The *Logistics, warehousing* sector is also prominent, with 55.1% of respondents using cloud. In contrast, *Agriculture, mining* has the lowest cloud usage, with 71.9% of enterprises not using cloud.

**Cloud is typically used by logistics and warehousing companies**

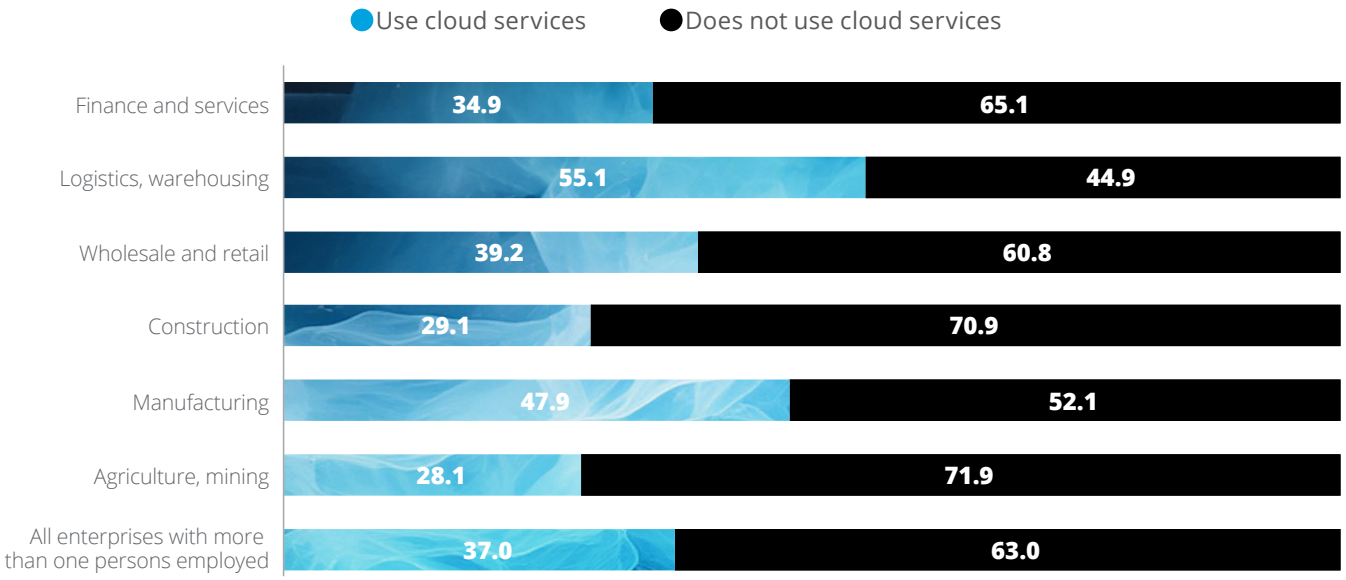



***Figure 9:** Cloud usage by industry sector (%)*

BellResearch has also produced an index of cloud development, called the Cloud Development Index. The score measures on a scale of 0-100 where a company stands in its adoption of cloud and "as a Service" solutions and managed services, using a complex approach that takes into account infrastructure, readiness and attitudinal factors in addition to penetration indicators.

This value is very high (close to 100) for highly developed companies that are already using cloud solutions on both the infrastructure (IaaS, PaaS) and software (SaaS) sides, at an increasing rate, with a wide range of other monthly IT services, high infrastructure provisioning, IT-aware and mature management decision-making, strong business embeddedness and significant cloud-related IT spending.

Low (close to zero) scores were given to companies where, on the contrary, not only cloud services do not yet exist (and are not planned), but also the infrastructure and personnel conditions, as well as business drivers (process automation, development, etc.) are not in place that could make the company suitable for this in the foreseeable future, or show the chance of development and positive prospects.

The index differentiates with a high degree of granularity, using multi-layer scoring to show nuances within the main categories, for example, how close a company is to adoption, whether it is close to adoption or not, and whether the conditions for adoption are met. Likewise, the aim was to be able to nuance the depth and embeddedness of cloud use in the business operations of companies using the cloud – to distinguish real, conscious, complex users (who often spend a lot on the cloud) from those who use cloud solutions only marginally, perhaps without consideration or choice.

The results of the survey show that in the size categories studied, smaller companies tend to have lower cloud maturity scores than larger companies. The vast majority of companies with 1-9 employees scored low, below 19 points, while the majority of larger companies scored between 30 and 59 points.

| | All enterprises with more than 1 employees | Enterprises with more than 250 employees | Enterprises with 50 to 249 employees | Enterprises with10 to 49 employees | Enterprises with 1 to 9 employees |
|---|---|---|---|---|---|
| | % | % | % | % | % |
| 0-9 points | 28.0 | 0.0 | 0.0 | 2.0 | 32.7 |
| 10-19 points | 35.1 | 1.1 | 3.9 | 20.4 | 38.2 |
| 20-29 points | 13.4 | 7.2 | 10.9 | 16.4 | 13.1 |
| 30-39 points | 10.3 | 13.9 | 16.6 | 24.2 | 8.1 |
| 40-49 points | 6.8 | 25.3 | 37.5 | 18.2 | 4.3 |
| 50-59 points | 3.2 | 21.5 | 13.2 | 4.1 | 2.7 |
| 60-69 points | 2.0 | 4.8 | 7.6 | 8.5 | 0.9 |
| 70-79 points | 8.0 | 17.9 | 7.6 | 4.2 | 0.0 |
| 80-89 points | 0.2 | 6.0 | 2.6 | 1.3 | 0.0 |
| 90-100 points | 0.1 | 2.4 | 0.0 | 0.8 | 0.0 |

***Figure 10:** Cloud Development Index by enterprise size class*

Based on the survey responses, companies in the industry segments surveyed typically have low cloud maturity. Most of them fall in the 10-19 point range, indicating a rudimentary level of cloud maturity. A minority of respondents have more advanced capabilities, but only a fraction of respondents has an outstanding score. It is fair to say that few companies have a score of around 100 (3 were identified in the survey). The construction industry has the highest concentration of scores in the survey, with 39.4% of respondents in this segment falling in the 10-19 point range, indicating a low level of cloud adoption.

| | All enterprises with more than 1 employees | Agriculture, mining | Manufacturing | Construction | Wholesale and retail | Logistics, warehousing | Finance and services |
|---|---|---|---|---|---|---|---|
| | % | % | % | % | % | % | % |
| 0-9 points | 28.0 | 29.1 | 19.0 | 33.1 | 25.6 | 13.2 | 30.6 |
| 10-19 points | 35.1 | 28.8 | 31.2 | 39.4 | 36.6 | 36.0 | 34.4 |
| 20-29 points | 13.4 | 22.5 | 17.2 | 10.9 | 12.3 | 11.1 | 13.5 |
| 30-39 points | 10.3 | 15.6 | 9.6 | 14.3 | 11.8 | 18.0 | 8.0 |
| 40-49 points | 6.8 | 1.9 | 17.5 | 0.7 | 6.8 | 12.1 | 6.2 |
| 50-59 points | 3.2 | 0.2 | 2.5 | 1.2 | 4.4 | 6.9 | 3.1 |
| 60-69 points | 2.0 | 1.7 | 1.7 | 0.0 | 0.8 | 2.4 | 3.1 |
| 70-79 points | 0.8 | 0.2 | 1.1 | 0.5 | 1.3 | 0.2 | 0.6 |
| 80-89 points | 0.2 | 0.0 | 0.1 | 0.0 | 0.1 | 0.0 | 0.4 |
| 90-100 points | 0.1 | 0.0 | 0.0 | 0.0 | 0.4 | 0.0 | 0.0 |

***Figure 11:** Cloud Development Index by industry sector*

## 4.4. Cloud Usage of Public Institutions

In Hungary, the development of the conditions for the use of cloud computing in the public / institutional segment started more than 10 years ago. The Government Cloud (KOF) project was launched in 2013 and has since been operated by NISZ Zrt.[53,54] This provides a basic level of cloud service (data storage and computing capacity) to the government and the Hungarian public administration institutions, without the additional benefits of advanced cloud usage detailed earlier.

The computing and storage capacity provided by KOF's infrastructure can be available to customers in a matter of minutes in optimal cases. KOF is a unified, centralized, virtualized infocommunications infrastructure with regular security audits. Connected institutions can replace their assets with virtual ones using KOF.

In addition, when moving to the cloud, it is important to plan properly, define the integration steps and obtain the necessary licenses. Pricing for KOF services is based on processor (CPU), memory (RAM) and storage size (HDD). Network traffic is part of the basic service at no extra charge.

A new unified Government Data Center (KAK) has been established under the Széchenyi 2020 program, which contributes to the operation of modern public administration with state-owned IT infrastructure. According to NISZ's statement, the new system aims "to enable one of the most secure data storage systems in Europe,"[55,56] and "...the Government Data Center (KAK), built as a result of the EU-funded project, is a state-of-the-art IT infrastructure with 1,531 m2 of floor space, which is expandable, offers cloud and hosting services and provides adequate accommodation for systems requiring the highest level of security. It has a capacity of nearly 8,000 terabytes. The KAK hosting is a stand-alone, separate environment of 731 m2, capable of meeting the needs of customers, typically for specialized equipment and specific configurations. The hosting service provides a reliable, redundant environment primarily for the consolidation of the computer rooms of NAV (National Tax and Customs Adminstration) and the Treasury...". [57]

In the context of the above, some respondents to our interviews added an additional layer of opinion to NISZ's statement: their feedback suggests that it is essential for the data center to continuously improve itself, not to stagnate at the initial deployment level, in order to be able to serve the ever-expanding user needs. Their responses indicate that a scalable, user-tailored, sophisticated cloud storage solution, with adequate hardware and software maintenance, would be more appropriate.

53 Government Cloud – Establishing a government data center and providing value-added IT services, [Link]
54 Government Cloud, [Link]
55 Modernization of public administration continues with a new Government Data Center, [Link]
56 Modernization of public administration continues with a new Government Data Center, [Link]
57 NISZ Zrt. – Faster public administration from the cloud, [Link]

# 05.

# Benefits and Economic Impact of Cloud Computing

To examine the economic impact of cloud computing, it is necessary to look at its operational benefits that ultimately drive the impact itself. The study looks at the opportunities enabled by the cloud: first from the perspective of the companies using it, then at the level of the national economy.

