# DIFFUSION AND APPLICATION OF CLOUD COMPUTING - TECHNOLOGY MANAGEMENT CHALLENGES IN THE DOMESTIC SME SECTOR

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# DIFFUSION AND APPLICATION OF CLOUD COMPUTING

# - TECHNOLOGY MANAGEMENT CHALLENGES

# IN THE DOMESTIC SME SECTOR

**THESIS**

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*Dedicated to the memory of Károly Borsy*

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# 1. Introduction

*„Felhő vagy te, olyan felhőbb, mint a felhő,*
*gyerek vagy te olyan, aki mikor felnő*
*tudja, kire hasonlít, azért is tagadja,*
*minden mérge elszállt, maradt a haragja…"*
*Dr. Zoltán Beck*

## 1.1 Trends and changes caused by digitization

The impact of technological development and digitalization on companies is an extremely diverse and colorful topic, the examination of the challenges and opportunities arising from technological changes and their possible effects appears in almost all theoretical and practical research involving social, economic and business fields. Just as in theoretical research and trends in economics, the central theme in the business environment is also the importance of reacting to changes caused by digitalization and the appreciation of technology. Starting in the 2000s, companies were faced with the fact that their primary task was to learn about and integrate technological trends and digital innovations in order to transform and support their business activities and processes. According to Pelser (2014), today's companies, in addition to operating efficiently in their current market, must also innovate and plan for "future markets". The role of digitization in the economy is now indisputable, rapid and continuous technological development prompts significant innovation and research and development activity. According to Nemeslaki & Sasvári (2015), the development of technology has created a "digital world" based on information and innovation, which poses significant challenges to the business sphere, while technological systems and capabilities are intertwined and built on each other. According to Evans (2000), the new forces that appeared in the business environment as a result of technological innovations changed the nature of competition and fundamentally modified and reduced the traditional boundaries of industries and companies. The increasing innovation activity of companies and the rapid technological development in almost all industries have eliminated the stability of the economic environment, the usual methods and sources of profitability and profitability of companies, so the professional principles linked to the concept of strategy management have changed, and the raison d'être of using paradigms has been questioned (Grant, 1991; Gregory, 1995; Gaynor, 1996; Davenport et al., 2006). The development and use of organizational-technological knowledge possessed by companies forces competing companies to focus on ways to improve the efficiency of the technology available to them, so corporate strategies increasingly focus on the integration and development of technology within the organization as a source of sustainable competitive advantage (Drejer, 1997; Antoniou & Ansoff, 2004; Nagy-Borsy, 2018). Technological issues are therefore increasingly important for companies, and the importance of theoretical and practical research on them has increased. For companies and enterprises, the maintenance, development, planning and management of their available technology has now become a key, strategic issue.

However, the effects of new technologies on companies are often quite unpredictable, the appearance of technological innovations and the descriptive and explanatory trends change rapidly (Pataki, 2005; Szakály, 2008; Shane, 2009). The rapid pace of technology development - in addition to its countless advantages - has created uncertainty for companies in competitive markets, changed the nature of competition and the sources of competitive advantage, thereby transforming thinking about competitiveness. Technological novelties and state-of-the-art developments appear at an extremely fast pace, and it follows that companies must adapt to changes in market trends in such a way that the widespread, available technologies are often considered outdated. However, strategically important technologies are not the same as state-of-the-art technology, the point of view of strategic management argues for a deeper integration of technology in order to create the most accurate and efficient fit with strategic goals. For companies, the key strategic question is not how the change in technology and digitalization transforms it and what effect it has on their processes and activities, but how they can transform their processes and activities through the deeper integration of technological innovations and digitalization. , in what way they can "digitalize".

Changes and paradigm shifts can be seen both in theoretical research and in business thinking. The spread of information and communication technologies, their widespread use, and the effects of digitalization in both society and the economy indicate a shift towards a service-oriented economy. The appearance of technological innovations and solutions collectively known as Cloud Computing fits into this trend. The spread of Cloud Computing has democratized the market for services based on information and communication technology (ICT), since solutions based on Cloud Computing are, with a slight exaggeration, available to everyone and easy to use by everyone (Mell & Grace, 2011). From the point of view of the digitization of companies, among the available technologies, Cloud Computing currently plays a particularly important role, which, according to Nemeslaki & Sasvári (2015), stands out from other digital technologies: it can be interpreted both in itself as a service technology and as another digital technology (for example, this in the former an inseparable component of the mentioned Big Data, AI or Smart City-Smart Home technologies).

We have an extremely large amount of country-, sector-, and industry-specific literature dealing with the trends of technology and digitalization, and moreover, due to the pace of technological development and developments, as well as its wide-ranging areas, it is not only the defining technology of the "future", but also the currently relevant, even the "most popular" technologies change very quickly. Based on the report of the American Gartner Inc. (2023), one of the most well-known consulting companies dealing with technological trends and forecasts, the 10 most important strategic technology trends in 2024 are AI-based fund management, risk management and security technology, management of exposure to continuous attacks, sustainable technology , platform design, extended AI developments, industrial cloud platforms, intelligent applications, democratized, generative AI, extended, connected workforce and machine clients. Based on the list, it can be concluded that in many cases these trends and technologies are still completely elusive, and their Hungarian names are currently not accurate or missing. It is also noticeable that technological trends that are still significant today are missing from the list, such as Smart City-Smart Home, Big Data, self-driving technologies or quantum computers. At the same time, the importance of Cloud Computing is strengthened by the fact that, in addition to the fact that industrial cloud platforms are on the list, the technological innovations listed in several cases (for example, AI-based technologies on the list, continuous exposure to attacks or intelligent applications) are unthinkable in cloud-based without technology. It should be noted that in Gartner's forecast for 2020 and 2023, Cloud Computing, distributed cloud and native cloud appeared in the "image". (Gartner, 2019, 2022).

The scientific examination of Cloud Computing started at the same time as digitization came to the fore, the topic is domestic (for example Bőgel, 2009; Nagymáté, 2010; Racskó, 2012; Nemeslaki & Sasvári, 2015; Füzes, 2018) and international (for example Wang & Laszewski, 2008; Scale, 2009; Kavis, 2015) emphasize the innovative nature of Cloud Computing, and the authors agree that Cloud Computing , creates business models and functionality for enterprises and companies, which affect the entire organizational operation – and thus competitiveness and the sources of competitive advantage. Based on Racskó (2012), the spread of Cloud Computing was supported by a number of trends and processes, including the continuous reduction of data storage costs, the intensive growth of data processing capacity, the intense competition experienced in IT developments, the spread and standardization of user-friendly solutions, and computer software spread and its growing role in IT systems.

The transformations in the business environment and the development of specialized literature research, the change in their focus, direction, and development are not independent processes, on the contrary: the subject and "theme" of the discipline of economics is the examination of the economic-social environment (macro level) and the participants (micro level) , the research and interpretation of changes, trends, transformations, as well as the exploration of cause and effect relationships, the analysis of alternatives and possibilities. Similarly, it can be established that the publication of the scientific investigation of the economic-social environment, research in this direction and topic, and their results can be directly or indirectly utilized in the economic-business environment, given that the information, connections, interpretations or descriptive analyzes discovered can influence and support the the decisions and behavior of participants, thereby affecting social processes, the operation of the economy, as well as the competitiveness and profitability of companies. The exploration of the use of a technology, the circumstances of its application, the examination of a technological trend, and the scientific research of these factors can therefore be justified both on the basis of scientific arguments and aspects and on the basis of business logic and the "interest" of companies. In addition to the unique analysis of technology, the maturity of information technologies, the maturity of IT management, and the acceptance of technology, it is essential that the role played by technology in maintaining a competitive advantage is studied with integrative methodologies that also apply a strategic focus.

It follows from the above that a complex, synthesizing study of these topics is possible with a scientific approach that includes both technological aspects and business aspects. The theory of technology management, and its expanded theory with a strategic focus, is strategic technomanagement, integrative fields of science that manage the above-mentioned subfields together in an interdisciplinary approach. The technology management focus enables me to examine the technological issues of companies from a business or, specifically, from a business, management point of view. Technology management interprets the technology-related activities of companies at three levels, at the macro level the impact of government policy on companies, at the organizational level the role played by technology in maintaining a competitive advantage, and at the micro level it focuses on the individual contribution to the technology management of companies. The theoretical basis of the research is provided by strategic technomanagement, a discipline that includes and interprets trends dealing with technology and technology management, as well as strategic management and innovation management (Burgelman, 2001; Bidgoli, 2010; Cetindamar, 2017). The rise of strategic techno-management is supported by the technological development of the past decades, the spread of info-communication technologies, the emergence and intensification of social, economic and industry changes that have already occurred or can be forecast due to them (Deutsch et al, 2019). The focus of strategic technomanagement research is the most accurate and effective integration of existing and new technologies into corporate strategy. Strategic technomanagement places the companies' technology management in a strategic context, manages business and technological aspects together, takes into account the company's external and internal environment, capabilities (push mechanisms) and requirements (pull mechanisms) affecting technology management functions.

Services based on Cloud Computing have now become one of the most important technological innovations of economic and social digitalization, which have a significant impact not only on business life, but also on our "everyday life". Cloud Computing, which poses a strategic challenge for companies and fits into the ever-increasing digitization trend, is therefore a significant technological innovation that forms or can form part of the technology management activities, tasks and developments of enterprises and companies, thus it is organically connected to the theoretical topics outlined above, within their framework can be examined. The purpose of the research is a multi-level (macro, organizational, individual) investigation of the application of a technology with a strategic focus (that is, considering the sources of the companies' competitive advantage), consequently the disciplines of technical sciences, innovation management or strategic management alone do not provide a sufficient framework for this. I had to apply a theoretical approach and foundation that unites these scientific disciplines and enables the research of how the application of a specific technology can contribute to the technology management activities of organizations and companies. The examination of Cloud Computing in the context of strategic technomanagement is a relevant research topic regardless of company size, however, based on the contents of the following chapter, the focus of my doctoral dissertation is on small and medium-sized enterprises.

## 1.2 The focus is on small and medium-sized enterprises

As stated in the title of my thesis, my research deals with the use of Cloud Computing and related challenges among domestic small and medium-sized enterprises. The international (for example Acs, 1992; Acs & Preston, 1997; Thurik & Wennekers, 2004; Hitchens et al. 2005; Chiao et al. 2006; Rizos et al. 2015) and domestic literature (for example Kállay et al., 2008; Némethné, 2010; Szerb, 2014; Hágen & Holló, 2017). with its role in the national economy, the characteristics of the sector's companies, and the challenges affecting SMEs, the key to their development and competitiveness or their obstacles and barriers. There is also a rich literature on research concerning various aspects of the application of Cloud Computing, including analytical research examining the application of Cloud Computing among small and medium-sized enterprises (e.g. Sultan, 2011; Abdollahzadegan et al., 2013; Alshamaila et al., 2013; Szabó et al., 2015; Hussin et al., 2019; Hassan et al., 2020; Fakieh et al., 2022, Gao, 2022). At the same time, it should be noted that during the systematic literature review, I was confronted with the fact that the largest number of economic, business and technical studies dealing with Cloud Computing were created in the period 2010-2015, after that the number of scientific researches in this direction is more moderate. This indicates that after the emergence of the technology, there was more interest in it at the beginning of its popularity than after. In my opinion, this does not undermine the relevance of the research, rather it is about the fact that the scientific consensus regarding Cloud Computing, its application and models was formed in the mid-late 2010s.

For both multinational companies and small and medium-sized enterprises, IT has a special role in managing the company's activities and processes, the use of IT and information communication tools increases productivity, reduces costs and improves the effectiveness of companies (Gubán & Sándor, 2021). Szabó el al (2013), Kavis (2014) and Ross et al. (2015), Fakiehet et al. (2022) and Joshi et al. (2023), the use of Cloud Computing is well suited to the specialty of the SME sector, due to the fact that dynamically scalable IT resources are available to companies as virtualized services and this service-oriented architecture with scalable infrastructure reduces the disadvantages resulting from economies of scale. Szabó et al. (2013), the use of Cloud Computing in the SME sector is clearly beneficial because a selected IT product or service can be used quickly without a lengthy implementation process and the development of the necessary infrastructure. Regarding the exploration of the benefits arising from the use of Cloud Computing by companies in the SME sector, relevant research clearly supports the relationship between gaining a competitive advantage and the use of Cloud Computing (Fakiehet al., 2022; Hari et al., 2022; Shrivastava et al., 2022) among the relevant sources, there is largely agreement regarding the realizable benefits of Cloud Computing for small and medium-sized enterprises, the authors (Alshamaila et al., 2013; Assante, 2016; Rooge et al., 2019; Abdullah et al., 2020; Lisowska & Pamula , 2020; Alqahtani et al., 2022; Shrivastava et al., 2022) the main advantages of using Cloud Computing are as follows :

- IT infrastructure investments are typically large-budget investments and developments that require lengthy planning. By using Cloud Computing, the costs and planning tasks associated with IT investments can be avoided, as well as the constraints associated with the established infrastructure can be reduced. Companies have access to Cloud Computing as highly customizable services, which fits well with the heterogeneity and variability of the players in the SME sector.

- Small and medium-sized companies are characterized by variability in the use of IT systems, they usually do not require continuous (0-24 hour) access to the systems, and they need resources of variable capacity and type during their activities. The scalability of the services enables the downsizing of underutilized IT resources, as well as the elimination of the use of IT resources that are not profitable in terms of their utilization.
- Cloud Computing is accessible and accessible by suitable computer devices with Internet access, thus smaller, more mobile, dynamically developing organizations can use the necessary technologies without interruptions in accessing services.

Regarding the application of Cloud Computing among small and medium-sized enterprises, advantages can be identified in this regard also along the lines of specific company functions and functional activities. The use of Cloud Computing strongly supports the financial awareness of businesses, cloud-based systems enable more advanced, higher-quality financial management activities (Gao, 2022; Nayak et al., 2022). Cloud Computing has a supportive effect on the strategy planning and opportunities of businesses (Hussinet al., 2018; Shrivastavaet al., 2022), and Lisowska & Pamula (2020) linked the possibility of the development of new business models to the technology. Abdullah et al. (2020)'s research realized advantages and opportunities in terms of the intersection of the application of Cloud Computing and the human resource management processes of enterprises. General advantages of the technology include that Hari et al. (2022) the long-term reduction of costs as a consequence of the introduction of technology, Guillermo Cordova-Castillo et al. (2022) associated the support of compatibility between IT systems and management activities of enterprises with Cloud Computing. Alqahtani et al. (2022), Palanisamy et al. (2023) and Zulkifli et al. (2023)'s more recent research revealed the relationship between Cloud Computing and data security and data protection.

Ross et al. (2015), by using Cloud Computing, small and medium-sized enterprises can realize benefits not only in their daily operations, but the use of Cloud Computing promotes the development of entrepreneurship, internationalization, and thus supports conscious planning and the competitiveness of companies. The use of Cloud Computing is well suited to adapting to competition in global markets, by using Cloud Computing, companies reduce their opportunity costs, while the services support internal innovation and technology-focused collaborations based on digitization. At the same time, the authors classify the difficulties of adapting to new business models, the necessity of building, applying and continuous maintenance of security systems and the associated costs, as well as the organizational transformation associated with mobility, among the dangers associated with the use of Cloud Computing, which primarily affect small and medium-sized companies. risks caused. Hungarian surveys related to the use of cloud-based services (e.g. Sági, 2014; Microsoft News Center, 2016) highlight mistrust of these services, concerns about data protection, and insufficient user knowledge. Based on Gubán & Sándor's (2021) research concerning the SME sector, the domestic small and medium-sized business sector has a limited openness to digitalization tools, and the authors highlight that the resistance is not only due to funding limitations, but appears as a common problem that the enterprises do not have enough information regarding a specific technology or innovation. Criticisms regarding the unreliability of cloud-based services and concerns about data protection have now significantly decreased, this is partly due to the fact that cloud-based services have spread among private users in recent years, primarily for the purpose of storing files and as a background for applications. But the lack of adequate user knowledge is a serious barrier to the spread of cloud-based services (Nagy-Borsy, 2020).

The relationship between small and medium-sized enterprises and the use of Cloud Computing does not only appear in theoretical literature, but is also part of domestic economic development strategies and concepts. The strategic document "Green Book on the Development Directions of the Infocommunications Sector 2014-2020" published by the Ministry of National Development in 2014 defines four pillars (Digital Infrastructure, Digital Economy, Digital Competences, Digital State) in terms of ICT developments, among which in the case of Digital Competences and Digital Economy, specific groups of tools and actions were formulated in order to develop the SME sector and the use of Cloud Computing. In the document entitled "National Digitalization Strategy 2022-2030" published by the Prime Minister's Cabinet Office, which supports the development of the digitalization of the domestic economy, the support for the use of Cloud Computing and the development of the necessary infrastructure is similarly emphasized.

In the case of the Digital Infrastructure pillar, the aim of the DI II.3 measure is to provide geo-redundant data centers and services in order to ensure that the service provided to educational and vocational training institutions is continuous and reliable, and that the data center conditions for the steps necessary to enhance information and cyber security are ensured. The Digital Economy DG I.1. the purpose of the measure is to further improve the digitization of domestic micro, small and medium-sized enterprises, the appropriate level of use of ICT tools and solutions, i.e. the integration of enterprises into the digital and data economy, thus increasing their competitiveness in all sectors and business segments. DG I.4. the purpose of the measure is to encourage the participation of enterprises in the data economy in order to improve their operational efficiency and promote their business development, specifically that the measure includes the development of a decision support system service based on digitization and automation (e.g. Cloud Computing), which can help micro, small- and in the improvement of the competitiveness of medium-sized enterprises and the development of their digital competences. The Digital State DÁ I.2. The purpose of his measure is to expand the use of central electronic public administration services on the basis of application providers, to connect and integrate specialist systems, and to further develop processes according to user needs, including the comprehensive development of infrastructure involving Cloud Computing.

The document developed by the Prime Minister's Office (2022) states that the use of Cloud Computing enables small and medium-sized enterprises to reduce IT investment costs, the use of higher-quality ICT solutions, and the introduction of cloud-based solutions contributes to domestic small and for the improvement of the internal and external corporate operations of medium-sized enterprises, thus improving the competitiveness of the sector. The results to be achieved through targeted support include the growth of the number of businesses using cloud-based solutions and the market of domestic IT businesses dealing with Cloud Computing, the expansion of the internationalization of businesses, the export of the domestic SME sector, and the digitization and competitiveness of the sector growth.

In the theoretical research of Cloud Computing, the investigation of the relationship between technology and the SME sector appeared already in the early 2010s, which has been a popular topic ever since. Due to the characteristics of Cloud Computing, technology-based services are accessible to businesses of any size that have a computer device or devices capable of managing an Internet connection. Based on the KSH (2017) data set, 94.3 percent of domestic small enterprises, 97.5 percent of medium-sized enterprises, and 98.8 percent of large companies already had a computer in 2017, in addition, 93 percent of all businesses had an Internet connection, of which 91 percent had broadband with a relationship. More recent data from the OECD (2023) show that in 2022, 94.1 percent of domestic small enterprises, 98.6 percent of medium-sized enterprises, and 99.8 percent of large companies had a broadband Internet connection. From the above, it follows that domestic small and medium-sized enterprises have the necessary infrastructure conditions for the application of Cloud Computing, and there are no barriers to the use or spread of the technology specifically related to device use, device requirements, or network access. Based on the fact that the conditions for the application of the technology are given and the advantages of the technology are particularly suited to the specialties of the sector, we may develop the preconception regarding the results of the research that there will be no significant deviation regarding the data characterizing the use of Cloud Computing by the companies in terms of the categories of employees of the companies, and the the rate of future diffusion of technology will be similar among the SME sector and large companies. (Nagy-Borsy, 2024)

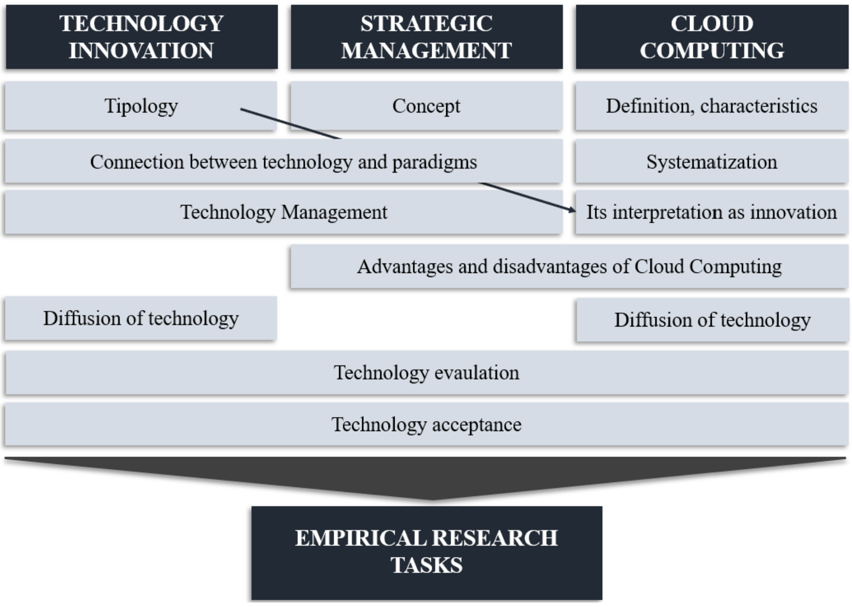
The purpose of my thesis is to examine whether the factors that support the importance of Cloud Computing revealed by previous research, the definable characteristics and advantages affecting the application of the technology, i.e. whether the suitability of Cloud Computing for the SME sector can be confirmed among domestic small and medium-sized enterprises.

My research questions serve this purpose: the exploration of macro, meso (corporate) and micro-level factors that determine the application of Cloud Computing and the interpretation of the related results. My research topic is therefore the strategic focus of Cloud Computing, and its subject is domestic small and medium-sized enterprises. Examining Cloud Computing is a relevant, current research topic among companies and businesses. The research of Cloud Computing is a relevant question for both large companies and small and medium-sized enterprises, the fact that the subject of the research is the enterprises of the domestic SME sector is only partially theoretically grounded, and partially has personal reasons. In favor of the relevance of small and medium-sized enterprises, the fact that the enterprises of the sector are extremely important players in the domestic national economy in terms of their number of employees and their sectoral extent. The importance of the SME sector is also strengthened by the fact that all major professional workshops in the domestic scientific and academic life deal with the sector's competitiveness, specialties, and role in the domestic economy. Based on the relevant literature sources, the characteristics of Cloud Computing are extremely well suited to the specialties of small and medium-sized enterprises. The study of Cloud Computing in the domestic SME sector is therefore a well-connected topic, but small and medium-sized enterprises are not primarily the topic of my research, but the object of it. The research primarily covers the strategic examination of a specific technology, carried out among domestic small and medium-sized enterprises.

## 1.3 Structure of the thesis

The purpose of my thesis is to investigate the significance and characteristics of Cloud Computing and the advantages associated with its application, to explore the question in practice of how these factors appear among domestic small and medium-sized enterprises. Within this framework, it is worth examining not only the digital readiness and digital maturity of SMEs, but also the relevant factors of the external and internal environment, the driving forces and obstacles to the application and applicability of Cloud Computing, the supporting and inhibiting effects. In connection with the acceptance of a technology, in addition to the economic, social and business factors and frameworks, there is also a significant role of the personal, subjective elements that determine the typical attitudes of the given participants, the behavior indicating the acceptance or rejection of the technologies. I carried out the examination of the above topics with exploratory research, for this purpose I formulated research questions. In order to provide adequate theoretical and practical support for the research, I processed the following topics.

1. Figure: Topics and key concepts involved in theoretical research

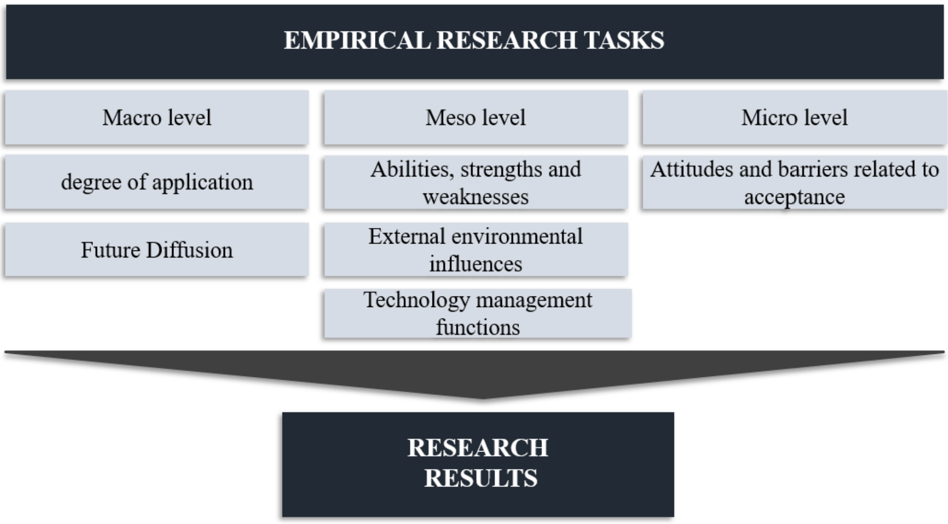



*Source: own compilation*

Figure 1 shows the main disciplines involved in the theoretical research, as well as the related theoretical topics and subfields. I started processing the theoretical literature with the interpretation and conceptual typology of the disciplines of technology, innovation, technological innovation and strategic management, the first chapter of my theoretical framework deals with the description of the concept of technological innovation. The topic of the second theoretical subsection of the thesis is technology management, while the third theoretical subsection examines the relationship between technology and strategy, in relation to the discipline of strategic technomanagement. The identification of the intersections of innovation, technology and strategic management areas was crucial for the research, and these concepts were later interpreted in relation to Cloud Computing as well. The last three chapters of my theoretical framework deal with the examination of technology at different environmental levels, at the macro level I describe the diffusion of technology, at the organizational level I present the models of technology evaluation, and at the individual level I present approaches to technology acceptance. A separate theoretical chapter is the presentation of Cloud Computing, which includes the definition of the technology, description of its characteristics, and the systematization of Cloud Computing. By processing the relevant literature, the advantages associated with the application of the technology can be determined, and the relationships and interpretations between the theoretical chapters and Cloud Computing can be explored.

The different areas in Figure 1 are connected by the concept of strategic technomanagement, this discipline was created from the integration of the above areas (innovation, technology and strategic management). Each area has its own conceptual framework and specific functions, which build on each other to form strategic techno-management. This approach allows companies to remain competitive in a rapidly changing technological environment and to effectively exploit the potential of innovation. The goal of strategic technomanagement research is to ensure that companies are in harmony with technological development and innovations in line with the company's long-term strategic goals, taking into account external environmental effects. The strategic technomanagement discipline provides the basis for theoretical and practical research, the subfield's conceptual system and approaches pervade all steps of the research.

2. Figure: Areas of empirical research




*Source: own compilation*

The lower level of Figure 1 refers to my empirical research tasks. The purpose of my practical research is to answer the research gaps arising from the framework that can be created on the basis of theoretical studies with practical experiences and practical methodologies. The data collected and analyzed during the empirical research support the detection of questions concerning the application and use of Cloud Computing, and help to reveal the specific problems and challenges that are relevant for domestic small and medium-sized enterprises in relation to Cloud Computing. Figure 2 shows the main areas of empirical research, as well as the related research steps and tasks, as a result of which, by answering the research questions, I can provide an account of relevant, sufficiently substantiated research results in my thesis.

Based on the theoretical framework, several dimensions of the relationship of domestic small and medium-sized enterprises with Cloud Computing can be examined. The purpose of my research was to examine the circumstances of the application of Cloud Computing at different environmental levels, primarily whether the suitability of Cloud Computing for the SME sector can be confirmed among domestic small and medium-sized enterprises. I formulated the research questions related to this and based on this. From the perspective of the macro environment, my study deals with the spread and diffusion of Cloud Computing, as well as the characterization of the digital maturity of the sector concerned (Q1, Q2). The meso-level part of the research focuses on the external and internal factors, driving forces, obstacles associated with the use of Cloud Computing by domestic small and medium-sized enterprises, as well as the quality of techno-management functions (Q3, Q4). In the course of the micro-research, I will investigate the attitudes of the participants of the domestic

SME sector regarding Cloud Computing (Q5). Based on the processing of theoretical literature and the identification of practical research gaps, I formulated the following research questions.

- **Q1.** To what extent do domestic small and medium-sized enterprises use Cloud Computing?
- **Q2.** What future spread (diffusion) can be expected regarding Cloud Computing in the domestic SME sector?
- **Q3.** How can the internal technology management capabilities and the external environmental effects of Cloud Computing be characterized among domestic small and medium-sized enterprises?
- **Q4.** What characterizes the individual technology management functions of domestic small and medium-sized enterprises in terms of the application of Cloud Computing?
- **Q5.** What are the typical attitudes related to the acceptance and use of Cloud Computing among domestic small and medium-sized enterprises?

Empirical research is a mixed-methodology research, due to the fact that the applied quantitative research methodology tools are replaced by a qualitative research approach, moving towards a micro focus. I developed the research questions based on the analysis of the relationship system of the topics and areas revealed on the basis of the literature research. The theoretical frameworks developed on the basis of international and domestic literature (components of technology, technology management, the discipline of strategic technomanagement, the importance and system of Cloud Computing, the role and characteristics of domestic small and medium-sized enterprises) and their cross-section define the sub-areas, concepts, research gaps, which potentially provide the opportunity for deeper investigations and analyses.

The expected result of my research is the characterization of the current spread and future diffusion of Cloud Computing based on the available data, the examination of external and internal factors determining the application of technologies, the evaluation of the existence and quality of techno-management functions among domestic small and medium-sized enterprises, and Cloud Computing exploring attitudes related to its use.

# 2. Theoretical framework

## 2.1 Conceptual framework of technological innovation

The word technology is a term of Greek origin, a combination of the words "techne" (craft, practical ability to create something) and "logos" (knowledge, knowledge, causality), so the term technology, narrowly interpreted, means the ability and knowledge that make it suitable does to create something. However, in the technical literature dealing with technology, experts and authors belonging to different scientific fields, using different approaches, attempt to give a more precise definition of technology. Due to the fact that my doctoral training and research are in the field of business sciences and economics, I will present the approaches of specialists in this field in the following.

The definition of Szakály (2002b p. 7.) is based on the content elements of the term technology, according to which technology is "the ability to do things and the set of knowledge that forms its background". Based on Steele (1989), this knowledge - what and how it can be done - is expanded by the fact that technology is also a system by which society satisfies its needs and desires. However, some authors (Simon, 1973; Shane, 1982; Pataki, 1999) interpret technology as a set of special knowledge that is necessary for the organization and operation of different systems. Schön's (1967) definition is similarly broad, according to which technology is any tool, technique, product, process, or equipment or method for doing something, with which human abilities and possibilities can be expanded.

In terms of the components of technology, one of the most well-known is the interpretation of Rogers (1976), according to which all technology in practice consists of two components, a hardware component, i.e. a device embodying the technology in the form of a physical or material object, and a software aspect, which provides the information base necessary for the use of the device. included. The approach used by Szakály (2002b) and Pataki (1999), which describes technology as a synergistic union of four knowledge elements, technoware, humanware, infoware and orgware, is more complex and broader than this. (1) The concept of technoware represents the objectified form of technology, it means the elements of machines, equipment, devices and factories necessary for the transformation processes of companies. (2) Humanware includes the elements of technology that can be linked to people, including all the abilities, skills and competencies that set the transformation processes of companies in motion. (3) The concept of infoware refers to the elements of technology that are related to the information supply and support of the transformation process, i.e. the elements of technology embodied in the form of documentation, such as specifications, plans, blueprints, diagrams, descriptions, can be classified here. (4) Finally, the concept of orgware includes the elements of technology embodied in an institutionalized form that are indispensable for the transformation processes of companies and enterprises, such as processes, systems, networks, allocations. Of course, these elements are also related to each other, since the technoware elements that form the basis of the transformation process are developed, introduced and operated with the help of humanware. Humanware is managed by infoware, the humanware knowledge element is responsible for its development, decision-making procedures, and application during the operation of technoware. And the knowledge element belonging to the orgware category supports the control and availability of the other three factors (Szakály, 2002b; Bhatia, 2018, pp. 7-8). The four elements of knowledge can therefore be interpreted in interaction with each other within a technology, not as separate parts of a given technology.

According to Pataki (2005, p. 23), technologies are most often grouped in the literature based on the professional content and essence of the technology, as well as its relation to competitiveness. Regarding the professional content of technology, according to Steele's (1989) classic definition, it can be product (-technology) or process technology, which can also be called production technology in the case of physical products. The input variable of the products is conceptualization (principle design), which includes the identification of customer needs, the specification of the characteristic features and performance of the product. Its output variable is the fixed product characteristics and the performance values of the given product. The creation of a construction that meets the specification (in terms of performance, quality, cost, manufacturability) is called practical (product) design (Harasztosi, 2009). Another component of product technology is the development of the application and the creation of the service. According to Pataki (2005), process technology includes material selection, material supply organization, supplier evaluation, processing and production planning, material handling, quality control, and maintenance.

Considering the essence of the technology, it can be divided into three groups based on Trott (1998) and Pataki (2005). Technologies that are an essential element or component of products and services are called core technologies, features that increase the use and functional value of products and services are called complementary technologies, and components that are more loosely connected, not necessarily necessary, are called peripheral technologies. for a given product or service (they only carry a surplus for certain market segments). Little (1981) categorized technology on the basis of its relation to competitiveness, on the basis of which the technologies and technological elements that all competitive players possess are called basic technologies, the technologies that determine the competitive position in the industry are called key technologies, while those technologies that are at the beginning of their development and only a (limited) part of industry players has them, we call it pace-setting technology. According to Harasztosi (2009), these technology types cannot be used as a static category, because pace-setting technologies may appear as key technologies after their spread, and for a similar reason, key technologies may also become basic technologies over time. Christensen (1997) and Chiesa (2011) supplemented the categories described by Little (1981) with the age of the technology, based on which we distinguish (1) emerging (subversive, pace-setting) technologies, these are technologies that only a narrow circle of industry players have and are at the beginning of their development, (2) key technologies, which are already developed technologies that determine the competitive position and competitive advantage, (3) core technologies, which are mature technologies that all competitive players in the given industry have and (4) declining or disappearing technologies, which are their life cycle end, typically obsolete technologies. A related interpretation is that technology can also be categorized on the basis of its life cycle, so a technology can be a technology in the discovery phase, a technology in development, a mature technology, or a discontinued technology (Utterback & Abernathy, 1975; Anderson & Tushman, 1990; Tassey, 2013).

In addition to the above typologies, it is worth presenting Arthur's (2009) technology groups, which can be interpreted based on the levels and complexity of the technology, thus distinguishing monolithic, composite or evolutionary technology. (1) The monolithic technology type consists of a single, large integrated system, where all components are tightly connected. This type is typically more difficult to modify or expand, as all components fit tightly together. (2) Composite technologies consist of a set of different, independent components that cooperate to form a system. These systems are more flexible and easier to expand or modify, as individual components can be replaced or upgraded. (3) Evolutionary technology is based on gradual improvements and refinements. These technologies are constantly evolving as more and more innovations are introduced and as the technology adapts to changing environmental and market conditions. Based on their relationship with the technologies of other sectors, technology can be substitutive and complementary, as well as sector-specific and cross-sector technology (Perillieux, 1991). In the 2000s, the typology of technology based on the conceptual structure of IT appeared in the literature (Benkler, 2006; Bainbridge, 2007; Zahran, 2019; Smith, 2022), which is not the same as the approach of Rogers (1976), who defines hardware and software he defined the term as a component of technology. Based on the structure of IT, the technology can be hardware, software, network technology or hybrid technology. (1) Technology as hardware refers to the physical components that form the physical basis of systems and devices. (2) Software is a set of programs and operating systems that control the operation of the hardware and perform various tasks. The two main types of software are system software (such as operating systems) and application software (such as office suites, applications). (3) Network technology includes the systems and protocols that enable the transmission and communication of data between different devices. This includes Internet technologies, local area networks (LAN), wireless networks (Wi-Fi), and network security systems. (4) Hybrid technology means systems that combine elements of hardware, software and network technologies in an integrated solution. The purpose of hybrid technologies is to combine the advantages of individual technological components and thereby raise the efficiency and functionality of the given system or device to a higher level. According to Perillieux (1991), technology can also be examined according to its geographical and regional spread, a technology can be regional, national or international-global, although it should be noted that in today's global market conditions, this grouping has less relevance. Based on Teece (1986), technology can be characterized according to the intensity of research and development required for its production, it can be high R+D intensity or low R+D intensity. According to the degree of technological diffusion, we can distinguish between fast-spreading and slow-spreading technology (Rogers, 1976). Table 1 contains different approaches to the conceptual typology of technology.

1. Table: Conceptual typology of technology

| The essence of approach | Typology | Authors |
|---|---|---|
| According to professional content | product<br>process | Steele (1989), Pataki (2005) |
| Technology at its core | seed<br>additional<br>peripheral | Trott (1998), Pataki (2005) |
| Relation to industrial competitiveness | basic technology<br>key technology<br>subversive or pace-setting technology<br>declining or disappearing technology | Little (1981), Tushman & Anderson (1986), Christensen (1997), Bone-Saxon (2000), Chiesa (2011), Thomas (2017) |
| Technology by life cycle | technology in the discovery phase<br>development technology<br>mature technology<br>outdated technology | Utterback & Abernathy (1975), Anderson & Tushman (1990), Tassey (2013) |
| By sector relationship | substitute<br>additional<br>sector-specific<br>intersectoral | Perillieux (1991) |
| According to the development of technology | monolithic<br>composite<br>evolutionary | Arthur (2009) |
| According to the structure of IT | hardware<br>software<br>network<br>hybrid | Benkler (2006), Bainbridge (2007), Zahran (2019), Smith (2022) |
| According to regional distribution | local<br>national<br>international-global | Perillieux (1991) |
| According to research and development intensity | high R&D intensity<br>low R&D intensity | Teece (1986) |
| According to the degree of technological diffusion | fast spreading<br>slow spreading | Rogers (1976) |

*Source: own compilation*

The above Table confirms that neither the conceptual approach to technology nor its typology is uniform in the literature. The individual groupings are greatly influenced by the research area and professional orientation of the given author. Looking at the interpretation of technology further on in the thesis, as a synthesis of the approach of Steele (1989), Szakály (2002) and Schön (1967), by technology I mean the knowledge with which human abilities and possibilities can be expanded, so the human acting and performance can be exceeded. In this sense, the boundaries of a given technology can be interpreted differently in terms of different typologies. The definition of Cloud Computing and its interpretation within each typology will be covered in more detail in a later chapter of the thesis. My most important findings regarding the concept and typology of technology are summarized below.

- The concept of technology means, on the one hand, the ability to do something, and on the other hand, knowledge, which can be used to expand a person's possibilities.
- Every technology consists of two components: a hardware component, which represents the physical, material objects and parts that make up the technology, and a software component, which represents the information base and intangible elements necessary for the use of the device.
- In a more complex approach, technology can be interpreted as a set of synergistic, overlapping and interacting knowledge elements of four knowledge elements. The knowledge elements that make up technology, technoware (material elements), humanware (human factors), infoware (information) and orgware (processes, systems).
- The relevant literature sources have grouped the forms of technology in a number of ways. Among the typologies of technology, the most well-known in the technical and economic fields are the professional content of technology (product or process), the essence of technology (core technology, additional technology, peripheral technology), the life cycle of technology (technology in the discovery phase, development technology, mature technology, obsolete technology) and categorization based on the relationship of the technology to competitiveness (basic technology, key technology, disruptive or pace-setting technology, declining or disappearing technology) is important.
- Due to the different approaches of the technological typologies and their different grouping criteria, the definition of a given technology, the interpretation of the boundaries and composition of the technology may differ with regard to the different typologies.

The interpretation of the concept of innovation can be said to be as old as the field of science, at the same time, the approaches in the literature generally accept the definition of the Oslo Manual ( OECD, 2020), based on the latest edition of which, innovation is a new or significantly improved product or service, a new process, a new marketing method, or a new organizational method means its introduction in business practice, workplace organization or external company relations. This definition of innovation focuses primarily on its content realizations, so it is worth presenting some forms and content types of innovation in more detail. According to the Oslo Manual (OECD, 2020), product innovation is the introduction of a good or service that is new or significantly renewed in terms of its properties or way of use. Product innovation can be achieved by modifying the technical description of the development, components and materials, embedded software, user-friendliness or other functional properties. Process innovation is the implementation of a new or significantly improved production or delivery method, including significant changes in technology, equipment or software. Marketing innovation is the application of new marketing methods that bring significant changes in product design, packaging, product positioning, product advertising, or pricing. Organizational innovation means the implementation of new organizational methods in the company's business practices, work organization or external relations.

The development of technology (production of new or significantly improved quality), which can be called technological innovation, can be interpreted in all of the above types (product, process, marketing method, organizational method), this is supported by the diverse typology of technology presented in Table 1. Technological innovation can therefore be well defined by the fact that it means the implementation of innovation in which the capabilities and possibilities of man are expanded with the innovation. The Oslo Handbook (OECD, 2020) emphasizes that all business functions can be interpreted as the subject of innovation activity. The term business function includes the production of goods and services, as well as support functions such as distribution and logistics, marketing, sales and after-sales services, as well as information and communication technology (ICT) services provided to the company, administrative and management functions, the company's engineering and technical processes, and product and business process development. If the given business function has a technological content, i.e. the organization uses technology, then in the case of its development we can talk about technological innovation. The Oslo Handbook (OECD, 2020) confirms this, according to which digital technologies and practices permeate business processes, so much so that the realization of product and business process innovations is closely related to the acceptance, development and modification of digital technologies.

The presentation of the conceptual typology of innovation is therefore essential when examining technological issues. According to one of the earliest interpretations, there are five basic cases of innovation (Schumpeter, 1980), according to which innovation can be realized by selling new goods or producing old goods in a new way, by introducing new transportation methods, exploring new markets, using new production materials (raw materials or semi-finished goods), by creating a new market situation. Schumpeter's classical innovation types can easily be matched to the definition of innovation contained in the Oslo Manual (OECD, 2020). The product innovation written in the Oslo Manual corresponds to Schumpeter's product and material innovation, the process innovation includes Schumpeter's delivery method and material innovation, the marketing method means, among other things, the discovery of Schumpeter's new markets, and the organizational method is Schumpeter's new market situation can be considered an innovation. As it was deduced from the definition of innovation, technological innovations cannot be assigned exclusively to one of Schumpeter's innovation types, but technological innovation can be interpreted in the case of all types. It follows from this that the innovation models that typologized innovation along the lines of implementation forms or specific characteristics of innovation can also be clearly interpreted in the context of technological innovation. Looking at the conceptual relationship between technology and innovation, it can be established that if a technology has new content or represents a significantly different quality compared to previous technology, that technology is considered an innovation. Innovations that have a technological content are called technological innovations. Technological innovation is therefore both technology and innovation in all cases, while technology is not necessarily innovation (if it has no new content, it is not innovation) and innovation is not always considered technology (if it has no technological content, it is not technology).

Considering the typologies of innovation, Freeman & Perez (1988) divided innovation into four main categories based on scope and novelty content. (1) Gradual or modifying innovations mean continuous, step-by-step developments, modifications of existing products and production technologies. (2) Radical innovations break with existing methods, processes, and production procedures, they mean explosive changes that result in the creation of new products and procedures. (3) Innovations in the production process include those innovations that have an impact on several companies and sectors at the same time, and sometimes lead to the emergence of entirely new sectors. (4) Paradigm change means the innovation, as a result of which new technologies appear, the technical-economic environment can be transformed. Henderson & Clark's (1990) innovation model focuses on the degree of innovation and the nature of change, and along these two axes, distinguishes four different types of innovation. (1) Gradual innovations retain the basic principles and components of the given system, and through their development result in a change in the functions of the system. (2) In the case of modular innovations, the innovation takes place by maintaining the structure and principles, only by changing and replacing the components. (3) Structural innovations, based on existing components, result in structural changes following new principles. (4) In the case of radical innovations, in this case the components, the relationships between them, and the principles used are changed.

, Bower & Christensen (1995) and Christensen (1997) distinguish between sustaining and disruptive innovations. Sustaining innovation means the continuous development of products and services, along the characteristics that the existing customer base considers important. Disruptive innovations, on the other hand, bring changes in the existing customer-producer relationships and are destructive in nature. Sustaining and disruptive innovations can be either incremental or radical in nature. The categories defined by Christensen (1997) are also applied in the literature to technological innovations and specific technologies. The characteristics of sustaining or sustaining technologies are that these technologies are aimed at improving performance within existing markets, the purpose of their application is to satisfy the needs of existing customers and ensure the continuous development of products or services. Disruptive or more often disruptive technologies target new markets. Disruptive technologies can eventually displace existing dominant technologies by changing existing markets, creating new markets, and attracting new customers. While sustaining innovations and sustaining technologies are based on existing knowledge and principles of use, disruptive innovations and disruptive technologies can be based on new principles, newly created technologies, and new combinations of existing knowledge and technologies.

Tidd et al. (2001) typologized innovation based on its strategic orientation, and defined different types of innovation from the point of view of whether they represent novelty for the company or the market. Their results were summarized in a matrix, which identified the following four different strategic directions in relation to innovation. (1) Product differentiation means low novelty for both the company and the market. (2) The structural innovation can be realized with a new combination of existing technologies or the development of new functions, this has a high novelty content for the market, but means a low novelty for the company. (3) Technological innovations are characterized by a high novelty content from the company's perspective and a low novelty content from the market's perspective. (4) In the case of complex solutions, the technology and the market develop together, so considering the strategic orientation of the innovation, this type of innovation has a high novelty content for both the company and the market.

2. Table: Conceptual typology of innovation

| The essence of approach | Typology | Authors |
|---|---|---|
| Types of innovation | new product<br>new shipping method<br>exploring a new market<br>new material<br>new market situation | Schumpeter (1980) |
| Scope of innovation | incremental or modifying innovation<br>radical innovation<br>production process innovation<br>paradigm shift | Freeman & Perez (1988) |
| The extent of innovation and the nature of change | incremental or incremental innovation<br>modular innovation<br>structural innovation<br>radical innovation | Henderson & Clark (1990) |
| Based on product-market changes | retainer or retainer<br>disruptive or disruptive | Bower & Christensen (1995), Christensen (1997) |
| According to strategic orientation | product differentiation<br>structural innovation<br>technological innovation<br>complex solutions | Tidd et al. (2001) |
| Based on the typology of innovation | incremental<br>radical<br>platform<br>system | Garcia & Calantone (2002) |

*Source: own compilation*

The literature research by Garcia & Calantone (2002) dealt with the typology of technological innovations and the terminology of innovativeness, the authors' aim was to clarify the differences between different types of technological innovations, as well as to determine the most appropriate method and system for classifying innovations. Based on Garcia & Calantone (2002), four basic categories of technological innovation can be distinguished. (1) Incremental innovation means developments that result in minor improvements to existing products or processes. Incremental innovations are often the further development of existing technologies and are relatively low-risk. (2) Radical innovation is aimed at creating new products or processes that are significantly different from existing ones. These innovations are high risk but potentially more rewarding. (3) The purpose of platform innovations is to create basic technologies or systems that enable the development of further innovations. These innovations can result in the opening of new markets and areas of application. (4) System innovations mean the creation or transformation of complex systems that require the integration of several technologies and processes. These innovations usually require significant organizational changes. The basic literary approaches to the typology of innovation are summarized in Table 2.

The above approaches have in common that innovation is examined by itself or by considering its business aspects. At the same time, the concept of innovation and technological innovation can also be interpreted in a broader context, in this connection it is definitely worth mentioning the theory of social constructivism. Based on Deutsch (2011), the theory of social constructivism deals with the social embeddedness of technology and innovation, the trend examines technological innovation in the context of the participants connected with it. The approach of social constructivism considers technological development and innovation to be fundamentally a social process, Luiten (2001) emphasizes that technology is determined by social processes, the effects of technology can be interpreted by knowing the values, opinions, and preconceptions of the creators and customers of the given technology. The meaning, limitations and possibilities of technology are formed by the users of the technology during use, and the scientific results and technical design that underpin the creation of a given technology provide a kind of framework that determines user needs (Deutsch, 2011). Bijker (1995) calls this the technological framework, which includes all the factors that influence the groups that come into contact with the technology during its application. From the point of view of a given technology, the relevant groups include those who form an opinion about the given technology and its use (construct), the users of the technology, the organizations and companies that use the technology, and even non-users of the given technology. Examining the technological framework can contribute to a deeper understanding and knowledge of the effects of the given technology, including the goals of the application of the given technology, the related problems, problem-solving strategies and requirements, the mapping of available knowledge, concepts, opinions, and attitudes about the technology. The technological framework does not affect the groups using the given technology to the same extent, the groups using it have different information and knowledge regarding the social embedding of a technology, the image of the technology. The theory of social constructivism expands our understanding of the concept and typology of technological innovation, the approach highlights that when examining a technology, an innovation, we cannot ignore the social and cultural context, the mapping of deeper factors that influence the users' perception of technology and their attitude towards technology.

My most important findings regarding the concept of innovation, typologies of innovation, and the relationship between innovation and technology are summarized below.

- Regarding the definition of innovation, the definition of the Oslo Manual is generally accepted, according to which innovation is a new or significantly improved product or service, a new procedure, a new marketing method, or a new organizational method in business practice.
- This definition is quite close to one of the earliest interpretations of innovation, Schumpeter's types of innovation. Based on this, the five basic cases of innovation are the sale or production of a new product, the new delivery method, the

exploration of new markets, the use of new production materials and the creation of a new market situation.

- Other typologies of the concept of innovation, most commonly used in the literature, include the definition of innovation based on its scope and novelty content (incremental or modifying innovation, radical innovation, production process innovation, paradigm shift), the typology according to the degree of innovation and the nature of the change (gradual or incremental innovation, modular innovation, structural innovation, radical innovation), and the approach focusing on product-market changes, on the basis of which we can distinguish sustaining and breaking (also known as disruptive) innovation.
- The relationship between the concept of technology and innovation is easy to see if we take the definition of the two concepts as a basis. Based on these, if a technology has novelty content (ie meets the definition of innovation), it is considered an innovation. We call innovation that has a technological content a technological innovation. An innovation does not necessarily qualify as a technology or a technological innovation, only in the case that the innovation can expand the capabilities and possibilities of action of the person.
- It is important to mention that scientific interest in innovation did not appear exclusively in technical and economic sciences (although these disciplines are the most important from the point of view of my research). The theory of social constructivism deals with the social embeddedness of technology and innovation, and examines innovation in the context of participants connected to innovation. Based on the trend, in order to gain a deeper understanding of the effects of innovation, it is necessary to examine the so-called technological framework (the purpose of the application, relevant knowledge, attitudes, opinions and problems).

## 2.2 Technology management and its functions

The interpretation and definition of the concept of technology management or technomanagement (in English, Technology Management or Management of Technology) is extremely versatile in the relevant literature, and even the exact delimitation of the topic, the definition of its purpose and functions does not show a unified picture (Nagy-Borsy, 2018). In addition, the development of the concept of technology management over time cannot be demonstrated, but at the same time, not surprisingly, there is often a connection between the topic, field, orientation of the given researcher, and the "character" and focus of the given literary definition. Researchers in the field generally accept the approach developed by the National Research Council (1987), according to which technology management combines the disciplines that focus on the creation of technology with those that enable its economic transformation. The focus of technology management is how technology is created and how it can be used to create business opportunities, how technology strategy can be integrated with business strategy, how technology can be used to gain a competitive advantage, how technology can improve the flexibility of production and service systems, how to build organizations that embrace technological change and when to enter and leave technology

(National Research Council, 1987). From the point of view of this research, we must definitely mention the approach that has become general among domestic researchers of the topic, which summarizes the above, according to which technology management is "the cross-functional activity that puts technology at the service of the effective and efficient functioning of the organization" (Pataki, 2005, p. 41). Based on the interpretation of the National Research Council (1987), the most important issues related to technology management, i.e. the management of technology, concern the following areas.

- How can technology be incorporated into the overall strategic goals of companies?
- How can you enter and exit technological developments faster and more efficiently?
- How can technology be assessed and evaluated more effectively?
- How to best implement technology transfer?
- How can the development time of new products be reduced?
- How can complex, interdisciplinary or inter-organizational projects and systems be effectively managed?
- How can the organization's internal use of technology be managed?
- How can you use the efficiency of technical specialists?

Based on Khalil (2000), technology management can be interpreted at different environmental levels, national economic, organizational and individual. At the national economic and governmental level, technology management contributes to the development of the public policy and regulatory environment affecting technological issues. It contributes to the creation and maintenance of competitive businesses at the organizational and company level. And on an individual level, technology management can be interpreted as a contribution to increasing the social value of a person. The National Research Council (1987) defines technology management as an interdisciplinary field concerned with planning, developing, and implementing technological capabilities to shape and achieve an organization's operational and strategic goals. From a macro-level perspective, technology management can be defined as a field of knowledge that deals with the development and utilization of technology and the formulation and implementation of policies dealing with the impact of technology on society, organizations, individuals and nature. It aims to stimulate innovation, create economic growth and promote the responsible use of technology for the benefit of humanity. Khalil (2000) emphasized that technology management connects scientific and engineering disciplines dealing with technology with business and management fields.

It follows that technology management is an integrative, interdisciplinary field that uses and combines tools and concepts from several other scientific fields (based on Khalil (2000): natural sciences, social sciences, industry practices, business approaches, engineering sciences) in order to put technology at the service of environmental levels (national economic, organizational, individual) goals. Table 3 contains the basic areas and tasks of technology management, in the context of how technology management itself connects the research areas of the natural sciences and engineering disciplines, as well as the focus areas of the business and management disciplines.

3. Table: Basic areas and tasks of technology management

| **Science and engineering discipline** | **Technology management** | **Business, management discipline** |
|---|---|---|
| • Natural science disciplines<br>• Material technology<br>• Product technology<br>• Production and process technology<br>• Information technology<br>• Environmental technology | • Strategic, long-term issues related to technology<br>• Science and technology policy<br>• Process of technological innovations<br>• R&D management<br>• R&D infrastructure and technological change<br>• Technology entrepreneurship and new ventures<br>• The product or process life cycle<br>• Technology forecasting and planning<br>• Technological innovations and strategic planning<br>• Technology transfer<br>• The role of international technology transfer and multinational companies<br>• Technological risk analysis and assessment<br>• Technology and economic analysis<br>• Technology and human, social and cultural issues<br>• Training and education issues in technology management<br>• Technology management in the production sector<br>• Technology management in the service sector<br>• Information technology and other emerging technologies<br>• Connection points for production, marketing and after-sales activities<br>• Technological change and organizational structure<br>• Management of technical projects<br>• Financing technology and financial decision-making<br>• Quality and productivity issues<br>• Technology management methodologies<br>• Eco-efficiency and environmental sustainability | • Finance<br>• Accounting<br>• Management<br>• Marketing<br>• Economics<br>• Business law |

*Source: own compilation, based on Khalil (2000)*

In Table 3, the basic areas of technology management deal with the technological base of companies (or national economies in the macro-level interpretation). The presentation of the concept of the technological base is also important for the interpretation of research and technology management. The concept of the technological base means the set of technological tools, knowledge and infrastructure available to a given organization, industry or country, this base includes the available technologies, the knowledge related to them, as well as the capabilities with which an organization or community can use these apply and further develop technologies. According to Gaynor (1996), the technological base of companies means the technological infrastructure owned by the organizations, as well as the knowledge and ability of the organizations that enable the development of new products in accordance with market needs, the production of these products while maintaining the appropriate quality and cost level, the development of new technology or adaptation to meet future needs. The traditional components of the technological base - operational infrastructure, product technology, process technology, ability and knowledge, information support, systems and practices - can be classified into the categories below, already embedded in new frameworks and combined with the related capabilities by Gaynor (1996).

- Basic technological tools represent the infrastructural part of the technology base, these tools form the basic technology of the organization, it means technologies embedded in products and processes that are crucial for the company's current and future competitiveness.
- Organizational tools are the factors that enable the company to create and exploit new technologies. They include five elements: the ability profile of employees and managers, decision-making and information-sharing procedures, organizational structure, strategies that guide action, and a culture that shapes shared assumptions and values.
- External technological tools represent the connections between the company and its environment, affecting the technological base. This includes relationships with current and potential partners, competitors, suppliers, customers, professional associations, research and educational institutions, consultants, political participants and local communities.
- Development processes cover product and process development activities, the actual results that create value for the company's customers. The technology development process creates the next generation of technologies that later become part of the core technology tools.
- Supplementary tools mean additional tools and processes necessary for the operation and exploitation of the technological base, such tools may be needed in terms of marketing, distribution, production, sales, and information and communication systems.

Based on the early theoretical and practical researches of technology management, Gaynor (1996) and Drejer (1997) identify five and four main development phases concerning technology management, respectively. At the same time, these phases describe the process of technology's rise to the strategic level, so they also present the historical periods of development of the strategic technology management discipline. The first-second (first according to Drejer) phase of the development of technology management is characterized by R+D orientation, in this sense technology is treated together with research and development as a strategic tool for long-term competitiveness and innovation. The third phase is innovation management, in which the management of the innovation process within the company is focused on. Due to the constant changes in the external environment, companies must use tools and methods suitable for predicting changes, through which technological strategic decisions can be made. Technology management represents the fourth phase, the trend draws attention to the planning of technological development appearing in a constantly changing business environment and the role of the planning and management toolkit for responding to it. The fifth, strategic techno-management, discussed later in the thesis: treats technology as the starting point of strategy, focuses on combining technological and business aspects and integrating these decisions into corporate strategy. (Deutsch et al., 2019)

4. Table: Phases of the content development of technology management

| Phase 1 | Phase 2 | Phase 3 | Phase 4 | Phase 5 |
|---|---|---|---|---|
| **R&D trend** | | **Innovation management** | **Technology management** | **Strategic technology management** |
| • R&D | • R&D<br>• Design<br>• Production | • R&D<br>• Design<br>• Production<br>• Marketing<br>• Sale<br>• Distribution<br>• Customer services | • R&D<br>• Design<br>• Production<br>• Marketing<br>• Sale<br>• Distribution<br>• Customer services<br>• IT systems<br>• Finance<br>• Acquisition<br>• Patents and legal issues<br>• PR<br>• General administration | • R&D<br>• Design<br>• Production<br>• Marketing<br>• Sale<br>• Distribution<br>• Customer services<br>• IT systems<br>• Finance<br>• Acquisition<br>• Patents and legal issues<br>• PR<br>• General administration<br>• Buyers<br>• Suppliers<br>• Other external and internal influencing factors |

*Source: own compilation, based on Gaynor (1996)*

Based on Gaynor (1996), the strong initial R&D orientation that characterizes corporate practice has continuously expanded in response to external environmental challenges with the integration of planning and production tasks, then innovation management, technological planning and finally strategic management, and as a result of this process, and the interdisciplinary research subfield that we know today as strategic technology management. The developmental phases defined by Graynor (1996) and Drejer (1997) and their content are summarized in Table 4. Based on the table, it can be concluded that technology management means significantly more than the R&D activities of national economies or companies. Research and development activities and inventions are fundamental components of the creation of technology and technological progress, but from the point of view of creating social welfare and corporate competitiveness, the exploitation, commercialization or protection of technology is much more important. Gregory (1995) classified the above activities related to technology management into so-called clusters and assigned these activities to different functions. The process perspective, regarding the relationship between clusters and functions, is relevant from the point of view of replacing the former static point of view with a dynamic point of view. The functions defined by it and the related technology management activities are contained in Table 5.

5. Table: Functions and processes that can be linked to technology management activities

| **Technology management** | | **Process approach** | | | | | |
|---|---|---|---|---|---|---|---|
| **Clusters** | **Key activities** | **Identification** | **Selection** | **Acquisition** | **Exploitation** | **Protection** | **Process approach** |
| **Competences and abilities** | Opportunity to take advantage of technology | | | | X | | |
| | Protection of key capabilities | | | | | X | |
| | Technological careers | | X | X | X | | |
| **R&D management** | Creating a connection between R&D and basic science | X | | X | | | |
| | Visibility and evaluation of new technologies | X | X | | | | |
| | Product management | | | | X | | |
| **Innovation** | Integration of innovation activities | | | X | X | | X |
| | Team structure and dynamics | | | | | | X |
| | Contextual and environmental influences | | X | X | X | | |
| **Organizational learning** | Involvement of employees | | | | | | X |
| | Ability to incorporate new knowledge | X | | X | | | |
| | Ability to reorganize to pursue new activities | | | | X | | |
| **Introducing a new product** | Managing overlaps between key activities | | | | X | | X |
| | Communication between functions | | | | | | X |
| | Speed and responsiveness to customer needs | | | | X | | |

*Source: own compilation, based on Gregory (1995)*

The definition of the functions of technology management was not only published in the research of Gregory (1995). In the context of the interpretation of technology management, the relevant literature actively deals with the content dimension of technology management, that is, what functions and activities within the company are related to technology management. The focus of technology management research is how companies can manage the available technology base, along with which functions, in what ways they can acquire the technology they need and how they can protect their technological innovations. These technological activities essentially cover the content dimension of technology management, however, the relevant authors of the topic define the technology management functions of companies in different ways. Table 6 contains the different approaches of the relevant literature regarding technology management functions.

6. Table: Functions of technology management

| Gregory (1995) | Rush et al (2007) | Arasti & Karamipou r (2017) | Cleland & Bursic (1991) | Kropsu & Vehkapera et al. (2009) | Pelser (2014) | Jemala (2012) |
|---|---|---|---|---|---|---|
| • Technology identification<br>• Technology selection<br>• Technology acquisition<br>• Exploitation of technology<br>• Protection of technology | • Search, getting to know<br>• Strategy, selection<br>• Acquisition, competence building<br>• Introduction, exploitation<br>• Learning | • Technology identification<br>• Technology selection<br>• Technology acquisition<br>• Exploitation of technology | • Creating technology<br>• Technology monitoring<br>• Technology assessment<br>• Technology transfer<br>• Acceptance of technology<br>• Use of technology<br>• Maturity of technology<br>• Decline of technology | • Technology strategy<br>• Technology development and application<br>• Information and knowledge management<br>• Technology acquisition and transfer<br>• Technology forecast<br>• Product development<br>• Life cycle management<br>• Introduction<br>• Continuous production management | • Getting to know technology<br>• Technology acquisition<br>• Technology and product design<br>• R&D organization and management<br>• R&D<br>• Investment<br>• Production and process technology | • Technology identification<br>• Technology introduction<br>• Introduction of technology |

*Source: own compilation, based on Deutsch et al. (2019)*

In addition to the functions identified by Gregory (1995) – technology forecasting, technology selection, technology acquisition, technology exploitation and technology protection – new categorization attempts have continuously appeared, but at the same time the individual groupings do not differ radically from each other. The model of Cleland & Bursic (1991) is an exception among the trends presented in Table 6 - without claiming to be complete - in which the individual functions are linked to the phases of the technology life cycle, focusing on the integration of technology. Deutsch et al. (2019), the functions of technology management are the processes dealing with the management of technology within companies, the identification of technology, the selection of technology, the acquisition of technology, the exploitation of technology, the protection of technology and the learning function. The functions of technology management are described in the relevant literature (Cory, 1988; Gaynor, 1996; Braun, 1998; Szakály, 2002a; Zuckerman, 2002; Tschirsky, 2003; Pataki, 2005; Pilkington, 2006; White & Bruton, 2007; Friedman, 2008; Based on Shane, 2009; Cetindamar, 2011; Pelser, 2014).

The identification of technology means the identification of technological opportunities, the process and means of monitoring external and internal environmental changes that support the acquisition and preservation of competitive advantage. The function of identification includes the preparation of technological forecasts, the evaluation of the organization's technological capability, the examination of macro- and sectoral environmental trends and tendencies, and the exploration of opportunities and obstacles related to the development of new technologies. (Deutsch et al., 2019)

The selection of technology deals with company-level strategic issues and their relationship with technology strategy, which also necessitate the existence of business-level strategic goals and priorities. During the selection of the technology, the technologies and technological areas deemed by the company to be of strategic importance can be determined based on the opportunities and threats, strong and weak points discovered on the basis of technological forecasts, external and internal environmental investigations. Under the function of selection, the key areas of technological development, the opportunities for the development of technological capabilities, as well as the range of technological projects for the realization of the goals formulated by the corporate, business and technological strategy, the criteria and method of selecting technological projects must be designated. (Deutsch et al., 2019)

The acquisition of technology is the determination of how the company acquires technologies of value to it, i.e. within this framework, a decision must be made regarding whether the organization develops it itself, jointly develops it with other organizations, or purchases technologies for gaining and maintaining a competitive advantage. . Technology acquisition is a key element of technology strategy and technology management activities. The dilemma of developing from internal sources or buying from external sources is influenced by what capabilities the company has, how important it considers the exclusive right of disposal over the technology for its future, how much it fears that its technology will be known by competitors and market partners, and how necessary it considers it to be to update its existing competencies and construction. However, regardless of whether the company decides to develop the technology independently or with the involvement of others, in both cases it is necessary to ensure proper management and operation of the related processes. The acquisition function includes the management of internal R&D activities and processes, the detection of possible forms of technological partnerships, and the management of technological partnerships. (Deutsch et al., 2019)

During the exploitation of the technology, the companies carry out the efficient transfer, introduction, operation of the technology within the organization and, ultimately, the marketing of the technology. Exploitation processes naturally include incremental developments, process adjustments and marketing activities. The determining element of maintaining and enhancing the competitive advantage is the exploitation and continuous renewal of the company's technological base, tools and capabilities. How and in what way the company's products and services are able to meet customer needs and their changes, as well as the organizational embeddedness of technological capabilities, influence the way and extent of technology exploitation. The scope of the exploitation function includes the bringing of technological innovations to the market, the use of process technologies and technological capacities, the characteristics of the organizational structure supporting the exploitation of technological capabilities, the establishment and operation of an organizational culture supporting exploitation, management and compensation systems. (Deutsch et al., 2019)

Technology protection includes the formal processes and tools that ensure the protection of a company's intellectual property, including the knowledge and expertise embedded in products and processes. The protection of technology serves to preserve the competitive market position of companies and to make it difficult for competitors to copy technological resources and capabilities. While competitors may be able to copy intellectual property by reverse engineering, luring employees, running similar projects, or studying patent applications, other documents, and publications, companies can choose between different means of protecting intellectual property based on the type of technological device to be protected. , complexity, and the nature of the knowledge that provides its foundations. Taking all of this into account, this function encompasses the possible methods and domestic regulation of the protection of technology and intellectual property rights, as well as the management of the intellectual property rights portfolio. (Deutsch et al., 2019)

The learning processes focus on the development of the company's activities, the sources of which are information obtained from the implementation of technological activities and projects and feedback from the external environment. The learning function essentially permeates the other technology management functions, and can be interpreted in relation to and in relation to all of them. The function includes the assessment and development of learning processes, the development of internal routines, the development and management of integration, evaluation systems and processes, as well as the integration of quality assurance systems and requirements into the company's processes. (Deutsch et al., 2019)

Unsual & Cetindamar (2015) also assign specific, specific tasks to technology management functions, and also identify areas that support technology management functions within the company. Technology identification includes R&D environmental monitoring, business unit level environmental monitoring, and corporate environmental monitoring. Technological mapping, the assessment of technological needs, and the examination of the technostrategy of business units are related to the selection of technology. R&D strategy, R&D portfolio management, technology transfer, and R&D financing are related to the acquisition of technology. During the exploitation of technology, the role of areas related to product portfolio management, technology adaptation, and project aftercare is significant. The protection of technology includes the management of intellectual property rights, while learning processes and functions come to the fore with the post-evaluation of projects. According to the authors, areas that support the functions of technomanagement include strategic management (corporate strategy, technostrategy, managing partnerships), innovation management (ideation, feasibility, project selection, creation of new business units), project management (project management, performance measurement, new establishment of business units), as well as knowledge management. Cetindamar et al. (2009) and Unsual & Cetindamar (2015), the interpretation of technology management functions and the explanation of the dimension of the technology management process already anticipates the raison d'être and context of the strategy technomanagement discipline.

As a summary of the above, the interpretation of technology management, its role within the company, and its functions can be summarized below based on the relevant literature.

- Technology management is an integrated, interdisciplinary field of study that connects technical sciences with business disciplines.
- Technology management can be interpreted at different environmental levels, at the national economic level, technology management contributes to the formation of the public policy and regulatory environment, and at the organizational level, its goal is to create and maintain competitive companies. On an individual level, technology management can be interpreted as a contribution to increasing the social value of a person.
- The technological base means the set of available technological tools, knowledge and infrastructure, this base includes the available technologies, the knowledge related to them, as well as the capabilities with which an organization or community can apply and develop these technologies.
- Technology management at the organizational level is aimed at managing the technological base of companies (evaluation, development, integration). Based on a narrower interpretation, technology management refers to the methods that are suitable for the development of available technologies and the acquisition and integration of unavailable technologies.
- Based on a broader interpretation, technology management appears as an integrated framework within a company, the purpose of which is to ensure that the organization uses and utilizes the available technology effectively, as well as to promote technological developments.
- The functions of technology management include the identification, selection, acquisition, exploitation and protection of technology, as well as the learning processes related to the management of technology.
- The function of identification means analyzing the external environment, forecasting technology, evaluating the technological base and identifying strategic opportunities.
- The function of selection covers the selection of the technology strategy, its alignment with company goals, the definition of technology needs, and the evaluation of the technology portfolio.
- The function of acquisition covers the operation of internal R&D processes, the acquisition of technology from external sources, and the establishment of external partnerships.
- The function of exploitation means bringing the technology to the market, spreading it, making use of the technological capacities, creating the supporting structure of the technological processes and developing the management systems.
- The function of protection covers activities dealing with the protection of intellectual property, the construction and maintenance of protection devices and

systems, and the assessment of risks and dangers associated with the use of technology.

- The function of learning means the establishment and maintenance of learning processes, integration, evaluation systems, and quality assurance.
- Technology management as a functional area is related to the innovation and R&D activities of companies, but the functions of technology management are also closely related to other areas, such as finance, production or project management or strategic management.

## 2.3 Strategic technomanagement as the convergence of technology and strategy

In parallel with the development of technology management as an established independent discipline, starting from the 1990s, technological development had an increasingly serious impact on business processes and economic life. Environmental changes indicated a shift towards a knowledge-based society and an economy based on technological developments and innovation. Professional thinking about competitiveness has been transformed, technology-oriented research trends of environmentally conscious management and social responsibility have appeared, as well as theoretical and empirical research trends dealing with technological development, digitalization and the specifics of companies. As a result, technology management, which previously mainly involved the technical field, came into more and more serious interaction with the theoretical trends of strategic thinking, as well as the theoretical and practical professional researches dealing with the management of technology drew more and more seriously and relied on the system of the concept of the strategic management discipline, the use of terms and tools. The trend focusing on technological developments within the company – previously R+D focused – was gradually expanded with the approach and tool system of innovation management, then technology planning and finally strategic management. The strategic approach to technology was also supported by the fact that the concept of strategic management deals with the business and operational activities of companies, as well as their interaction with the competitive environment, so the trends and industry effects in the economy (such as technological development and the radical increase in the role of technology in the economy, development) significantly influence the direction and focus of theoretical research in strategic management. (Deutsch et al., 2019) At the same time, the concept of sustainable and then temporary competitive advantage, the resource and ability-based paradigm (Barney, 1991), then the trend of dynamic capabilities developing from it and the concept of temporary competitive advantage (Teece, 1997, Cetindamar et al., 2009), the role of companies with dual capabilities has been appreciated (Tushman et al. 1996). The role of technology has therefore become more and more prominent in the theoretical trends of strategic management, in addition, the importance of the use of technology and the "management of technology" has also increased in the business environment.

The paradigms that emerged and became dominant during the development of strategic management formulated the conditions and reasons for companies' competitiveness in different ways, consequently identified the sources of competitive advantage in different ways, and thought differently about the process and starting points of strategy creation. Some paradigms of strategic management used different approaches regarding technology and technological innovations. In order to understand the development of the strategic role of technology within the discipline of strategic management, it is necessary to explain the role played by technology and technological innovations in gaining and maintaining a competitive advantage, and its scientific development. Starting from the 1960s, in the evolutionary process of strategic management as a discipline, a trend following three well-defined approaches to strategy creation and application was created and became the defining paradigm of the given era. First, the Harvard school, then the paradigm based on industry position marked by the name of Michael Eugene Porter, and finally the paradigm of resources and capabilities, and the theory of dynamic capabilities that can be derived from it, emerged. Although the individual paradigms were formed one after the other in time, reflecting on each other, the theories, models and approaches contained in them did not lose their validity later. From this point of view, it is also important to explain the approaches of the individual paradigms to strategy creation and the sources of competitive advantage, and within this to present the role of technology and technological strategy in competitiveness.

The conceptual definition of the strategy has an extremely broad background in the literature, Deutsch et al. (2019, p. 42), the sources agree that the strategy is "the definition of how the company or business wants to gain a competitive advantage, or how it tries to keep the competitive advantage it has already acquired". According to the purpose of the strategy, it includes the definition of the basic goals and mission of the company, the establishment of its scope of operation, the mapping and exploitation of existing and potential competitive advantages, and also lays the foundation for the economic and non-economic values provided to the stakeholders (Chikán, 2020). Regarding the levels of the strategy, there is agreement among the literature sources that the strategy has three levels in a hierarchical relationship with each other. Based on Rideg (2023), the highest-level strategy is the company-wide strategy, which contains the organization's vision, mission, goals and the strategic actions necessary to achieve the goals. (1) The company-wide strategy answers the questions in which areas and markets the company should operate. If the given company is active in several branches of business, the corporate strategy deals with the relationship between the corporate center and the corporate units, and the creation of the corporate portfolio. The task of corporate centers is to develop a strategy that is in line with the interests of the company's owners and other stakeholders, to create and share the necessary resources, and to create an organizational structure, management and incentive system that supports implementation. (2) The next level of the strategy, the business strategy, formulates the desired position in the given industry and market and the specific competitive strategies necessary to achieve these goals in relation to the given product-market configurations. (3) The third level of strategy is functional strategies. Functional strategies define the company's goals and the means of achieving them in each functional area in accordance with the corporate and business strategy.