## 5.1. Potential of Cloud Computing for its Users

Cloud computing can provide a number of benefits for companies that can greatly contribute to maintaining or improving economic performance.[58,59,60,61]

**Scalability and Flexibility**

Market demand for companies' products often changes very quickly. Using cloud services can give them the flexibility to respond quickly, as in case of a rapid, explosive increase in demand they **do not have to go through the time consuming process of expanding IT infrastructure, with additional investment and commitment**. More resources can be immediately requested from the service provider instead, and if demand falls, this is easily reversible. In addition, service levels are contractually binding, so there is no exposure to risks stemming from locality. The cloud also reduces the risk of experimentation and innovation: there is no need to invest in new IT infrastructure and computing solutions to try new things, services can be consumed on demand, as needed for a particular project.

**Reducing IT Costs – Improving Efficiency**

With any form of cloud service, the user pays for the actual traffic and usage and does not need to invest in spare storage or computers. Furthermore, large cloud service providers enjoy economies of scale that other companies, especially in the SME sector, would not have access to on their own. Objective evidence of this is provided by a 2016 study from Deloitte, commissioned by the European Commission, which found that **cloud adoption reduces overall IT costs by 20-50%.**[62]

**Faster Work and Increased Focus on Core Activities**

Companies do not have to procure and install the IT peripherals needed to get up and running initially, so **they can enter the market faster**. Later in their lifecycle, they will not need to build up an IT operations department with the skills and staffing levels they had before, so companies (especially smaller ones) can focus on their core value-creating activities without having to give up the competitive advantage they may have from their speed and agility.

**Easier Cooperation**

By storing your data in the cloud, you **can make it accessible from anywhere, at any time, to anyone** via an internet connection. Data sharing or collaboration can impact business practices both at the employee level and across organizations. Organizations can modernize the way they work, improving collaboration through real-time access to shared resources, and supporting mobility and teleworking.

**Data Security**

Cloud service providers are contracted to **ensure the physical security of data** through geo-redundancy and backups.[63] Data stored in large service providers' data centers (with the customer and service provider sharing responsibility - „dual responsibility" concept) may be more secure than in an office or local server room, where the latest security updates might not be installed and unauthorized persons might have access to the premises.

58 Deloitte – Economic and social impacts of Google Cloud (2018), [Link]
59 Oracle – The Top 10 Benefits of Cloud Computing, [Link]
60 Google Cloud – Advantages and Disadvantages of Cloud Computing, [Link]
61 AWS – AWS investment in the U.S., AWS economic impact study (2023), [Link]
62 Deloitte – Measuring the economic impact of cloud computing (2017), [Link]
63 Geo-redundancy is a security and high availability measure whereby critical systems and infrastructure elements (such as servers) are located in geographically separated data centers.

An additional benefit of advanced cloud usage is that companies can use services developed with full functionality. For example, AWS has more than 240 complete services (SaaS) available, such as: computing power, data storage, database management, data analytics, networking, machine learning, artificial intelligence, Internet of Things (IoT), mobility, data security, virtual and augmented reality (VR and AR), media services, and application development, deployment, and management.

In the context of competitive advantage, it is also worth mentioning the potential *leapfrog* effect of cloud computing adoption, which can be observed in organizations that have compressed their digital transformation into a shorter timeframe (skipping a few steps, if necessary) by an aggressive and progressive technology strategy. These organizations typically show tremendous progress following successful digital transformation, while focusing on the core capabilities of their IT systems and embedding innovation throughout the organization.

According to a targeted study[64], organizations at the forefront of investing in – among others – cloud computing and artificial intelligence have seen their revenues grow up to five times faster than those not utilizing technology. Yet many companies have only recently begun exploring such technologies, largely to maintain the quality of their business and technology operations in a changing global environment.

It is important to note that **each company needs to consider its ideal cloud solutions on an individual basis and analyze them economically. The optimal use of the cloud may depend on the size of the company, the number of applications used, their lifecycle, their quality, and the amount of data used**. The benefits listed above are generic, but it may not be worth for every company to use all its IT services on a cloud basis. For example, if a company is dealing with a huge amount of data (several petabytes per day), it may be more efficient to store the data on-premises, but it may still be worthwhile to run its data processing applications through a cloud service provider.

## 5.2. Broader Economic and Competitive Benefits of Cloud Computing

The economic benefits of cloud computing are not only at the level of companies, but also at the level of the national economy, where it offers significant opportunities to support public administration processes. Cloud computing will facilitate and accelerate the digital transformation that is inevitable in the future, according to McKinsey's 2021 forecast, which predicts that the benefits of cloud computing could generate more than $1,000 billion for the global economy by 2030.[65]

Based on previous studies, the utilization and take-up of cloud computing has the following general economic benefits:

- **Economic boom**: according to McKinsey's research in Poland, cloud usage is driving significant economic growth in several sectors, with the most notable cloud impacts in the retail, consumer goods, transport and logistics industries.[66]
- **Manufacturing industry**: 42.8% of participating manufacturing companies in an AWS Germany survey say that cloud usage has contributed to product and service development, and around a third of respondents see a correlation between cloud usage and the success of the business model used.[67]
- **Education**: in many cases, cloud service providers are playing a role in increasing digital literacy in society. For example, Amazon plans to provide free technology skills training to 29 million participants by 2025.[68]
- **Sustainability**: using cloud services can be more energy efficient (for example, AWS infrastructure is 3.6 times more energy efficient than the average US enterprise data center, according to the company) and carbon emissions can be significantly reduced by up to 80% when using the cloud.[69]

In a regional analysis, BCG examined the economic impact of public cloud computing on countries in the Asia-Pacific region. They calculated that cloud computing had a measurable impact on annual GDP between 2019 and 2023. For each country, the following percentages apply:

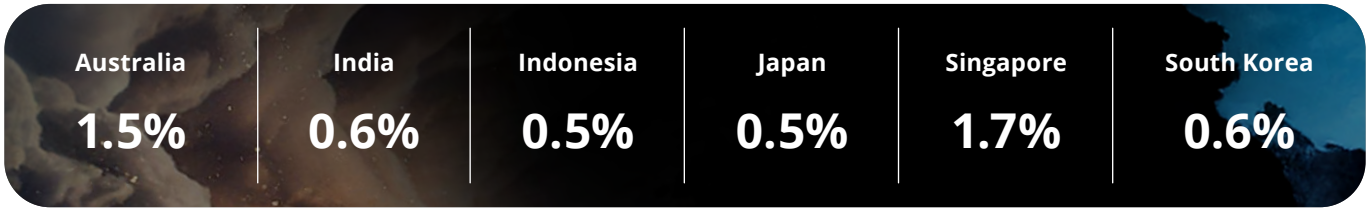



***Figure 12:** Share of countries' GDP generated from cloud services*[70]

64 Scaling Enterprise Digital Transformation | Accenture, [Link]
65 McKinsey: Cloud 2030: Capturing Poland's potential for accelerated digital growth
66 McKinsey: Cloud 2030: Capturing Poland's potential for accelerated digital growth
67 IW Consult – AWS impact study Germany, [Link]
68 AWS INVESTMENT IN THE U.S. – AWS Economic Impact Study, [Link]
69 AWS INVESTMENT IN THE U.S. – AWS Economic Impact Study, [Link]
70 Ascent to the Cloud: How Six Key APAC Economies Can Lift-off (bcg.com), [Link]

Although currently of limited relevance to Hungary, it is worth noting that, in addition to the benefits of cloud computing, large data center deployments can have further positive effects on a national economy:

- Construction and operation will create jobs for local businesses and residents.
- They generate significant tax revenues during both construction and maintenance.
- Spill-over effects of the investment are realized through supply chains, benefiting other industries.

A case study illustrates the potential economic impact of investing in technology: between 2017 and 2021, AWS invested nearly €700 million to build and operate new cloud centers in the AWS Europe (Paris) region, and between 2022 and 2031, it plans to invest a further €5.3 billion for similar purposes. In their 2022 economic impact study, they concluded that the €6 billion investment planned between 2017 and 2031 will generate €16.8 billion of GDP growth in the French economy over this period, including 5,271 full-time supplier jobs. [71]

## 5.3. Economic Impact of Cloud Adoption in Hungary

By conducting an econometric analysis on BellResearch's ICT Report database the company concluded that the **annual revenue per employee** of companies using cloud services is **nearly HUF 2.4 million higher** than that of their competitors not using such services.

In the econometric model, cloud usage (defined in accordance with the dichotomous model described in the chapter on cloud usage in the enterprise segment) was considered as an explanatory variable, with the industry classification and the size of the company as control variables. The dependent variable most strongly associated with cloud usage was annual revenue per employee, but BellResearch also examined several other variables in the modelling (e.g. absolute sales, percentage increase in sales, absolute profit after tax, percentage increase in profit after tax, profit after tax per employee).

Looking back to the previous two chapters, the mechanism behind the results may be shaped by factors such as:

- **Scalability and Resilience:** faster and more efficient work through cloud-delivered applications, without the capacity constraints of physical infrastructure slowing down the workflow, and with less downtime and service outages, resulting in higher overall work efficiency.
- **Reducing IT Costs – Efficiency:** a given level of output can be achieved with fewer employees, resulting in higher specific output for companies using the cloud.
- **Fast and Core-Focused Work:** more management attention can be focused on core activities, as less time is spent on IT. This reduces decision-making bottlenecks and induces more efficient core operations, thus helping to increase output.
- **Easier Collaboration:** shared work and collaboration in daily work reduces turnaround times, helps avoid duplication of effort, which in turn translates into increased work efficiency.
- **Data Security:** avoids additional recovery and rework due to possible data loss, i.e. eliminates potential inefficiencies.