Functional strategies are responsible for the optimal use and management of resources, the development and provision of capabilities that support the company's competitive advantage. (Deutsch et al., 2019)

Among the paradigms of strategic management, the paradigm of the Harvard school deserves mention first. The theoretical foundations of the paradigm were given by the prominence of financial and then strategic planning, and its most important model is the rational process of strategic planning developed by prominent representatives of the trend (Chandler, 1962; Ansoff, 1965; Learned et al., 1969; Andrews, 1971). The model is based on the assumption that the (internal and external) environment can be analyzed and understood using rational means, and that these analysis methods and independently interpretable models (e.g. PESTEL, functional analysis, SWOT, BCG) make companies suitable for they can identify the main characteristics and trends of the external and internal environment, thus being able to develop and implement strategic plans that can provide the company with a competitive advantage. In this sense, the source of competitive advantage is the accuracy of analyzes and planning. The Harvard school defined the competitiveness of companies in terms of creating harmony between organizational characteristics and external environmental conditions. Based on the rational process model, the future of the companies can be known and planned, so if the companies apply the appropriate planning steps, as well as appropriate planning and analysis methods, and the strategic plan based on this is implemented in practice, according to the representatives of the paradigm, the companies are above average they can gain a competitive advantage that ensures profit (Deutsch et al., 2019).

The paradigm of the Harvard school treated technological issues on an equal footing with other functional activities within the organization. Regarding technology and the creation and implementation of technological strategy, no separate model or analysis framework was spread under the paradigm of the Harvard school, but this does not mean that the approach of the paradigm cannot be connected to the issue of technology. Ansoff's growth matrix developed by Igor Ansoff (1965), a prominent representative of the paradigm, is based on the evaluation of the company's technological base. During the later interpretation and use of the Ansoff matrix, it left the close connection with the company's technological resources and capabilities and is usually interpreted in the literature as a matrix of corporate growth (Rideg, 2023), however, the original growth matrix shows the companies' growth directions (market expansion, product development , market development, diversification) is specifically interpreted in the context of the available technological base and possible product-market combinations. It is also worth mentioning the model developed by Miles & Snow (1978), which examined the strategic orientation of companies and their adaptation to their environment. The authors defined three types of companies, defense, research and analysis companies, which categories show significant differences in terms of their technological foundations and innovation efforts (Deutsch et al, 2019). Burgelman et al. (2001), the connection between the Harvard paradigm and technology is also strengthened by Abell's (1980) model dealing with the mission and activities of companies, in which, in addition to the company's consumers and the needs of these consumers, the technology used by the company was defined as a determining factor in terms of the company's operation.

The next paradigm of strategic management, the paradigm based on industry position, is based on the assumption that the performance of companies is determined by the attractiveness of the given industry and the company's relative market position in the industry. The attractiveness of a given industry is influenced by the behavior of the companies operating in it and the industry structure. According to the best-known and most important representative of the paradigm, Michael Eugene Porter (1980), during strategy creation, the examination of the external environment should be placed before the analysis of the internal environment, since the characteristics of the external environment (primarily the industry chosen by the companies) have a much more serious impact on the performance of the companies, as internal factors of companies. Porter saw and explained the difference between the companies' performance primarily in the difference between the profitability of the industries. According to Porter (1980), companies competing in a given industry have similar resources and capabilities, so a company's performance can be increased primarily not by a combination of resources and capabilities that exceed competitors, but by operating in an industry that promises higher profitability potential. He summarized the factors that determine industry profitability, i.e. profitability, in the five-factor or five-forces model, which is very often referred to in the literature, based on these, the structure typical of a given industry, the nature and intensity of industry competition, the strength of entry barriers, the availability of substitute products, and the suppliers and customers bargaining power affects In terms of strategy creation and implementation, the paradigm model based on the industry position starts from the analysis of the external environment, including the industry position. According to the paradigm, companies can develop their corporate and business strategy based on the results of the analysis of the industry's competitive forces. According to Porter (1980), the focus of corporate strategy should be whether the company wishes to continue competing in the given industry or leave it and enter another industry. Regarding the business strategy of companies, competitive strategies (cost leader, differentiator, focused-cost leader, focused-differentiator) were defined (Porter, 1980). In the paradigm based on the industry position, the value chain model, also associated with Porter's name, was developed in relation to the resources and capabilities of companies. By applying this, the company can analyze the value-creating ability of its resources and capabilities and its contribution to satisfying consumer needs along the lines of its own value-creating processes.

Deutsch et al. (2019), the examination of the role of technology is a key factor in Porter's work, Porter (1980) deals in detail with the issues of technological change and technological strategy, according to him, technology is one of the most important factors that has the greatest impact on the conditions of competition, which also affects the industry competition, the competitive strategy chosen by companies, and the creation of value chains. In the paradigm based on industry position, the purpose of the technology strategy is for companies to be able to decide which technology should be developed and procured from external sources, and which technology-innovation strategy the company should use to strengthen its competitive position in the industry, thereby preserving its competitive advantage. Despite the fact that the paradigm deals with the issue of technology and technological strategy, in Porter's (1980) approach, technology is primarily a functional issue, so it represents one of the functional subfields of corporate strategy.

The resource and capability paradigm was developed in opposition to the industry position paradigm approach. According to prominent representatives of the paradigm (Grant, 1991; Prahalad & Hamel, 1993; Barney, 1991; Peteraf, 1993), the differences in the performance of companies are not explained by the difference between the profitability of the industries, but by the difference between the factors under the influence of the companies. The assumption of the paradigm is that the activities of the companies in terms of combining their available resources and capabilities represent a more significant difference between the companies than the differences between the profitability of the given industries. It follows that the source of sustainable competitive advantage is those long-term stable factors (resources and capabilities) under the company's influence that explain differences in the performance and profitability of companies competing in the same industry under the same external conditions (Deutsch et al., 2019). According to Barney (1991) and Grant (1991), the corporate strategy aimed at obtaining or securing a competitive advantage cannot be based on external environmental factors independent of the company's decisions, but companies must base their strategy on the resources and capabilities they possess. According to the paradigm based on resources and capabilities, the strategy creation process must begin with the evaluation and review of the company's resources and capabilities. On the one hand, the examination of the external environment becomes necessary along the lines of the assessment of resources and capabilities (I will write more about this when describing the VRIO model), but Deutsch et. under (2019), the next step in the strategy-making process is the selection of corporate and business strategies for exploiting the opportunities provided by the external environment and the company's resources and capabilities. The paradigm based on resources and capabilities therefore "performs" strategy-making by moving from the examination of internal factors to external factors, in contrast to the industry position paradigm, where strategy-making proceeded from the analysis of the external environment to the evaluation of internal factors.

The VRIO model is used to evaluate the resources and capabilities of companies, the name of which refers to its four factors, i.e. value, rarity, copyability and embeddedness (Value, Rarity, Imitability, Organization). According to the structure of the VRIO model, the assessment of resources and capabilities takes place in four steps. (1) A resource or ability is valuable if it is able to create value for the company's customers and also supports the exploitation of external environmental opportunities and the prevention of threats. The possession of valuable resources and capabilities for companies leads to competitive parity, so valuable resources and capabilities alone do not provide companies with a competitive advantage, but their absence clearly leads to a competitive disadvantage. (2) A resource or capability is rare if only a few of the company's competitors possess it. The possession of rare resources and capabilities gives companies a temporary competitive advantage, the competitive advantage can be interpreted as long as the given resource or capability can maintain its "rarity". (3) A resource or ability is difficult to copy or replace, if it is difficult for the company's competitors to copy or replace the given resource or ability. Hard-to-copy resources and capabilities also provide companies with a temporary competitive advantage, in order to preserve the competitive advantage in this case it is necessary to protect the copyability and substitutability of the given resource or capability. (4) A resource or capability is organizationally embedded if the company has organizational conditions and processes that enable the use and exploitation of the given resource or capability. Organizationally embedded and exploited resources and capabilities give companies a sustainable competitive advantage. The structure of the VRIO model supports companies in mapping and evaluating the resources and capabilities they possess in terms of their contribution to the company's competitiveness. According to Prahalad & Hamel (1993), the company's essential (or basic) capabilities are those resources and capabilities that can create value for consumers, are rare among competitors and difficult to copy, or in terms of which resources and capabilities the given company is significantly better at at its competitors. The sources of a company's sustainable competitive advantage are its core capabilities. Deutsch et al. (2019) in relation to the VRIO model notes that the application of the model, and thus the resource and capability-based paradigm, has received several criticisms from the point of view that the evaluation system of the model is difficult to implement in practice, is quite subjective, and the authentic self-evaluation of the company plays a major role in it.

In the discipline of strategic management, the theory based on dynamic capabilities did not become an independent paradigm, but appeared as a further development of the paradigm based on resources and capabilities (Teece & Pisano, 1994; Teece et al. 1997; Eisenhardt & Martin, 2000; Zollo & Winter, 2002, Shane, 2009; McGrath, 2012). According to the theory of dynamic capabilities, the external and internal environment of companies changes turbulently, therefore the essential capabilities of companies cannot be exploited in the long term, since all essential capabilities quickly become obsolete in the changing environment. Deutsch et al. (2019), the essential capabilities of companies can become a source of resistance to change, causing rigidity in the organization and impairing the company's competitiveness. The theory of dynamic capability links the sources of gaining and maintaining a competitive advantage to the organizational capabilities and higher-level routines through which companies are able to build, redesign and integrate their capabilities in accordance with the rapidly changing environmental needs, thus dynamizing the resources they own in accordance with environmental changes and abilities. The understanding of dynamic capabilities is supported by Marfo et al. (2017) categorization, which hierarchically divided the organization's skill levels into four categories. The individual skill levels cover the degree of development and strategic focus within the organization, the third-level skills represent the most advanced, dynamic skills. Marfo et al. (2017), dynamic capabilities are the capabilities of the organization that support the renewal, reconfiguration, and re-creation of resources, capabilities, and essential capabilities. Hierarchical levels of capabilities, their associated activities, and resource and capability categories are included in Table 7.

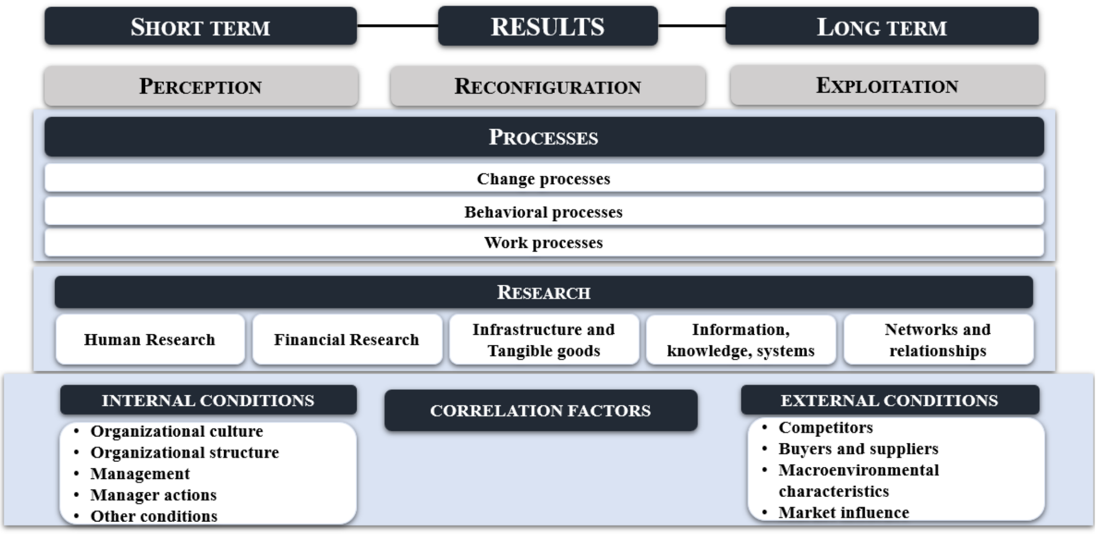
7. Table: Levels of your organizational resources and capabilities

| Your skill levels | Activity | Categories |
|---|---|---|
| Zero-level skills | They create the foundations of the organization. | Resources |
| First level skills | They represent the combination of resources within the organization in order to achieve a given goal. | Skills |
| Secondary abilities | A given set of capabilities that provide strategic direction for the organization. | Essential skills |
| Tertiary Abilities | The capabilities of the organization that support the renewal, reconfiguration, and re-creation of resources, capabilities, and essential capabilities. | Dynamic capabilities |

*Source: own compilation, based on Marfo et al. (2017)*

Sunder M. et al. (2019) created the framework of the theory of dynamic capabilities, which presents the relationships of organizational resources, processes and conditions in an integrated way, as well as their impact on short- and long-term results. The theory of dynamic capabilities focuses on how organizations are able to adapt to rapidly changing environmental conditions, how they can continuously renew and transform their resources and capabilities in order to achieve a sustainable competitive advantage. As shown in Figure 3, the structure of the diagram can be divided into three main parts, the levels of processes, resources and conditions. These are closely related to each other and jointly determine organizational performance.

3. Figure: The theoretical framework of dynamic capabilities




*Source: own compilation, Sunder M. et al. (2019) based on*

One of the fundamental elements of the theory of dynamic capabilities is the flexibility and reconfiguration of organizational processes. The diagram distinguishes between change, behavioral and work processes. Change processes show the organization's ability to adapt to changes in the environment, while behavioral processes represent the influence of organizational culture and organizational behavior. Work processes refer to the daily operational activities that ensure the basic operation. Resources play a critical role in maintaining dynamic capabilities, the figure shows that the authors have separated five resources, human resources, financial resources, infrastructure and assets, information and knowledge, and networks and relationships. These resources interact with each other to shape the organization's abilities to respond quickly and efficiently to market changes. The figure divides the conditions for the operation of dynamic capabilities into three large categories, internal conditions and external conditions, and the interrelationship factors that connect the two. Internal conditions such as organizational culture, structure, leadership and managerial actions determine the adaptability of the organization. These conditions influence how quickly and efficiently the organism can adapt to changing environmental conditions. External factors, such as competitors, customers and suppliers, as well as macro-environmental characteristics, directly influence organizational strategy and exert continuous pressure to develop dynamic capabilities.

The purpose of Figure 3 is to present organizational performance over different time horizons. In the short term, organizational performance is determined by the speed of perception and reaction, while in the long term, the organization's ability to sustainably utilize and increase its resources and capabilities. The middle section of the figure, "reconfiguration," depicts the process by which an organization restructures and optimizes its resources to adapt to changing environmental conditions. Marfo et al. (2019) created a comprehensive framework for understanding dynamic capabilities theory that integrates internal and external resources, processes, and conditions to achieve organizational success. The framework emphasizes that organizational competitive advantage is not static, but rather a continuously developing and adaptive capability based on the effective management of internal resources and successful coping with external challenges.

Schane (2009) draws attention to the fact that in a paradigm based on resources and capabilities, the technological base of companies can be a source of competitive advantage in itself. The technological resources and capabilities possessed by companies should not be adjusted to external environmental expectations, but the goal of the company's technological strategy is to create a two-way harmony between the company's technological base and the competitive environment. Among the paradigms of strategic management, the paradigm based on resources and capabilities clearly assigns the greatest role to technological issues and the company's technological strategy. According to Madsen (2010), the capabilities that ensure the renewal and dynamism of companies, identified on the basis of literature sources, are closely related to the companies' technological base and innovation capabilities. The paradigm based on resources and capabilities considers the technology and technological capabilities possessed by companies as a direct source of competitive advantage, while dynamic capabilities do not only attribute a major role to the management of technology, but to the technological strategy defined and applied by the companies, as well as to the companies' willingness to innovate and innovation activity as well. While the Harvard school, the paradigm based on industry position, dealt with the technological issues and activities of companies in a well-defined way, the paradigm based on resources and capabilities treated the evaluation of the technological base of companies as an integral part of strategy creation. In the theory of dynamic capabilities, questions related to the management of technology owned by companies (evaluation, development, selection) have already appeared, and the researchers of the concept (Teece et al. 1997; Shane, 2009; McGrath, 2012) have already specifically dealt with technology management issues in companies. in the context of its strategy.

The impression of this is the emergence of the concept of technostrategy, which narrowly interpreted (Ford, 1988; Hampson, 1997) means the part of the strategy that deals with the use, development and maintenance of the company's technological knowledge and capabilities, based on a broader definition (for example, Szakály, 2008) technostrategy includes all corporate strategic decisions that companies make in order to create, search for, spread, and embrace technology. In contrast, Burgelman et al. (2001) does not consider technostrategy as part of strategy, but interprets it as the level of technological competences and investments, which deals with the selection of specific technologies and the management of the company's technology portfolio, so although technostrategy does not belong to the company's formal strategy, at the same time the authors admit that technostrategy concerns important strategic issues (such as portfolio management, investments).

With more content than technostrategy, strategic technomanagement has become an independent discipline with an increasingly strong right to exist, which, according to Deutsch (2018), deals with the relationship between the existing and future technological resources of organizations, in relation to the organization's strategic goals and competitiveness. At the same time, the interpretation and definition of the elements of strategic technomanagement - as a summary term - (technology, technology management, technostrategy) also do not show a uniform picture in the international and domestic literature.

Strategic technomanagement was defined in the earliest researches as part of the strategist, Roberts (1993) defined it as a combination of technological planning and strategic development, Braun (1998) interpreted strategic technomanagement as part of strategic planning, which focuses on internal and external technological effects. Husain & Sushil (1997) interpreted strategic technomanagement as a supporting and managing function of technological developments, during which technology can be put at the service of companies' products and markets. Based on Price (1996) and White & Bruton (2011), however, we can interpret not only product development based on market needs as strategic technomanagement, but also all technological development and innovation aimed at changing the processes of functional company areas, sustainable technology plays a central role in increasing the company's efficiency and thereby the company's competitiveness. According to Cleland & Bursic (1991), strategic technomanagement refers to the ability of organizations to manage technology, product life cycles, and the management of organizational strategy. Ansoff (1987), then Antoniou & Ansoff (2004), Tesar et al. (2008) and Cetindamar et al. (2016) based on the innovation-centered approach, strategic technomanagement is part of business processes and strategy, during which organizations focus on the management and development of technology and innovation. The broadest interpretation is given by Sahlman (2010) and Sikander (2011). According to Sahlman's definition, strategic technomanagement is the planning, organization and management of technological activities, the application of corporate structures, in order to ensure that the basic goals of the company, their implementation, and the resources of the organization be distributed efficiently. According to Sikander (2011), strategic technomanagement is the development of the organization's technological strategy, the development of technological methods supporting the strategy, the implementation and management of the strategy, and the incorporation of technological policies into organizational routines. (Nagy-Borsy, 2018)

Based on Drejer's (1997) categorization, strategic technomanagement schools can be divided into technology-based, organizational and technology-based, and integrated strategic technomanagement schools, which combine technological, business, and strategic aspects. In technology-based strategic technomanagement schools, technology can be interpreted as the starting point of strategic management. In organization and technology based schools, the research focus is on human resources and the integration of organizational performance with technology. Based on the position of the schools of integrated strategic technomanagement, technological developments and business strategic decisions must be determined based on strategic management, without taking into account organizational issues. The common feature of the above approaches is that in the corporate environment, technology is integrated with business strategy by managing technology activities. (Nagy-Borsy, 2018)

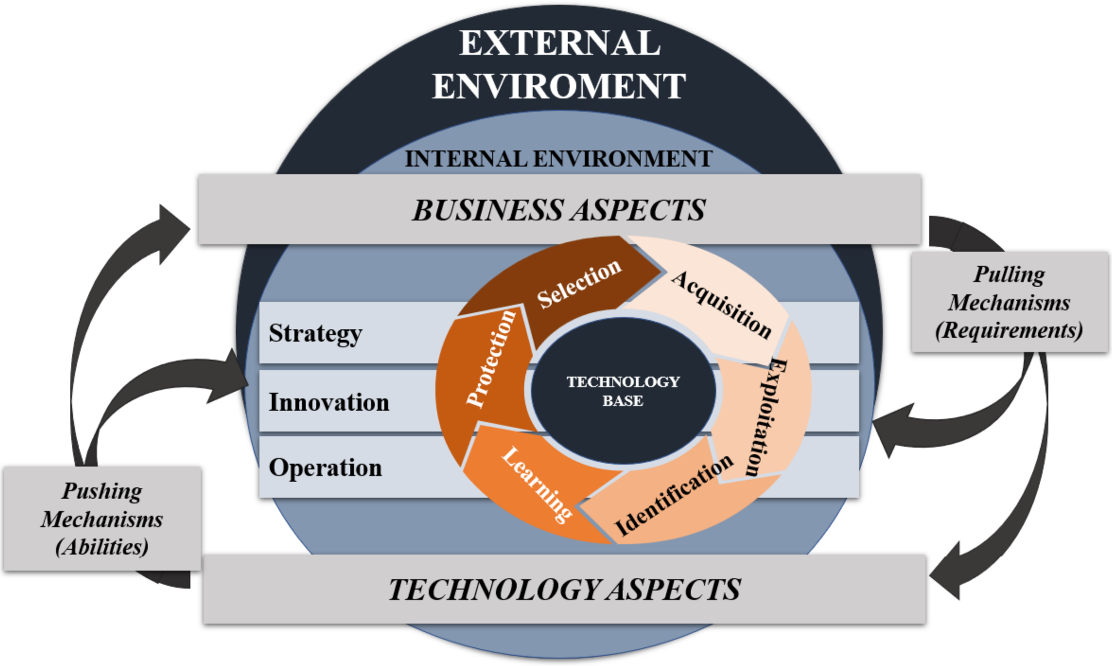
8. Table: Names and major authors of the theoretical disciplines involved

| Concept | Authors |
|---|---|
| **Technology Management (TM)** | Cleland & Bursic (1991), Gregory (1995), Gaynor (1996), Cory (1998), Szakály (2002), Zuckerman (2002), Pataki (2005), Friedman (2008), Shane (2009), Andriole (2009), Sikander (2011), Pelser (2014), Jemala (2015), Cetindama et al. (2016) |
| **Management of Technology (MoT)** | Braun (1998), Tschirsky (2003), Pilkington (2006), White & Bruton (2007) |
| **Technology Strategy (TS)** | Ford (1988), Hampson (1997), Burgelman et al. (2001), Pieterse (2005), Beard (2008), Shane (2009), Sikander (2011) |
| **Strategic Technology Management (STM)** | Cleland & Bursic (1991), Drejer (1997), Braun (1998), Tesar et al. (2008), Sahlman (2010), Sikander (2011), Cetindamar (2017) |
| **Strategic Management of Technology (SMT)** | Ansoff (1987), Roberts (1993), Husain & Sushil (1997), Burgelman et al. (2001), Ansoff & Antoniou (2004) |

*Source: own compilation*

The interpretation and use of the theoretical disciplines and concepts involved in the research therefore show a very diverse picture, the literature research presented above is organized in Table 8. However, when comparing the approaches of different authors, it emerges that the concept of strategic technology management provides the broadest, most forward-looking framework. At the same time, in recent decades, specialists dealing with the topic have developed a number of more or less different models to describe the process and elements of strategic technomanagement, none of which has become generally accepted (Deutsch et al., 2019, p. 42). To organize these modeling experiments in a unified framework, Cetindamar et al. (2016, 2017) made an experiment, who developed their integrated model based on the concepts and interpretations found in individual literature sources (Figure 4). The authors emphasize that during the creation of the model, in order to highlight the dynamic nature of strategic techno-management, the framework should present strategic technomanagement embedded in the surrounding corporate and external environmental context, taking into account in the model the knowledge flows that are the relationship between business and technological perspectives. create and sustain, and connect the business and technology perspectives of companies. (Nagy-Borsy, 2018)

4. Figure: Integrated model of strategic technomanagement




*Source: own compilation, based on Cetindamar et al. (2017) and Deutsch et al. (2019)*

Based on the integrated model of strategic technology management (Cetindamar et al., 2017 Deutsch et al., 2019), the technology management functions managed by companies (technology acquisition, exploitation, identification, protection, selection, and learning processes related to the management of technology) are closely related and they interact with strategic, innovation and operational core processes. Therefore, if strategic technomanagement is interpreted as an interdisciplinary scientific field, then it can be defined as an intersection of the disciplines of strategic management, innovation and technology management, with the important proviso that the listed scientific fields do not "take part" with equal weight and have relationships that are not assigned to each other. It follows from the strategic and technological orientation of strategic technomanagement that the discipline is also connected to the operative, operating processes and activities of the companies, and can and wants to enter into an interpretable interaction with them. The model contains the key activities of strategic technomanagement and also manages the change over time of all these aspects and their effects on each other. The role of business and technological aspects, which are both part of the internal and external environment of companies, is also revealed. The pull mechanisms and requirements coming from business aspects determined by the external and internal environment determine the technological aspects, which appear as push mechanisms and driving forces in the form of corporate capabilities. At the same time, technological aspects can also be interpreted in relation to the external environment, technological development and change outside the company has an impact on the management of strategic, innovation and technological processes of companies. Based on the model, the general goal of strategic technomanagement can be well described, according to which the discipline deals with the technological issues of companies with a strategic orientation, using its tools.

Strategic technomanagement shows more than technology management not only by expanding the environmental focus and strategic orientation. The proactive approach that can also be found in the context of dynamic capabilities is typical of strategic technomanagement, as opposed to the reactive approach of technology management. Looking at technology management functions, the selection, acquisition and exploitation of technology in technology management means the creation of knowledge, the transformation of knowledge into technology and the adaptation of technology to user expectations. In strategic technomanagement, on the other hand, the approach of dynamic capabilities appears, here the above technology management functions can be described with the steps of detection, reconfiguration and exploitation.

A more detailed description of the concept of technological capabilities, which also appears in the integrated model of strategic technomanagement, is also necessary to understand the above discipline from the point of view of research. Technological capabilities are the activities and tasks of companies that are necessary for the evaluation and development of their available technology, as well as for the monitoring of technology from external sources, as well as for the performance of the operational tasks that operate them. Levin & Bernard (2008) organized technological capabilities into four main categories, these categories and the technological capabilities related to them are summarized in Table 9.

9. Table: Systematization of technological capabilities

| **Creation of scientific and technological knowledge** | **Ensuring the transformation of knowledge** | **Ensuring the alignment of technology and market expectations** | **Providing organizational support** |
|---|---|---|---|
| • Ideation<br>• R&D environmental monitoring<br>• R&D technological strategy creation<br>• R&D portfolio management<br>• Intellectual property management<br>• Audit after project closure | • Technology mapping<br>• Product line, platform design<br>• Product/service portfolio planning<br>• Feasibility<br>• Project management<br>• Technology transfer<br>• Technological adaptation<br>• Support after project closure | • Business environmental assessment<br>• Corporate environmental assessment<br>• Business/Business strategy<br>• Corporate strategy<br>• Identification of technological need<br>• Business/Business Technology Strategy<br>• Corporate technology strategy<br>• Program and project selection<br>• R&D funding<br>• Creation of new business units | • Performance management<br>• Human resource management<br>• Management of technological collaborations and partnerships |

*Source: own compilation, based on Levin & Bernard (2008)*

In addition to technological capabilities, strategic technomanagement also names technology management capabilities separately, which can be interpreted in a broader context and represent capabilities and tasks necessary for the technology management activities of companies. In light of this, technology management functions can be interpreted as technological capabilities. These are summarized in Table 10.

10. Table: Technology management capabilities

| Ability | Routines |
|---|---|
| Recognition | Identification of the economic and technological elements that initiate change processes in the external and internal environment |
| Coordination | Ensuring alignment between business strategy and proposed change |
| Acquisition | Recognizing the limitations of the technological base. to external sources of knowledge, information, equipment, etc. the ability to connect, to transfer and connect technology from various external sources to the appropriate internal points in the organization. |
| Creation | Ability to create aspects of technology in-house – R&D, internal engineering teams, etc. through. |
| Selection | Exploring and selecting the most appropriate response to environmental triggers that match the strategy and internal resource base/external technology network. |
| Control | Managing new product or process development projects from initial idea to final launch, monitoring and controlling such projects. |
| Implementation | Managing the introduction of change – technical and otherwise – in the organization to ensure the acceptance and effective use of innovation. |
| Learning | Be able to evaluate and reflect on the innovation process and recognize lessons for improving management routines. |
| Organizational development | Embedding effective routines within the organization into the structure, processes, organizational behaviors, etc. |

*Source: own compilation, based on Tidd et al. (2001)*

Strategic technology management is nothing more than planning, organizing, leading and controlling technological activities in coordination with corporate capabilities, so that the application of knowledge, structures, resources and the socio-economic environment contributes to the fundamental long-term goals and objectives of the company to define and implement it, and to ensure the necessary activities and resource allocation (Tschirky, 2003). It is important to emphasize that the starting point of strategic technology management is that the planning process and steps of the technological strategy cannot be separated from the planning process of corporate and business strategies. Based on this line of thought, the integrative nature of technology and strategy can be illustrated embedded in the iterative process system of strategy creation and application. The technology management issues related to the sub-areas of strategic management are summarized in Table 11.

The concept of strategic technology management emerged and developed in parallel with the paradigms of strategic management and focuses on the ability of businesses and corporations to discover and exploit technological capabilities that can be relied upon to gain a competitive advantage. In this sense, corporate success and long-term outstanding performance depend on the excellence and maturity of strategic technology management within the organization. The integration of strategic management and technology management, which can be established on the basis of Tables 9, 10 and 11, is of critical importance for companies, since the performance of technological capabilities and technology management tasks fundamentally affects the competitiveness and long-term survival of companies. Addressing technology issues at a strategic level allows companies to respond flexibly and quickly to market changes while maintaining and developing their technological capabilities, thus ensuring long-term competitiveness and sustainable growth.

11. Table: Connection of strategic management and technology management

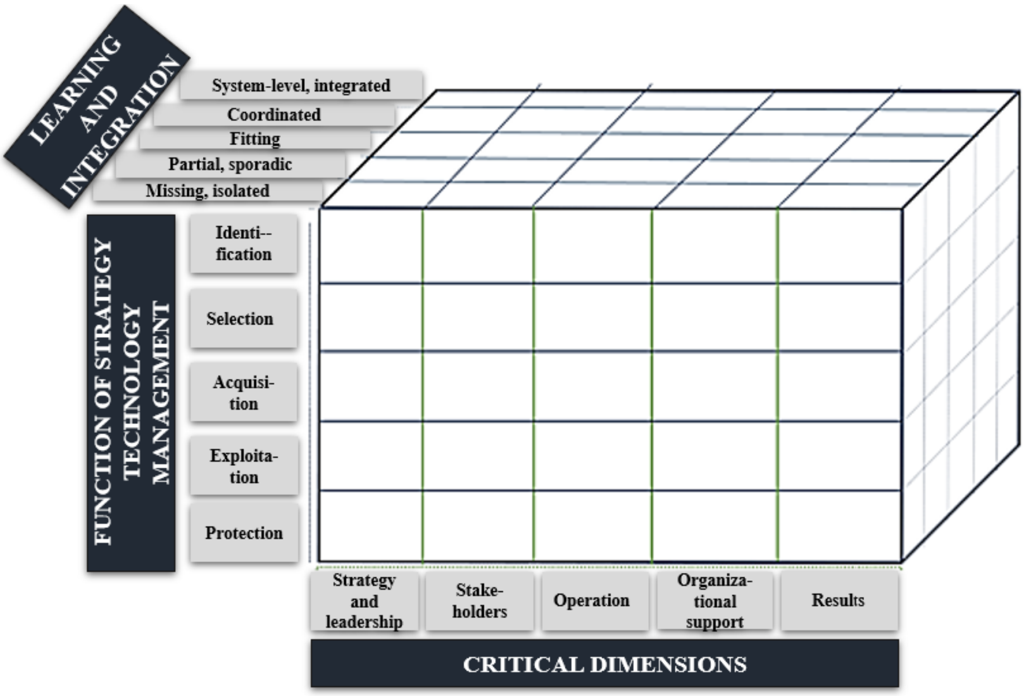
| Strategic management function, sub-area | Technology management issues |
|---|---|
| Strategic goals | • Degree of innovation<br>• TQM level<br>• Patent position<br>• Technology sales |
| Analysis of the external environment | • Innovation environment<br>• Patent analysis<br>• Technological intelligence<br>• The allure of technology |
| Company diagnostics | • Product, market and technology analysis<br>• New technologies<br>• Technological strengths<br>• Technological opportunities |
| Strategic options | • Basic technologies<br>• Outdated technologies<br>• Technological fusion<br>• Pioneer, follower, collaborator<br>• Technological decisions<br>• Technology portfolio |
| Strategic decision making | • Basic technologies<br>• New or obsolete technologies<br>• Make, buy, sell, keep<br>• Role of allies |
| Implementation of strategy | • R&D projects<br>• Milestone examination<br>• Technology calendar<br>• Technological controlling |

*Source: own compilation, based on Tschirky (2003)*

The performance of the functions of technology management naturally depends to a large extent on the performance and support nature of the organizational functions of companies and enterprises in the traditional sense. An attempt to investigate this is made by Deutsch et al. (2020) strategic technology management excellence model. The systems approach and integrated point of view of strategic technology management enables, based on the models and theoretical background of the discipline, frameworks that can be utilized for businesses and companies competing in technology-intensive, complex and complex industries for the purpose of understanding, planning, managing and measuring their technology management performance practices, capabilities and results, let's create models. Deutsch et al. (2020) created their framework of excellence using the tools of technomanagement and strategic technology management, which, according to its purpose, enables enterprises and companies to evaluate and identify the current state of the given organization in the development process leading to excellence in strategic technology management, thus the model contributes to eliminate corporate obstacles and weaknesses, to allocate scarce resources to developments that support the achievement of a competitive advantage. Due to the fact that the concept of strategic technology management aims to develop, improve and renew the critical capabilities that a company must build in order to gain and maintain a competitive advantage, it is highly relevant for organizations to raise their activities and capabilities related to strategic technology management to a routine level for several reasons. . Financial and customer results, maintaining the performance of enterprises and companies, balancing the unique interests of key organizational interest groups, and consequently short- and long-term profits all strongly depend on the organizations' strategic technology management practice and its excellence and maturity. (Deutsch et al., 2020) The excellence model is thus organically connected to my research topic, since the possibility and obstacle to the application and integration of a specific technology is a techno-management issue of strategic relevance for businesses and companies. The excellence framework of the authors, including myself, in its current state, in the absence of validation of the model, does not provide a sufficient basis for the assessment of the areas to be mapped and evaluated during empirical research, and thus for the examination of the internal factors, opportunities and obstacles associated with the application of Cloud Computing.

The excellence framework (Deutsch et al., 2020) is based on the main theories and models of the authors involved in the thesis (e.g. Gregory, 1995; Hampson, 1997; Cetindamar et al., 2017), the integrated, systemic point of view of the excellence model is still a novelty it matters Based on the literature, among the business excellence models based on the foundations of TQM (total quality management), the Deming Award, the Malcolm Baldridge National Quality Award (MBNQA), and the European Foundation for Quality Management (EFQM) model are among the most frequently used (Deutsch et al, 2020), however, the applicability of the models - from the point of view of my research - is not sufficient, due to the fact that the elements of technomanagement and the theoretical foundations and tools of strategic technomanagement are not named. The advantage of the excellence framework presented below is that it examines business excellence specifically from the perspective of strategic technology management. Deutsch et al. (2020, 102), the principles and elements of the business excellence models, which basically focus on quality management, can be applied to the field of strategic technology management according to nine aspects. (1) Based on visionary leadership, management must define the organization's clear direction and values, and management must focus on internal and external customer needs and requirements, and empower the workforce to strive for excellence in order to achieve competitive advantage in recognizing and exploiting technological opportunities. (2) According to customer centricity, understanding the current and future needs of current and future customers, building customer loyalty and commitment is vital to the value creation required to maintain a sustainable competitive advantage. (3) Workforce-centricity means that the construction, development and exploitation of technological capabilities and capacities is not possible without the continuous development of employees' knowledge, skills, creativity and motivation. (4) Strategic integration means the integration of technological, business and corporate strategies, the simultaneous planning, coordination and implementation of strategies. (5) On the basis of partnership development, it is essential to establish long-term and mutually beneficial partnerships in order to acquire and develop dynamic capabilities that support technological exploration and exploitation, as well as to create value for various interest groups. (6) Organizational learning means that individual and organizational learning and knowledge transfer are fundamental elements of maintaining a competitive advantage by exploring and exploiting current and potential organizational technological capabilities and capacities. (7) According to fact-based management, the continuous improvement of strategic technology management supporting the acquisition and maintenance of competitive advantage requires the systematic management of processes, practices and functions based on facts and feedback. (8) Results orientation, measuring and balancing the corporate performance of value creation is the key to maintaining success and a sustainable competitive advantage for all interested parties. (9) Social responsibility, legal, social and ethical responsibility related to technological development and use is a critical part of successful operation and long-term market presence.

5. Figure: Critical dimensions of the strategic technology management excellence model




*Source: own compilation, based on Deutsch et al. (2020)*

Deutsch et al. (2020), it can be concluded that organizational performance and corporate excellence in strategic technology management can be determined from three different but interrelated dimensions (Figure 5), these include the functions of technology management (strategic technology management dimension), management practices business and strategic the level of its integration (learning and integration dimension) and the critical elements of business excellence (excellence dimension). With the help of the excellence framework, an analytical map can be created that can be used in any given organization to determine the level of excellence in strategic technology management. The purpose of the model is to serve as a practical tool for company managers, strategists, technology managers to understand and manage technological capabilities and capacities in order to improve organizational performance, and to enable them to analyze the different segments of strategic technology management for continuous improvement (Deutsch et al., 2020).

The proposed framework for evaluating corporate excellence in strategic technology management supports the evaluation of all activities related to strategic technology management, organized according to the critical functions of identification, selection, acquisition, exploitation, protection and learning. The model evaluates technology management functions based on predetermined criteria of technological excellence, which are leadership and strategy, stakeholder orientation, organizational processes and operations, organizational support (culture, structure and systems), and outcomes that determine internal and external conditions and opportunities. As learning and knowledge management activities must impact all steps and functions of strategic technology management in order to effectively support the discovery and exploitation of dynamic technology capacities and capabilities for sustainable competitive advantage, the shift towards technology management excellence is achieved between business and technology. depends on the level of integration. Accordingly, the proposed framework enables management to determine the level of organizational readiness and the maturity of technology management practices. (Deutsch et al., 2020)

My most important findings regarding the paradigms of strategic management, paradigms and technology, and the issue of technological strategy are summarized below.

- The concept of strategy refers to the activities and framework for obtaining and maintaining the competitive advantage of companies. Strategic management covers tasks, goals and activities related to the management of the formal and emerging strategy of companies.
- There are three levels of strategy in a hierarchical relationship: corporate strategy, business strategy and functional strategy. The corporate strategy provides an answer on which markets the company should compete on, the business strategy deals with the method of the competitive strategy, and the functional strategies represent the sub-strategies of the corporate functions (subordinated to the corporate and business strategy).
- With the development of the strategic management discipline, three well-defined approaches to strategy creation and application were created and became the defining paradigm of the given era. The paradigms treated the technological issues of the companies and the issues related to the technological strategy with a different approach.
- The Harvard school defined the competitiveness of companies in the creation of harmony between organizational characteristics and external environmental conditions, the source of competitive advantage in this case being the accuracy and reliability of planning and analysis. The paradigm of the Harvard school did not deal separately with the technological issue of companies, nor did it define a separate technological strategy.
- The paradigm based on industry position starts from the assumption that the performance of companies is determined by the attractiveness of the given

industry and the company's relative market position in the industry. Based on the paradigm, the source of the competitive advantage is not to be found in the internal factors of the companies, but rather from the relative industry position and the profitability of the given industry. In the paradigm based on industry position, the purpose of the technology strategy is for companies to be able to decide which technology should be developed and which to acquire from external sources, and which technology-innovation strategy the company should use in order to strengthen its competitive position in the industry. At the same time, in the paradigm, technology as a functional area is displayed.

- According to the representatives of the resource and capabilities-based paradigm, the differences in the performance of companies are explained by the difference between the (internal) factors under the influence of the companies. The assumption of the paradigm is that the activities of companies in terms of combining their available resources and capabilities represent a more significant difference between companies than the differences between the profitability of specific industries, the source of sustainable competitive advantage is the company's valuable, rare, hard-to-copy and organizationally embedded resources and capabilities. In the paradigm based on resources and capabilities, the technological base of companies can be a source of competitive advantage in itself.
- According to the theory of dynamic capabilities, the external and internal environment of companies changes turbulently, so the representatives of the theory link the sources of gaining and maintaining a competitive advantage to organizational capabilities and higher-level routines. The theory of dynamic capabilities can be considered a further development of the paradigm based on resources and capabilities, its theoretical approach and models already anticipate the formation and development of strategic technology management.

I summarize the results of the literature review of strategic technomanagement and my main related findings below.

- Based on the literature approaches of strategic technomanagement, strategic technomanagement includes elements of both technology management and technostrategy. While technomanagement focuses on the development and management of technological resources and capabilities within the organization, and integrates them in accordance with the organization's operational goals, technostrategy manages the technologies and innovations found in the organization and to be acquired from outside in accordance with the organization's strategy.
- The scope of strategic technomanagement includes the management of companies' available technology, the acquisition and integration of technologies from external sources, the development of the company's technology strategy, the development

of technological methods supporting the strategy, and the integration of technology and innovation into organizational routines.

- The rationale for research into strategic techno-management is that technological developments, R&D and innovation have now become a key strategic issue for companies, the use of technology in the life of a company cannot be interpreted as an additional, supporting activity, but an integral part of its corporate and business strategy forms.
- Strategic techno-management interacts with corporate and business strategy and is influenced by the organization's internal technological resources, capabilities and competences, as well as external environmental effects, trends within the industry and affecting other industries, as well as the available and missing technological resources and abilities.
- Strategic techno-management places the companies' technology management in a strategic context, accordingly, the companies' technology-related activities are to be interpreted with a strategic focus, great emphasis is placed on the companies' technological capabilities (push mechanisms), and the external factors affecting the companies' technological base (driving forces, effects, pull mechanisms) are also valued) role.

When interpreting the concept of technology management, it was shown that technology management does not only mean the management of companies' technological issues, but that technology management can be interpreted at the macro level and at the individual level as well. In the approach of strategic technomanagement, the macro level already has a prominent role, the environment of companies directly influences their technological possibilities and the requirements affecting their technology management activities. Individual factors affecting the acceptance and use of technology appear in the context of technological capabilities affecting the organization in the framework of strategic technomanagement. As a result of the fact that the aim of the research is to explore the circumstances of the application of a technology at different environmental levels, I have to examine the given technology from a different point of view at different macro, organizational and individual levels. The macro-level examination of technology can be interpreted in the context of the diffusion of technology, at the organizational level, various technology evaluation models and approaches are relevant, and I can explore the micro-level, individual factors by examining the acceptance of technology. In the following chapters, the relevant literature approaches and applied models are presented according to these levels.

## 2.4 Investigating the diffusion of technology

Technology management and strategic technology management focus on the internal capabilities and resources of companies, as well as the identification, selection, acquisition, utilization and protection of technology, as well as the learning processes that connect them. However, in addition to the micro-level examination of a given technology, we cannot ignore the macro-level examination, which focuses on the technology's availability, use, familiarity, and application at the macro-environmental level. In the framework of strategic technology management (for example, Cetindamar, 2016), external environmental influences appear as pulling mechanisms, so the technological challenges, demands, conditions and opportunities coming from the external environment determine the technomanagement capabilities and functions of companies. This has significant consequences in terms of companies' strategic technology management activities from two perspectives. On the one hand, from the point of view of the use of a technology, we cannot ignore the external environmental factor, which type of innovation we can talk about with regard to the given technology, what information and experience companies have about it, and to what extent the technology is considered new in terms of the technological environment and opportunities surrounding the company. On the other hand, whether the external environmental conditions allow the acceptance of a given technology, whether its spread has already "reached" the enterprise or company, and whether the given organization can access the for the technology required for him. These strategic technology management questions redirect us to the discipline of innovation, including the topic of the spread of innovation. For this reason, it is essential from the point of view of my research topic that, in addition to mapping the circumstances of the use and application of a technology, I also investigate the spread of the given technology, and for this purpose, I also review the literature dealing with the spread of technological innovations - without claiming to be exhaustive. The literature review dealing with diffusion theories relies heavily on Nagy-Borsy's (2024) study.

Schumpeter (1980) distinguishes three levels of innovation: invention, i.e. the birth of a new idea, innovation, which expresses the embodiment and material appearance of an idea, and diffusion, which means the spread of a new product or service resulting from an invention. Diffusion modeling is an investigation tool for the spread of a technology, by which we mean the modeling and quantifiable prediction of the future application and use of a technology. According to Szakály (2008), regarding the domestic literature dealing with the theory of diffusion, during the diffusion of a new product, service or technology, information about the novelty flows between companies, and this process can be interpreted by showing the market share of new products or services based on the technology. Examining the relevant international literature, we can find similar approaches. According to Rogers (1962), diffusion is a process during which a new idea (innovation) spreads among the individuals of a society. According to Rogers' approach, the condition for diffusion is the interaction between individuals, where the early adopters of the innovation influence the later adopters with their behavior. Mansfield (1961) interprets the concept of diffusion specifically in the case of technology, according to him, diffusion is the process of accepting technological innovations in industries and companies. Bass (1969) defined diffusion as the time process of market acceptance of new products or services, where, similar to Rogers' approach, there is a difference between innovators (who are the first to adopt a new product or service) and imitators (who follow the example of others the new product or service is accepted) The approach of Rogers & Shoemaker (1971) emphasizes the role of communication in the spread of innovations, according to the authors, during the process of diffusion, the innovation reaches the members of a social system through communication during a given time. Based on Mahajan, Muller & Bass (1990), diffusion can be interpreted specifically among consumers (either individual or corporate consumers), its dynamics depend on the given market environmental effects, consumer behavior, the given competitive situation and applied market strategies. Geroski's (2000) definition also includes the technology life cycle, whereby new technologies and innovations spread among industries and companies during diffusion, gradually replacing and then replacing older technologies. The concept of diffusion can therefore be well defined based on the literature, in the case of a specific technology, its spread means the application of the technology, either among companies or among individual consumers. (Nagy-Borsy, 2024)

Since the 1960s, researchers have used diffusion models to investigate and measure the rate of diffusion. According to the definition of Orova (2010), the purpose of diffusion models is to use a simple mathematical function to express the extent of the spread of technology as a function of the time from the introduction of the product. Many domestic and international studies deal with the categorization of mathematical models of diffusion, but at the same time, the grouping of the models is not uniform, partly because diffusion models are used by different scientific disciplines (in addition to economics and business sciences, marketing, sociology or medicine in different areas) are used for different purposes. Mahajan, Muller & Wind (2000) group diffusion models based on the fact that all members of the market have the same chance of accepting a product in the model or that different preferences can be identified at the individual level (individual-level, intermediate-level or market-level models). Orova (2006) similarly groups diffusion models, in the case of intermediate-level models, he distinguishes two additional categories, individual models with limited parameters and multi-state models. Szakály (2008) groups diffusion models according to their purpose and nature (for example, gravity models, epidemic models, equilibrium models, models based on the prediction of consumer behavior, learning models). The application of models for different purposes has different data and information requirements, and they are suitable for modeling the diffusion of different types of innovation – a new process, a given new product or service, a new material according to Schumpeter (1980), or new information or a new technology according to Bass (1969). Network theoretical models they examine the structure of social networks and the pattern of interactions in order to be able to model how information and innovations spread in the given network (Newman, 2010), gravity models can also be classified here. Jackson & Zenou (2014) deal with game-theoretic diffusion models, these models examine individual decisions and interactions in terms of the spread of novelties, assuming that the decisions of individuals are adapted to the decisions of other individuals. Game theory models also include equilibrium models. Based on Hethcote (2000), epidemic models or epidemiological models are designed to model the spread of epidemics, such as the SIS (Susceptible Infected Susceptible) and SIR (Susceptible Infected Recovered) models. Agent-based diffusion models model the behavior and interactions of individuals and agents in a complex system (Epstein, 2006). In addition to the former, a larger group of diffusion models is made up of market penetration models specifically examining the spread of new technology (most often in the form of a new product or service). According to Orava (2010), the difference between these diffusion models lies in the fact that the different models target different segments (full market spread, partial market spread, diffusion between individuals) and parameters (time, innovation, imitation, mixed parameters) are taken into account, and the flow between segments is interpreted with different effects (e.g. first purchase, repeat purchase, full market test, simulated market test application models). Table 12 contains the grouping of diffusion models and the differences between different approaches revealed in the literature. (Nagy-Borsy, 2024)

12. Table: Grouping and characteristics of diffusion models

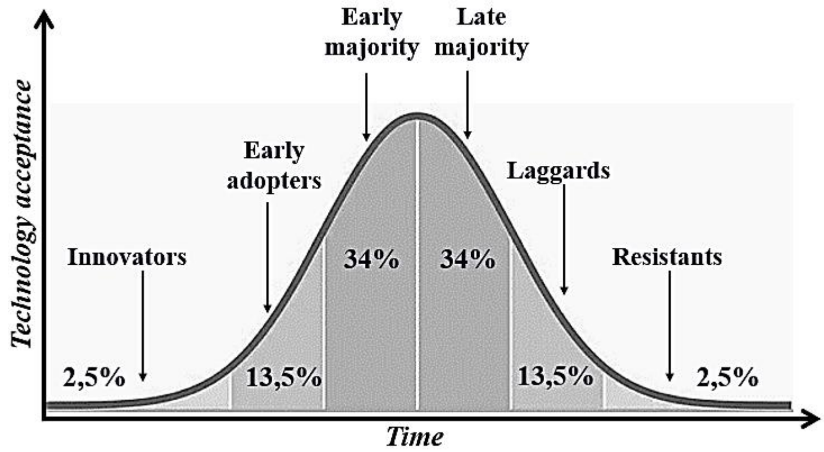
| A group of models | The essence of approach | Key parameters | Areas of application |
|---|---|---|---|
| **Network theoretical models** | Examination of the structure of networks, interactions between elements, and patterns. | Network data, network structure, interactions, patterns, geographic data. | Sociology, communication, system analysis, marketing. |
| **Epidemic or epidemiological models** | Investigating the spread of information or distinctiveness, modeling awareness, "contagion", and the saturation point. | Infection data, infection rate, re-infection, recovery rate, population size, saturation point, interventions. | Epidemiology, medicine, communication, investigation of spiral and hierarchical spread. |
| **Game theory models** | Investigation of individual decisions, interactions, assumption of rationality. | Description of decision-making situations, decision-making strategies, expression of equilibrium state, estimation of willingness to cooperate. | Economics, behavioral science, decision theory, game theory. |
| **Agent-based models** | A joint examination of individual (consumer) behavior and the effect of agents. | Rules of conduct, environmental data, number of interactions, purpose of dissemination. | Economics, behavioral science, marketing. |
| **Market penetration models / Technology models** | Forecasting the spread of a specific product or service, and investigating the spread of a specific technology. | Determination of market data (new customers, old customers), demographic data (total market, potential market), innovation and imitation coefficients. | Economics, technomanagement, marketing. |

*Source: own compilation*

Among the models relevant for the research are the market penetration models, a group of which can be used specifically for technological forecasting and for modeling the diffusion of a technology. Market penetration models model diffusion with a normative approach, on mathematical bases, and by defining specific parameters. One of the first quantifiable models suitable for estimation and forecasting is the pure innovation model of Fourt & Woodlock (1960), which modeled the purchase of a new product over time with an exponential function. The pure imitation model is the approach of Fisher & Pry (1971), whose basic assumption is that when a new product spreads, the rate of acceptance is proportional to the interaction between the rate of acceptance of the older product and the rate of penetration, so the model describes diffusion with a logistic curve. The models of Mansfield (1961) and Floyd (1962) examine the process of industry acceptance of technological innovations. The rate of spread of innovations in the industry and between companies is determined by estimating the imitation rate, the diffusion curve is approximated with a logarithmic function. The most cited model in the literature is the diffusion model of Bass (1969), which, together with its various additional versions, is considered the most widely used diffusion model in practice. The model describes the temporal dynamics of the acceptance of a new product or service, or specifically a specific technology. In terms of innovation acceptance, he distinguishes two types of adopters, innovators who are the first to adopt a new product, regardless of social influences, and imitators who follow the example of others to adopt a new product, service or technology. In the model, both the innovation (external) and the imitation (internal) effects appear, mathematically the model can be understood as a synthesis of the Fourt & Woodlock and Mansfield models. Norton & Bass's (1987) model is a frequently used extension of the original Bass model. The model takes into account the substitution and acceptance of successive generations of technology, and consists of two parts, the first part describes the acceptance of the new technology, and the second part models the replacement of the old technology by the new technology. The Weibull diffusion model (Bemmaor, 1994) describes the temporal distribution of product acceptance with a Weibull distribution. The flexibility of the model allows different diffusion patterns to be modeled, and is particularly useful for predicting long-term technological diffusion. It is also worth mentioning the stochastic models, which take into account the randomness and uncertainty inherent in the diffusion process. In stochastic models, probabilistic approaches are used to describe the acceptance and spread of an innovation, with particular attention to random effects and market variances (Mahajan & Peterson, 1985), which means that the application of the model requires more data than the previously described market penetration models. From the point of view of examining the diffusion of a technology, relevant models include market penetration models in which the dependent variable is defined as an innovation parameter, such as Fourt & Woodlock (1960), Mansfield (1961), Bass (1969), Fisher & Pry (1971), and the models of Norton & Bass, (1987). These models model the spread of technology by estimating its acceptance (application), this approach is well applicable in the case of diffusion of a technology. (Nagy-Borsy, 2024)

Mention should also be made of the model of one of the most cited authors in the literature (Szakály, 2008), Rogers' innovation acceptance theory. Rogers' (1962, 1976) model is limited in its ability to estimate the future spread of diffusion, but at the same time, it is a model with significant explanatory power for characterizing the degree of diffusion and the acceptance of innovation and technology among companies. Based on Nagy-Borsy (2023), the author categorized companies (or consumers) according to when they typically adapt a given innovation, a new product or service. Members of different groups can also be separated according to their social characteristics (although this can be interpreted more in terms of individual consumers), and each group has a specific share in relation to the entire society or market. According to Rogers (1962), the factors determining the adaptation of technology include the perceived advantage of novelty, the compatibility and complexity of the technology, the simplicity of applying and testing the innovation, as well as the accessibility of information about the new technology, the "observability" of the technology. (Nagy-Borsy, 2024)

6. Figure: The Rogers diffusion curve




*Source: own compilation, based on Rogers (1976)*

The different groups defined by Rogers (1976) that characterize the acceptance of innovation are included in Figure 6. The five groups can be characterized as follows. (1) Innovators, who make up 2.5 percent of all joiners, are characterized by a willingness to take risks and an increased interest in new things. (2) Early adapters, who represent 13.5 percent of all connectors, are characterized by the fact that they represent a model and a significant source of information for potential adapters. (3) The first major group in joining is the early majority, which represents 34 percent of all joiners. They play a very important role in the diffusion process, as they form the transition between early and relatively late adaptors. (4) The late majority represents 34 percent of all joiners, in their case the adaptation stems from economic and social necessity. (5) Laggards (13.5 percent) and resistants (2.5 percent), who represent 16 percent of all joiners, are typically distrustful of changes and innovations.

In Rogers' original concept, categorization was specifically applied to consumers, but at the same time, the model can be applied not only at the individual level, but also at the organizational level. In the research, the examined market can be clearly identified, as well as the number of market players (domestic companies), as well as which of the examined individuals apply the given innovation (the spread of the technology). The interpretation of the model is supported by the fact that the use (or lack of use) of services based on Cloud Computing can be specifically identified in the case of domestic enterprises and companies.

A comparison of market penetration diffusion models is provided in Table 13. Different approaches model diffusion with different mathematical formulas and also use different parameters. Based on Mahajan, Muller & Bass (1990), the model of Mansfield (1961), Bass (1969), and Norton & Bass (1987) can be used specifically for modeling the diffusion of technology. There are many other versions of the Bass (1969) model that are "refined" from a mathematical point of view or operate with different assumptions.

13. Table: Comparison of market penetration diffusion models

| Model name | Mathematical approach | Key parameter(s) |
|---|---|---|
| **Fourt & Woodlock (1960)** | linear function | innovation coefficient |
| **Mansfield (1961)** | logarithmic function | imitation coefficient |
| **Floyd (1962)** | logarithmic function | imitation coefficient |
| **Bass (1969)** | differential equation | innovation and imitation coefficient |
| **Fisher & Pry (1971)** | logistic function | imitation coefficient |
| **Norton & Bass (1987)** | differential equation | innovation and imitation coefficient |
| **Weibull model (Bemmaor, 1994)** | Weibull distribution | innovation coefficient |
| **Stochastic models (Mahajan & Peterson, 1985)** | differential equation | random variables |
| **Rogers' diffusion curve (1962, 1976)** | normal distribution | expected value, standard deviation |

*Source: own compilation*

I summarize my most important findings regarding diffusion models below.

- The concept of diffusion, which can be easily defined based on the relevant literature, means the spread of a new product or service resulting from an invention, even among individual consumers. During its diffusion, information about a technological innovation flows between users. In the case of a technology, its diffusion means the application of the technology, which can be interpreted by showing the market share of new products or services based on the technology.
- The purpose of diffusion models is to use a simple mathematical function to express the extent of the spread of technology as a function of the time from the introduction of the product.
- Diffusion models are used for different purposes by different scientific disciplines (in addition to economics and business sciences, marketing, sociology or different fields of medicine).
- Many domestic and international studies deal with the categorization of diffusion models, the main groups of models are network theory models, epidemic or epidemiological models, game theory models, agent-based models, and market penetration models or technological models.
- Market penetration (or technological) diffusion models may be suitable for investigating the future spread of a technology, and the most accurate prediction of these can be given by the most frequently cited and applied model in the literature, Frank Bass's (1969) diffusion model.

## 2.5 Evaluation of technology management

The concept and models of technological evaluation can be interpreted in two ways based on the relevant literature sources. On the one hand, the technology audit is part of the planning process of the technology strategy, an analysis step with the help of which we can get information about the technological base of companies, its strengths and weaknesses, and the results of the audit can form the basis of the technology strategy. Looking at the other meaning of technological evaluation, it covers a systematic analysis and evaluation framework, based on which the activities and processes of the technological base of the companies can be evaluated, thereby identifying the development areas of management activities and processes. In this chapter, I use the second approach to the concept. Technology evaluation models typically consist of a list of questions and their associated evaluation options and criteria. Technology evaluation models have in common that they serve two purposes: they simultaneously measure the "quality" of the organization's technological activities, processes, and capabilities, i.e. their adequacy based on the model's system of criteria, and thereby identify the areas to be developed from the point of view of the organization's technological performance, the essential factors that according to the structure of a given model, they show a worse value.

Knowing and presenting models of technology assessment is crucial for research. I can evaluate the quality of the application of Cloud Computing and the technology management preparedness of enterprises in this regard by evaluating the technology. In order to do this, I collected the technological audit models found in the literature by means of a systematic literature search. The aim of the systematic literature research was to map the studies in the technical literature dealing with the evaluation and auditing of technology and innovation, and then, after organizing them, to find the approaches and models relevant to the research.

I performed the systematic literature search in the SCOPUS, Google Scholar and Cossref databases. Based on my previously presented literature results, I searched for studies not only in the field of technology evaluation, but also in the field of technological innovation and innovation, due to the fact that the relevant literature sources often use the terms technology and innovation as synonyms or substitutes for each other. Based on these, my chosen search words were the terms "technological audit", "technological innovation audit" and "innovation audit" in English, which I searched for in the titles of the studies. As a narrowing criterion, I searched for the year of the publications from 1990, and in terms of the type of publications, I searched for journal articles, monographs, books, book chapters, and conference journals. As a result, I found 53 studies in the SCOPUS database, 561 studies in Google Scholar, and 349 studies in the Crossref database. After that, I applied further narrowing, regarding the field of science, limiting the results to the field of business, management and engineering sciences. I found a total of 746 studies, which I further narrowed down taking into account the relevance of the studies. Based on these, 35 studies in the SCOPUS database, 249 studies in Google Scholar, and 20 studies in the Crossref database remained in the sample. After filtering out duplications, I collected a total of 205 studies on the topic.

After processing the 205 studies, the number of studies relevant to the research was further narrowed down. On the one hand, no technology-innovation evaluation model or approach was developed in some of the studies, and on the other hand, many studies used another model found in the sample. In addition, it happened that I came across the publication of the multiple application of a model, and of course, despite the multiple filters, studies that were not relevant remained in the sample. In addition to the reduction of the sample, there was also an example of its expansion. By reviewing the references of the studies, I found additional studies that were not included in the sample but related to the research, and I also collected relevant approaches older than 1990. In the field of technology and innovation audits, I collected and processed a total of 64 relevant research-related models. Table 14 contains the results of the systematic literature research, along with the organization and characterization of each model.

The average "year of birth" of the studies is 2006, which proves that the topic of technology evaluation cannot be said to be a recent topic in the field of business and economics. Among the collected studies, in addition to technological evaluation models, approaches dealing with the auditing of innovation activity and its success factors are emphasized. I mentioned earlier that the literature does not treat these two concepts uniformly, so I could not limit the research exclusively to models dealing with technological auditing in their name. The results of the systematic literature research confirmed that works dealing with the auditing of innovation, the maturity of innovation or success criteria have a similar relevance from the point of view of the topic. It is common for a model dealing with an innovation audit to actually deal with a technology audit, but the study does not define the technology. In the literature, the concept of maturity of innovation is used almost synonymously with the maturity of technology. Due to the lack of conceptual unity, I could not rule out approaches dealing with innovation either.

Based on Table 14, the models dealing with technology and innovation evaluation can be classified into several larger groups. Models dealing with the evaluation of innovation success factors establish success criteria related to some aspect of innovation and audit companies based on them. The dimensions of the success criteria can be very different. Some of the models emphasize organizational culture and organizational climate (Rickards & Bessant, 1980; Cook et al., 1982; Koester & Burnside, 1992; Rothwell, 1994; Rao & Weintraub, 2013; Blackbright, 2020), the other a common approach is that the success criteria are defined in connection with the innovation activity of companies (Deutschman, 1994; Ahmed, 1998; Van de Ven et al., 1999). Another evaluation method, also based on success criteria, is Trott's (1998) assessment of incentives for organizational innovation Cooper et al. (2004a, 2004b, 2004c) models, which identified good practices in the field of product development, and Björkdahl and Holmén (2016) placed problems related to the innovation activity of employees at the center of the evaluation.

14. Table: Technology and innovation evaluation models

| Focus of models | The essence of approach | Authors |
|---|---|---|
| **Evaluation of innovation success factors** | evaluation of success factors of organizational values and working conditions | Cook et al. (1982) |
| | evaluation of success factors of organizational climate and creativity at the individual level | Koester and Burnside (1992) |
| | evaluation of the quality of organizational culture and project management | Rothwell (1994) |
| | examining the innovation success criteria of companies with advanced technology | German (1994) |
| | evaluation of incentives for organizational innovation | Trott (1998) |
| | examination of organizations with outstanding innovation performance | Ahmed (1998) |
| | evaluation of the success factors of innovation | Van de Ven et al. (1999) |

| Focus of models | The essence of approach | Authors |
|---|---|---|
| | activities | |
| | identification and evaluation of good practices in product development | Cooper et al. (2004a, 2004b, 2004c) |
| | evaluation of organizational culture, innovative culture with scale evaluation | Rao & Weintraub (2013) |
| | examination of organizational culture | Blackbright (2020) |
| | examination of the generation of innovative ideas in the organization | Rickards & Bessant (1980) |
| | examination of problems related to the innovation activity of employees | Björkdahl and Holmén (2016) |
| **Evaluation of innovation activities** | ratio of product innovations and process innovations, evaluation of technological indicators | Vilys et al. (2015) |
| | evaluation of quantitative performance indicators | Zheng et al. (2009) |
| | evaluation of innovation culture and organization (macro level) and technological performance (micro level). | Mohammad et al. (2010) |
| | development of planning audit tools, SME focus | Moultrie et al. (2007) |
| | evaluation of the performance of management activities | Crane et al. (2019) |
| | identification of strengths and weaknesses, examination of the service innovation triangle | Cuthbertson et al. (2015) |
| | evaluation of internal factors in a strategic context, with scale evaluation | Tidd et al. (2001) |
| | evaluation of innovation activities with scale evaluation | Baciu and Brezuleanu (2022) |
| | organizational innovation efficiency, evaluation of organizational innovation capabilities | Tang (1999) |
| | evaluation of innovation processes, capabilities, examination of resources, with scale evaluation | Dooley et al. (2000) |
| | audit of innovation capabilities | Francis (2000) |
| | assessment of innovation performance, with scale evaluation | Radnor & Noke (2002) |
| | evaluation of internal company factors in a strategic context | Cormican & O'Sullivan (2004) |
| | evaluation of organizational culture, decision-making, communication | Aiman-Smith et al. (2005) |
| | assessment of resources and capabilities along company functions | Adams et al. (2006) |
| | audit with R&D orientation | Hull et al. (2000) |
| | assessment of innovation capacity for development purposes | Müller et al. (2005) |
| | evaluation of the innovation capacity of organizations, with scale evaluation | Morel & Boly (2008) |
| | evaluation of resources and capabilities with a strategic approach | Frishammar et al. (2018) |
| | evaluation of technological innovations along company processes | Liao et al. (2011) |
| | assessment of innovation capacities, development of innovation capabilities, with scale evaluation | Vladuţ et al. (2018) |
| | examination of the organization of service companies | Ozyilmaz & Berg (2004) |
| **Technology assessment** | assessment of technological capacity management | Cetindamar & Günsel (2009) |
| | assessment of the consistency of existing and to be developed technological competences and management skills | Walsh & Linton (2011) |
| | evaluation of the technological capacity, procedures and needs of organizations | Kelessidis (2000) |

| Focus of models | The essence of approach | Authors |
|---|---|---|
| | identification of a company's technological strengths and opportunities, examination of technological development activities, with scale evaluation | Garcia-Arreola (1996) |
| **Evaluation of technology departments** | evaluation of the management of technology departments, with a strategic approach | Adler et al. (1992) |
| | evaluation of technology management of technology departments | Hecklau et al. (2022) |
| | identification and evaluation of the company's technological and innovation capabilities | Selada et al. (1998) |
| | evaluation of technological innovations (product and process innovations) with scale evaluation | Chiesa et al. (1996) |
| **Assessment of technological capability** | assessment of technological capabilities, examination of organizational units and the company's technological strategy | Burgelmanet al. (1998) |
| | assessment of technological capabilities along company functions | Yam et al. (2004) |
| | assessment of technological capabilities along innovation functions | Wiratmadja et al. (2017) |
| | assessment of technology management ability based on a scale assessment | Rush et al. (2007) |
| | three-level evaluation of technological capabilities (national, sectoral, corporate), sustainable technology focus, with scale evaluation | Hobday (2002) |
| **Evaluation of innovation maturity** | assessment of innovation maturity | Toole et al. (2010) |
| | innovation capabilities maturity model | Essmann & Preez (2009) |
| | service innovation capabilities qualifications, open innovation qualification framework | Li et al. (2010) |
| | integrated innovation maturity model | Forrester Research (2013) |
| | examination of the maturity of success factors influencing innovation activity | Mohammad & Romeri (2007) |
| | integrated innovation maturity model, lean-based assessment of innovation capability | Müller-Prothmann & Stein (2011) |
| | assessment of innovation maturity | Berg (2013) |
| | evaluating the maturity of innovation activities | Nauyalis (2010) |
| | examination of the maturity of innovation management processes and activities | Fenn & Harris (2013) |
| | evaluating the maturity of innovation management and change management | Gupta (2011) |
| | evaluating the maturity of innovation capabilities | Mann (2015) |
| | evaluation of the maturity of innovation capabilities and processes | Peisl & Johansen (2012) |
| **Evaluation of techno-management maturity** | open innovation graduation framework | Enkel et al. (2011) |
| | assessment of the maturity of open innovation and technology management skills | Habicht et al. (2012) |
| | technology maturity framework knowledge management focus | Esterhuizen et al. (2012) |
| | evaluation of techno-management maturity, organizational and change management focus | Cross (2013) |
| | evaluation of the maturity of techno-management skills, change management focus | Rouse (2011) |

*Source: own compilation*

Most of the literature models are included in the category of evaluation of innovation activities. It specifically deals with the evaluation of companies' innovation activities, using the Likert-scale model of Radnor & Noke (2002) and Baciu and Brezuleanu (2022). It also uses a Likert-scale assessment, but focuses on the examination of innovation capacities Morel & Boly (2008), Vlăduţ et al. (2018). Liao et al. (2011) dealt with the evaluation of technological innovations along company processes. The evaluation model for evaluating innovation capabilities was developed by Tang (1999) and Muller et al. (2005). The innovation activity of companies was examined with a strong strategic focus by Cormican & O'Sullivan (2004), Tidd et al. (2001), Moultrie et al. (2007), Cuthbertson et al. (2015) and Crane et al. (2019). Dooley et al. (2000), Adams et al. (2006) and Frishammar et al. (2018) related the examination of innovation activities to the assessment of resources and capabilities. Francis (2000) specifically sought to evaluate innovation capabilities in his model. The quantitative approach appears in Zheng et al. (2009) and Vilys et al. (2015) approach, the latter authors considered it important to examine the ratio of product innovations and process innovations in connection with the evaluation. Similar to Hull et al. (2000)'s approach, who focused on the assessment of companies' R&D activities. The evaluation of innovation activities category also includes models related to organizational culture and organizational structure (Aiman-Smith et al., 2005; Ozyilmaz & Berg, 2004), Mohammad et al. (2010) also evaluated technological performance in his model in addition to innovation culture, so both qualitative and quantitative perspectives appeared in his evaluation approach.

The models dealing with the evaluation of technology are already closer to the approach of technology management. Kelessidis (2000) and Cetindamar & Günsel (2009) dealt with the assessment of technological capacities. The examination dimensions of Cetindamar & Günsel's (2009) model (technological capacities, product development, process innovation, technology procurement, management, resources) evoke technology management functions. Kelessidis (2000), on the other hand, defined its dimensions much more along the company functions (organization, human resources, technological capabilities, technological innovation, innovativeness, products, cooperation, networking, technological needs, quality, marketing, environment, HR, R&D product development, manufacturing organization). Walsh & Linton (2011) carried out an evaluation of the consistency of existing and developing technological competences and management skills of companies, in this framework the dimensions of the model are composed of a combination of management skills and technological elements, including general managerial skills, special managerial skills, technological capabilities and specialized engineering capabilities. Garcia-Arreola's (1996) model echoes the approach of strategic technomanagement, the purpose of the model is to identify the company's technological strengths and opportunities, and evaluate technological development activities. The dimensions of the model are the technological environment, the categorization of technologies, markets and competitors, the innovation process, value-added functions and the acquisition and utilization of technology.

The models belonging to the evaluation of technological departments differ from the former category in that in this case the authors did not examine the technological base of the companies in general, but in relation to the technological departments of the companies, so they put the emphasis on the management processes. Chiesa et al. (1996) and Selada et al. (1998) dealt with the evaluation of companies' technological innovation capabilities and technological innovations. Chiesa et al. (1996) model includes the identification of new product concepts, product development, process innovation, technology acquisition, leadership, resources, systems and tools, and competitiveness. Selada et al. (1998) follows a much simpler structure in the technology audit model, evaluating companies along only three dimensions, the technological base evaluation dimension, the technological management capability evaluation dimension, and the structure and strategy evaluation dimension. Hecklau et al. (2022)'s approach, technology management appears, the dimensions of the model are the technological base, products and services, and the synergy achieved through cooperation and partnerships, while Adler et al. (1992)'s model, the strategic approach can be seen in action (position, guidelines, adjustment processes).

The models classified as technological capability evaluation have in common that the technological evaluation of companies is carried out by examining their technological capabilities. This approach is the closest to the previously described approach to strategic technomanagement. Burgelman et al. (1998)'s evaluation model is aimed at evaluating the technological capabilities of companies, examining organizational units and the company's technological strategy. The components of the model are made up of innovative capabilities. Burgelman et al. (1998) identified are resource availability, technological knowledge, strategic management capacity, structural and cultural context, and understanding of competitors' innovative strategies and industry development. Yam et al. (2004) and Wiratmadja et al. (2017) evaluated the technological capabilities according to the company's functions, these models have in common that they both focus on the management's point of view, and the logic of the evaluation takes place along the company's processes and functions. Yam et al. (2004) model's capability dimensions are learning capability, R&D capability, resource allocation capability, manufacturing capability, marketing capability, organizational capability and strategic planning capability, while Wiratmadja et al. (2017) defined the structure of the evaluation in a similar way, the dimensions they defined are learning ability, R&D ability, resource allocation ability, production ability, marketing ability, organizational ability, strategic planning ability, external environmental ability and performance indicators. Rush et al. (2007) created a model for technology management ability-based assessment, in which companies can be audited with a Likert-scale assessment. The dimensions of the model are awareness, search, development of core competence, evaluation and selection of technological strategy technology, technology acquisition, implementation and acceptance of technology, learning and building external relations. Rush et al. the basis of his model was essentially developed by Hobday (2002), his approach can be said to be special among models, the author created a three-level (national, sectoral, company) evaluation system of technological capabilities. The focus of sustainable technologies appears in the model, so the model is suitable for evaluating a specific technology or technologies. The technological capability of companies is evaluated using a scaled evaluation. The dimensions of the model (awareness, search, core capability, strategy, evaluation and selection, acquisition, application, learning, relationships and collaboration) can be matched to the functions of technology management (identification, selection, acquisition, exploitation, protection, learning). The purpose of Hobday's (2002) Technology Needs Assessment (TNA) model is to enable countries, industries and companies to identify and assess their technological needs. This model helps countries and organizations to map their technological needs and determine their order of priority, so that they can more effectively select the necessary technology and apply it for their development. The model places great emphasis on the role of the following factors.