Using the above outcome, we used an Input-Output model to examine the macroeconomic impact of cloud adoption over the next 10 years. Two scenarios were defined for the analysis:

1. In the **Conservative Scenario,** or the base case if you like, we have assumed a moderate further increase in cloud usage, with an average annual growth of 2.6 percentage points, reaching 71% of cloud take-up by the end of the period.
2. In the **Ambitious Scenario,** we have projected a higher growth rate of 4.1 percentage points per year, resulting in nearly 86% of enterprises using some form of cloud service by 2033.

The two scenarios can also be seen as different imprints of government actions and general attitudes towards the cloud:

1. In the **first case,** we assumed a neutral attitude, whereby the institutions regulating cloud use do not support it, but also do not discourage its use by regulatory means.
2. In the **second case** on the contrary, we assumed a supportive attitude, where the regulatory orientation explicitly promotes and encourages the use of cloud by companies.

71 AWS Economic Impact Study – AWS Investment in France, [Link]

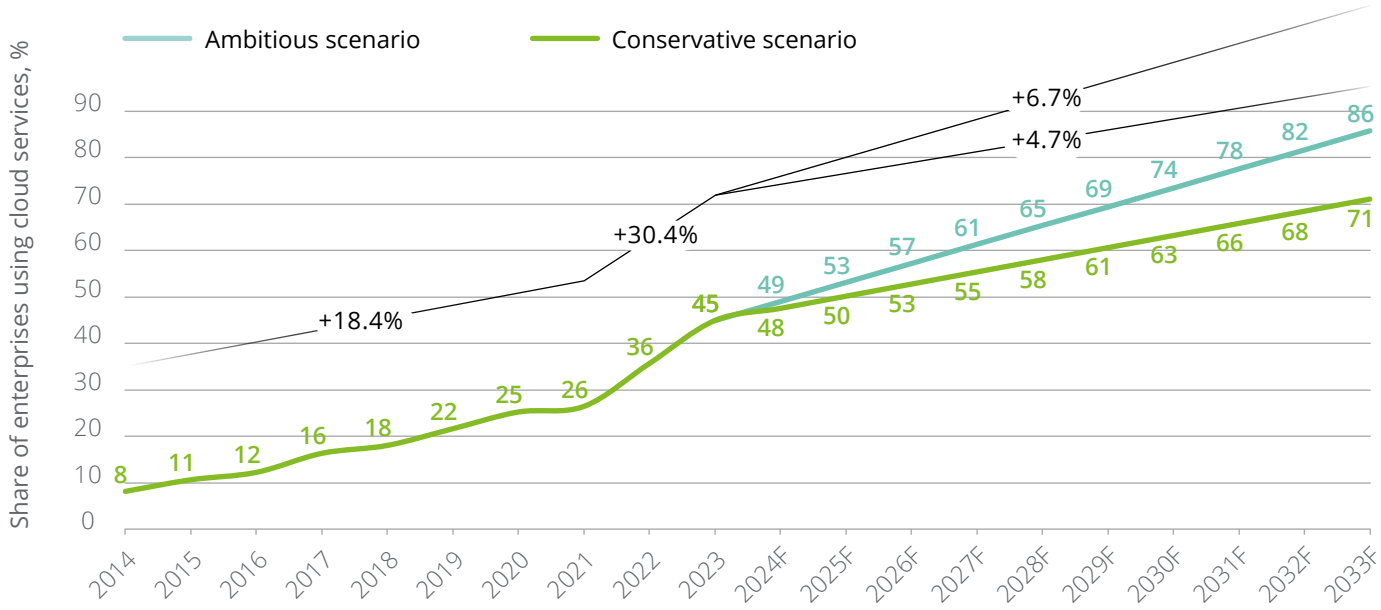
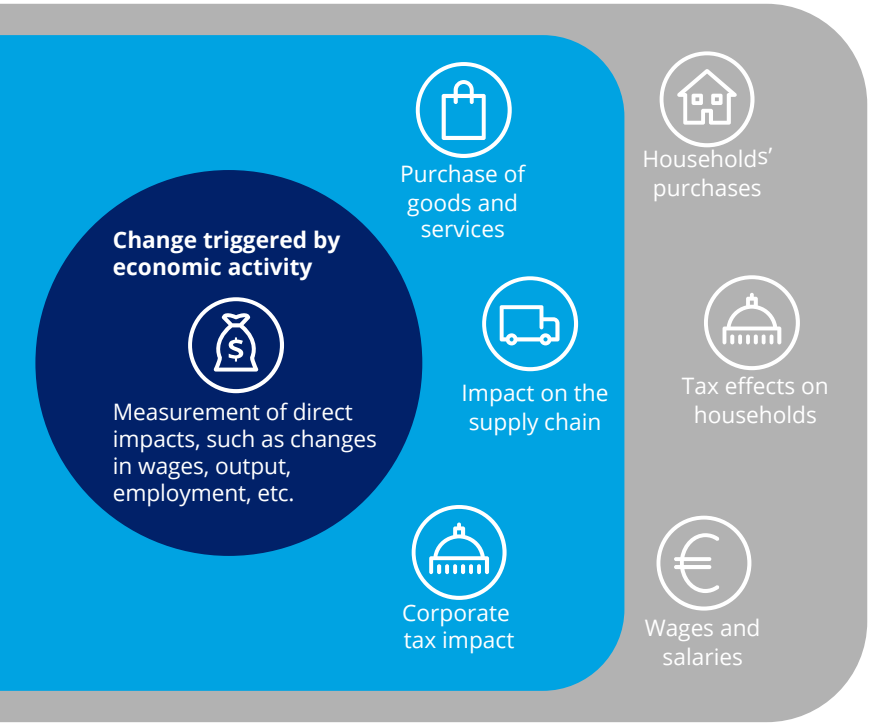



***Figure 13:** Evolution of the share of companies using the cloud in the ambitious and conservative scenarios up to 2033*

It is important to note that the above growth rates reflect the rate of cloud adoption by enterprises, not the growth rate of the cloud market itself. Industry forecasts suggest that the latter could grow at rates of up to 20% or more over the period under review, which could be slightly higher than the growth in usage rates due to two main factors:

1. In addition to volume growth, it is also affected by price increases.
2. The use of cloud services by the companies will also become more extensive and more diverse over time (e.g. a Microsoft 365 user will also use CRM and database services from the cloud).

We then quantified the direct, indirect and induced impacts using the I-O model. The direct impacts in this case are due to the increase in gross output by new firms entering the cloud user community. Higher output leads to higher GDP and tax revenues. Indirect effects also take into account the fact that higher output requires more products and services purchased from other industries, which leads to higher output in these industries, too, also increasing GDP, employment and tax revenues. Finally, households will also spend more of the extra income generated by the increase in output, which will trigger growth in new industries, creating induced effects.




**Direct Effects**
These are the initial changes that result from the economic activity. The I-O model will display how the country's economy will respond to these initial changes.

**Indirect effects**
These are the impact of industries buying goods and services from other industries as a result of the initia changes.

**Induced effects**
The response of the economy to an initial change that occurs through spending of income received by wage earners.

***Figure 14:** Typical impact mechanism of I-O models*[72]

72 What Can I do with Implan? [Link]

The estimated direct, indirect and induced macroeconomic impacts of the two scenarios are summarized in the table below:

| Indicators (10 years) | Conservative scenario | Ambitious scenario |
|---|---|---|
| Increase in corporate revenues (HUF billion) | 10,197 | 15,948 |
| Gross output (HUF billion) | 23,924 | 37,418 |
| GDP (HUF billion) | 12,704 | 19,869 |
| Employment (full-time equivalents) | 1,115,085 (or an average of 111,509 persons per year) | 1,744,056 (or an average of 174,406 persons per year) |
| **Tax revenues (HUF billion)** | **5,015** | **7,844** |

***Table 1:** Summary of macroeconomic impacts*

A **further increase in cloud usage** over the next 10 years **could add** on average **1.7%-2.7% to Hungary's GDP annually** (as a % of the 2023 base), depending on whether the governments' attitude is neutral or supportive towards the cloud. The **difference** between the two end points of the range **amounts to HUF 7,000 billion** additional GDP over 10 years.

# 06.

# International Best Practices

In this chapter, we review European (UK, Estonia, Italy) and non-European countries (Singapore) that have faced similar issues to domestic ones in the adoption of cloud computing over the past decades. These selected countries share a common commitment to new technologies, openness to digital developments, and significant resource allocation to education, all while maintaining a focus on security. The aim of this chapter is to briefly describe their efforts and successes and to provide an insight into the highlights of these developments in a consolidated case study format.

## 6.1. United Kingdom

### *Market Overview*[73]

**Public Cloud market size**

**26.73 billion USD**

gross revenue (2024)

**Most popular solution**

**13.61 million USD**

Software as a Service (SaaS)

**Annual growth rate**

**9.08 %**

CAGR 2024-2028

**Market volume**

**37.84 billion USD**

by 2028

### *Government Measures*

The UK Government is committed to technological progress and has developed the One Government Cloud Strategy (OGCS) to support this commitment. The aim is to encourage government institutions to move relevant functions of their operations to cloud computing under a unified vision and to continue operating according to this vision in the years ahead.

In 2013, the UK government became the first European country to introduce Cloud First regulations[74], and following the COVID-19 pandemic, more and more government institutions have decided to review their operational and technology policies, particularly with regard to data protection and cloud services. This had led to a wider adoption of hybrid or multicloud approaches. Simultaneously, the UK government is providing its institutions with controls, financial resources and other support frameworks to help them adopt cloud computing.

The Government Cloud (G-Cloud) is a UK Government initiative to facilitate the procurement of cloud services by government departments and to encourage the widespread adoption of cloud computing across government. G-Cloud involves a series of framework agreements with cloud service providers (such as Microsoft, Amazon, Google, Oracle) and the availability of these services through an online marketplace, the Digital Marketplace, which allows public sector organizations to compare and procure cloud services without undergoing a full tendering or procurement process. Participation in the Digital Marketplace requires a voluntary declaration of compliance, which is then verified by the Governmental Digital Service (GDS).[75]

G-Cloud's classification process was simplified in 2014 to reduce the time and cost for the UK government. Additionally, the government's security classification system was streamlined from six levels to three: Official, Secret and Top Secret.