- Identifying technology gaps: The model helps countries or organizations identify the technology areas where they have the biggest gaps. This includes assessing the level of existing technologies and identifying areas for improvement.
- Capacity assessment: The model examines the current capacity of the concerned country or organization in terms of technology application and development, including human resources, technology infrastructure, and research and development capabilities.
- Analysis of technological options: The model helps to explore which new or advanced technologies would be most useful in a given context, taking into account local conditions, needs and resources.
- Prioritization: The TNA model allows stakeholders to prioritize their technology needs and thus focus on developments with the greatest impact.
- Development of an action plan: Based on the identified technological needs and opportunities, the model proposes the specific actions by which the necessary technologies can be acquired, applied and maintained.

The categories of innovation maturity and evaluation of techno-management maturity include the models that examine the technology-innovation base or ability of companies specifically from the point of view of maturity. In the case of models, the conceptual confusion that can be found in the literature is particularly evident, the authors use the concepts of technology and innovation quite freely in relation to maturity. Among the models included in the sample, Toole et al. deals with the evaluation of the innovation maturity of companies and the maturity of innovation activities. (2010), Nauyalis (2010), Berg (2013) and Fenn & Harris (2013). Essmann & Preez (2009), Li et al. (2010), Peisl & Johansen (2012), Mann (2015) focus on the audit of companies' innovation capabilities in relation to the maturity of innovation. There are models in which open innovation is focused on according to the maturity of technology and innovation (Li et al., 2010; Enkel et al., 2011; Habicht et al., 2012). Mohammad & Romeri (2007), Müller-Prothmann & Stein (2011) and Forrester Research (2013) created integrated graduation models. The change management focus in the approach of Gupta (2011), Rouse (2011) and Cross (2013), Esterhuizen et al. (2012)'s model, knowledge management appears in connection with the evaluation of technological innovation maturity of companies.

The aim of the systematic literature review was to collect the models dealing with technology and innovation evaluation noted in the literature, so that I could select approaches relevant to the research. Models based on the examination of innovation success factors cannot be applied from the point of view of the focus of the research, these models do not allow the analysis of a specific technology with a technology management focus. Similarly, different maturity models measure different things and are aimed at different things, they examine the maturity of companies and technology, not the circumstances of the application of a given technology. Among the large number of models dealing with the evaluation of innovation activities, strategic orientation appears (Cormican & O'Sullivan, 2004; Tidd et al., 2001; Moultrie et al., 2007; Cuthbertson et al., 2015; Crane et al., 2019), however, in terms of the conceptual framework of technology and innovation, these approaches cannot be applied to the evaluation of a specific technology, or only with a very serious interpretation transformation.

Among the models dealing with technology evaluation, the approach of Garcia-Arreola (1996) may be suitable for evaluating a technology in terms of companies, the model also shows the approach of strategic technomanagement (the purpose of the evaluation is to determine the company's development activities based on its strengths and aimed at maintaining or gaining a competitive advantage), however the micro perspective is extremely dominant in the model, the evaluation of specific and specific internal factors of the companies, as a result, the factors of the model cannot be queried in a wider circle without a serious loss of information. Among the models dealing with technology evaluation, I had to exclude those that audit the technological capacity of companies (Kelessidis, 2000; Cetindamar & Günsel, 2009). Walsh and Linton's (2011) model, in which the success and profitability of companies dominates instead of technology management aspects. Models dealing with the evaluation of technology departments cannot be applied to the evaluation of a specific technology with a strategic focus.

The approach of the models dealing with the assessment of technological capabilities is the most compatible with the purpose of the research, these models have in common that they focus on the technological capabilities of the companies, so they contain an important element of the approach of strategic technomanagement, the examination of internal push mechanisms. Yam et al. (2004) and Wiratmadja et al. (2017)'s models are suitable for evaluating a specific technology from a strategic perspective, the evaluation of technological capabilities in both takes place along the corporate functions. Both models are elaborated in great detail and use several dimensions and sub-dimensions during the evaluation, but due to the detailed nature of the evaluation tool, the models are much more applicable to the evaluation of a specific company than to the general examination of a technology. In the models, the assessment of various corporate and technological performance indicators, which are less relevant in relation to the examination of a specific technology, is extremely prominent. The assessment of technological capabilities is also dealt with by Hobday (2002) and Rush et al. (2007) model, the two approaches are based on common foundations, Hobday notes Rush's (2007) model as a co-author. The essence of the approaches is that the technological capability of companies is evaluated based on the logic of technology management, so although the authors structured it differently in the dimensions of the models, technological capabilities are evaluated along the lines of identification, selection, acquisition, protection and learning. The evaluation and assessment of technological capabilities among companies is a good tool for examining a specific technology. Hobday's (2002) three-level model (that is, national economy, sector and company level) contains the important element of the techno-management approach to strategy, according to which the technology management activities of companies are influenced by both the internal and external environment. Although the two models are based on almost the same structure, Hobday's (2002) study contains the specific set of questions for the multi-level assessment of technological capabilities, as well as the related evaluation and interpretation aspects. Based on the systematic literature research, taking into account the most accurate fit between my research goals and the models found in the literature, I use Hobday's (2002) model dealing with the evaluation of technological capability for my empirical investigation.

The models of technology evaluation found in the literature deal with the evaluation and assessment of the companies' technological base, departments, capabilities, and technological maturity. I summarize the most important results of my literature research below.

- Technological evaluation means a systematic analysis and evaluation framework, on the basis of which the activities and processes of the companies' technological base can be evaluated, thereby identifying areas for development of management activities and processes.
- In order to fully examine the models of technology evaluation, I conducted a systematic literature search. After the necessary narrowing, 205 studies were reviewed, of which I found relevant approaches related to the topic in 64 studies.
- In the context of technology assessment, it is not enough to review the sources specifically dealing with technology audits, as the literature does not use the concepts of innovation, technological innovation and technology in a uniform manner, considering the purpose of the research, I also had to collect the different models dealing with innovation assessment.
- After organizing the 64 models that emerged as a result of the literature research, the models can be classified into several groups. The focus of the different approaches is different, the models deal with the examination of innovation success factors, the evaluation of innovation activities, the general evaluation of technology, the evaluation of technological departments, the evaluation of technological capabilities or the assessment of innovation and technology management maturity.
- The aim of the empirical research is to examine a specific technology with a strategic focus, which includes the tools of technology management, among domestic enterprises. This goal is met by models dealing with the assessment of technology and the assessment of technological capabilities. After reviewing the relevant models, taking into account the fit between my research goal and the structure and application possibilities of the models, I chose Hobday's (2002)

model dealing with the evaluation of technological capability as the framework for my empirical surveys.

## 2.6 Models of technology acceptance

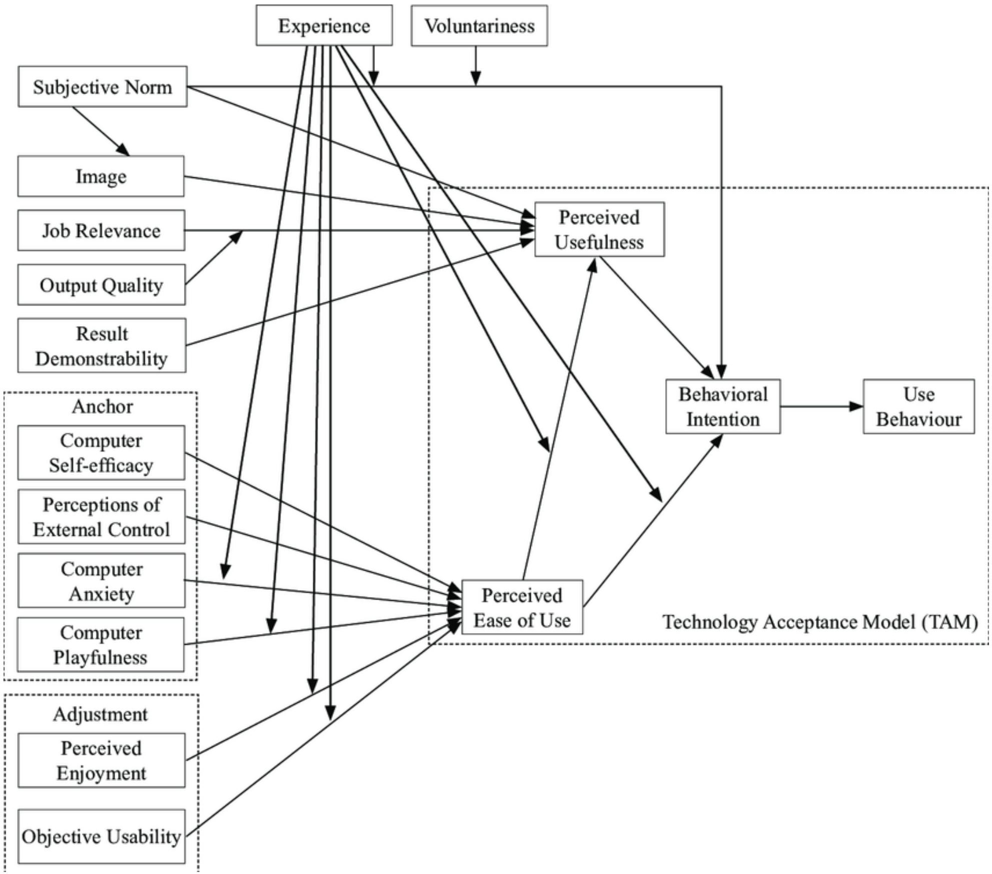
In addition to examining the spread of technology, it is also worth looking at the models and approaches that deal with the acceptance of technology. What these models have in common is that they primarily focus on the factors that influence the acceptance of a technology, in contrast to diffusion models, which focus on the (future) spread of the technology. Acceptance of technology primarily means putting it into use, i.e. when consumers, companies, and other organizations start using the given technology. When examining the application conditions of a technology, in the fields of strategic management, innovation management, and marketing, the product life curve and the technology S curve interpreted as its distribution function are most often analyzed (Szakály, 2002a), the acceptance of the technology is determined by the different life stages of the curve, and the management related to the life stage they are explained and examined with the need for action. Deutsch et al. (2019), in the introduction phase, the technology spreads slowly, has low or non-existent profit-generating capacity, in terms of the acceptance of the technology, the emphasis is placed on its familiarization and presentation. In the growth phase, the technology begins to grow dynamically and exponentially, the technology becomes accepted and known among consumers, substitutes and copies of the technology appear. The stage of maturity is characterized by stagnation, the given technology then has the greatest profit-generating capacity, and in terms of technology acceptance, we can speak of a mature, widely used technology. In the decline stage, the sales, profitability, and application of the technology decrease, and it is gradually phased out and replaced by a new technology. Product life curves and the technological S-curve describe well the spread of a given technology and the management challenges and tasks associated with its application, they do not provide information about the reasons for its application, inhibiting and supporting factors. The reasons and explanations of consumer decisions regarding technology acceptance are dealt with by various technology acceptance models, including models that display the acceptance of technology in their name, behavioral models, models that examine resistance to technology or the relationship between technology and tasks related to its application.

Research on the acceptance of technology has been published since the 1980s, and the most cited models in the literature can be dated to the 1990s and 2000s. The purpose of technology acceptance models is that the parameters of the given model (the external and internal variables used) can characterize and estimate the acceptance of a specific technology as accurately as possible. This approach resulted in the development of the models mostly meaning an increase in the number of variables used and examined, and the models becoming more and more complex. Deutsch et al. (2019) ask the question that if the problems related to the practical applicability of individual models stem from the relevance and reliability of the variables used, as well as the possible lack of information, how does the inclusion of additional variables and the increasingly complex models support the reliability and applicability of technology acceptance models. Keszei & Zsukk (2017) also draw attention to the contradiction that one of the goals of using models dealing with technology acceptance is to increase the success of the introduction of technologies and reduce the risks arising from the conditions of acceptance, but at the same time, in the literature, the application of the models is in most cases for already introduced technologies focuses on its (ex post) examination, literature research mostly uses the various models of technology acceptance for past analysis rather than for predicting the future.

The models presented below examine the acceptance of the technology according to different aspects, the described models can be divided into two main groups. First, the traditional approaches to technology acceptance are discussed, which are considered to be the most cited models in the literature, or their improved, combined versions (for example, the combination of TAM, UTAUT, TTF, TAM and TTF), then alternative approaches are discussed, in which technology acceptance is more they deal with its psychological aspects and behavioral characteristics or focus on the investigation of resistance. The presented models of technology acceptance support the understanding of what factors can influence consumers and companies regarding the use of certain technologies or, on the contrary, what factors can strengthen resistance to the use of a technology.

Among the models dealing with technology acceptance, the first and still the most well-known is the Technology Acceptance Model (TAM) by Davis (1989). The model aims to understand and predict how consumers will accept and then adopt new technologies. The model focuses on two main factors, measuring perceived usefulness and perceived ease of use. Perceived usefulness expresses the value when the consumer becomes aware that the use of the given technology improves his performance. The value of perceived ease of use means when the consumer is convinced that the use of the given technology is easy for him and does not require effort. According to the model, these two variables are influenced by external variables, the external variables include the personal characteristics of the user, the characteristics of technological innovations, and the characteristics of the social, economic and cultural environment. Perceived usefulness and perceived ease of use together determine the consumer's attitude towards the use of the given technology, resulting in the intention to use it, which is later embodied in actual use. In the TAM 2 model, the external factors related to the perceived usefulness of the technology are explained in more detail. Based on Venkatesh-Davis (2000), these can be classified as social influencing factors (e.g. subjective influencing norms, expected social status, experience, and the role of volunteering) and cognitive influencing factors (e.g. work fit, expected quality of results, visibility and comprehensibility of results). By expanding the model, the relationships between the influencing factors can be better known and investigated, thus a better fit can be achieved by applying the model. Venkatesh & Bala (2008) published the TAM 3 model, in which external factors affecting the perceived ease of use were elaborated in more detail. Among the new factors of the TAM 3 model are certain behavioral anchors (internal knowledge of technology use, existence of resources supporting technology use, anxiety about technology, nervousness, enjoyment of technology use, joy of discovery) and correction factors (perceived enjoyment value, objective usability). Figure 7 combines the TAM model and its developed versions.

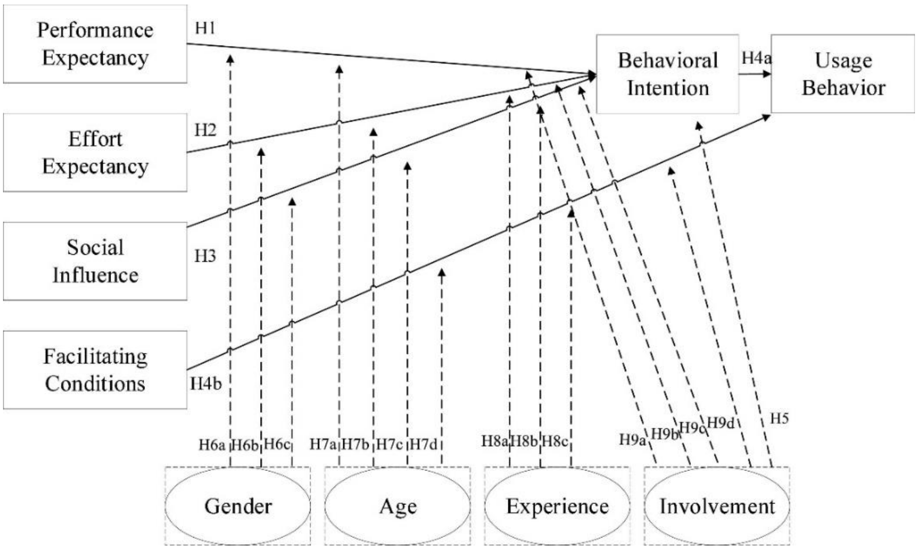
7. Figure: The TAM, TAM 2 and TAM 3 models




*Source: Keszey & Zsukk (2017, p. 41)*

The Unified Theory of Acceptance and Use of Technology (UTAUT) model (Venkatesh et al., 2003) is also a well-known and often cited approach in the literature. The UTAUT model was created by combining different models of technology acceptance. UTAUT identifies four key variables that influence technology acceptance, expectation of technology performance, expectation of technology use, social influence, and enabling factors. These factors determine behavioral intention and actual usage. The model also identifies four moderating variables, namely age, gender, level of experience and level of volunteering. The UTAUT model can also be understood as a synthesis of previously published models dealing with technology acceptance, the purpose of the model was to condense a large number of factors from previous models. A further development of the UTAUT model, the UTAUT 2 model (Venkatesh et al, 2012), expands the scope of the original variables. In the UTAUT 2 model, additional factors relevant to the consumer context appear, including the enjoyment effect (how much pleasure and entertainment the consumer finds in using the technology), the price-value ratio and the degree of habituation to the technology. The additions to the model help to better understand technology acceptance and the dynamics of its use in the modern, digital consumer environment. Figure 8 contains the combined model of UTAUT and UTAUT 2.

8. Figure: The UTAUT and UTAUT 2 models




*Source: Keszey & Zsukk (2017, p. 42.)*

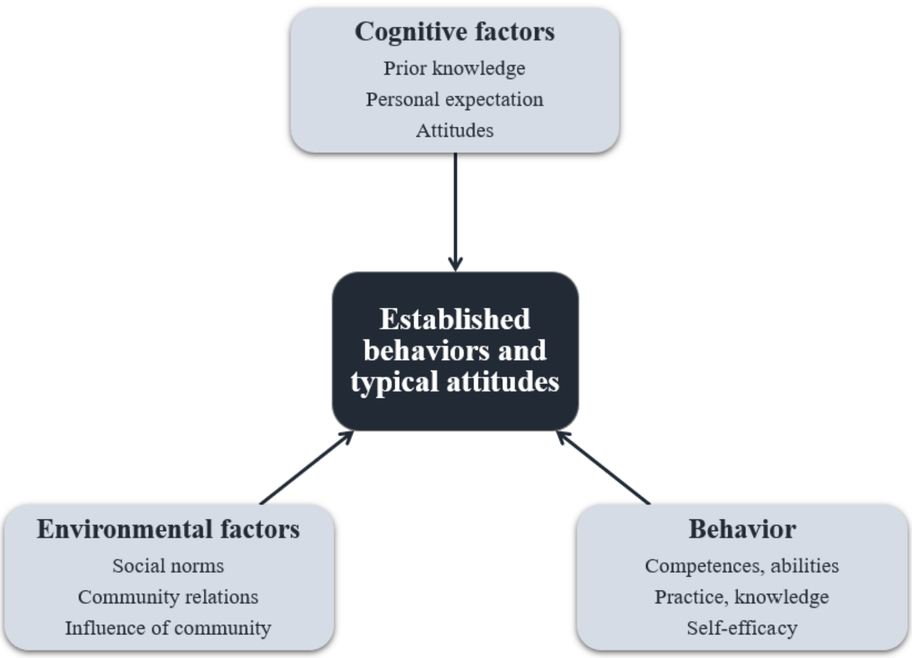
The Task-Technology Fit (TTF) model published by Goodhue & Thompson (1995) examines how well a given technology fits the specific tasks it is intended to support. According to the model, a technology will be accepted among consumers if it fits well with the users' tasks and work environment. By TTF we actually mean two different approaches, a utilization-centric model and a fit-centric model. Among the variables of the utilization-centered model are the characteristics of the technology, the factors (attitudes) influencing the use of the technology, these determine the use of the given technology and the effects that can be derived from the performance of the technology. The fit-centered model starts from the characteristics of the technology and the characteristics of the specific task, these variables determine the fit of the given technology, which affects the performance of the technology. The essence of the TTF models approach is that the performance of the technology is measured directly and the acceptance of the given technology is examined in this context. There is also a combined version of the two models, in which the elements of the utilization-centered and the fit-centered approach are included.

A natural solution for combining TAM and TTF models. Dishaw & Strong (1999) started from the fact that it has been empirically proven in the literature that both approaches have sufficient explanatory power in terms of the examination of technology acceptance, so the combined model provides the opportunity for new, more detailed analyzes by revealing the relationships between the two approaches. The authors took the original TAM model as a basis and supplemented it with the elements of the TTF model, primarily incorporating the fit of technology and task into the model. Compared to the original TAM model, the addition of TTF constructs increases the explanatory power of the model, especially in understanding the use and acceptance of technology, but the complexity of the model may limit its application in terms of data requirements.

Rogers' (1962) diffusion theory was presented in the previous chapter, but the model is also worth mentioning in terms of technology acceptance. In addition to the diffuser categories identified by Rogers (1962), the author also pointed out that the acceptance of new technologies occurs in five stages among consumers. In the first stage, consumer awareness plays a major role, at which point the technology is accepted and applied by those specifically informed about it. The second stage is interest, then technology acceptance is determined by attention and interest in technology. In the third stage, the evaluation of the technology supports its acceptance and thus its application. In the fourth stage, the test of the technology takes place, at which point the results of the application of the technology and the tests are available, and consumers can gain concrete evidence and experience of the use of the given technology. The fifth and last stage is acceptance, by which time consumers accept the new technology.

Social Cognitive Theory (SCT) is one of the behavioral models, Bandura (1986) emphasizes the importance of the dynamic and mutual interaction between behavior, the environment and personal factors, the model was originally created for psychological use, but later it was used in business and technological spread in the field of sciences. SCT is widely used in the investigation and research of the conditions of technology acceptance, as it provides an opportunity to understand the complex relationships between different factors. The variables of SCT can be classified into three groups. Cognitive (or personal) factors include individual knowledge, expectations and attitudes towards technology. Environmental factors include social norms, community relations, and the influence and ability of other members of society. The third, behavioral factors, include the existence of the necessary skills, practice, experience and self-efficacy, which is the individual's belief in his own abilities in order to successfully complete his tasks. Figure 9 presents the factors and structure of the Social Cognitive Theory.

9. Figure: Factors and structure of Social Cognitive Theory




*Source: own compilation*

The Theory of Planned Behavior (TPB) model also belongs to the range of behavioral models, Ajzen (1991) when creating the model focused on mapping the behavioral intention influencing technology acceptance, the effort an individual is willing to make during his action (during technology acceptance). According to the model, behavior is determined by three variables, the attitude towards the behavior, subjective norms (the individual's beliefs about the judgment of his behavior) and perceived behavioral control. The novelty of the theory is that it also takes into account the behavioral control variable, which can reduce the probability of the desired behavior occurring. According to the structure of the model, individual attitude, social subjective norms and perceived behavioral control determine the behavioral intention, which influences real behavior and action.

Regarding the topic of technology acceptance, it is also important to describe the models that specifically examine resistance to technology. One of the most cited models in the literature, Innovation Resistance Theory (IRT), focuses on the factors that cause consumers to resist the acceptance and use of new technologies. (Ram, 1987) The purpose of IRT is to better understand innovation, the factors preventing technology acceptance and the relationship between them. According to the model, the reasons for resistance to technology can be functional factors, psychological factors, and factors related to the characteristics of the technology (the complexity of the technology). Functional resistance variables include usability barriers, technology value barriers, and technology use risks. The variables of psychological resistance are tradition (tradition, beliefs, customs) and the image of technology. In the model, the characteristics of innovation include compatibility, complexity, observability and trialability. The essence of Samuelson & Zeckhauser's (1988) Status Quo Bias Model (SQB) approach is that consumers tend to stick to the status quo, thereby resisting change, even if new technology can bring benefits to them. Sources of resistance can be habituation, fear of risks associated with change, and uncertainty about new technology. The model assumes that a preference for the status quo underlies resistance to new technology. If we want to break the established resistance, then the factors that support the existing situation must be changed. Liang & Xue's (2009) Technology Threat Avoidance Theory (TTAT) model examines how consumers avoid threats related to new technologies. According to the theory, consumer behavior will be characterized by distance from or avoidance of technology if consumers feel that the use of technology poses (perceived or real) dangers for them. In the model, consumers perceive the technological threat (this is measured by the variables of the probability of the perceived threat and the severity of the consequences of the perceived threat), this creates the avoidance intention in them, which is embodied in the behavior aimed at avoiding the technology.

Table 15 summarizes the most important models and approaches related to technology acceptance, according to their key parameters, advantages and disadvantages of their application. The table includes models specifically dealing with the use of new technologies, approaches focusing on behavioral characteristics, and models dealing with resistance to the use of technology.

15. Table: Models dealing with the acceptance of technology

| Model name | Key parameters | Application benefits | Disadvantages of application | Authors |
|---|---|---|---|---|
| **Technology Acceptance Model (TAM)** | • external factors<br>• perceived usefulness<br>• perceived ease of use | • easy to understand<br>• can be widely used in different technologies<br>• numerous empirical studies support the validity of the model | • contains only two main factors<br>• it does not take into account the personal and social context | Davis (1989) |
| **TAM 2** | • above, respectively<br>• social influencers<br>• cognitive influencers | • elaboration of external factors in the case of perceived usefulness | • it does not take into account the personal and social context | Venkatesh & Davis (2000) |
| **TAM 3** | • above, respectively<br>• behavioral anchors<br>• correction factors | • elaboration of external factors in case of perceived ease of use | • it does not take into account the personal and social context | Venkatesh & Bala (2008) |
| **Unified Theory of Acceptance and Use of Technology (UTAUT)** | • performance expectation<br>• usage expectation<br>• social influence<br>• supporting factors | • considers several factors in terms of technology acceptance<br>• synthesizing nature<br>• effective in predicting technology acceptance | • more complicated and more difficult to apply than TAM models<br>• more data is required to apply the model | Venkatesh et al. (2003) |
| **TRAVEL 2** | • above, respectively<br>• pleasure effect<br>• value for money<br>• degree of habituation | • considers several factors in terms of technology acceptance<br>• synthesizing nature<br>• effective in predicting technology acceptance | • more complicated and more difficult to apply than TAM models<br>• more data is required to apply the model | Venkatesh et al. (2012) |
| **Task-Technology Fit (TTF)** | • characteristics of technology<br>• influencing factors (attitudes)<br>• task characteristics | • examines the fit between the technology and the task, which is essential from a practical point of view<br>• helps identify how technology can improve the performance of tasks | • it is mostly applicable to the organizational and workplace environment<br>• it requires detailed data collection and analysis | Goodhue & Thompson (1995) |
| **Combining TAM and TTF** | • external factors,<br>• perceived usefulness<br>• perceived ease of use<br>• characteristics of technology<br>• influencing factors (attitudes)<br>• task characteristics | • synthesizing nature<br>• complex structure, its practical application is relevant in many fields | • complex application<br>• it requires detailed data collection and analysis | Dishaw & Strong (1999) |
| **Diffusion of Innovations** | • consciousness<br>• interest<br>• evaluation<br>• test | • a long-standing and widely used approach<br>• breaks down the technology acceptance process into stages | • it does not take into account individual differences and specific | Rogers (1962) |

| Model name | Key parameters | Application benefits | Disadvantages of application | Authors |
|---|---|---|---|---|
| | • acceptance | • easy to understand, simple structure | technological factors<br>• due to the complexity of adopting a new technology, it is difficult to apply it to specific situations | |
| **Social Cognitive Theory (SCT)** | • cognitive (personal) factors<br>• environmental factors<br>• behavioral factors | • individual and social factors play an important role in the model<br>• applicable to a wide variety of behaviors and technological environments | • measuring self-efficacy and social factors can be complicated<br>• it does not take into account the specific technological context | Bandura (1986) |
| **Theory of Planned Behavior (TPB)** | • behavioral beliefs<br>• normative beliefs<br>• control beliefs | • it can be applied not only to technology acceptance, but also to other forms of behavior | • it does not take into account technology-specific factors<br>• measuring attitudes and subjective norms requires complicated data collection | Ajzen (1991) |
| **Innovation Resistance Theory (IRT)** | • functional resistance<br>• psychological resistance<br>• characteristics of innovation | • identifies different reasons for resistance to innovations<br>• helps to develop innovation strategies to reduce resistance<br>• a model often used empirically | • it focuses on specific causes and takes less account of other factors<br>• the characteristics of innovation include factors that are difficult to measure | Ram (1987) |
| **Status Quo Bias Model (SQB)** | • habit<br>• fear of risks<br>• uncertainty about new technology | • highlights the reasons for individuals' resistance to change.<br>• it helps to understand why people stay with existing systems | • it does not take into account all factors related to technological change<br>• it mainly focuses on adherence to existing systems | Samuelson & Zeckhauser (1988) |
| **Technology Threat Avoidance Theory (TTAT)** | • perceived likelihood of a technological threat<br>• perceived severity of a technological threat | • identify ways to avoid technological threats<br>• well applicable in the field of data security and data protection | • it focuses mostly on threats and takes less into account other factors<br>• it requires complex data collection and analysis processes. | Liang & Xue (2009) |

*Source: own compilation*

From the point of view of the research, technology acceptance takes on importance at the micro level, in the context of what are the soft factors and attitudes that determine the acceptance and application of Cloud Computing. The complexity and data requirements typical of the TAM and UTAUT models do not make them suitable for use in micro research. Among the behavioral models, the Social Cognitive Theory (SCT) and among the approaches focusing on technological resistance, the Innovation Resistance Theory (IRT) model, according to its structure, factors and purpose, may be suitable for exploring the inhibiting factors and attitudes characteristic of users. As a result of the fact that the interpretation and measurement of the variables defined by IRT is more complicated, factors based on the Social Cognitive Theory (SCT) model were queried to explore attitudes related to Cloud Computing.

I have summarized my most important findings regarding models dealing with technology acceptance below.

- The reasons and explanations of consumer decisions regarding technology acceptance are dealt with by different technology acceptance models, the models have in common that they emphasize what factors influence the acceptance of a technology, in contrast to diffusion models, which focus on the (future) spread of the technology.
- One of the goals of the application of models dealing with technology acceptance is to increase the success of the introduction of technologies and to reduce the risks arising from the conditions of acceptance, but at the same time, in the literature, the application of the models in most cases focuses on the (ex-post) examination of technologies that have already been introduced.
- The described models can be divided into two main categories. One group includes the most cited models in the literature, the traditional approaches to technology acceptance, and their improved, combined versions (for example, combining TAM, UTAUT, TTF, TAM and TTF).
- The other group is made up of alternative approaches, which deal more with the psychological aspects and behavioral characteristics of technology acceptance, and focus on the examination of resistance.
- From the point of view of the research, technology acceptance takes on importance at the micro level, in the context of what are the soft factors and attitudes that determine the acceptance and application of Cloud Computing. As a result, from the point of view of the research, the structure of the behavioral models, including the Social Cognitive Theory (SCT) model, best fits the goals of the research.

# 3. Cloud Computing

## 3.1 Definition, characteristics

Cloud Computing (Cloud Computing) is one of the most decisive IT innovations of the last two decades. Cloud-based computing, the use of Cloud Computing (in English, Cloud Computing) generally spread in the corporate environment from the beginning of the 2010s, at the same time, the relevant literature sources dealt with the technology even earlier, and from the mid-2000s there were business solutions and services for companies that could be classified here. The name of Cloud Computing comes from the pictogram for marking this type of service, which symbolizes that the given service is not available in the locally available physical technological environment, but far from it, "somewhere in the cloud".

Based on the relevant literature, the definition of Cloud Computing can be said to be uniform, generally accepted and used by the US National Institute of Standards and Technology (NIST, National Institute of Standards and Technology), which was first published by Peter Mell and Timothy Grance in 2002, then in 2009, and in its latest version in 2011. Based on this, cloud computing is a model that enables convenient, on-demand access to shared, customizable computing resources (such as networks, servers, storage, applications, and services) that are available quickly and require minimal management effort or require interaction with a service provider. Cloud Computing has five basic characteristics, it can be implemented in three service models and with four access methods (Mell-Grance, 2011, p. 2). There is also a different approach to the definition of Cloud Computing in the international literature. According to Wang & Laszewski (2008), Cloud Computing is a set of network-supported services that are scalable, customizable, and offer low-cost platforms. Plummer et al. (2008) also highlights the scalability of services, adding that the reach of customers is not quantitatively limited and does not require the existence of physical infrastructures. According to Scale (2009), Cloud Computing is a paradigm shift in the field of IT, because the sharing and use of applications and resources of the network environment is realized without the user owning and managing the resources and applications of the network. Similarly, Vouk (2008) and Vaquero et al. focus on virtuality. (2009), according to the authors, Cloud Computing is a set of easy-to-use virtual resources consisting of cyber infrastructure and distributed network capacities.

The definition of Cloud Computing includes the description of the five components and characteristics of the technology, which can be summarized as follows based on Mell-Grance (2011). (1) On-demand and self-service: Users can automatically order and manage services directly as needed, without human contact with the service provider. (2) Wide network access: Cloud services operate over a network (usually the Internet) using standard mechanisms and protocols that facilitate their use on different platforms (computer, tablet, mobile phone). (3) Resource pooling: Service providers pool their computing resources (such as storage, processing, network bandwidth) using a multi-tenant model, so that various physical and virtual resources can be dynamically assigned and redistributed according to consumer needs. Users are independent of the resources in the sense that they generally have no knowledge of the exact "location" of the given resources, and no possibility to check them. (4) Speed and flexibility: Service providers can flexibly provide, release and scale resources and capabilities in accordance with current demand. For consumers, this means that the necessary resources are at their disposal without limitation. (5) Service measurability: Cloud-based systems automatically measure, check and optimize the use of resources and services, supporting the optimization of resource use. Services can be measured, resource usage can be monitored, ensuring transparency for both service providers and consumers.

The emergence and spread of Cloud Computing has brought significant changes in many industries and among small and medium-sized enterprises (SME sector). The launch of Amazon Web Services (AWS) in 2006 marked a breakthrough in the widespread recognition of the technology, but the use of cloud-based solutions in a corporate environment only began to spread in Hungary in the early 2010s. However, literature research (Bőgel, 2009, Mell & Grance, 2009, Wei & Blake, 2010) already dealt with the technology before this, and in fact, the most extensive literature on the topic is available from this period. The early literary sources quite accurately predicted the changes that have occurred since then, according to which the service model based on Cloud Computing will fundamentally transform the IT activities of companies, the access to IT solutions (infrastructure, platform or software) as a service will bring radical changes to the economic and social in many areas of life. Bőgel (2009) deals in detail with the trend that the services available on the Internet will eventually become "public" and that Cloud Computing will play a key role in this. Researchers in the field generally predicted the rapid spread of technology, however, Racskó (2013) identified several factors that could specifically appear as an obstacle to the spread of technology in the European environment. Regarding the importance and future role of the technology, the relevant domestic and international literature has unanimously placed great hopes on Cloud Computing (Nemeslaki & Sasvári, 2015, Füzes, 2019), and even Nagy et al. (2018), Cloud Computing, as a component of artificial intelligence, Big Data or the Internet of Things (IoT), can still be considered one of the most important digital technologies due to its integration with these technologies.

While the name Cloud Computing includes several technologies and technological systems, the components of cloud-based services can be defined clearly and more narrowly, which follows from the fact that in this case it is sufficient to describe the factors necessary for the operation and realization of the given services. Armbrust et al. (2009) and Bőgel (2009), the components and conditions of cloud-based services include the following elements:

- device, hardware, which is suitable for running the given service;
- network access, which usually covers broadband Internet access;
- the program representing the IT and software background of the service;
- various security technical solutions for managing user rights and accesses, as well as creating data security conditions;
- high-performance server centers, server parks,

- and systems and platforms enabling the management of the administrative processes required to use the services.

By using services based on Cloud Computing, users can access similar or even identical functions and applications as in the case of locally installed systems. The main difference between the two service models is that, in the case of "traditional", local systems, the user owns the hardware and software park necessary to run the IT environment, while Cloud Computing ensures access to the necessary functions independently of the user. The user pays for the IT functions as services, and the implementation environment that supports the implementation and creation of the service is usually not owned by the user, but by the service provider. An exception to this are solutions based on certain Cloud Computing (for example, the possibility of building private clouds), where the IT environment is partially owned by the user, but at the same time, access to it and its functions are used as a service. According to Füzes (2018), a clear trend among traditional service providers is to place their traditional services on Cloud Computing. This technological change in itself does not mean the expansion and development of the offered functions, so in this case the novelty can only be seen in the way of access. At the same time, the expansion, development and connection possibilities of IT services based on Cloud Computing are many times greater than those of traditional, locally-based systems. Due to the fact that systems based on Cloud Computing can be accessed from anywhere, at any time, providing quite a lot of flexibility in terms of user devices, these services and systems potentially have radically new functionality (Füzes, 2018). By using Cloud Computing, companies' internal communication activities, data storage, work sharing, and collaboration options can be carried out on an order of magnitude wider than the solutions offered by local-based systems.

The benefits that can be realized for companies and the identifiable obstacles associated with the use of Cloud Computing are the relevant literature sources (for example, Lewis, 2012; Nemeslaki & Sasvári, 2015; Rittinghouse & Ransome, 2016; Dempsey & Kellihe, 2018; Füzes, 2019, Mansell, 2021) were summarized in Table 16.

16. Table: Advantages and obstacles associated with the use of Cloud Computing

| Advantages | Obstacles |
|---|---|
| • Low infrastructure costs<br>• Reduction of investment risks<br>• Possibility of cooperation<br>• Speed, efficiency<br>• Accessibility, availability<br>• The possibility of sharing information<br>• Reliability<br>• Flexibility and customization of systems<br>• Scalability, scalability<br>• Possibilities inherent in services | • Questions related to data protection and data security<br>• Access problems, network dependency<br>• Lack of information, lack of knowledge about systems and services<br>• A cumbersome, complicated application<br>• Language addiction<br>• Platform dependency<br>• Distrust of systems<br>• Lack of standards, interoperability<br>• Problems with accessing service providers<br>• Difficulties related to learning and application |

*Source: own compilation*

Based on the table, it can be concluded that the advantages and disadvantages and obstacles related to Cloud Computing can be clearly derived from the definition described above. Due to the fact that Cloud Computing is based on the use of a non-physical network (most often the Internet) (of course, for example, the Internet as a network also has physical infrastructure elements, but these are usually not visible to users), it follows directly that Cloud Computing the services being built are accessible from anywhere, fast, convenient, and can be introduced at a relatively favorable price, but at the same time there is a strong dependence on the network, and the available data transmission speed is limited. Due to the fact that we can only identify services in the case of Cloud Computing - so products based on Cloud Computing cannot be interpreted based on the definition of Mell-Grance (2011) - customization, ease of use, and the scalability of the applied systems are of particular importance to users. These are often accompanied by a lack of service-related standards, platform and language dependency, and the fact that users can only choose from services currently available on the market, which means a different type of engagement and availability than a product (for example, a software package). Users can use services based on Cloud Computing in real time, separated in space, shared, and interacting with each other, but this entails the vulnerability of the systems, increased exposure to attacks or illegal use, and extremely significant data storage and protection, mapping and management of risks related to its use.

Based on the above, it can be concluded that the technological factors and conditions necessary for (domestic) companies to use cloud-based services are largely given. Although they cannot directly influence the types and availability of the services offered by service providers, cloud-based services are typically offered today not only by multinational technology companies (such as Microsoft, Google, SAP, Amazon, etc.), but also by domestic small and medium-sized enterprises. services. The essence of the service model is that instead of traditional "box" or license-based sales, users access the given service through a subscription. Bőgel (2009) pointed out that despite the fact that the sale of cloud-based services - as a business model - has become technically possible, in the future users may wonder what advantages this "new" model can offer them, how competitive it is, and whether there is a chance for it to spread widely and overcome the business model of product-oriented sales prevailing at the time. However, the examination of cloud-based services by itself is not as informative as a deeper analysis of Cloud Computing, without mapping the circumstances of their applicability. The spread and rate of diffusion of cloud-based services does not only depend on the existence and availability of the conditions of the services (which were largely given to companies already in the 2010s, also in Hungary), but other components of the technology must also be taken into account. Moreover, in connection with the use, application, and spread of a technology, we cannot go beyond the examination of external environmental driving forces, barriers, push and pull mechanisms, as included in the strategic techno-management approaches and models presented in the previous chapter, which serve as analytical frameworks.

## 3.2 Systematization of Cloud Computing

The organization and grouping of Cloud Computing can also be said to be uniform in the literature, this is largely due to the fact that the generally accepted definition includes that Cloud Computing can be categorized in three ways based on the type of service implemented and four ways based on the method of access (Mell & Grance, 2011, p. 2.). In the following subsections, the relevant literature sources (for example, Armbrust et al., 2009; Mell & Grance, 2009, 2011; Weinhard et al., 2009; Nagymáté, 2010; Mietzner, 2011; Lin & Chen, 2012; Jula et al., 2014; Nemeslaki & Sasvári, 2015; Dempsey & Kelliher, 2018).

### 3.2.1 Cloud Computing groups based on the service implemented

Depending on the implemented services, we can distinguish three interdependent service layers, which - moving from the lower level to the more complex service level - are the infrastructure (Infrastructure as a Service, IaaS), the platform (Platform as a Service, Paas), and the software (Software as a Service, SaaS). The grouping of services based on Cloud Computing can therefore be interpreted not only on the basis of differences in their properties, but also in relation to building on each other. The number of users increases along with the depth and complexity of the services, so software as a service representing the highest level is the most widespread Cloud Computing with the most users, and infrastructure as a service is the least used technology. While in traditional IT systems the various IT/computing features and capabilities are managed and owned by the users, in the case of services based on Cloud Computing, to varying degrees, the service provider manages the given resources (Table 17). From the above, it follows that in the case of software as a service, the traditional IT tasks and resources underlying the given service are already fully managed by the service provider, while in the case of infrastructure as a service, only a part of them is managed.

17. Table: Service models based on Cloud Computing

<table>
<tr><th>Traditional IT tasks and skills</th><th>Infrastructure as a service model</th><th>Platform as a service model</th><th>Software as a service model</th></tr>
<tr><td>Applications</td><td rowspan="6">Managed by client</td><td rowspan="3">Managed by client</td><td rowspan="10">Managed by a service provider</td></tr>
<tr><td>Data</td></tr>
<tr><td>Security</td></tr>
<tr><td>Running programs</td><td rowspan="7">Managed by a service provider</td></tr>
<tr><td>Shared/Middleware</td></tr>
<tr><td>Operating system</td></tr>
<tr><td>Virtualization</td><td rowspan="4">Managed by a service provider</td></tr>
<tr><td>Server</td></tr>
<tr><td>Storage space</td></tr>
<tr><td>Networks</td></tr>
</table>

*Source: own compilation, based on Jula et al. (2014), Roussev et al. (2016)*

At the same time, we cannot state that in terms of user engagement and use, the use of the infrastructure as a service would mean a significantly lower standard than the use of the platform or software as a service. This can be explained by the fact that the software, as a service, includes all of the traditional IT tasks and capabilities, but at the same time, in addition, users typically use other (not based on Cloud Computing) systems that they own and manage in parallel. Due to the fact that services based on Cloud Computing offered on the market can currently be used for different, different purposes, by using the infrastructure as a service, users typically use services that are still currently tied to traditional product or hardware-based IT/computing technologies.

Cloud-based software as a service is not without precedent, already in the 1960s, IBM used centralized computer centers that provided certain dedicated services for machines connected to the terminal. With the spread of the Internet, the so-called Application Service Providers (ASPs) were created, which typically made various, mainly business, services available by using the Internet network, but at the same time, the use of ASPs also appeared with regard to public administration services. Cloud-based software as a service can be considered an extension of ASPs, while in the case of ASPs, the application and program of a third company (that is, different from the user and the organization connected to it) was usually available to the users, the software as a service In the case of Another difference is that in the case of ASPs, we can talk about applications in the traditional sense, the use of which required the installation of some client software (which continued to function as a service, so a product was not installed), while to access the software as a service, it is sufficient the existence of a device with an Internet connection.

Software as a service is the highest level of Cloud Computing, in this case the service provider provides access to software or applications running on the infrastructure it owns, which users can access by creating a client user account. The use of cloud-based software as services supports companies to use IT applications and programs in the classical sense tailored to their own needs, gradually expanded and modernized, thereby avoiding the typically high costs associated with IT developments and infrastructure investments. Widespread, well-known cloud-based software and applications are, for example, Google Apps, software offered by SAP, and Microsoft Office 365+.

The cloud-based platform as a service can be interpreted as a layer below the software as a service presented above. In this case, the service provider does not only provide a ready-to-use software or application, but also an interface on which users can compile, create and install the applications they need. The service provider provides the technological background and infrastructure necessary for the operation of the platforms, the complex development environment, which includes the load distribution and task transfer required for the use of the platforms, the development and maintenance of the user interfaces, and the maintenance and updating of security requirements. The two most basic cases of a cloud-based platform as a service are business platforms and development platforms.

The platform as a service can also be interpreted as an extension of the infrastructure as a service presented below. By using the service, companies use not only the central infrastructure, but also the platform environment, operating system, development and server software, and database managers that run on it. In the case of the platform as a service, users do not have to deal with the installation and updating of components, these are provided by the service provider. Cloud-based platform services include, for example, Google App Engine, Amazon Web Services or Windows Azure.

Infrastructure as a service is the lowest-level cloud service model, but, as I mentioned above, it is not the most widespread service based on Cloud Computing with the most users. In the case of infrastructure as a service, the service provider provides virtual resources (storage, memory, processor, etc.), servers, load distribution or network to users, but the condition of operation is that the user's operating system and platform environment are suitable for running infrastructure-type services. In this case, the user is responsible for creating, setting up and managing the operating and software environment. By using infrastructure as a service, companies can access infrastructure of any size, customizable and variable type, with which they can partially or completely satisfy their needs and demands in this direction. The most common implementation types of cloud-based infrastructure as a service are storage services and the provision of computing capacities, the more well-known programs include, for example, Amazon EC2 or Google Compute Engine.

### 3.2.2 Cloud Computing groups based on how it is accessed

Another general grouping system of Cloud Computing is the categorization based on the method of access and delivery, on the basis of which we can distinguish between public cloud (Public Cloud), private cloud (Private Cloud), hybrid cloud (Hybrid Cloud) and community cloud (Community Cloud).

In the case of the public cloud, the services are "public", so their use is available to all users. The provision of infrastructure and services is linked to a specific service company, which owns the resources and capabilities required for the technology, and manages and operates the services available to users. In the public cloud model, the target market is not only companies, but also individual consumers, the public sector, and other organizations. It follows that this type of technology can typically be provided and operated by the largest companies in the service market (Google, Microsoft, Amazon). Services based on public cloud technology can be accessed directly, quickly, at the most favorable price or even for free, users are only slightly and short-term bound by the service provider. At the same time, the disadvantage of the technology is that access to data created, stored, and used in the public cloud is relatively poorly protected, and in addition to attacks from third parties, the service provider itself also collects, stores, and monitors the transactions and processes taking place here.

In terms of access, the technology of the private cloud eliminates the disadvantages of the public cloud, and is thus able to implement specialized services. In this model, the infrastructure is set up in a protected location and only certain users, or even a circle of users, can access the services and platforms. Infrastructure, platforms and software based on private cloud technology are created by a company or organization for itself, so their maintenance, maintenance and management are also within the company's own powers and activities. In this case, service providers cooperate in building and securing the technological background, they do not necessarily have insight into the processes existing in the private cloud, they are owned by companies and organizations. The privately owned infrastructure created by this type of company, although more expensive than services based on the public cloud, means safer, exclusive use for the company, can be customized to a greater extent, and allows for the establishment of differentiated, individual user rights. In this access model, the data is stored in a private environment, but at the same time, the central infrastructure and control unit that ensures the operation and operation of the private cloud can be established both at the company's premises and at a location provided by the service provider.

The hybrid cloud is a combination of solutions provided by the public and private cloud, the infrastructure, platform or software services can be used in a mixed, integrated and completely individual way. In the model, the scalability and cost-effectiveness of the public cloud is combined with the data security provided by the on-premise systems provided in the private cloud. The technology of the hybrid cloud ensures the highest degree of implementation of personalized solutions, allows a high degree of flexibility in the design of the systems, but at the same time, the difficulties related to the creation of the integrity of the various systems, as well as the uncertainty and learning difficulty arising from the lack of usage knowledge, can act as a serious obstacle.

The community cloud operates in a closed system, similar to the private cloud, but in this case, the solutions provided by Cloud Computing are not owned by a single company or organization, but by a closed group of them. In this way, the infrastructure, platform or software created in the cloud is shared between several companies, which jointly enjoy its benefits and are responsible for the operation and maintenance of the system. The development and creation of comprehensive security requirements and conditions, the reduction of security risks, and the management of user rights are particularly important in connection with the development of services based on the community cloud. Systems based on community cloud technology can be owned by one or more companies, or even by a third party or service provider. In the relevant literature sources, when categorizing Cloud Computing based on the method of access and delivery, they do not always mention the community cloud as a separate group, since it is extremely close to the technology of the private cloud in terms of its properties.

### 3.2.3 Groups of Cloud Computing based on KSH/Eurostat

Although it is less relevant from a scientific point of view, the queries and data of the Hungarian Central Statistics Office (KSH) and Eurostat regarding Cloud Computing have an important role for my empirical research. Based on the same methodology and indicators, the two organizations investigate the use and spread of Cloud Computing among the population and companies (small and medium-sized companies, as well as large companies).

The harmonization of data collection by Eurostat and KSH is required by the referenced regulation of the European Parliament (2004). Based on the provisions of the decree, the European Commission required the production of annual statistics for the member states, in order to achieve the goals set out in the action plans of the European Union in order to have coordinated and coherent performance indicators on the use of information and communication technologies that provide reliable information for political and policy decision-makers, for preparatory bodies. Based on Lieber (2016), the CSO, together with the other member states of the European Union, participates in the work process, the purpose of which is to develop implementation measures and laid down principles regarding the production of community statistics required by the decree. In Hungary, the KSH collects data on the use of ICT tools by businesses in OSAP No. 1840, "Qualitative and quantitative data of the stock of information and communication technologies" (KSH, 2020).

The Central Statistical Office and Eurostat have been collecting data on the use of Cloud Computing since 2014. The categories included in the statistical surveys are also a kind of grouping of Cloud Computing, although it is important to note that surveys for this purpose research cloud-based services and their undeclared goal is to channel all services based on Cloud Computing into the categories of the survey with scientific sophistication. Nevertheless, the grouping used separates the cloud-based services used by companies in a logical and clear way. Based on domestic and European Union databases and statistics (KSH, 2015; Eurostat, 2020; KSH, 2020), the following groups of cloud-based services can be distinguished.

- E-mail computing services: Its essence is that it only transmits signals containing information, unlike traditional mail, which also delivers the physical carriers of the signals to the recipient. In the ESMTP version of the current standard, it is also possible to transmit 8-bit files, i.e. accented texts, images, music, and videos.
- Office software applications: Any software that companies can use for operational or administrative purposes and is not part of the additional category. This includes integrated enterprise management and resource planning (Enterprise Resource Planning, ERP) software, the purpose of which is to make the information and processes of various business functions of companies, as well as everyday transactions, manageable in an integrated manner. ERP systems typically enable the recording and management of planning, purchasing, sales, marketing, customer relations, financial and human resources.
- Provision of database storage space: Cloud-based access to the storage spaces required for the storage, management and use of databases used by companies, this includes not only the (own) databases owned by the companies, but also the use of external databases "purchased" in various subscription models, the access as well.
- File storage: Cloud-based storage capacity, use of storage space to store the company's own documents.
- Financial or accounting software applications: The use of software for the management and handling of financial and accounting processes and tasks, either managed by the companies themselves or operated, operated and used by an external partner.
- Customer relationship management software applications for managing customer-related information: Customer relationship management (Customer Relationship Management, CRM) is a management method, the essence of which is that by collecting, integrating, processing and analyzing customer information through

the intensive use of information technology, companies make the focus of their business activities their customers cost. We can distinguish operative CRM systems, in which the customer-related information is managed by the administrator or customer reference, and analytical CRM systems, in which the analysis of the available data on the customers and their transformation into relevant information is carried out with IT support.

- Use of infrastructure and capacity required to run software: Central processor (CPU), memory, computing capacity rental, remote use to run companies' software or other high-performance applications, programs or calculations.

## 3.3 Interpretation of Cloud Computing as innovation

The interpretation of Cloud Computing as an innovation, as well as the collection of conclusions that can be drawn from it, is an important part of theoretical research. One of the goals of the conceptual systematization of technology and innovation is to be able to categorize the specific technology examined in the empirical research based on its characteristics, properties, and innovative nature, thus, in addition to how Cloud Computing can be defined, I will also get an answer to what characterizes this technology, taking into account the conceptual frameworks of technology management and innovation management disciplines. Cloud Computing is a technological innovation that, in the nearly 20 years since its appearance, both as an independent technology and as a component of other technologies, has sparked extraordinary interest in academic and business life (Nagy-Borsy, 2018). However, the interpretation of Cloud Computing as an innovation is not an easy task, literature researches do not show a uniform picture in this field (Füzes, 2019). On the one hand, the application methods of Cloud Computing and the quality requirements characteristic of the technology have changed and developed over the past decade, and on the other hand, the evaluation of the impact of Cloud Computing on companies and their operations is the subject of continuous professional discourse.

According to Scale (2009), Cloud Computing has brought about a paradigm shift in business life, but at the same time, the author examined the technology primarily from a strategic, business point of view, so the finding cannot be applied to the innovation aspects of Cloud Computing. Looking at the structure of IT (Benkler, 2006; Bainbridge, 2007), Cloud Computing is an IT, including network technology, which enables users to access and use different services (Wang & Laszewski, 2008; Mell & Grance, 2011). Armbrust et al. (2009) and Lin & Chen (2012), the importance of Cloud Computing lies in the fact that additional, new technological innovations and standards based on technology, business models using technology, and the functionality of services based on technology have such an impact on the organizational functioning of companies, which can directly affect the competitiveness of companies. According to its professional content (Steele, 1989), Cloud Computing is considered a service technology, according to Mietzner (2011), Wang & Laszewski (2008), Cloud Computing is a component of network-supported services. It follows that in terms of the essence of technology (Trott, 1998) we can talk about core technology, as it embodies the technological basis and conditions of various functions (networks, servers, storage, applications and services) (Mell & Grance, 2011; Armbrust et al., 2010). Based on the relationship with industry competitiveness (Little, 1981), Cloud Computing has now clearly become a basic technology (Buyya et al., 2009), regardless of industry, the use of Cloud Computing is of fundamental importance for all competitive players (Đorđević et al., 2020; Abusaimeh et al., 2023). Partly by taking into account the time that has passed since the appearance of the technology, and partly by the prevalence and familiarity of the technology, it can be justified that there is agreement in the literature (Nagy et al., 2018; Füzes, 2019; Abusaimeh et al., 2023) that Cloud Computing is the based on the technological life cycle (Utterback & Abernathy, 1975; Anderson & Tushman, 1990) it is considered a mature technology. According to sector relations (Perillieux; 1991), Cloud Computing is considered a complementary technology, from the definition of technology (Mell-Grance, 2011) it follows that it can essentially be compatible with any hardware technology, and any local-based software solution can be replaced by Cloud Computing. According to the characteristics of technology development (Arthur, 2009), we can talk about composite technology, based on Wang & Laszewski (2008), Cloud Computing is a set of network-supported services that can be scaled, customized and offer low-cost platforms, this is in line with the definition of composite technologies that these technologies connect different units and systems and can be flexibly expanded and developed. According to regional distribution (Perillieux, 1991), Cloud Computing is clearly an international-global technology, and the largest multinational technology companies are among the developers and service providers of the most well-known specific corporate and individual solutions based on the technology. According to the research and development intensity characteristic of the technology (Teece, 1986), we can speak of a technology with a low R+D intensity, the cloud-based model fits into the range of digital solutions based on the Internet in terms of its technological composition and structure (Armbrust et al., 2010). Considering the degree of technological diffusion (Rogers, 1976), Cloud Computing is a rapidly spreading technology (Bőgel, 2009).

Cloud Computing is a technological innovation according to the common opinion of specialized literature sources (for example, Buyya et al., 2009; Bőgel, 2009; Iyer & Henderson, 2010; Sultan et al., 2012; Nemeslaki & Sasvári, 2015; Füzes, 2018). In terms of Schumpeterian innovation types (Schumpeter, 1980), it can be classified as product innovation, which in this case means service innovation, since based on the definition of Cloud Computing described earlier (Mell & Grace, 2011), Cloud Computing clearly provides the network background of a service, therefore, it can be apostrophized as a component of the given service. Considering the strategic direction of the innovation (Tidd et al., 2001), we can also speak of technological innovation, since Cloud Computing has novelty value for companies, but this technological architecture was already known to the market (Scale, 2009). Cloud Computing has had a strong impact on the innovation of the business model of companies, since new business models based on Cloud Computing have been formed, both for the provider (a company that provides services based on Cloud Computing) and for the user (a company that uses services based on Cloud Computing). on the side. However, regardless of the fact that the use of services based on Cloud Computing may have resulted in business model innovations for companies, Cloud Computing itself is not a business model innovation, because the technology is clearly a service technology, so it can be interpreted as a component (sub-technology) of a specific service, and not as a business as a component of models.

Henderson & Clark categorized innovation based on the novelty content of the innovation and the degree of innovation, Cloud Computing Armbrust et al. (2010) and Marston et al. (2011), a radical innovation, since not only the basic concept, but also the relationship between the concept and the components changed during the innovation. According to Mansell (2021), the emergence of Cloud Computing fundamentally transformed traditional IT infrastructures and services, the former product-oriented model was replaced by the service-oriented model. Instead of maintaining and using their own data centers and servers, companies access and use their IT resources on demand via the Internet. Companies no longer own the IT resources they need, but use them as a service. Following the emergence of Cloud Computing, companies must think radically differently about their IT activities and related functions (Sultan & Bunt-Kokhuis, 2012; Dasilva et al., 2013). Freeman & Perez (1988) typologized innovation on the basis of its scope and novelty content, even taking into account the grouping they used, Cloud Computing can be considered a radical innovation. According to Freeman & Perez (1988), radical innovations mean a break with existing methods and procedures, as a result of which new products and services can be created, according to Wang & Laszewski (2008) and Sultan & Bunt-Kokhuis (2012), the most important impact of Cloud Computing new services and business models developed by the access method based on the Internet network replacing the previous local IT structure.

In their work synthesizing innovation typologies, Garcia & Calantone (2002) distinguish between incremental, radical, platform and system innovations. Cloud Computing can be considered an incremental innovation from the point of view that it changed a process or procedure, and the novelty it brought spread with low risk. However, the relevant literature (Wang & Laszewski, 2008; Sultan & Bunt-Kokhuis, 2012; Füzes, 2018; Mansell, 2021) clearly identifies Cloud Computing as a radical innovation from this point of view, even though its spread was not characterized by high risk developments. Radical innovations are aimed at creating new products or processes that are significantly different from existing ones (Garcia & Calantone, 2002). Füzes (2018) showed in detail that Cloud Computing is based on new technical standards and a new service provider-customer relationship compared to previous local networks. Cloud-based services are based on new standards for virtualization, identity management, security, end-user access, and mobile device access, and cloud services serve multiple users on the same infrastructure (Rittinghouse & Ransome, 2016). Cloud Computing can therefore be evaluated as a radical innovation in terms of its architecture and the business models and relationships based on it.

In terms of product-market changes caused by innovation (Christensen, 1997), Cloud Computing is disruptive, i.e. disruptive innovation. The relevant literature sources (eg Govindarajan & Kopalle, 2006); Yu & Hang, 2010; Iyer & Henderson, (2010); Sultan & Bunt-Kokhuis, 2012) agree that Cloud Computing has brought significant changes regarding the product and market dimension of innovation. Dasilva et al. (2013), Cloud Computing brought more flexible, cost-effective and accessible services to companies than the previously available IT solutions, which overrode the role of traditional computer infrastructure and previous business models. In his study, Füzes (2018) empirically examined the disruptive nature of Cloud Computing, taking into account the results of the research, Cloud Computing results in new technical standards and new functionality for companies, which represent a significant positive change compared to previous local networks. According to Füzes (2018), Cloud Computing meets the requirements of disruptive innovation. Disruptive technologies target new markets, this can be interpreted in relation to Cloud Computing as the fact that the product-based sale of IT services has been replaced by the provision of service-based access, and the use of local, hardware-based IT resources has been replaced by the use of remotely accessible, non-physically owned resources. Disruptive technologies can over time displace the existing, dominant technologies, but at the same time, its realization is not legal, in relation to Cloud Computing, it is rather visible that the two systems work side by side, although the developments and modern solutions both point in the direction of the dominance of Cloud Computing (Füzes, 2019).

Table 18 contains the interpretation of Cloud Computing in terms of technology and innovation typologies. The definition of Cloud Computing as innovation in the literature is not uniform, however, individual sources differ not in how they evaluate and characterize the innovative content of Cloud Computing, but in which approach they use in relation to the technology.

18. Table: Interpretation of Cloud Computing as an innovation

| The essence of approach | Understanding Cloud Computing | Authors |
|---|---|---|
| According to professional content | service technology | Steele (1989), Wang & Laszewski (2008), Mietzner (2011) |
| Technology at its core | core technology | Trott (1998), Armbrust et al. (2010), Mell & Grace (2011) |
| Relation to industrial competitiveness | basic technology | Little (1981), Buyya et al. (2009), Đorđević et al. (2020), Abusaimeh et al. (2023) |
| Technology by life cycle | mature technology | Utterback & Abernathy (1975), Anderson & Tushman (1990), Nagy et al. (2018), Füzes (2019), Abusaimeh et al. (2023) |
| By sector relationship | complementary technology | Perillieux (1991), Mell-Grance (2011) |
| According to the development of technology | composite technology | Wang & Laszewski (2008), Arthur (2009) |
| According to the structure of IT | network technology | Benkler (2006), Bainbridge (2007), Wang & Laszewski (2008), Mell & Grace (2011) |
| According to regional distribution | international-global technology | Perillieux (1991) |
| According to research and development intensity | technology with low R&D intensity | Teece (1986), Armbrust et al. (2010) |
| According to the degree of technological diffusion | fast spreading | Rogers (1976), Bogel (2009) |
| Types of innovation | service innovation | Scumpeter (1980), Mell & Grace (2011) |
| Scope of innovation | radical innovation | Freeman & Perez (1988), Wang & Laszewski (2008), Sultan & Bunt-Kokhuis |

| The essence of approach | Understanding Cloud Computing | Authors |
|---|---|---|
| | | (2012) |
| Degree of innovation and nature of change | radical innovation | Henderson & Clark (1990), Armbrust et al. (2010), Marston et al. (2011), Sultan & Bunt-Kokhuis (2012), Dasilva et al. (2013), Mansell (2021) |
| Based on product-market changes | disruptive innovation | Christensen (1997), Govindarajan & Kopalle (2006), Yu & Hang (2010), Iyer & Henderson (2010), Sultan & Bunt-Kokhuis (2012), Dasilva et al. (2013), Füzes (2019) |
| According to strategic orientation | technological innovation | Tidd et al. (2001), Scale (2009) |
| Based on the typology of innovation | radical innovation | Garcia & Calantone (2002), Wang & Laszewski (2008), Sultan & Bunt-Kokhuis (2012), Rittinghouse & Ransome (2016), Füzes (2018), Mansell (2021) |

*Source: own compilation*

Regarding the interpretation of Cloud Computing as technology or innovation, we can make the following important statements.

- Cloud Computing belongs to IT technologies, including network technology. Based on the definition presented above (Mell & Grace, 2011), Cloud Computing can be interpreted as a component or "background" of various services, Cloud Computing can be defined as a part or sub-technology of services, i.e. core technology.
- It is a mature technology due to its prevalence, familiarity, and availability, which is considered a basic technology from the point of view of sectoral competitiveness.
- Cloud Computing is clearly technological, and as a result of the fact that Cloud Computing is a component of services, taking into account Schumpeter's categories, it is a product innovation, which in terms of context means a service innovation. By developing services based on Cloud Computing and using them, companies can develop business model innovations, however, since Cloud Computing, considering its technological architecture, is not related to business models but to services available via the Internet, it cannot be considered a business model innovation in itself.
- Whether we look at the scope of the innovation or the extent of the innovation and the nature of change, based on the literature sources, Cloud Computing is a radical innovation. Cloud Computing has also changed the way and process of accessing services, as well as brought about a significant change in the relationship between the service provider and the user, and between the user and the technology base he owns.
- Cloud Computing is a disruptive innovation. Disruptive innovation is characterized by the fact that disruptive products or services bring a high-impact, significant change to sector competition, change its requirements, and have new parameters that make previous technological solutions obsolete. In the case of

disruptive technologies, it is different when the previous technology is supplanted, in the case of Cloud Computing, it can be seen that it is present alongside the previous local-based systems and services with an ever-increasing dominance.

# 4. Research concept and methodology

## 4.1 Synthesis of theoretical chapters

The main question of research concerning strategic technomanagement is how the technologies used by enterprises can be fitted into a strategic context, and what strategic challenges enterprises face in their technology management activities. Taking into account the characteristics of small and medium-sized enterprises, the interpretation and importance of technology management functions is given a different emphasis than in the case of large enterprises. While in the case of large companies the challenges caused by switching between technologies and the role of advantages and disadvantages associated with the use of standards are of particular importance, for small and medium-sized enterprises the most important technology management challenge is the acquisition of available technologies, the organizational integration and embedding of technologies, as well as technological developments and managing difficulties and risks arising from the capital requirements of investments. At the same time, as explained in the previous subsection, the characteristics of Cloud Computing and the business and technological design of the services based on it are well suited to the characteristics of small and medium-sized enterprises. The use of services based on Cloud Computing can strongly reduce the disadvantages arising from the size of businesses, due to the fact that this type of service is accessible to anyone, taking into account the technological requirements, and can be used offering a high degree of personalization. The transition to cloud-based technological solutions and the partial outsourcing of the company's activities can therefore also be interpreted as a strategic issue for businesses. The spread of service-oriented platforms replacing the product-oriented approach is in itself a strategic techno-management issue, however, the spread of services based on Cloud Computing can bring about a paradigm shift for small and medium-sized enterprises, therefore the investigation of this is a relevant research topic.

I can determine the tasks of the empirical research and my research questions based on the results of the theoretical chapters. To this end, I organized and synthesized my findings contained in the theoretical chapters, the results of which are contained in Table 19. By processing the topics covered in the theoretical chapters, it became possible to select the key concepts, the interpretation and definition of which essentially created the theoretical framework of the research. The interpretation of the topics and the definition of the relevant concepts (these are included in the conceptual framework column in Table 19) can have two outcomes. On the one hand, the theoretical results can be applied to Cloud Computing, which is how I expand my theoretical results. On the other hand, the theoretical results designate and delineate the research areas in connection with which further empirical investigations are necessary in order to achieve my research goals.

19. Table: Results of the theoretical chapters and their application

| Key concepts, topics | Conceptual framework | Application of results |
|---|---|---|
| the relevance of the small and medium-sized business sector | The domestic small and medium-sized business sector is a relevant subject for theoretical and practical research in terms of both its importance to the national economy and its business characteristics. The characteristics of Cloud Computing are extremely well suited to the specialties of the SME sector. | **Empirical research: What kind of digital maturity and technology use characterizes the enterprises of the domestic SME sector in terms of Cloud Computing?** |
| technology | Technology is the knowledge that can be used to expand a person's abilities and possibilities. | Cloud Computing is a mature network technology, as it is a component of services, and therefore a core technology. |
| innovation | An innovation is a new or significantly improved product or service, process, marketing method or organizational method in business practice. | Cloud Computing can be interpreted as technological innovation, service innovation, radical innovation and disruptive innovation. |
| technology management | Technology management is the assessment, management and development of the available technological base and capabilities of companies. Its functions are identification and selection. acquisition, exploitation, protection and learning. | **Empirical research: What characterizes the technology management functions of enterprises in terms of the application of Cloud Computing?** |
| strategic management paradigms | The paradigms of strategic management have dealt with the issue of technology in different ways. In parallel with the development of paradigms, it has become more and more important for companies to evaluate and manage the technological base at their disposal with a strategic focus. The development of the discipline of technology management was based on the perception of the direct relationship between technological resources and capabilities and the acquisition and retention of competitive advantage. | The management of technological issues, the evaluation, design and development of the technological portfolio have become a strategic issue for companies. The use of Cloud Computing guarantees competitive parity for companies. |
| strategic technomanagement | Strategic technomanagement places the technology management of companies in a strategic context. The approach of strategic technomanagement handles both business and technological aspects, takes into account the company's external and internal environment, capabilities (push mechanisms) and requirements (pull mechanisms) affecting technology management functions. | When empirically examining Cloud Computing, both external and internal environmental elements, company capabilities, and business requirements must be taken into account. |
| technology diffusion | Diffusion of technology means modeling the future spread of a specific innovation or technology. The spread of technology is influenced by the willingness of users to innovate, the characteristics of the technology and environmental effects. The macro-level examination and prediction of the diffusion of a technology can be carried out using mathematical models. | **Empirical research: What characterizes the future spread of Cloud Computing in the domestic SME sector?** |
| technology evaluation | The models dealing with the evaluation of technology deal with companies' technological ability, technological maturity, innovation success factors, and quality criteria | **Empirical research: What characterizes the technology management capabilities of enterprises regarding the** |

| Key concepts, topics | Conceptual framework | Application of results |
|---|---|---|
| | for the application of technology. Approaches focusing on the assessment of technological capabilities are suitable for examining a specific technology. | **application of Cloud Computing?** |
| technology acceptance | Models dealing with technology acceptance deal with business, technological, behavioral and external environmental aspects in different ways, but typically together. Behavioral models, which are typically psychologically loaded, are suitable for mapping attitudes related to technology acceptance. | **Empirical research: What characterizes the acceptance of Cloud Computing in the domestic SME sector?** |

*Source: own compilation*

The "theoretical-type" results of the theoretical research are contained in the unhighlighted fields of the third column of Table 19. Based on the definition of the concepts of technology and innovation and the presentation of the typologies noted in the literature, it became possible to characterize Cloud Computing and interpret it as innovation. The correlations between the paradigms of strategic management and the management of technological issues have highlighted that the management of technology has become a strategic issue for companies. The application of Cloud Computing will not be a source of competitive advantage for companies, the technology is at most sufficient to achieve competitive parity. The framework of strategic technomanagement combines these approaches and gives a strategic focus to technology management and the innovation activities of companies. It follows from the application of the strategic management approach that the empirical examination of Cloud Computing must take into account both external and internal environmental elements, company capabilities (pull mechanisms) and business-economic requirements (push mechanisms). The models used during the empirical research must therefore fit the elements of the strategic technomanagement framework.

Additional results of my theoretical research can be identified, which are contained in the bold highlighted fields of the third column of Table 19. These do not refer to the characterization of Cloud Computing or the approach to research, but point to the missing results of research. The relevance of the small and medium-sized business sector - as the subject of the research - appears in all empirical studies, however, the mapping and presentation of the current use of Cloud Computing is a closely related task. The field of technology management deals with the management of the technological base and capabilities of companies, the technology management functions of companies can be determined based on the authors of the topic. Empirical research is required regarding the application of these functions and Cloud Computing. A similar research gap can be seen in terms of technology diffusion, technology evaluation and technology acceptance, these are the areas in which I need to conduct practical research in order to fulfill my research goals.

The theoretical framework presented in Table 19 and the synthesis of the theoretical chapters contain the topics and key concepts involved in the theoretical research, their explanation and interpretation, as well as the revealed research results or research tasks and gaps related to the topic. I can formulate my research questions along the lines of the latter research gaps, which form the basic structure of exploratory empirical research.

## 4.2 Presentation of research questions and research strategy

In my thesis, I formulated personal, practical and academic goals for myself. My personal goal is to use my work to draw attention to the specialties and importance of domestic small and medium-sized enterprises, to the growing role of technology and digitalization, and to the fact that the growing market and impact of digital services, such as solutions based on Cloud Computing, represent strategic opportunities for companies, thus for participants in the SME sector. My practical goals include being able to make relevant and credible statements about the topic by conducting empirical research, uncover relevant social and economic trends, processes, and make strategic findings regarding the relationship between the SME sector and Cloud Computing. My scientific goal is to investigate whether the factors that support the importance of Cloud Computing revealed by previous research, the definable characteristics and advantages affecting the application of the technology, i.e. the suitability of Cloud Computing for the SME sector, can be confirmed among domestic small and medium-sized enterprises.

My research questions are based on the topics defined by the relevant theoretical fields presented above and explored on the basis of their relationships, and can be derived from and justified on the basis of the resulting technical/empirical gaps and problems. Derived from my main research question, I formulated the following research questions.

- **Q1.** To what extent do domestic small and medium-sized enterprises use Cloud Computing?
- **Q2.** What future spread (diffusion) can be expected regarding Cloud Computing in the domestic SME sector?
- **Q3.** How can the internal technology management capabilities and the external environmental effects of Cloud Computing be characterized among domestic small and medium-sized enterprises?
- **Q4.** What characterizes the individual technology management functions of domestic small and medium-sized enterprises in terms of the application of Cloud Computing?
- **Q5.** What are the typical attitudes related to the acceptance and use of Cloud Computing among domestic small and medium-sized enterprises?