**Simplified data classification model for the UK Government Cloud**[76]

| Official | Secret | Top Secret |
|---|---|---|
| Most of the information created or processed by the public sector involves routine business operations and services. While some of this information could potentially have harmful consequences if lost, stolen or disclosed to the media, it does not fall under a higher threat profile. | Highly sensitive information justifies enhanced security measures to protect against resilient and highly capable threats. For example, such threats could seriously damage military capabilities, international relations or the investigation of organized crime. | The UK Government's (HMG) most sensitive information requires the highest level of protection from the most serious threats. For example, a compromise could cause widespread loss of life or otherwise threaten the security or economic well-being of the country or friendly nations. |

73 United Kingdom Cloud Services Market, [Link]

74 Goverment Cloud First Policy, [Link]

75 United Kingdom Government-Cloud (G-Cloud) – Microsoft Compliance | Microsoft Learn, [Link]

76 UK gov introduces simpler security classifications – 90% of data now cloud friendly (diginomica.com), [Link]

The UK government's aim in introducing data classification is primarily to enhance data security and ensure that data is adequately protected according to its sensitivity and importance. The data classification model enables the government to tailor security measures, effectively manage risks, enforce regulations, optimize resource allocation, and ensure strong data protection throughout the data lifecycle.

### *Lessons Learned*

In 2019, the Government Digital Service conducted a back-test[77] to see if the "Cloud First" regulatory approach was still relevant six years later. The results of the survey confirmed that the strategic directions remain appropriate:

- Several government departments' strategies directly align with the "Cloud First" approach,
- many interviewed public servants emphasized the importance of the cloud in developing modern public services and transforming their organizations,
- numerous reports have highlighted significant efficiency gains following the transition to the cloud.

Ofcom reports[78] that government departments procured £363 million worth of cloud services under G-Cloud in the 2022-2023 fiscal year.

## 6.2. Estonia

### *Market Overview*[79]

**Public Cloud market size**

**120.1 million USD**

gross revenue (2024)

**Most popular solution**

**45.6 million USD**

Software as a Service (SaaS)

**Annual growth rate**

**13.71%**

CAGR 2024-2028

**Market volume**

**200.8 million USD**

by 2028

### *Government Measures*[80]

Estonia is a pioneer in creating a digital state and is further strengthening its position with the introduction of government cloud computing solutions. The introduction of government cloud solutions provides an excellent foundation for public services, **making Estonia the most "digital" country in the world**. The Estonian Government Cloud is managed by the Estonian IT Centre (RIT).

The Estonian government's cloud strategy aims to modernize and renew existing information systems to take advantage of the opportunities offered by cloud computing. This approach will enable greater flexibility in the delivery of e-services by government agencies and critical service providers to citizens. An additional benefit of a cloud server solution is that it helps integrate the Estonian public sector's currently siloed IT infrastructure into a shared resource-based system, allowing for more efficient use of data assets.

The Estonian government has developed a long-term plan to establish "Data Ambassadors", which are data centers located in friendly foreign countries, to support Estonia's digital independence and ensure the smooth operation of IT-based public services in case of emergencies. Luxembourg is the location of the first Data Embassy, chosen for its high-quality technical capacity and openness to new concepts. Through this cooperation, Luxembourg and Estonia are pioneers in creating a unique and innovative solution to ensure digital continuity worldwide.

### *Lessons Learned*

Estonia's recent digital regulation is an important step towards a secure, efficient, and digitally empowered future. It marks a breakthrough from traditional on-premises solutions to hybrid approaches, including the full adoption of public cloud infrastructures.[81] Estonian public institutions are gradually, rather than immediately, migrating from their existing systems to a government cloud solution developed according to ISKE (IT baseline security system) to ensure compliance with security and quality requirements, with a special focus on the confidential storage and handling of personal data.[82]

77 Technology in Government – Cloud First is here to stay, [Link]
78 Ofcom – Cloud services market study, [Link]
79 Public Cloud – Estonia | Statista Market Forecast, [Link]
80 e-Governance Cloud, [Link 1], [Link 2]
81 e-Governance Cloud, [Link]
82 Estonia's Bold Step Towards Public Cloud Adoption (linkedin.com), [Link]

The Data Hub is an extension of the Estonian government in the cloud, meaning that the state owns server resources outside its borders. This is an innovative concept for managing government data, as states typically store their data within their physical borders. The Data Hub resources are under the control of the Estonian state, providing protection against cyber-attacks and crisis situations using KSI blockchain technology. These resources are capable of not only backing up data but also running the most critical services.

## 6.3. Italy

### *Market Overview*[83]

**Public Cloud market size**

**10.7 billion USD**

gross revenue (2024)

**Most popular solution**

**3.3 billion USD**

Platform as a Service (PaaS)

**Annual growth rate**

**11.11%**

CAGR 2024-2028

**Market volume**

**16.4 billion USD**

by 2028

### *Government Measures*[84]

The Italian government's cloud strategy aims to provide long-term guidance for the deployment and maintenance of cloud solutions for public administrations. According to its principles, the move to the cloud will enable public administrations to provide modern, scalable, evolving, and cost-effective digital services, while maintaining a secure, efficient, and reliable technological infrastructure. This approach aligns with personal data protection and international data management practices, ensuring the country's strategic autonomy, public security, and control over its data assets.

Italy's strategy is based on three fundamental pillars:

1. **Classification of data and services:**

   To mitigate systemic risks, a key element of the Italian cloud strategy is a systematic data and service classification process to help standardize and manage migration to the public cloud. This classification process assesses the importance of data and services to determine the magnitude of damage caused by a potential compromise. These classes are defined as follows:

   - **Ordinary**: data and services whose disruption does not cause an interruption of public services and does not threaten the economic and social well-being of the country;
   - **Critical**: data and services whose compromise could affect social, health, security, and functions essential to maintaining the economic and social well-being of the country;
   - **Strategic**: data and services whose compromise could affect national security.

The classification focuses solely on the potential impact on the country, enabling the identification of security and regulatory requirements. For example, data and services related to government functions and services are classified as *Strategic*, citizen health data as *Critical*, and data and services related to institutional websites as *Ordinary*.

2. **Qualification of cloud services**

   To facilitate and guide the implementation of the Cloud First policy, Italy's Digital Agenda Agency has established a pre-certification scheme to ensure that the adaptation of cloud services is simplified and regulated from both a technical and administrative perspective. Qualified cloud services can be used by public institutions according to the data classification results, subject to the following restrictions:

   - **Average** data and services in a **Public** and **Encrypted Public** Cloud;
   - **Critical** data and services in an **Encrypted Public, Licensed Private/Hybrid** or **Private** Cloud;
   - **Strategic** data and services must be stored in a **Licensed Private/Hybrid** or **Private** Cloud.

   The data center of a public cloud must be located in Europe, whereas clouds with a more restrictive classification (Encrypted Public, Licensed Private/Hybrid or Private) can only be situated within the borders of Italy.

   Italy aims to create a digital marketplace akin to the UK's, providing public bodies with access to certified cloud services. The marketplace will offer a unified and streamlined procurement process, thereby facilitating digital development.

83 Public Cloud – Italy | Statista Market Forecast, [Link]
84 The Italian Cloud Strategy (innovazione.gov.it), [Link]

3. **National Strategy Hub (NSH):**

   The National Strategy Hub (NSH) aims to furnish public administrations with cloud computing and infrastructure that guarantee the highest levels of reliability, resilience, and independence. To achieve this goal, data centers will be established across various regions of the country, with operational management entrusted to national service providers meeting the requisite technical and organizational standards. These centers are tasked with ensuring data control in compliance with relevant legislation and facilitating the establishment of appropriate contractual terms between public administration and cloud service providers.

### *Lessons Learned*

Italy's National Cloud Strategy was devised to mitigate the technical and organizational risks inherent in the rigid procurement procedures of public institutions and the adoption of new services. Through the implementation of data classification and cloud service qualification mechanisms, the migration to the cloud infrastructure has established a secure, efficient, and reliable framework for delivering digital public services. These diverse cloud solutions adhere to both local and European data protection principles, ensuring the preservation of the country's strategic autonomy.

## 6.4. Singapore

### *Market Overview*[85]

### *Government Measures*[86,87]

The Government of Singapore is doubling down on cloud computing to deliver more flexible digital applications and services to its citizens. Over the past decade, a number of major initiatives have been launched to support

| Public Cloud market size | Most popular solution | Annual growth rate | Market volume |
|---|---|---|---|
| **7.3 billion USD** | **2.9 billion USD** | **14.32 %** | **12.5 billion USD** |
| gross revenue (2024) | Infrastructure as a Service (IaaS) | CAGR 2024-2028 | by 2028 |

Singapore's digital development:

4. **1. Government on Commercial Cloud**: In 2019, the Singapore Government launched the Government on Commercial Cloud (GCC) project to standardize the integration of government agencies into the public cloud. The GCC provides a platform for government agencies to adopt cloud services from providers such as AWS, Azure and GCP. This initiative aims to expedite procurement and licensing processes, allowing agencies to acquire commercial cloud services from the private sector at a reduced cost. By leveraging cloud service providers, agencies gain access to a global ecosystem offering off-the-shelf solutions for developing their digital services, eliminating the need to create entirely new, proprietary solutions. Furthermore, these cutting-edge ICT capabilities are complemented by robust cyber defenses and systems to safeguard data stored on commercial cloud platforms.
1. **Smart Nation Strategy**: As part of its commitment to digital transformation, the Singapore government initiated the Smart Nation Strategy[88], leading to the establishment of the Smart Nation and Digital Government Office in 2017. The overarching goal was to digitalize nearly 100% of transactions in the country by 2023. Leveraging data and new technologies, the government aims to enhance service quality, improve efficiency and productivity, and innovate new ways of engaging with citizens and businesses. The Ministry emphasizes the successful transition has been made possible by the dedication of public authorities, coordinated efforts among government agencies, and consistent financial support.
2. **Digital Academy**: The Digital Academy (DA[89]) established by the Government Technology Agency (GovTech), serves as a technology-focused learning institute that seamlessly integrates IT training with government operations. Through strategic partnerships with industry leaders like Microsoft, the Academy prioritizes the development of skills in areas such as data science, application development, and product management. By nurturing future leaders and managers adept at driving digital transformation within the public sector, the DA plays a pivotal role in advancing the Smart Nation Strategic Initiative. With a vision for a continually evolving digital public workforce, the government aims to enhance adaptability to new challenges and deliver more efficient services to government, businesses and citizens.