Based on the research questions, my narrowly interpreted empirical research topic and related tasks can be formulated and defined, which is the use and spread of Cloud Computing, as well as the exploration of external and internal technology management effects and attitudes related to the application among domestic small and medium-sized enterprises. The research is exploratory research, so my goal is to examine the developed research questions with relevant methodological tools and to analyze and interpret their results with scientific precision. Due to the exploratory nature of the research, and accepting the opponents' comments of my thesis draft, no hypotheses were formulated in the framework of my research. The theoretical foundation of the research questions is adequate for the successful completion of exploratory research, the quality and relevance of my research results depends on the quality of the execution of my research activity.

I developed my research strategy based on answering the following questions.

- At what levels can the research questions be interpreted (macro level and/or micro level)?
- What topics and subfields do the research questions affect?
- What data are available, and what data would I need (quantitative and/or qualitative) to answer the research questions?
- What approach (quantitative and/or qualitative) and what specific methodologies support my research objectives along the individual questions?

Both macro-level and micro-level studies play an important role in research. I can analyze the spread and diffusion of Cloud Computing on the basis of national economic data and information characteristic of the entire SME sector, while the exploration of the circumstances of technology use (driving forces, obstacles) and attitudes related to the acceptance and rejection of technology clearly requires a micro-level approach involving companies. This is in line with the approach of strategic technomanagement, which interprets the technology management of companies at both external and internal environmental levels.

Looking at the research subfields, I was able to identify the disciplines involved based on the literature research, the models and approaches of innovation (spread of innovation, diffusion models), strategic management tools (environmental analysis, identification of strengths and weaknesses), technology management (investigation of techno-management functions) have a role in the research. , and the intersections of these areas (evaluation of technological capabilities, acceptance of technological innovations).

For the successful implementation of my research, I need to use both quantitative and qualitative data. In terms of quantitative data, the KSH and Eurostat databases presented in the previous chapters can provide a good starting point, and I should strive to collect additional data that better fits my research questions. I can also rely on my own data collection to obtain quality data. As a result of the fact that I need to use both quantitative and qualitative data, I have to use both quantitative and qualitative methodologies during the research. My research map developed as a synthesis of the above (Table 20) contains my research strategy in an integrated manner, including the research focus, the topics and subfields involved in the research, the research questions, as well as the related methodologies, models and research orientation.

20. Table: Research map

| Focus | Affected topic | Research question | Applied methodology | Orientation |
|---|---|---|---|---|
| MACRO LEVEL | SME sector | Q1. To what extent do domestic small and medium-sized enterprises use Cloud Computing? | descriptive statistics | **quantitative** |
| | spread of technology | Q2. What future spread (diffusion) can be expected regarding Cloud Computing in the domestic SME sector? | diffusion modeling (Bass, 1969) | |
| MEZZA LEVEL | technology evaluation | Q3. How can the internal technology management capabilities and the external environmental effects of Cloud Computing be characterized among domestic small and medium-sized enterprises? | questionnaire expert survey (Hobday, 2002) descriptive statistics statistics revealing patterns network analysis | **quantitative** |
| | technology management | Q4. What characterizes the individual technology management functions of domestic small and medium-sized enterprises in terms of the application of Cloud Computing? | | |
| MICRO LEVEL | technology application | Q5. What are the typical attitudes related to the acceptance and use of Cloud Computing among domestic small and medium-sized enterprises? | semi-structured interviews (Bandura, 1986) | **qualitative** |

*Source: own compilation*

Based on the focus of the research, it is macro-, meso- and micro-level research, and its theoretical background is provided by an interdisciplinary, synthesizing field of science, strategic technomanagement, which includes the subfields of innovation, technology management, and strategic management. I examine the research questions developed based on the processing of the literature with a mixed (quantitative and qualitative) methodological orientation. Empirical research consists of several stages that are separate from each other, but at the same time partly built on each other, which are adapted to the environmental levels of the research and to the research questions. During the research, the focus of the research and the orientation of the applied methodology both change, I move from a macro-level focus to a micro-level focus, while the applied quantitative orientation is replaced by a qualitative approach. After the three stages of the empirical research, I summarize and synthesize the results of the research.

## 4.3 Presentation of research methodology

During the empirical research, I use a mixed or hybrid methodology, which means combining quantitative and qualitative methodologies. According to Neulinger (2016), the primary advantage of using a mixed methodology is that by using both methodologies, a deep understanding of a scientific problem or case can be ensured at the same time, while accurate statistical analyzes can also be performed, and we have the opportunity to answer the research question as fully as possible and draw more well-founded conclusions. According to Tashakkori and Teddlie (2003), we can only talk about mixed-methodology research if the application of quantitative and qualitative methods is organically integrated within the research, so different types of data and methodologies are handled in an integrated manner during the analysis. In this sense, the macro- and meso-level focused investigations of the research (answering Q1, Q2, Q3, Q4) do not qualify as a mixed-methodology investigation, since in this case I only analyze quantitative data using quantitative methodologies. At the same time, I use qualitative methodology in the micro-level part of the empirical research (answering Q5), so when interpreting the research as a whole, the mixed methodological orientation holds its place. This is confirmed by the interpretation of Neulinger (2016), based on which I use the two methodologies within one (exploratory) research, the boundaries between the individual parts are preserved. During the research, methodologies with different orientations are used and analyzed within their own paradigms, the connections appear at the level of interpretation and synthesis of results. Mixed methodology research can be grouped and interpreted in several ways, according to the way in which quantitative and qualitative methodologies are applied and combined (only in approaches, during data collection or connected, sequentially or in parallel). Regarding the latter, the different methodologies are applied in parallel in the research, the qualitative studies are carried out alongside the results of the quantitative research. The use of mixed methodology is also supported by the fact that during the research I strive to synthesize the results of studies based on each other, but with different methodologies, my goal is a complex, integrated interpretation and explanation of the conclusions that can be drawn from different types and sources of data.

Empirical research consists of four stages, the final, fourth stage encompasses the synthesis, interpretation and summation of the results revealed by the empirical research. In the first stage of the research, quantitative methodologies will be applied with a macro-level focus. In the second stage, a meso-level focus that treats external and internal, micro- and macro-level factors at the same time is characteristic, in this case also a quantitative methodology is used. In the fourth stage, the focus of the investigation and analysis is on the micro level, and the applied methodology is qualitatively oriented.

In empirical research, parallel to the change in the focus of the analysis, - as I move from macro-level studies to micro-level research - the application of qualitative methodologies, the qualitative research approach, plays an increasingly important role. The methodology used during the empirical research will be presented in detail in the next chapter. The description of the individual research methodologies, research steps and activities is carried out based on the same criteria, I present the related research questions, the purpose of the analysis, the source of the necessary data, the steps of the analysis and related tasks, as well as the expected results of the analysis. My goal is to be able to successfully answer my research questions by conducting empirical research, and in the fourth stage of the research to compare and interpret these results to give an account of the research process and its most important results and findings.

The aim of the macro-level research is to present the main related data and characteristics of domestic small and medium-sized enterprises supported by numbers, to characterize the digital maturity of SMEs, to evaluate the changes of recent years in the context of the European Union. The source of the data for the analysis is Eurostat and the databases containing representative data of the Central Statistical Office (KSH). My research questions related to macro-level research are the following.

- Q1. To what extent do domestic small and medium-sized enterprises use Cloud Computing?
- Q2. What future spread (diffusion) can be expected regarding Cloud Computing in the domestic SME sector?

During macro-level research, I use descriptive and descriptive statistics and diffusion modeling. Based on the descriptive statistics, domestic small and medium-sized enterprises can be quantitatively characterized in terms of the use of cloud-based services, and the values of the domestic sector can be compared with the European Union average and the values of the same indicators of the EU member states. Based on the systematized and revealed data, the digital maturity of companies in the domestic SME sector can be characterized in terms of the use of Cloud Computing. Based on the relevant literature, the description and interpretation of Bass's (1969) diffusion model gives me the opportunity to characterize the spread of Cloud Computing innovation among domestic small and medium-sized enterprises. Based on Rogers' (1962) diffuser categories, I can draw conclusions from the results of the diffusion models regarding domestic SMEs and their groups and regarding the spread of Cloud Computing.

The purpose of the meso-level research is to examine the characteristics of domestic small and medium-sized enterprises regarding the use of Cloud Computing, as well as to map the factors supporting and inhibiting the use of Cloud Computing along the lines of technology management functions. The data required for the analyzes are produced on the basis of primary research, with a individual questionnaire-based expert survey. My research questions related to meso-level research are the following.

- Q3. How can the internal technology management capabilities and the external environmental effects of Cloud Computing be characterized among domestic small and medium-sized enterprises?
- Q4. What characterizes the individual technology management functions of domestic small and medium-sized enterprises in terms of the application of Cloud Computing?

During meso-level research, I use questionnaire surveys and descriptive and pattern-revealing statistics. The purpose of the individual questionnaire survey is to obtain information from primary sources regarding the circumstances of the use and application of Cloud Computing, driving and inhibiting factors in the domestic SME sector. Based on the relevant literature, the questionnaire survey is considered a quantitative methodology, and the analysis of the received data in this case is also done using quantitative tools. At the same time, during the creation of the questionnaire, the qualitative researcher's approach comes to the fore, due to the fact that, according to my intention, in the questionnaire, I am mainly asking about qualitative, scalable characteristics and factors. The target group of the questionnaire survey is experts with relevant knowledge and experience in the field. The purpose of the analysis, based on statistics revealing patterns, is to reveal and explain the correlations and connections between meso-level variables (that is, containing both external and internal environmental elements) created on the basis of the questionnaire.

The purpose of micro-level research is, on the one hand, to explore the attitudes (acceptance, rejection, neutrality) and attitudinal characteristics that determine the use, use or lack of Cloud Computing, and on the other hand, to discover the differences in attitudes that characterize domestic small- and medium-sized enterprises, their groups. The source of the data is obtained through a primary query. My research question related to micro-level research.

- Q5. What are the typical attitudes related to the acceptance and use of Cloud Computing among domestic small and medium-sized enterprises?

During the micro-level research, qualitative research methodologies are applied, and in order to deepen and supplement the meso-level research results, I conduct semi-structured interviews. On the basis of the interviews, it becomes possible to reveal relevant trends and characteristics regarding the deeper attitudes related to the use of Cloud Computing among domestic small and medium-sized enterprises. I conduct the interviews with experts in the field, making sure that the interviewees are selected from different sectors and from different types of workplaces (corporate, academic).

# 5. Macro-level research: The use and diffusion of Cloud Computing

## 5.1 Source of data and analysis methodology

The aim of the macro-level research is to characterize the current spread of Cloud Computing among domestic small and medium-sized enterprises based on representative data, and to be able to provide a methodologically supported forecast for the future spread and diffusion of the technology. The source of data for the empirical analysis is the databases of the Central Statistical Office (KSH, 2023) and Eurostat (2023). The two organizations conduct surveys among domestic companies using the same indicator system and harmonizing methodology, the KSH conducts the survey regarding Cloud Computing using OSAP No. 1840, *"Qualitative and quantitative data of the stock of information and communication technologies" (KSH*, 2015). The Eurostat databases contain the data queried by the KSH, but at the same time, the KSH databases do not contain the data related to the SME sector, which are contained in the Eurostat databases. The survey was carried out every year with stratified sampling, for the stratification the KSH takes into account the sector classification, the staffing categories of the companies, as well as the geographical regions. The KSH carried out the sampling in relation to individual strata by assigning a random number to each of the organizations per stratum, and then arranging the organizations in descending order according to the size of the random numbers. Among the organizations arranged in this way, the first ones per stratum were selected for the sample. During the sample distribution, the number of elements of the population per stratum was known, after which the final sample was determined using Neyman's optimal allocation. The frequency of rotation of the companies participating in the sample is 3 years, the sample size queried annually covers approximately 7,000 companies. In this research, I used data on the use of KSH Cloud Computing, taking into account the period from 2014 to 2023. The data used can be found in Annex 1.

The current prevalence of Cloud Computing was analyzed using basic descriptive statistics. In order to set up the diffusion models, it is necessary to explore and define the parts of the given market. Three parts of the total market (TM(t)) can be separated: the current market (N(t)), which represents the adopters, those who have already purchased the new product or service, the potential market (P(t)), who already know the given product/service and plan to buy from it, as well as the untouched market (TM(t)-TN(t)), which means those who either do not know about the existence of the innovation or do not expect that the innovation will become potential consumers. Market participants learn about an innovation through mass media, internal information flow, marketing, and individual experience, and as a result, they migrate from one segment to another. The potential market can also be written as the set of people who have already heard about the product (TN(t)), in this case P(t)=TN(t)-N(t). In the context of this research, I considered the entire market to be domestic small and medium-sized enterprises, the potential market to those enterprises that have internet subscriptions, by the current market I mean those enterprises that have already used a cloud-based service, and the potential market to those enterprises with internet subscriptions which do not yet use a cloud-based service.

Regarding the future diffusion of the technology, the Bass model was applied. Bass's (1969) diffusion model aims to predict the rate at which an innovation will spread in a given market or sector. The assumption of the model is that a customer buys only one unit (this is the general approach of market penetration models), the size of the total and the potential market is constant over time, and that the spread of innovation is initially supported more strongly by innovators, and is later "driven" by imitators. the diffusion. According to the model, the acceptance rate of the innovation is initially low and then increases exponentially until the saturation point, from where the rate of diffusion begins to decrease, as fewer and fewer new customers remain who have not yet accepted (purchased) the new technology. New customers are selected from among those who have not yet used the given technology, so the probability that a new customer will adapt the technology at a given time can be determined by applying the Bayes theorem. Based on Orava (2010), the probability of a new purchase at a given time can be written as a linear function of previous purchases:

$$P(t) = \frac{f(t)}{1 - F(t)} = p + qF(t)$$

where:

t random variable is time,

density function f(t) the unconditional probability of purchase at time at,

The distribution function F(t) indicates the probability of all purchases during time at,

p is the innovation-specific parameter,

q is the parameter characteristic of imitation,

and F(0)=0 and F$(T) = \int_0^T f(t)\, d(t)$

Based on the model, up to a given time t, all purchases are N(t)=mF(t), where today means a potential market, during the entire lifetime of the innovation. The number of new purchases at a given time (m(t)=mf(t)) can be written with the following differential equation, which is the commonly known formula of the Bass model:

$$\frac{dN(t)}{dt} = \left[p + q\frac{N(t)}{m}\right][m - N(t)]$$

where:

N(t) is the number of purchases made up to time (t),

total market size today,

p is the innovation coefficient,

q is the imitation coefficient.

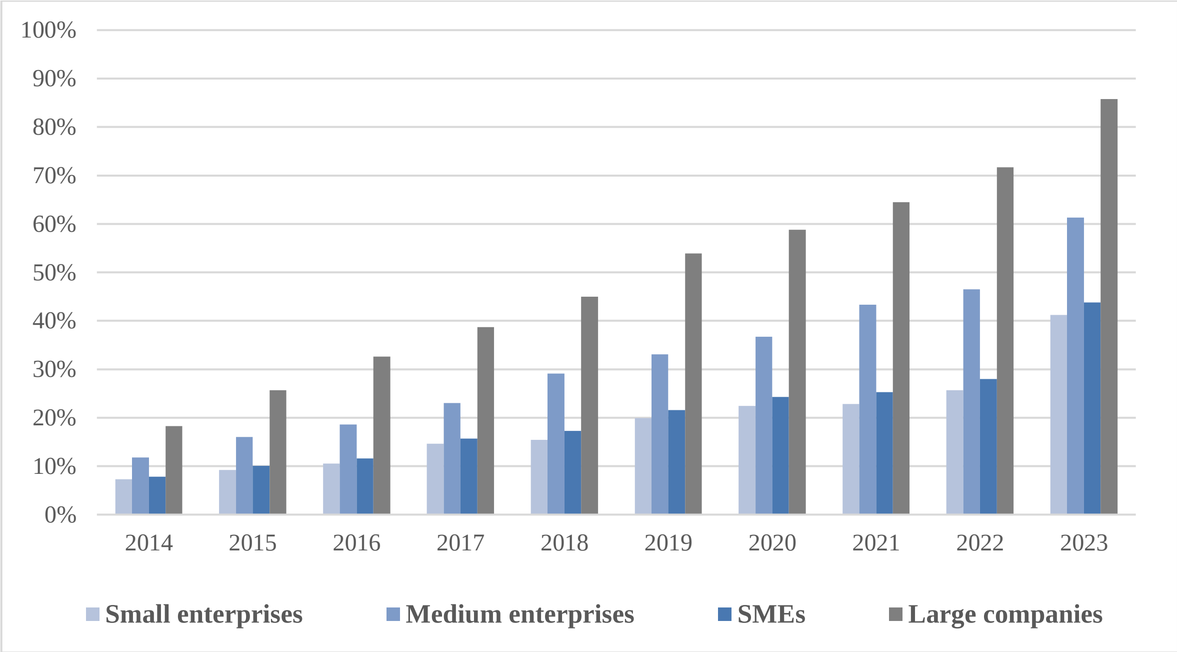
There are several methods for estimating the parameters (m, p, q) of the model. The total market (m) can be estimated and determined by looking at industry benchmarks, previous research, or the characteristics of the given innovation. If data on the size of the entire market is available, only ap and aq parameters need to be determined to write the model. In addition, knowing the entire market, if past time series data on previous purchases are available, the parameters ap and aq can be accurately calculated. With regard to Cloud Computing, the available data show the rate of use of technology by domestic enterprises, so they characterize the use of technology for a given year and the purchases up to that point in percentage form. In this case, the size of the entire market means all businesses, so m=100, since the data on previous purchases are also available in percentage form. I carried out the forecast of the Bass model for Cloud Computing taking into account the staffing categories of domestic enterprises, so I used a separate estimate for small enterprises, medium-sized enterprises and the SME sector.

I calculated the parameters (p and q) necessary for predicting the future diffusion of Cloud Computing, as well as writing and calculating the differential equations using the Python programming language. For this, I used the NumPy and SciPy Python libraries, using the NumPy library for data loading and mathematical calculations, and using the SciPy library for nonlinear fitting and optimization. I wrote down and calculated the differential equations in the following steps. I prepared the available time series data (regarding the previous use of Cloud Computing) and transformed it into the required form, then implemented the mathematical formula of the Bass model and since the size of the entire market (m) was given, only the innovation (p) and the an imitation (q) coefficient had to be fitted. To fit the parameters of the model, I used non-linear optimization, using the "curve_fit" function in the Python programming language, which allows fitting the parameters of non-linear functions. Based on the time series data belonging to each staffing category, parameters p and q characterizing the diffusion of each category were calculated. Knowing the parameters m, p and q, the future purchases in terms of Cloud Computing became calculable with the differential equation of the Bass model, i.e. the future diffusion of the technology regarding the different company staff categories. I validated the obtained results by calculating and interpreting the Mean Absolute Error (MAE), Mean Squared Error (MSE) and Root Mean Squared Error (RMSE) values, and performed correlation calculations between the real data available from 2014-2023 and the values estimated by the model.

## 5.2 The use of Cloud Computing in the domestic SME sector

Figure 10 shows the percentage of the use of Cloud Computing among domestic enterprises, in terms of their staffing categories, between 2014 and 2023. In order to effectively compare and interpret the data of small and medium-sized enterprises, the data of large companies are also included in the figure. The data of the SME sector includes the values of small and medium-sized enterprises, taking into account their quantitative distribution. In terms of all three staff categories, the extent of the use of technology has increased spectacularly, but the extent and pace of the increase is different. The usage rate of small enterprises increased from 7.3 percent in 2014 to 41.2 percent, which means an average increase of 3.78 percent per year. Medium-sized enterprises also achieved significant growth, from 11.8 percent in 2014 to 61.3 percent in 2023, which corresponds to an average annual growth of 5.52 percent. The data of the SME sector are extremely close to the data of small enterprises, the reason behind this is that the data of the SME sector mostly shows the data of small enterprises, since small enterprises are present in a significantly larger number in the SME sector. In 2014, small and medium-sized enterprises were characterized by a combined usage rate of 7.8 percent, which increased to 43.8 percent by 2023, both values barely exceeding the values of small enterprises. The average increase was 4 percent per year.

10. Figure: The use of Cloud Computing in the domestic SME sector and among large companies

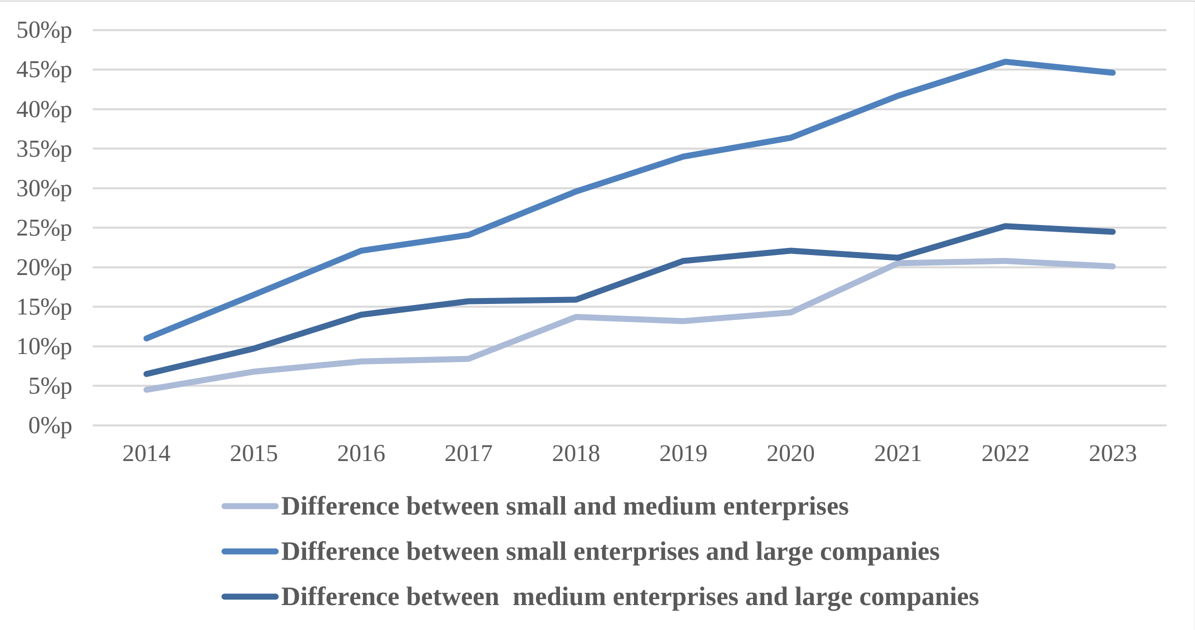



*Source: own compilation*

Looking at the data of large companies, we can already see significant differences compared to the previous ones. In 2014, 18.3 percent of large domestic companies used Cloud Computing, which is much higher than the data of small companies, but compared to the data of medium-sized companies, it may not yet seem like an extraordinary difference. By 2023, the technology usage rate among large companies has increased to 85.8 percent, which already shows a much more serious difference compared to the data of both medium-sized and small enterprises. Among large companies, the average annual growth rate was 7.5 percent, which also exceeds the growth rate of enterprises in the SME sector. A similar picture emerges when looking at the percentage point increase of each staffing category. Among large companies, the rate of use of Cloud Computing increased by 67.5 percentage points in the examined period, that of medium-sized companies by 49.5 percentage points, that of small enterprises by 33.9 percentage points, while the rate characteristic of the SME sector increased by 36 percentage points.

Regarding the growth of small and medium-sized enterprises - compared to the previous years - there is no clear trend, in the examined years, a significantly fluctuating growth of between 2 and 12 percentage points was experienced. It should be noted that the rate of growth (percentage) for both headcount categories has been continuously falling since 2017, in terms of small enterprises, a 37 percent expansion was experienced in 2017, while in 2021 it was 12 percent, and the same for medium-sized enterprises was 23 percent and 11 percent, respectively. This somewhat contradicts the expectation that, as a result of the spread of the COVID-19 virus starting in 2020 and the resulting economic and social changes, the strengthening of digitization, especially the faster spread of cloud-based solutions, was forecast.

11. Figure: The difference between the use of cloud-based services among domestic enterprises

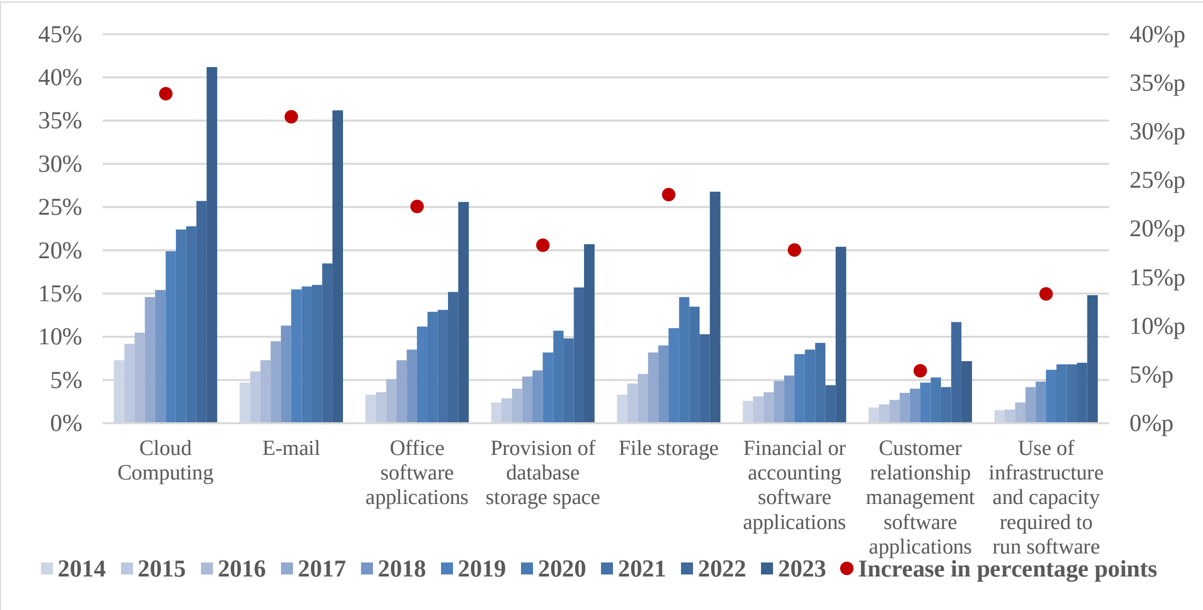



*Source: own compilation*

The difference between small and medium-sized enterprises was already evident based on the previous figures, however, it is worth examining the change in the difference between the categories of employees in the examined period, supplemented by the data of large companies. Based on the size of the domestic companies, a significant difference can be observed in the use of cloud-based services, and even the difference between the companies of the SME sector and large companies increased continuously during the period under review (Figure 11). This is consistent with the fact that the growth rate of large companies significantly exceeded the growth rate of the other two categories, so the initial differences between the individual headcount categories became more and more significant. The biggest difference can be seen between the data of small enterprises and large companies, the difference of 11 percentage points in 2014 has changed to 44.6 percentage points by 2023. Within the SME sector, the difference of 4.5 percentage points increased to 20.1 percentage points between 2014 and 2023, while between medium-sized enterprises and large companies it increased by 6.5 percentage points to 24.5 percentage points. The data for 2023 are encouraging from the perspective of the SME sector in that it was the first time since 2014 that the percentage point difference compared to large companies did not increase, but decreased.

Figure 12 shows the use of Cloud Computing by small enterprises in relation to the categories queried by KSH, the categories were presented in chapter 3.2.3. Due to the fact that the data of the SME sector are very similar to the data of small enterprises, I will not discuss them separately. Regarding small enterprises, the rate of use of cloud-based services increased from 7.3 percent to 41.3 percent in the period under review. The most used service every year was the email service, which increased from 4.7 percent to 36.2 percent. The use of office software applications and the storage of files changed from 3.3 percent to 25.6 and 26.8 percent, respectively. Database storage and the use of financial and accounting applications increased to 20.7 and 20.4 percent by 2023, respectively. In 2023, CRM applications (7.2 percent) and computing capacities (14.8 percent) were still used in relatively low proportions by small enterprises as cloud-based services. Both in terms of the use of services based on Cloud Computing and in terms of the individual categories, there was an extremely spectacular jump in terms of the use of technology in 2022.

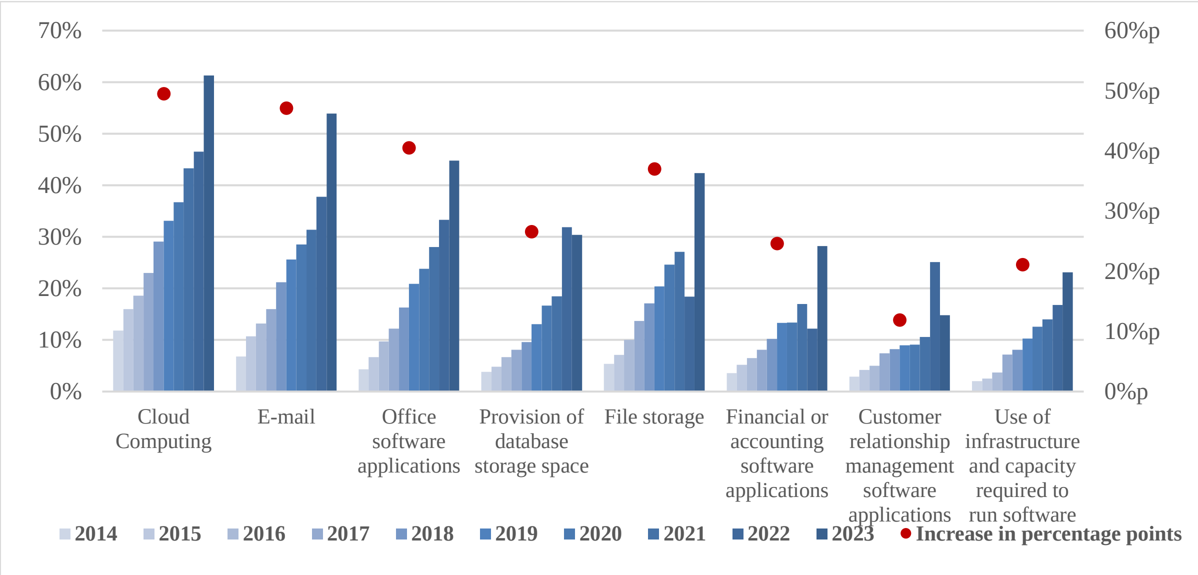
12. Figure: Use of cloud-based services among domestic small enterprises




*Source: own compilation*

On the basis of Figure 13, it can be concluded that cloud-based services are considered to be significantly more widespread among domestic medium-sized enterprises, overall the use of cloud-based services increased from 11.8 percent to 61.3 percent between 2014 and 2023. In 2023, more than half of domestic medium-sized enterprises (53.9 percent) started using email services, while office software and file storage were used by 42-45 percent of medium-sized enterprises as cloud-based services. Similar to small enterprises, the use of financial and accounting applications and database storage increased at the same rate, from 3.6-3.8 percent in 2014 to 28.2 and 30.4 percent in 2023, respectively. The use of CRM applications and the use of computing capacities were characterized by an extremely low usage rate (2.9 and 2 percent), which increased to 14.8 and 23.1 percent by 2023, respectively. Similar to the data for small enterprises, in 2022 there was also an extremely significant jump in the use of Cloud Computing by medium-sized enterprises.

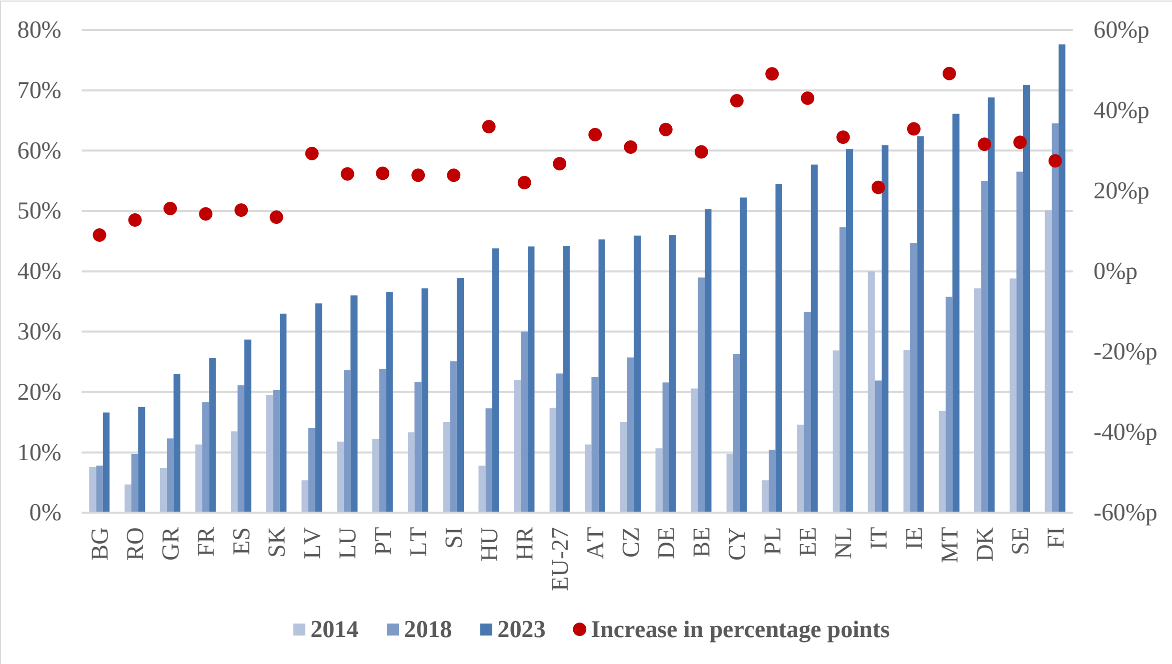
13. Figure: Use of cloud-based services among domestic medium-sized enterprises




*Source: own compilation*

Considering the use of Cloud Computing by domestic small and medium-sized enterprises, I consider it important to evaluate the data characteristic of the enterprises in the EU context as well (Figure 14). The KSH and Eurostat assess businesses based on the same methodology and expect the data to be published, so data from different countries can be compared. The average value of the use of cloud-based services in the 27 EU member states was 17.4 percent in 2014 and 23.1 percent in 2018, which increased to 44.2 percent by 2023. Among domestic small and medium-sized enterprises in 2014, the sixth lowest percentage value was typical in the years under review, lower usage was only experienced in Bulgaria, Greece, Poland, Latvia and Romania. By 2023, the domestic data approached the EU average, and Hungary was in the middle of the EU countries in terms of the use of Cloud Computing. The average of the EU member states increased by 26.8 percentage points, in Hungary there was an increase of 36 percentage points in the period under review (only Cyprus, Estonia, Poland and Malta had a higher percentage point increase). Based on the data from the member states, the domestic SME sector was significantly behind in the use of services based on Cloud Computing, but this changed in 2022, and since then the use of Cloud Computing by small and medium-sized enterprises has been closer to the EU average.

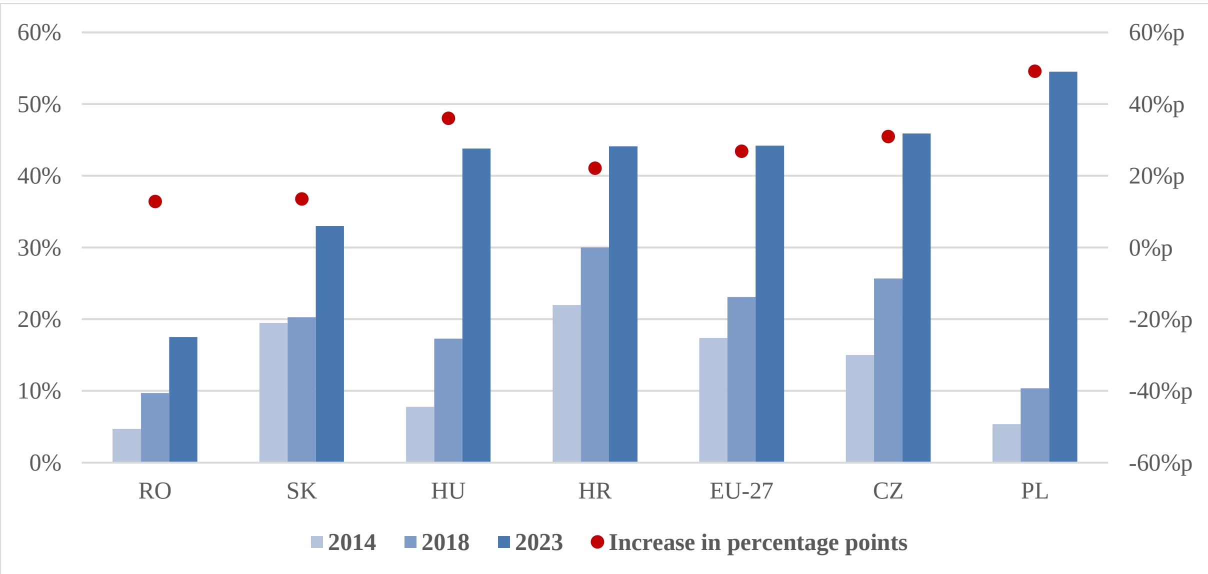
14. Figure: Use of cloud-based services in the member states of the European Union




*Source: own compilation*

In addition to the EU data, it is necessary to examine how domestic enterprises can be evaluated in terms of the use of cloud-based services in relation to the closest countries from an economic-geopolitical point of view.