85 Public Cloud – Singapore | Statista Market Forecast, [Link]
86 Digital Government Blueprint (tech.gov.sg), [Link]
87 Building-Blocks-for-Digital-Transformation.pdf (microsoft.com), [Link]
88 Transforming SG Through Tech (smartnation.gov.sg), [Link]
89 Home – GovTech Digital Academy, [Link]

### *Lessons Learned*[90]

The Singapore government has demonstrated robust support for cloud computing within the public sector, notably through initiatives like the Government in the Commercial Cloud (GCC) service. This service streamlines and secures the adoption of cloud services from providers such as Amazon, Microsoft and Google. As part of their plans for 2023, the government aimed to increase the coverage included of government systems using commercial cloud services to at least 70%. This expansion in included mission-critical systems housing sensitive or confidential data, which are slated to operate on Amazon's new *Dedicated Local Zone*[91] service. With substantial resources and a steadfast commitment to digital transformation and education, Singapore has emerged as a global leader in ICT utilization. Since 2018, over 150 government systems have transitioned to the commercial cloud, and contracts totaling $870 million were signed in 2020 alone to further expand the number of systems in the commercial cloud.

**90** Inside the Singapore government's cloud journey | Computer Weekly, [Link]

**91** AWS Dedicated Local Zones, [Link]

# 07.

# Challenges and Barriers to Cloud Adoption

## 7.1. Obstacles

Despite all the advantages of cloud computing, there are several factors that hinder its adoption, some of which have already been mentioned in our study. The purpose of this chapter is to provide a systematic overview of the challenges and barriers to wider cloud adoption, based on our own professional experience, interviews conducted, and relevant factors found in literature review.

### 1. Lack of Human Resources / Competences

According to Statista's[92] global overview survey from 2020 to 2023, one of the biggest barriers to cloud adoption is the lack of competencies and skilled experts in cloud computing. In 2022, around 50% of respondents to their survey indicated this barrier in their response, which has slightly decreased by 2023, but still remains high at 37%, preceding others.

The main factors based on feedback from the interviews are as follows:

- **Expert Resource/Competence Gap**: some interviewees do not yet have the necessary technological competence to allow for a large-scale adaptation of the cloud. There is a lack of knowledge to enable operational development, maintenance, and day-to-day business operations to be cloud-based, and to be open to continuous technological and organizational evolution (the situation may shift by workers' generation change and related technological and cultural changes.)
- **Lack of Executive Knowledge**: the lack of appropriate decision-maker competences can further slowdown the adoption of cloud, as they may underestimate the potential financial and other benefits of cloud computing and may not embrace cloud transformation because of the (also not adequately understood) risks involved.

### 2. Lack of Understanding and Security Concerns

For the majority (63%) of users and decision-makers surveyed in BCG's 2019 survey[93], the biggest difficulty is lack of knowledge on public cloud. Some organizations are concerned about the perception that outsourcing data storage or processing to a third party inherently compromises data security. This perception may change over time as cloud computing becomes more widespread and as confidential computing solutions become more familiar and well-known, but for the time being, security concerns remain a recurring barrier for the organizations surveyed.

The main factors based on feedback from the interviews are as follows:

- **Data Security Concerns**: the shared responsibility model requires a new perspective on data security management, as service provider involvement and advanced cloud security features may lead users to underestimate their responsibility, creating real security risks. Therefore, particular attention should be paid to guaranteeing basic data and IT security principles (leaks of user or administrator login information can still be a risk) and managing the risks (especially the definition of service provider guarantees) when using cloud computing.
- **Business Continuity Risks**: in the event of a service disruption or anomaly on the service provider side, customers using cloud services have little opportunity to intervene effectively to restore services if their infrastructure (either on-premises or other cloud) is not prepared in advance. A cloud service outage is typically much lower risk (historical outage records are available for most cloud service providers such as AWS[94], Google[95] and Microsoft[96]) than that of an on-premises system's, but user-side preparedness is still required to maintain business continuity.
- **Lack of Awareness of Available Security Solutions**: security risks may increase if stakeholders do not know and understand the data security solutions offered by cloud service providers (e.g. user and administrator privilege management configurations, automated detection and response security systems [Detect&Response SecOps]). However, with the appropriate application of security tools and protocols, the security level of the solutions is usually increased thanks to cloud transformation.

### 3. Budgetary Constraints

Financial challenges can also be a major limiting factor for cloud adoption and growth, though moving to the cloud typically requires much lower CAPEX resources than a traditional IT transformation but it is often difficult to accurately estimate the subsequent maintenance costs. To measure the costs and keep them under control, it is necessary to hire FinOps specialists.

92 Barriers to cloud adoption worldwide 2023 | Statista, [Link]
93 Ascent to the Cloud: How Six Key APAC Economies Can Lift-off, [Link]
94 Post-Event Summaries (amazon.com), [Link]
95 Google Cloud Service Health, [Link]
96 Azure status history | Microsoft Azure, [Link]

The main factors based on feedback from the interviews are as follows:

- **Lack of Financial Means:** some organizations or public institutions do not have the resources to move their systems to the cloud, even if the benefits of cloud computing outweigh the costs in the medium to long term.
- **Underestimating the Potential Financial Benefits:** lack of awareness and understanding of the potential uses and benefits of the cloud can be a barrier to cloud adoption. In Deloitte's analysis[97], 14% of companies using public cloud reported a lack of awareness, which may be even higher among non-cloud users.

**4. Regulatory Challenges**

Regulatory constraints, whether on the governmental or organizational side, mostly manifested in restrictions regarding the place where data are stored, processed or transferred. Many of these restrictions stem from data protection or public procurement legislation, including prohibitions on transferring data across borders, requirements to keep local copies of data or to process data locally.

The main factors based on feedback from the interviews are as follows:

- **Restrictions on Cross-Border Providers**: rigid regulation of international providers can hinder the spread of technology and can also reinforce the aforementioned budgetary barriers if users cannot buy global or regional cloud services.
- **Inconsistency of Procurement Rules**: some respondents argue that current procurement rules are not compatible with the specific (on-demand) nature of cloud computing, as they are not applicable to the up-front procurement of operational (OPEX) costs in the IT area, as opposed to other procurement areas (e.g. electricity or natural gas).
- **Regulatory Risk-Aversion**: risk-avoidant regulatory attitudes (e.g. requiring data to be stored on home servers, requiring resource-intensive disaster recovery and disaster management processes and solutions to be designed, requiring extremely high service continuity levels, etc.) lead to regulations that impose high entry thresholds for cloud computing (companies adopting them must ensure that they comply with strict precautions).

**5. Technological Limitations**

Technical barriers can also affect the use of cloud services, especially if they require moving data or applications and creating interfaces between different systems.

The main factors based on feedback from the interviews are as follows:

- **Low Internet Coverage in Rural Locations**: the availability and bandwidth of local internet service, as well as the internet serving capacity between the customer and the service provider, can all be factors in the uptake of cloud computing (without sufficient speed and capacity of public or private network coverage, the utility nature of IT to be available at any time from anywhere, cannot be realized).
- **Lack of International Standards**: in many cases, custom-built IT systems do not use common standards and interfaces, which can lead to a number of technically complex issues that require specific expertise to resolve.

**6. Commitments**

Previous contractual commitments can be a barrier in cases where an organization is "locked-in" to the cloud service provider through its specific applications and other integrated services, preventing a convenient switch. This can sometimes create an uneven playing field and even prevent an organization from adopting a multi-cloud solution, resulting in a financially or technologically disadvantaged situation. Legacy IT obligations may also delay or prevent migration to the cloud.

Based on interview feedback, vendor switching can be further complicated if the local IT organization no longer has the competence to transform the IT infrastructure due to a commitment to the chosen cloud service provider. To address this risk, vendor[98] and regulatory[99] solutions have already been proposed that can provide support to stakeholders.

97 Deloitte – Economic and social impacts of Google Cloud (2018)

98 Cloud exit planning guidelines for financial services institutions – Microsoft Industry Blogs, [Link]

99 EBF-Cloud-Banking-Forum_Cloud-exit-strategy-testing-of-exit-plans.pdf, [Link]

## 7.2. Data security concerns in the cloud

Focus on data security concerns reflect the importance of cybersecurity in today's economy as much of the global economy's cumulative data assets are now transmitted or stored digitally, hence the loss or corruption of data can cause serious damage to companies, public institutions and individuals alike.

In the early history of the cloud, on-premises solutions gave data owners better control and allowed for custom security measures. During this period, the pooling of large amounts of data assets from different sources in a public cloud posed a *single point of failure* risk. However, the management of these – and similar – risks[100] has developed a lot. These effective risk mitigation approaches should not be neglected when considering the applicability of cloud computing to specific tasks.

Careful use of cloud computing can lead to enhanced data security. Large public cloud service providers have access to a diverse and broad range of expert resources and take advantage of economies of scale, so that their investments in physical, logical or custom security can be leveraged by their customer base. This broad customer base also provides a powerful incentive for such investments, as any breach, loss of data or loss of service would have significant commercial and reputational consequences. Through a combination of access to cloud resources, economies of scale and incentives, **cloud service providers can provide an advanced level of security that is harder for customers to achieve by building**, developing and operating their **own physical infrastructure**.

The potential data security benefits of using proven high quality public cloud services with appropriate technical certifications include:

- **Data encryption.** Cloud service providers can offer a wider range of data encryption solutions than those achieved via internal competence of organizations. Examples include horizontal scaling ("sharding"), where each data packet is broken down into smaller sub-packets ("shards"), encrypted and then physically stored in different locations, while still logically forming a single entity. Thus, even if a physical storage location becomes unavailable, the unit is preserved, ensuring that data integrity is maintained. Logical separation allows for the implementation of additional data replacement procedures that can recover missing data packet elements in the event of physical data loss. The encryption methods provided by Privacy Enhancing Technologies (PET) can be more easily developed in the cloud. This includes differential privacy, homomorphic encryption and several other privacy solutions.
- **Authentication.** Public cloud services offer a wide range of authentication methods, including two- or multi-factor authentication for regular users and physical security keys for critical or vulnerable users.
- **Control and flexibility.** Even though users of public cloud services do not own and operate the underlying infrastructure, they can still use a number of control mechanisms to configure their specific access and security settings, depending on the services they choose (e.g. AWS Systems Manager Explorer[101], Google Cloud Resource Manager[102] and Microsoft Azure Resource Manager[103]).
- **Physical security.** The big public cloud service providers have considerably higher level of expert resources to achieve, maintain and continuously ensure a sufficient level of security for each physical data center compared to what users could provide for on their own. As we have shown before, the broad customer base of public cloud service providers provides a strong incentive for all security investments, and specifically for physical security investments. **It should be stressed that the physical location of data is not the only factor of data security and control, as all interconnected IT system components – whether data storage or user devices – are exposed to general cyber security risks that cannot be adequately addressed by localisation measures only.**

    - The assumption inherited from the early days of the cloud was that the best way to protect data was to require it to be stored in-country. However, with advances in data security technology, control over data is no longer a geographical issue and is not primarily a matter of further developing physical protection. The dual objectives of exploiting the value of data and protecting data are now best served by logical-level protection tools that do not require storage in a specific geographical location.
    - The trend that logical level protection is becoming more and more important both inside and outside the cloud is demonstrated by the fact that the vast majority of successful attacks on data are not carried out by physical means, but by some logical means or method. Therefore, improving logical protection is a bigger step towards total data security than investing additional resources in preventing physical attacks that cause less damage. Moving our data to the cloud opens up the possibility of applying additional logical defenses.
    - Storing data within a country not only addresses but also creates risks. For example, in-country storage is particularly contraproductive in mitigating extreme geopolitical risks.

**100** Concentration_Risk_Perspectives_092020.pdf (microsoft.com), [Link]

**101** AWS Systems Manager Features – Amazon Web Services (AWS), [Link]

**102** Resource Manager | Google Cloud, [Link]

**103** Azure Resource Manager overview – Azure Resource Manager | Microsoft Learn, [Link]

- Balanced regulation on data localization is also very important because cloud computing requires large scale of operation, which is not compatible with fragmentation of data by countries. Unfortunately, offshore storage is not a matter of choice, but the necessary precondition for the full realization of true cloud benefits. Paradoxically, over-emphasis on data location does not reduce but increases the real, practical risks regarding data by making it more difficult to take advantage of the protection measures offered by the cloud.
- One example of modern security solutions available in the cloud is confidential computing, which provides cryptographical protection of data at all stages of its lifecycle in the cloud, including the stage of data usage. Confidential computing thus satisfies the user and regulatory demand for not only legal, but also cryptographic protection of data in the cloud service provider's systems – even from the cloud service provider itself. Previous cryptographic methods only protected data at rest and in transit.

- **Innovation.** Again, given the wide range of resources and incentives available – as mentioned above – public cloud services are in a great position to constantly develop new solutions to mitigate the risks of their services, exploiting and researching the latest technologies and responding promptly to new threats.
- **Automated processes.** When deploying and managing your own IT infrastructure, security risks often arise from human error, for example, not checking that all user passwords set and continuously updated are secure due to the lack of resources or not installing up-to-date, tested software updates and security patches. In many cases, such processes are automated by public cloud service providers, potentially reducing the risks associated with manual work.

# 08.

# Recommendations

The challenges and constraints identified above are hindering or delaying the adoption of cloud computing for many organizations, which could put Hungary and local businesses at a disadvantage in terms of competitiveness and economic benefits. As our macroeconomic analysis has shown, government policy makers could induce economic growth by introducing measures that address the challenges associated with the use of cloud computing. The study proposes 3 sets of recommendations for policymakers that cloud serve as guidance to support cloud take-up:

1. Developing a Cloud Strategy
2. Building Government Commitment and Favorable Regulatory Environment
3. Supporting Cloud Adoption of SMEs

## 8.1. Developing a Cloud Strategy

Although our study goes on to list a number of measures that we consider necessary, this is no substitute for a national cloud strategy, which may also take other aspects into account. Following the examples of international best practice presented earlier, we believe that a well-thought strategy could credibly and emphatically articulate the full range of changes needed for the sake of enhanced use of cloud computing and thus provide a direction for the future. We propose that the strategy should serve as a first step towards creating a more cloud-friendly and mature cloud-user Hungary. The measures presented in the following sub-chapters are a suggestion for the guidelines of the cloud strategy that the authors of the study believe is needed.

### Main measures proposed in the short term:

1. **Developing a national cloud strategy based on Cloud First policy**, which recommend regulatory measures and programs that:
    - puts the Hungarian data at the service of national and economic goals by continuously identifying and implementing the most appropriate technical and organizational methods,
    - fully meets the need to protect data and information of national security, economic and other value in the face of constantly evolving risks,
    - identifies and develops innovative solutions to achieve all of the above,
    - mobilizes the resources and expertise of government and the private sector,
    - is in line with the relevant EU recommendations.

A Cloud First policy encourages government agencies to consider cloud native[104] solutions first before other alternatives. A cloud strategy not only helps public organizations to operate more efficiently and reduce costs with cloud-based solutions, but also provides an opportunity for the private sector to drive digital transformation and increase its competitiveness. Effective Cloud First policies (e.g. also in the case of the UK or Singapore) are usually accompanied by additional measures, which are explained in the following subsections.

The national cloud strategy should set out the funding needed for implementing actions, the resources required, the action plan and the responsible parties, in order to create a viable, result-oriented program. Along these strategic lines, a joint effort by government and the private sector can enhance the country's digital infrastructure and competitiveness in the global market.

## 8.2. Building Government Commitment and Favorable Regulatory Environment

The OECD (Organisation for Economic Co-operation and Development) also recognizes[105] that governments, as early adopters of new technologies, can have a significant impact on wider uptake, for example in cloud computing. The move by governments to cloud services not only encourages innovation, but also sets high security and regulatory standards that can foster trust and adoption of cloud computing in the private sector.

As part of a national cloud strategy, government commitment and the right regulatory environment are of paramount importance. A **stable and transparent regulatory environment** provides a secure, reliable and legally clear operating framework that **protects data** and minimizes risks. In addition, well-designed regulations **reduce red tape** and **facilitate international cooperation**, which is essential for maintaining global competitiveness and economic growth.

104 Cloud native refers to an approach to designing and developing cloud-based applications and services that is specifically optimized for the cloud environment.

105 Stimulating digital innovation for growth and inclusiveness : The role of policies for the successful diffusion of ICT | OECD Digital Economy Papers | OECD iLibrary (oecd-ilibrary.org), [Link]

Main measures proposed:

*Short term:*

1. **Establish data classification** for public sector data to facilitate decisions on cloud usage and its implementation. In the UK, for example, a simplified model has been introduced that defines three data levels (Official, Secret and Top Secret), with different protocols for storing data depending on the data level.
2. **Review data localization policies, assess the potential of confidential computing** in line with data classification, so that all data except those requiring the highest level of protection can be stored in foreign data centers of public cloud service providers, while maintaining an appropriate level of security.
    - With confidential computing technology and similar advanced protection methods, Hungarian governments and companies can have full control over their data even when it is in the cloud service provider's foreign data center.
    - Confidential computing is one of the keys to preserving Hungarian data sovereignty in the case of foreign (global or regional) storage.
    - As part of the review of the data localization provisions, we propose to set up a working group of experts from government, academia and service providers to examine the applicability of confidential computing in the light of data sovereignty objectives.


3. **Develop a cloud-friendly procurement process in line with a Cloud First policy,** allowing government organizations to select cloud service providers on a case-by-case (on-demand) basis. This process should allow organizations to account for the cost of the IT platform as operating expense (OPEX), an alternative to the traditional upfront investment (CAPEX) model. The procurement policy should detail aspects such as the tendering process and evaluation and selection criteria.

*Medium term:*

4. **Develop a public sector migration plan** by a dedicated organization to ensure a smooth transition to the cloud. The transition can reduce the cost of government services and improve their availability, quality, efficiency and security. Cloud infrastructure will facilitate the upgrades/replacements required every few years for the vast public sector IT systems, which currently require an extraordinary investment of time and resources. Developing a reliable template can also help the private sector to support the digital transformation of businesses.
5. **Increase the technological competence of public institutional actors**, including cooperation with cloud service providers. The interviews with business and institutional stakeholders highlighted that cloud computing competence-building is a priority, without which an effective transition is not possible. For example, the Government of Greece considers achieving an adequate level of technological expertise as a pillar of its digital transformation, which has facilitated its development.
6. Appoint so-called **"Cloud Ambassadors"** in the public sector to lead and promote cloud computing. They can be appointed through government agencies or from the private sector.

*Long term:*

7. Provide guarantees, in cooperation with industry, to ensure that **cloud service providers do not** unduly **restrict the portability** of **data and applications.**
8. Other proposed measures to support public procurement:

   a. **Develop framework agreements** with potential cloud service providers to streamline public sector procurement processes.
   b. **Create a digital marketplace** to facilitate the procurement of cloud services for government departments. In the case of the UK, the local platform provides the opportunity to compare different certified services, procure them directly and support their implementation.

9. **Continue and intensify discussions with cloud service providers on the establishment of a Hungarian / regional public data center / edge location.** Edge locations have a place in the global service architecture, especially in use cases where storage location and latency are critical factors. The establishment of data centers in nearby countries such as Poland, Austria or Serbia may provide the momentum for the domestic implementation of data centers or at least so-called cloud "on-ramps".[106]

## 8.3. Supporting Cloud Adoption of SMEs

Limited awareness and understanding of the benefits and risks of using the cloud is hindering wider uptake. As discussed in the *Challenges and Barriers to Adoption* chapter, many organizations have limited understanding of the benefits and features provided by cloud service providers. To gain a broader understanding of the potential benefits, more competence is needed, both for cloud migration in general and for advanced cloud services such as artificial intelligence.

### Main measures proposed:

*Short term:*

1. **Designate** or create **an organization to coordinate the migration** of Hungarian companies to the cloud, with the task of implementing the following measures, launching programs and providing professional advice.
2. **Create a central online platform** with key information on the cloud, such as the benefits of the cloud, practical steps to move to the cloud and best practices.
3. **Develop** easy-to-use, **practical guides** for businesses on cloud security features, including in partnership with cloud service providers.
4. **Host knowledge-sharing presentations and workshops** in cooperation with businesses that have successfully migrated data to the cloud.

*Medium term:*

5. **Provide resources and financial support** to businesses to facilitate migration to the cloud. At international level, programs in Singapore and South Korea, for example, are providing funding, advice and training to local businesses to make good use of cloud-based digital solutions. Financial support can take several forms:

   a. Similar to the previously successful voucher scheme to encourage domestic solar installations, whereby the state subsidizes the migration of companies at a decreasing intensity.
   b. By setting up a credit support scheme with cloud service providers, whereby the state would offer vouchers purchased from cloud service providers to companies that can demonstrate a suitable migration plan. This option, in addition to ensuring that the subsidy is used for the intended purpose, is likely to generate significant national and international attention.
   c. The government could also provide tax incentives for businesses that invest in the deployment of cloud computing, thereby reducing the cost of migration.

6. **Develop cloud certification programs, as part of digital upskilling courses or as stand-alone programs** in partnership with cloud service providers to support individuals and businesses in developing a general understanding of cloud computing in key areas such as AI, machine learning, data science or cybersecurity, and to provide qualifications for individuals who have the necessary expertise in cloud platforms, services and architectures. The European Commission's Digital Education Action Plan provides a useful framework for technology-related skills initiatives and objectives.

106 Cloud on-ramp (also known as "cloud connect") is a private, direct connection to a cloud service provider. On-ramps allow organizations to connect their data center infrastructure directly to cloud services without using a public internet network. What is Cloud On-Ramp? The Ultimate Guide (phoenixnap.com), [Link]

7. **Create a dedicated portal for comparing cloud service providers**, which will help companies to choose a provider by indicating key aspects (e.g. security, compliance with industry-specific regulatory requirements). In Germany, the "Trusted Cloud" initiative is available to showcase and compare cloud services that meet stringent local standards in terms of security and privacy. This initiative helps businesses and institutions to find the right cloud service provider for secure data storage and management, which could be implemented within the budget of the coordinating organization.

## 8.4. Evaluation of Recommendations

Looking at the efforts needed to implement the measures[107] and the impact they will have[108] , certain focus areas emerge. It can be said that the proposals would all have a medium to significant impact on cloud adoption. Promising quick wins include the creation of a central online platform (3.2), the designation of a coordinating organization for cloud adoption by enterprises (3.1), and the establishment of a data classification (2.1). In addition, increasing the technological competence of institutional actors (2.5) and developing framework contracts with cloud service providers (2.8a) will also have a major impact but will require more effort. While it is useful to consider the individual complexity and impact of the measures, the logical relationship and sequencing between them are also important aspects of scheduling, again underlining the need for a cloud strategy.

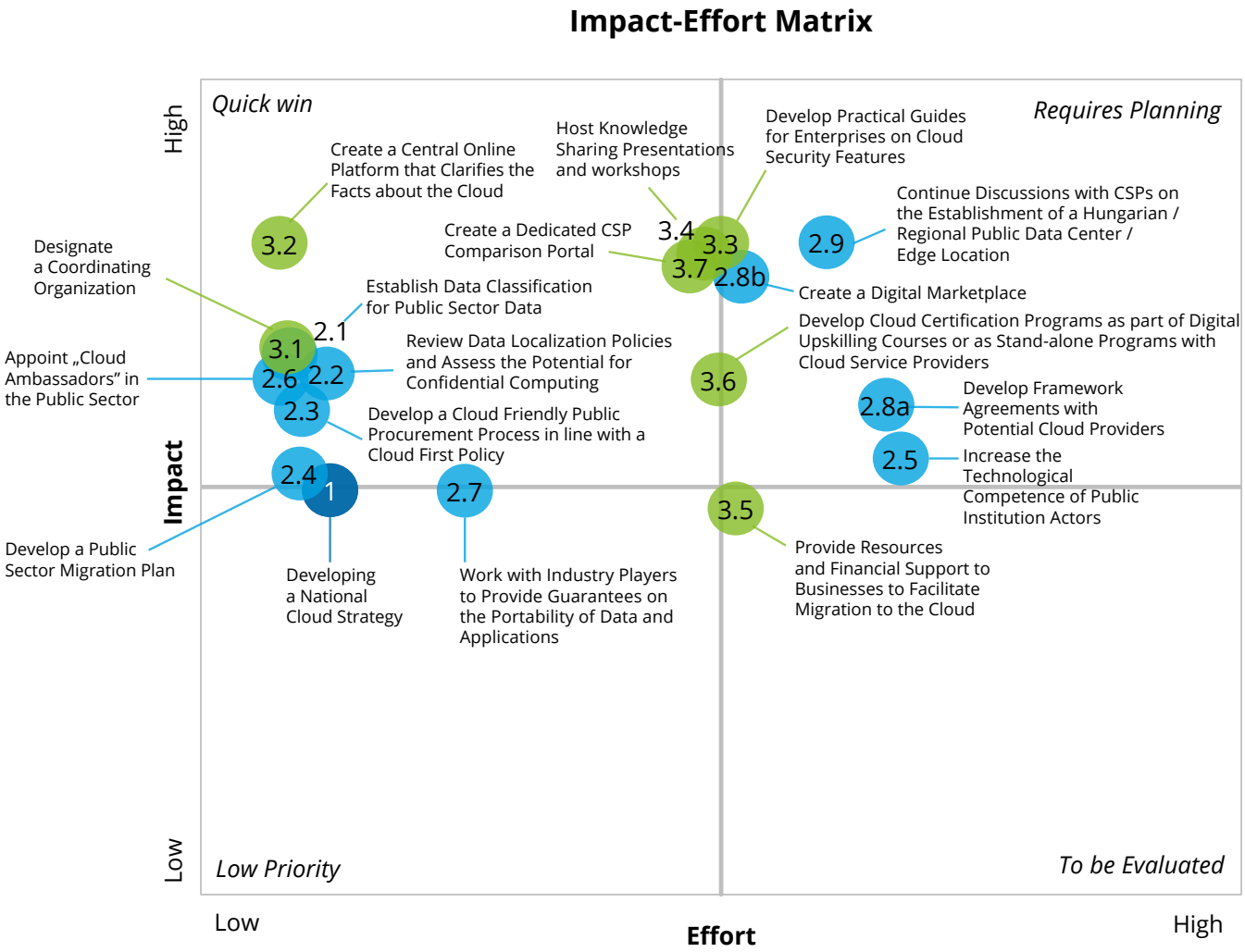



*Figure 15: Impact-Effort matrix of proposed measures*

107 Sub-criteria taken into account: high level costs, implementation time, government influence

108 Sub-criteria taken into account: industry impact, driving force for cloud adoption, time to deliver results

## 8.5. Related Areas

Given that cloud computing is closely interlinked with other technologies and that they influence each other in various ways, we believe it is worth drawing attention to these interconnections.

**Artificial Intelligence**: we have previously described the benefits that cloud computing offers for AI. Accordingly, we believe that efforts to widely deploy the two technologies need to be synchronized. We recommend that the future cloud strategy should be developed with the involvement of the Artificial Intelligence Coalition and take into account Hungary's Artificial Intelligence Strategy.

**Telecoms Infrastructure**: as pointed out in the *Challenges and Barriers to Cloud Adoption* chapter, reliable and fast telecoms networks are needed to access cloud services and transfer data. The fundamental benefits of cloud services can be undermined if fixed or mobile broadband coverage does not provide consistent availability and performance. And from a telecom's perspective, the assumed growth in the use of cloud services, which our study has tried to predict, and which will certainly be addressed in the future cloud strategy, will lead to an increase in data traffic and network load. It is therefore appropriate that government efforts to stimulate the adoption of cloud computing and those for telecommunications networks are aligned. It is proposed to initiate a dialogue with the bodies responsible for and supporting the national telecom strategy, such as the 5G Coalition, and to channel the needs in each of these areas.

# 09.

# Annexes

## 9.1. Difficulties in Applying the NIST Definition in Practice

Unfortunately, the practical applicability of the NIST definition is limited by the fact that it proposes to distinguish cloud from its alternatives on the basis of criteria that are difficult to measure and does not provide thresholds for these criteria. Practical applicability is further limited by the fact that the large number of not clearly prioritized criteria (five) has led to a feeling of empowerment among practitioners to consider platforms that meet only some of the five criteria as cloud. As other actors considered another subset of criteria as mandatory or other levels of criteria as entry thresholds, it was increasingly the intention of the developers rather than the objective characteristics of the platform that determined what was labelled as a cloud. Without qualification, the term cloud became difficult to use for the purposes of professional discourse.

In the business context, definitional uncertainty has been further increased by some actors attributing the cloud label as a sales enabler and attaching it to certain services without justification. This conceptual looseness led to interpretive disputes in which other operators preferred to escape the controversial cloud term and did not use the term cloud for services that met the NIST criteria more tightly than platforms previously called cloud.

The NIST definition is not expected to help define the cloud on the business level, as it is only intended to provide a technical (architectural) definition of the concept. For this reason, for example, when discussing the "rapid elasticity" and "on-demand" criteria, which are among the five characteristics, the NIST definition does not address whether ceasing demand at a time or stopping the use of a cloud service in the sense of elasticity reduces the cost to the customer (the amount of the next monthly invoice). The economic importance of the cloud is whether the cost is immediately reduced by discontinuing its use, without which cloud services cannot be considered more innovation-friendly and elastic than traditional platforms. The NIST definition is also met by a service in which the reduction in the volume of use frees up resources only in technical terms but does not reduce costs.

For the above reasons, we have supplemented the NIST definition and made it more practical by considering the *economic impact of the service* in question.

## 9.2. Methodology Used in Modelling Microeconomic Impacts

### Source of Input Variables

The source of the input variables is BellResearch's regular market research, the Hungarian ICT Report 2023.

### Interpretation of Cloud Penetration Used in the Impact Assessment

Companies were classified as cloud users if they used at least one of the following three application areas:

- Microsoft 365 service
- any IaaS service
- any PaaS service

The main reason for including IaaS and PaaS penetration in the model is that these were the ones best describing advanced, infrastructure-based cloud adoption among the available set of variables.

Microsoft 365 take-up was our best approximation of SaaS in the variable set. For this reason, and because of the lack of variables to split Microsoft 365 users into basic and advanced users, especially for micro enterprises, we were forced to include the entire Microsoft 365 user group in the model for the analysis.

## The Modelling

Cloud usage is represented in 4 different defined inputs in the models:

- **Narrow Definition of Cloud (in technological terms)**
- Broader Definition of Cloud (business, user-side approach)
- Cloud Usage and IT Development Index (on a scale of 0-100)
- Cloud Usage and IT Development Index in 3 Categories (low, medium, high)

The explanatory variable was tested with the following indicators:

- **Annual Revenue Per Employee**
- Percentage Change in Annual Revenue 2022/2021 (Growth Rate)
- Percentage Change in Annual Revenue 2022/2020 (Growth Rate)
- Percentage Change in Annual Revenue Per Employee 2022/2021
- Percentage Change in Annual Revenue Per Employee 2022/2020
- Nominal Difference in Annual Revenue 2022-2021
- Nominal Difference in Annual Revenue 2022-2020
- Nominal Difference in Annual Revenue Per Employee 2022-2021
- Nominal Difference in Annual Revenue Per Employee 2022-2020
- Nominal Difference in Profit After Tax Per Employee 2022-2021
- Nominal Difference in Profit After Tax Per Employee 2022-2021

Of all the possible combinations, the highlighted version ("narrow" cloud definition and annual revenue per employee) showed the most consistent results.

Control variables were size class (based on number of employees) and industry sector in all models.

Two versions of the models were produced, the first with only these two control variables and the second with the revenue category as a third control variable. Of these, the second version clearly produced better results. Only these models are presented below.

Two subversions of these models have been produced:

- Mod1: Basic extreme value filtering: annual revenue per employee < 500 m HUF
- Mod2: Higher level of extreme value filtering: annual revenue per employee < 100 m HUF

The results of the second version were used for further calculations due to the goodness of fit. In the second subversion, cloud usage according to the narrow definition of cloud was given the following coefficient in the model:

- Mod2: 2,388.5 (k HUF, $R^2$ : 0,3389, corrected $R^2$ : 0,3255)

According to the above results, each employee of companies using the cloud generates HUF 2.4 million more revenue per year than their counterparts not using cloud services.

## 9.3. Methodology Used in Modelling Macroeconomic Impact

A 4+1 step methodology was used to estimate the expected macroeconomic impacts of cloud usage in Hungary over the next 10 years. A model based on the latest input-output tables published by the Hungarian Central Statistical Office (KSH) was used for the calculations. The input-output tables describe the supply chain interconnections of the Hungarian economy in a detailed, static, industry-by-industry breakdown, showing in a matrix structure how much input each industry uses from the goods produced by other industries, and how much output and value added it generates. The consumption side shows what percentage of goods produced by the different industries are being consumed by households and government.

The modelling steps were as follows:

**0.** The input data was the result of the regression analysis described in the previous section, which shows that the annual revenue per employee of companies using the cloud is nearly HUF 2.4 million higher.

**1.** We then outlined two alternative cloud deployment trajectories for the 10-year horizon under consideration. Of these, the conservative trajectory assumes an environment free of regulatory intervention, while the ambitious ramp-up assumes a positive regulatory attitude and the implementation of supportive measures.

**2.** The estimated microeconomic impact was aggregated for the two development paths using the business statistics (e.g. number of companies), which served as input data for the I-O modelling of the macroeconomic effects.

**3.** The direct macroeconomic effects are calculated by considering the increase in output of companies using the cloud and the resulting income, employment and tax effects.

**4.** To fully estimate the indirect and induced effects, we used industry multipliers calculated from the I-O model to estimate the total impact on GDP, employment and tax revenues. The indirect effects summarize the additional output and income generated in the supply chain, while the induced effects describe the additional output and income generated by consumption expenditure on the resulting labor income.

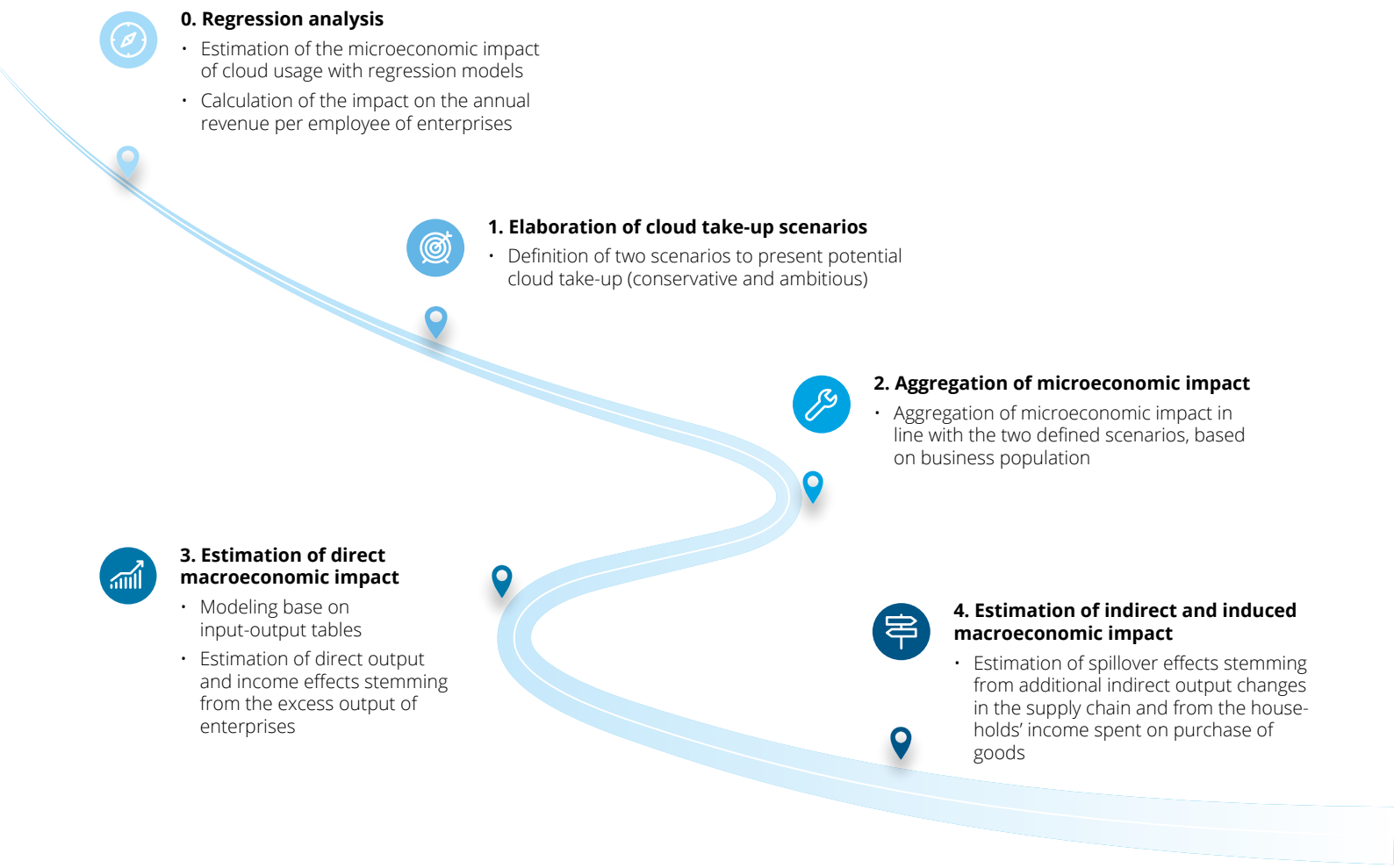



***Figure 16:** 4+1 step methodology for modelling macroeconomic impact*

The calculations resulted in an estimated value of the macroeconomic effects of cloud usage on firms' productivity growth projected over 10 years under two development scenarios.

Regarding the calculation of impacts, it is important to mention the use of some restrictive framework assumptions:

- The model implicitly assumes that the excess output from the increase in annual revenue per employee can be absorbed by the market (domestic or export), that firms face unlimited demand for their products, that the price of products remains unchanged as output increases, and that the value of goods produced does not fall as a result of the excess output being brought to market.
- It is also an implicit assumption in the model that the increase in unit output is reflected in higher total output for firms, rather than firms trying to achieve the same level of output with fewer employees.

## 9.4. Cloud Usage Index Scoring

The main areas for scoring and the maximum number of points that can be obtained (100 points in total):

*Cloud Preparedness, Needs and Potential – maximum 35 points:*

- IT infrastructure asset maturity – up to 10 points
- Professionals and IT managers, the role of ICT in the life of the company – up to 10 points
- Digitalization of business operations, extent and depth of digital transformation – up to 15 points

*Current Cloud Usage – up to 65 points*

- Use of subscription-based IT operations, consulting and other IT services, complexity of usage patterns – up to 20 points
- SaaS usage and spending – up to 10 points
- IaaS, PaaS usage and spending – up to 25 points
- Shift towards services with monthly recurring fees and IT outsourcing – up to 10 points

## 9.5. Explanation of Typical Cloud Usage in the Enterprise Segment

The following abbreviations appear in the graphs shown:

- BIZ LB: large companies with 250+ employees
- BIZ MB: medium-sized enterprises with 50-249 employees
- BIZ SB: small enterprises with 10-49 employees
- BIZ CB: micro-enterprises with 1-9 employees
- BIZ Total 1+: partnerships with at least 1 employee (CB+SB+MB+LB)