15. Figure: Use of cloud-based services in the V4 countries, Romania and Croatia



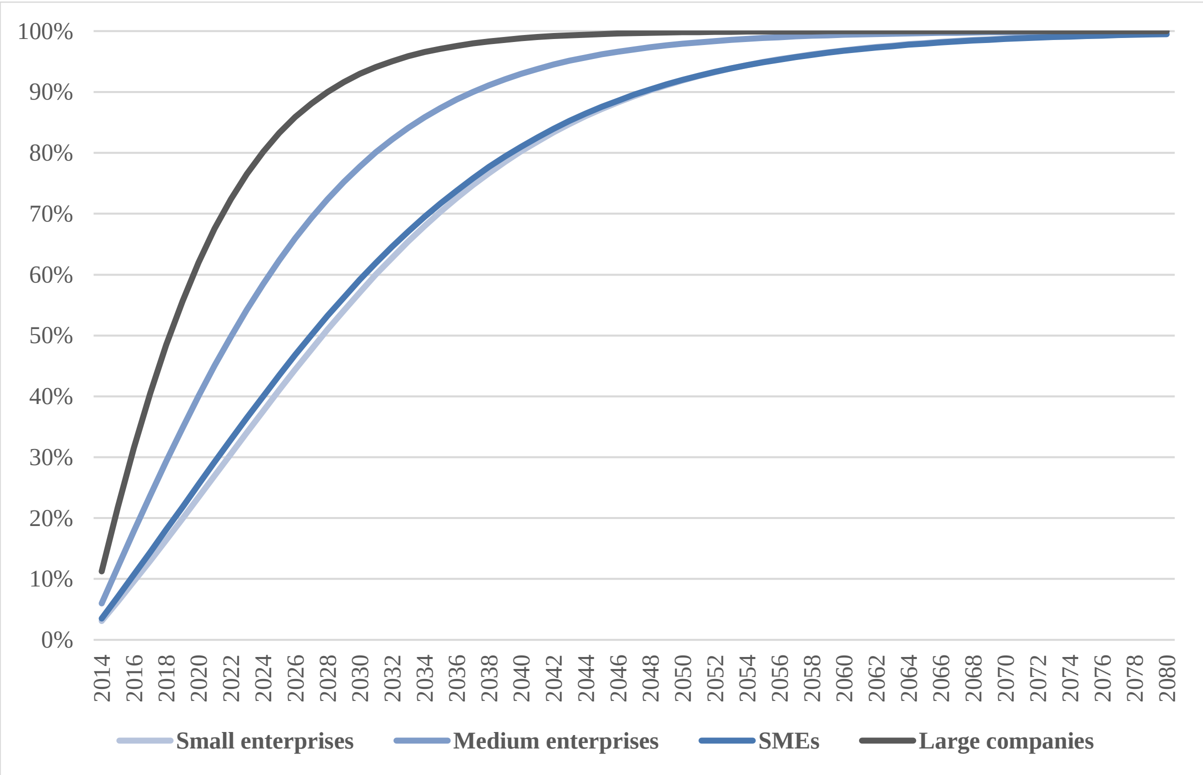

*Source: own compilation*

Examining the data of the V4 countries (Czech Republic, Poland, Hungary, Slovakia), as well as Romania and Croatia (Figure 15), it can be seen that domestic small and medium-sized enterprises in the region have caught up by 2023 in terms of the use of Cloud Computing. In the countries of the region, an average increase of 27.4 percentage points was observed, which is much higher than the domestic increase of 36 percentage points, which was higher only in Poland. In 2023, apart from the Czech Republic and Poland, the data of the other countries in the region will fall short of the EU average, although Hungary and Croatia are extremely close to it. In terms of the rate of growth, the most intense growth can be seen in Poland and Hungary during the examined period. In 2014, Romania, Poland and Hungary were characterized by a strong lag in terms of the use of Cloud Computing in the SME sector. By 2023, Hungary has successfully caught up with the Czech Republic and Croatia, while in 2023 Poland has the highest rate of technology use among the countries examined.

## 5.3 Diffusion of Cloud Computing

The emphasis of the macro research was the writing of the relevant, applicable diffusion model, with the help of which I estimated the future spread of cloud-based services. The sources of the data used are the KSH databases described above. The diffusion of Cloud Computing was estimated using the methodological steps presented above, using the Bass model. Figure 16 shows the diffusion of Cloud Computing by workforce category until 2080 based on the Bass model. In addition to the aggregated data of small and medium-sized enterprises and the SME sector, I also carried out the diffusion estimate for the data of large companies, so that the future spread of Cloud Computing among companies of different staff categories becomes comparable.

16. Figure: Diffusion of Cloud Computing based on the prediction of the Bass model




*Source: own compilation*

Taking into account the data of the forecast, the diffusion of Cloud Computing among medium-sized enterprises will be realized more strongly and faster compared to small enterprises, while the growth rate of large enterprises will continue to exceed the companies of the SME sector in the future (Nagy-Borsy, 2024). The diffusion characteristic of the SME sector essentially moves in parallel with the values estimated for small enterprises, so the data of the SME sector will not be analyzed separately in the future. The diagram shows significant differences in terms of staffing categories regarding the future spread of technology, which is in line with the past data used for the estimation and presented previously. It also stems from the specificity of the Bass model that the rate of diffusion starts to slow down in the case of all personnel categories, and then essentially continues to a very small extent. (When calculating the model, I performed the calculations until full market saturation, this does not happen in 2080 for all staff categories, but this date was appropriate for the representation of the results.) The data estimated based on the Bass model are included in Annex 2.

The p and q parameters presented above play a major role in the calculation of the forecasts for each staffing category. The two coefficients of the Bass model can be calculated using the size of the total market and available historical time series data. The p value, the innovation coefficient, is responsible for the rate of diffusion in the initial phase of technology diffusion, while the aq value, the imitation coefficient, is responsible for the diffusion coefficient in the later phase of diffusion. The model thus expresses the practical phenomenon with the methods of mathematics that the novelty will be applied first by individuals more receptive to innovation, and later by those who "copy" those who use the technology. The innovation coefficient indicates the influence of innovators, while the imitation coefficient refers more to social effects. The value of p and aq must always fall between 0 and 1, so when interpreting the model, the coefficients are often explained as percentage values.

21. Table: The coefficients of the Bass model for the different staffing categories

| | **p (innovation coefficient)** | **q (imitation coefficient)** |
|---|---|---|
| **Small enterprises** | 0.0304 | 0.0676 |
| **Medium enterprises** | 0.0599 | 0.0643 |
| **SME sector** | 0.0347 | 0.0590 |

*Source: own compilation*

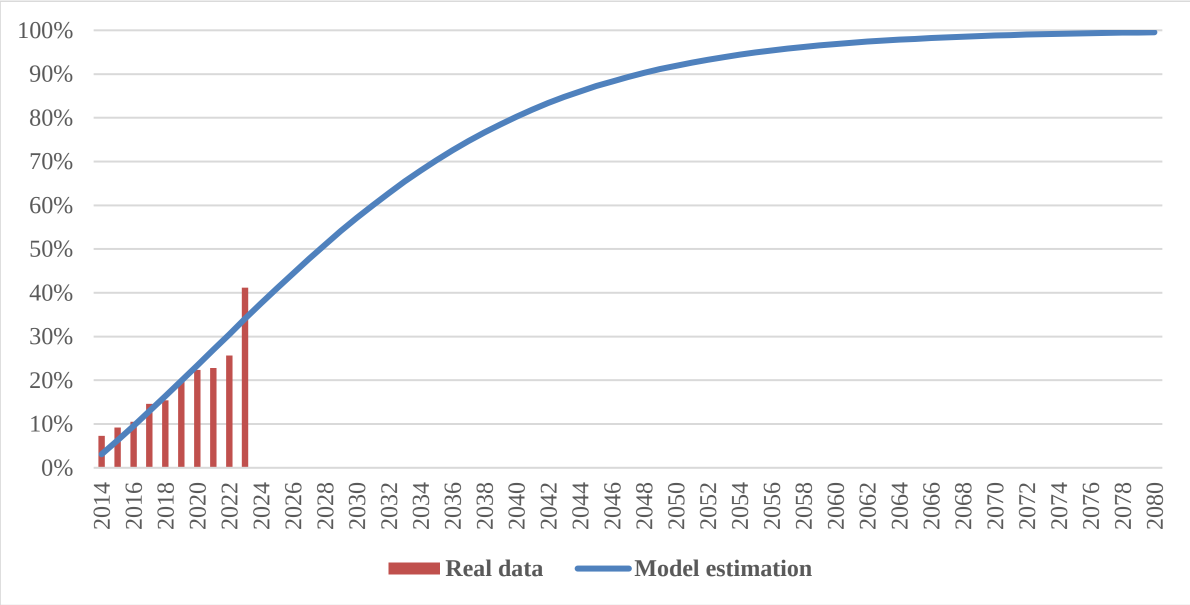
Table 21 contains the coefficients calculated for each staffing category. In the case of the innovation coefficient, it is clearly visible what characterizes the innovation propensity of each staff category. The p value is the highest for large companies (11.57 percent), which means that their receptiveness to Cloud Computing as a novelty is the most typical among them. The willingness to innovate of medium-sized enterprises (5.99 percent) is also significantly higher than that of small enterprises (3.04 percent), while the aggregate value of the SME sector (3.47 percent) is close to that of small enterprises. With regard to the imitation coefficient, no such significant differences can be observed. For each staffing category, 6-7 percent is typical. Compared to each other, the imitation (copying) effect is the highest among small enterprises, followed by large enterprises, and then among medium-sized enterprises, but in terms of the imitation coefficient, we can only speak of very minimal differences. The lower imitation coefficient of the SME sector explains that, while at the beginning of the diffusion, the values of the SME sector exceeded those of small enterprises, later they take on essentially identical values during the diffusion, so considering small and medium-sized enterprises together, the willingness to innovate is to a small extent, but it exceeds the value of small enterprises, this no longer exists in the case of the imitation effect.

According to the research of Mahajan, Muller & Bass (1985), the value of the innovation coefficient (p) most often falls between 0.01 and 0.03, while the imitation coefficient (q) typically ranges from 0.3 to 0.5, ap is average value is 0.03, while aq averages 0.38. Orova (2010) specifically used domestic data series as a basis in his calculations for the Bass model, but at the same time, the coefficients calculated from these were generated from rather old data - between 1999 and 2005. Based on these, for example, for the diffuser of the mobile subscription, ap=0.0166 and aq=0.2709, for the diffusion of the video camera, ap=0.0157, aq=0.3639, for the diffusion of the flash drive, ap=0.0045, aq=0.2036, while for the diffusion of the MP3 player, ap=0.0038, aq=0.3163. Due to the differences characterizing specific products and technologies, as well as the "obsolescence" of the data used, these values are not suitable for comparison with the values obtained in the case of the diffusion of Cloud Computing. It is more worthwhile to compare the values obtained by me with the ranges given by Mahajan, Muller & Bass (1985). Regarding the innovation coefficient, the values of small enterprises and the SME sector correspond to the average value of ap, the innovation coefficient of medium-sized enterprises and large enterprises is well above the average range, so in these cases the willingness to innovate is higher than the average value estimated by the authors. In the case of the imitation coefficient, however, the value of each category was well below the average range. This may be due to the fact that the data used show the use of technology among enterprises in percentage form, so the entire market (m=100) is nominally close to the first data characterizing the use of technology. It follows that the imitation coefficient, which is later "responsible" for diffusion, falls short of the range estimated by Mahajan, Muller & Bass (1985), because the entire market spread is also realized with a lower imitation propensity. Examining the innovation and imitation coefficients according to the categories of employees, it can be concluded that small enterprises and the SME sector are characterized by average acceptance of Cloud Computing and moderate imitation, medium-sized enterprises are characterized by faster acceptance, but a similar rate of imitation, while large companies are characterized by particularly fast acceptance, innovation it is characterized by willingness, with a moderate imitative effect.

### 5.3.1 Diffusion of technology among small enterprises

Figure 17 depicts the diffusion of Cloud Computing among small enterprises, supplemented with real data characterizing the use of the technology. Based on calculations regarding the accuracy of the Bass model estimation, the mean absolute error (MAE) is 1.55 percentage points, the mean square error (MSE) is 4 percentage points, while the root mean square error (RMSE) is 2 percentage points. This means a reliable estimate, the model's prediction assumes an average deviation of only two percentage points compared to the real data. The coefficient of determination of the use of Cloud Computing by small enterprises and the values estimated by the model (so specifically considering the period between 2014-2023) is 93.73 percent. According to Mahajan, Muller & Bass (1985), the fit of the model is adequate if the coefficient of determination ($R^2$) is higher than 90 percent.

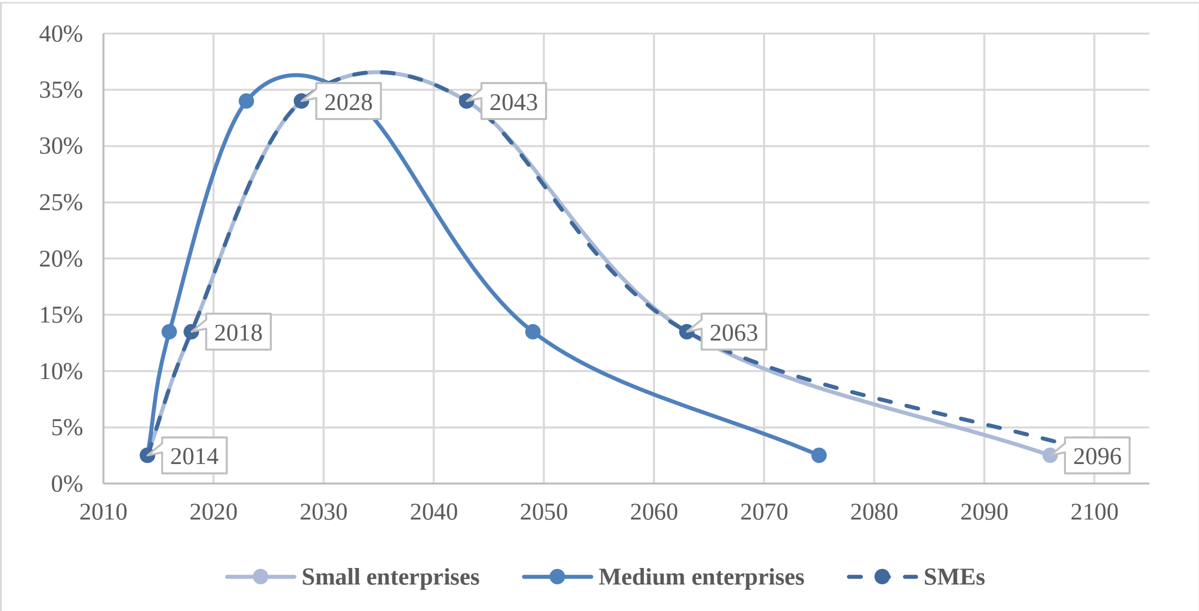
17. Figure: Forecast of the Bass model for small enterprises




*Source: own compilation*

According to the estimation of the Bass model, among small enterprises, taking into account Rogers' categories, innovators and early adopters (16 percent of all small enterprises) used Cloud Computing in 2018 (Figure 18).

18. Figure: Rogers' diffusion among small enterprises




*Source: own compilation*

The early majority (50 percent of small enterprises) will become technology users in 2028, and the late majority (84 percent of small enterprises) in 2043. Laggards (97.5 percent of small enterprises) are expected to adopt cloud technology among small enterprises in 2063, and resistants in 2096. The forecasts affecting the SME sector are not analyzed separately, the reliability of the values estimated by the Bass model (MAE: 2.79, MSE: 12.5, RMSE: 3.54) and the R2 (94.43 percent) for the values of small enterprises in comparison, they developed in the same order of magnitude, the degree of diffusion also follows the data estimated in the case of small enterprises, even taking into account Rogers' categories, we can identify almost identical years (2014, 2018, 2027, 2043, 2063, 2098). The diffusion of different types of services based on Cloud Computing is estimated separately.

Taking into account the most important coefficients of the estimate for small enterprises (Table 22), we obtained a suitable fit for all types except for the use of financial and accounting applications and the storage of files, and in the former two cases the reason for the worse fit is that the use occurred in 2022 a decline, which makes the estimate fit less well with the original data. The value of p (innovation coefficient) in the case of the e-mail service, the office software application, and the storage of files fall within the range defined by Mahajan, Muller & Bass (1985), in other cases they indicate a slightly lower willingness to innovate than the average 0, A value between 01 and 0.03. The value of q (imitation coefficient) is in all cases below the range described by the authors as typical (0.3-0.5), but the reason for this is similar to the previously described circumstance in the case of small and medium-sized enterprises, that the spread of technology is relatively fast, and there is little time takes place below, so the imitation effect will typically be lower.

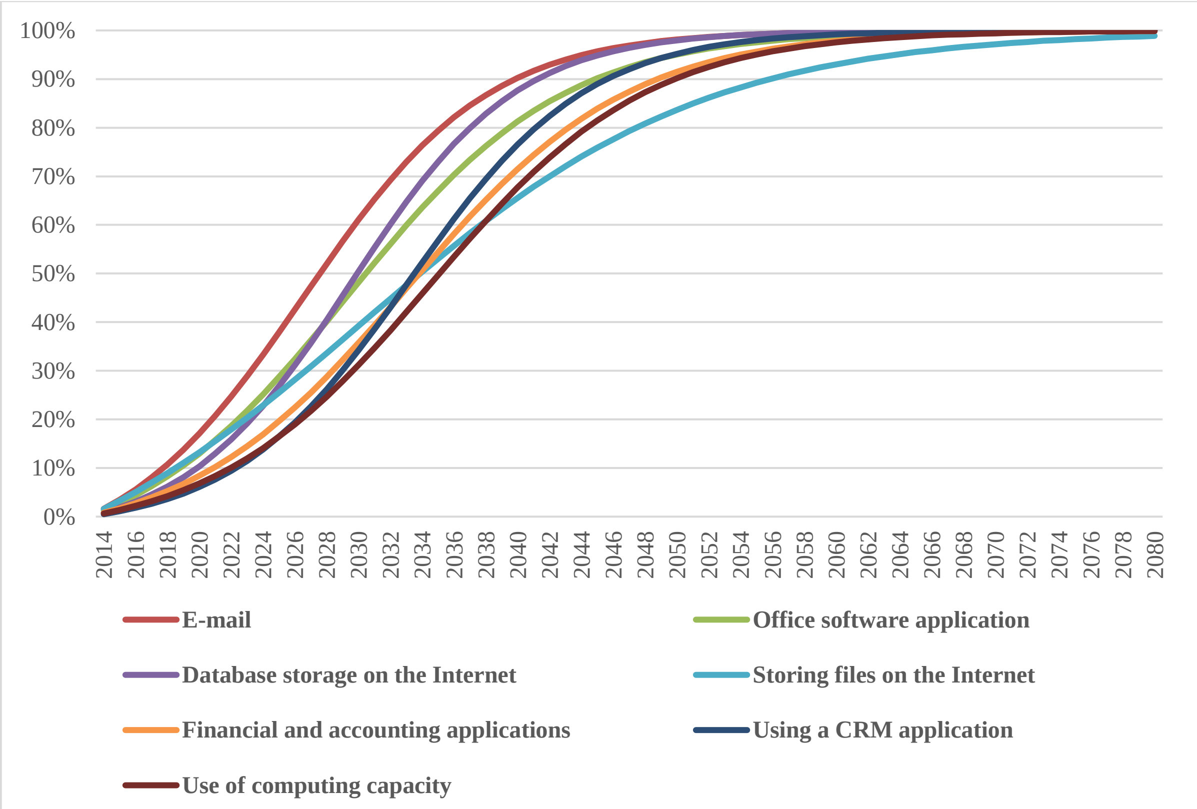
22. Table: Bass model coefficients for different types of cloud-based services among small enterprises

| Type of cloud-based service requested | p (innovation coefficient) | q (imitation coefficient) | $R^2$ (determination coefficient) |
|---|---|---|---|
| E-mail | 0.0151 | 0.1581 | 91% |
| Office software application | 0.0122 | 0.1352 | 95% |
| Database storage on the Internet | 0.0079 | 0.1831 | 98% |
| Storing files on the Internet | 0.0154 | 0.0785 | 86% |
| Financial and accounting applications | 0.0076 | 0.1363 | 77% |
| Using a CRM application | 0.0046 | 0.1751 | 91% |
| Use of computing capacity | 0.0060 | 0.1405 | 92% |

*Source: own compilation*

The diffusion of different types of services based on Cloud Computing among small enterprises is shown in Figure 19. In the case of e-mail services, database storage and office software applications, a stronger spread can be observed, while the diffusion of other types of services will take place at roughly the same rate, according to the model's estimation. In the case of file storage, aq (imitation coefficient) takes on an order of magnitude lower value compared to the other categories, as a result of which diffusion will take place at a slower rate, according to the model's estimate. Looking at Rogers' diffuser categories, the early majority (50 percent of small enterprises) will use email service, office software application, database storage on the Internet between 2028-2031, while file storage, financial accounting applications, CRM in terms of applications and the use of computing capacities, this is expected to be realized in 2034-2035. If the late majority (84 percent of small enterprises) were used, the model already estimated larger differences. The email service in 2037, the storage of the database on the Internet in 2039, the office software application in 2042, the use of the CRM application in 2034, the use of financial and accounting applications in 2046, the use of computing capacity in 2047 and file storage will be used by the late majority of small enterprises in 2051.

19. Figure: Estimation of the Bass model for different types of cloud-based services among small enterprises

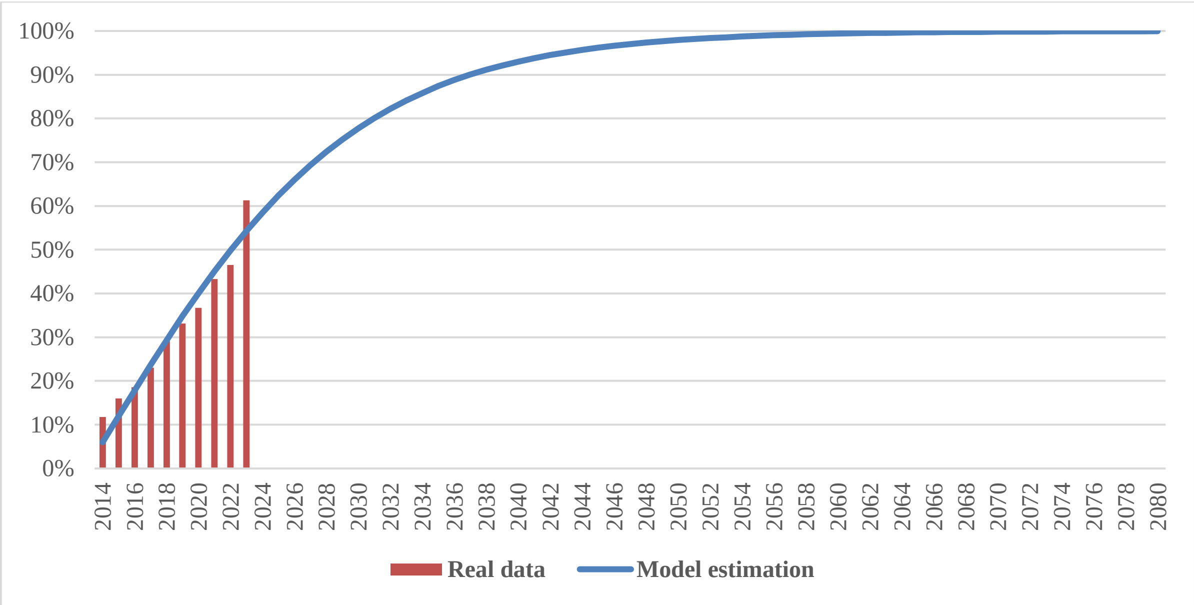



*Source: own compilation*

### 5.3.2 Diffusion of technology among medium-sized enterprises

Figure 20 shows the diffusion of technology among medium-sized enterprises, supplemented with real data characterizing technology use. In terms of forecast accuracy, the mean absolute error (MAE) is 2.86 percentage points, the mean square error (MSE) is 12.84 percentage points, while the root mean square error (RMSE) is 3.58 percentage points. The reliability of the Bass model is adequate in this case as well (an average difference of 3.58 percentage points), but the values show a worse fit than in the case of small enterprises. The correlation between the real data characterizing the use of technology by medium-sized enterprises and the data estimated by the model exceeds the value calculated for small enterprises, in this case the determination coefficient ($R^2$) is 97.43 percent.

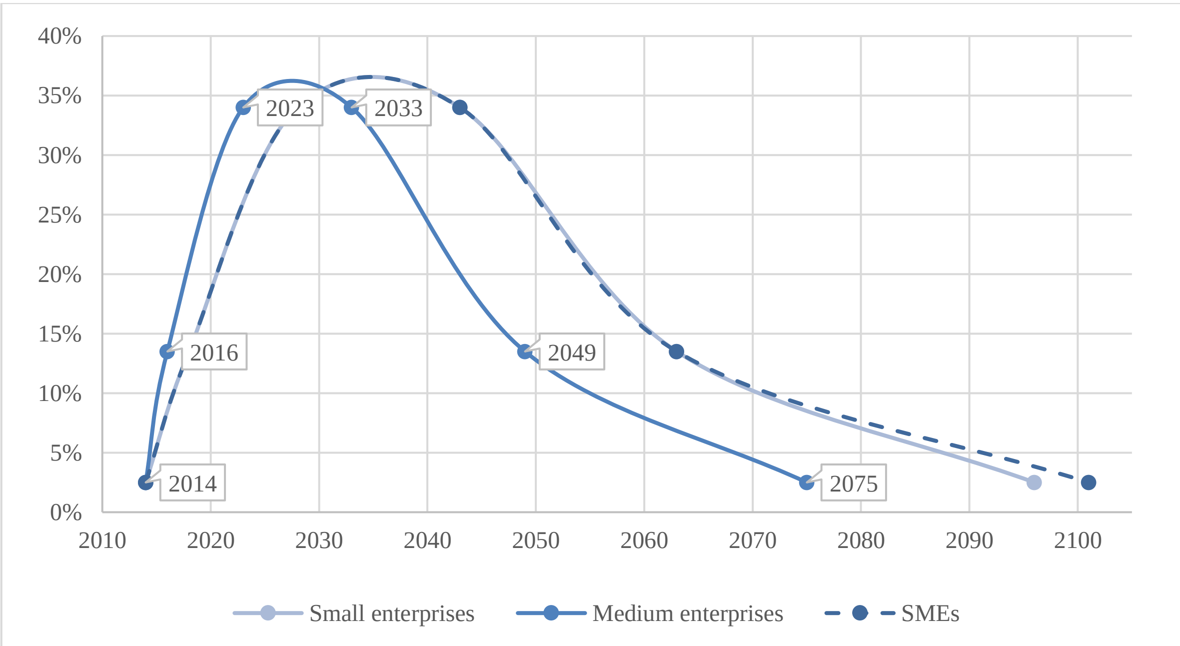
20. Figure: Prediction of the Bass model for medium-sized enterprises




*Source: own compilation*

Among medium-sized enterprises, taking into account Rogers' categories (Figure 21), innovators and early adopters (16 percent of medium-sized enterprises) used Cloud Computing in 2016. The early majority (50 percent of medium-sized enterprises) will become users of the technology in 2023, and the late majority (84 percent of medium-sized enterprises) in 2033. Laggards (97.5 percent of medium-sized enterprises) are expected to adopt Cloud Computing in 2049, while resistants in 2075.

21. Figure: Rogers' diffusion among medium-sized enterprises




*Source: own compilation*

The diffusion of different types of services based on Cloud Computing is estimated separately. Taking into account the most important coefficients of the estimate for medium-sized enterprises (Table 23), I obtained a good fit in all cases, except for the use of CRM applications. The value of p (innovation coefficient) for each type of use falls within the range defined by Mahajan, Muller & Bass (1985). The value of q (imitation coefficient) is in all cases below the typical band written by the authors (0.3-0.5), but the reason for this is similar to the previously described circumstance in the case of small and medium-sized enterprises, namely that the spread of technology is relatively fast, with little time takes place below, so the imitation effect will typically be lower. When storing files, using financial and accounting applications, and using the CRM application, the model estimated a lower imitation effect compared to the other usage categories.

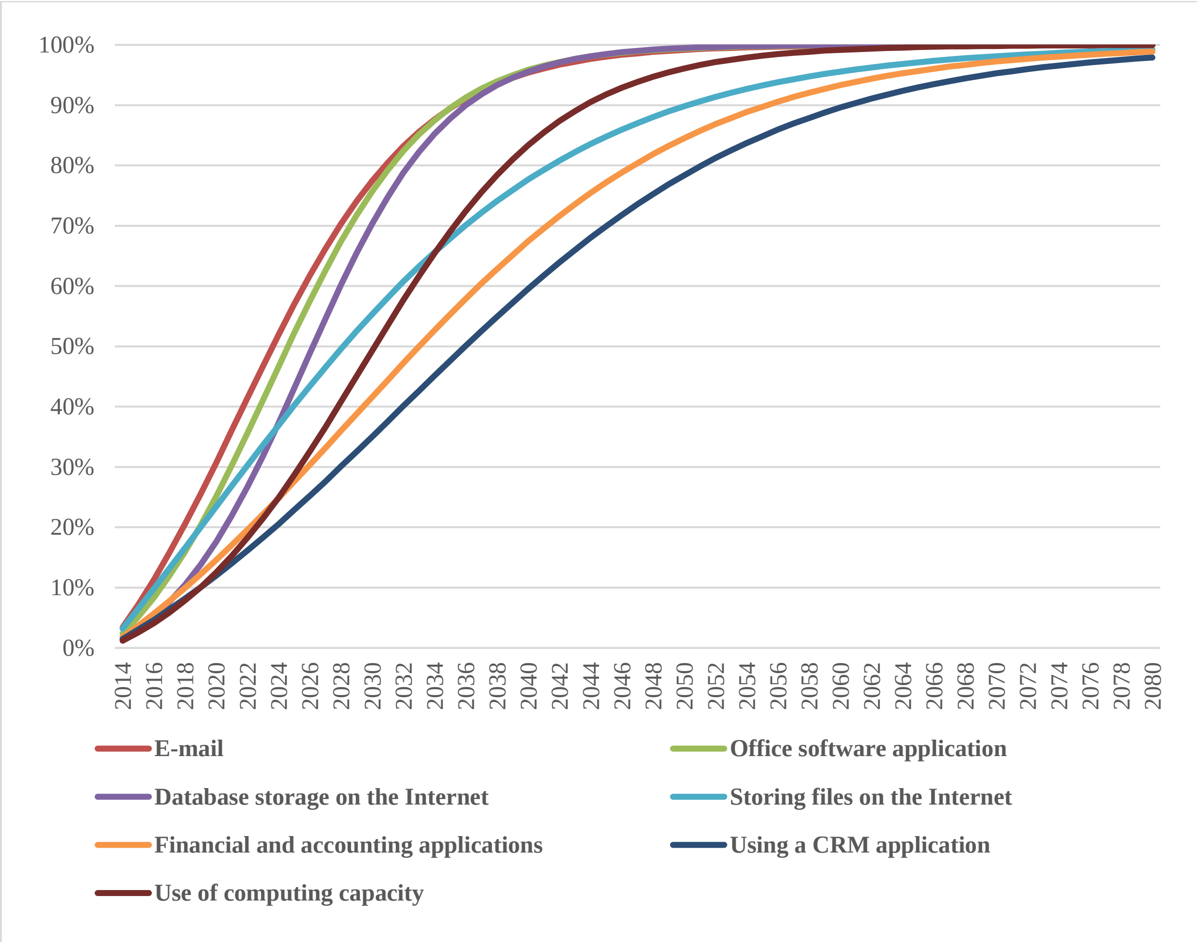
23. Table: The coefficients of the Bass model for different types of cloud-based services among medium-sized enterprises

| **Type of cloud-based service requested** | **p (innovation coefficient)** | **q (imitation coefficient)** | **$R^2$ (determination coefficient)** |
|---|---|---|---|
| E-mail | 0.0323 | 0.1428 | 97% |
| Office software application | 0.0222 | 0.1752 | 99% |
| Database storage on the Internet | 0.0129 | 0.2058 | 97% |
| Storing files on the Internet | 0.0318 | 0.0556 | 89% |
| Financial and accounting applications | 0.0174 | 0.0743 | 89% |
| Using a CRM application | 0.0143 | 0.0695 | 83% |
| Use of computing capacity | 0.0112 | 0.1473 | 99% |

*Source: own compilation*

The diffusion of different types of services based on Cloud Computing among medium-sized enterprises is shown in figure 22. Similar to small enterprises, a stronger spread can be observed in the case of e-mail services, database storage and office software applications, while the diffusion of other types of services will take place at almost the same rate, according to the model's estimation. Due to the lower value of aq (imitation coefficient) in the case of financial applications and CRM applications, diffusion will also take place at a slower pace, according to the model's estimate. Looking at Rogers' diffuser categories, the early majority (50 percent of medium-sized enterprises) will gradually use different types of usage categories. The email service in 2024, the office software application in 2025, the storage of the database on the Internet in 2027, the storage of files in 2029, the use of computing capacity in 2031, the use of financial and accounting applications in 2034, the CRM applications will be used by the early majority of medium-sized enterprises in 2036. The late majority (84 percent of medium-sized enterprises) shows a more uniform picture regarding the use of different categories. Email service, office software application and database storage will be used in 2033-2034, computing capacity usage and file storage in 2041-2045, while financial applications and CRM applications will be used in 2050-2055. the late majority of medium-sized enterprises.

22. Figure: Estimation of the Bass model for different types of cloud-based services among medium-sized enterprises




*Source: own compilation*

My first research question (Q1) related to the macro-level research was "To what extent do domestic small and medium-sized enterprises use Cloud Computing?". Representative data on the use of Cloud Computing is available for the period between 2014 and 2023. Based on these, the use of technology has increased in each of the different categories of business staff, but the pace of these shows a very different picture. It can be concluded that a larger company size (in terms of staffing categories) shows a higher rate of technology use. In the examined period, technology spread much more strongly among large companies than among small and medium-sized enterprises, and the difference between the sectors - excluding the data for 2023 - also increased every year. By 2023, 41.2 percent of small enterprises, 61.3 percent of medium-sized enterprises, and 85.8 percent of large companies will have used Cloud Computing. In light of the fact that, in connection with the use of technology, companies do not, or only to a negligible extent, encounter infrastructural barriers and obstacles related to the use of devices, this is a rather serious difference in terms of the staffing categories of the enterprises.

My second research question (Q2) is "What kind of future spread (diffusion) can be expected regarding Cloud Computing in the domestic SME sector?". I examined the future diffusion of technology using the Bass model. For each staffing category, I received a forecast with a suitable fit. The model, in line with the existing time series data, continued to estimate serious differences in terms of the spread of technology in terms of company size. In terms of Rogers' categories of innovation acceptance, in the case of large companies, the market spread has essentially been achieved (the late majority of companies apply the technology and the laggards are already starting to use it), while in the case of medium-sized companies, this ratio (minimum 84 percent of the companies) by 2033 , can be forecast for 2043 in the case of small enterprises. It should be noted that the model gave a rather conservative estimate, as the usage rate indicated for 2023 was slightly below the actual usage rate typical for businesses in all categories, so it is conceivable - if the value in 2023 is not just a one-time outlier - that in reality the diffusion will take place somewhat faster than estimated by the model. The model's forecast in this form can therefore be considered a negative scenario.

# 6. Meso-level research: Technology management activities of domestic enterprises

## 6.1 Presentation of the methodological background of the research

During the meso-level research, I prepare an individual questionnaire survey, as well as statistics revealing patterns from the resulting data. The steps of a individual questionnaire survey include developing, validating, modifying, testing the questionnaire, conducting the survey (directly contacting the questionnaires), processing the questionnaires, filtering and correcting errors and deficiencies, and evaluating the questionnaires. The individual survey was conducted in the form of a questionnaire available online, and its target group was the managers of domestic small and medium-sized enterprises who have significant knowledge and experience in the application of Cloud Computing, and are considered experts in terms of both technology and the SME sector. The purpose of the questionnaire survey was not to represent small and medium-sized enterprises, but to collect the opinions of experts with relevant knowledge about the sector. The expert survey was supported by the fact that some of the domestic small and medium-sized enterprises presumably do not have sufficient knowledge of the topics and concepts covered in the survey to be able to evaluate the statements on merit (this preconception of mine was convincingly confirmed during the validation of the survey), and that at my disposal it was not possible to conduct large-scale, representative research among domestic small and medium-sized enterprises with existing research tools.

### 6.1.1 Application of Hobday's (2002) evaluation model

The questionnaire survey was based on Michael Hobday's (2002) model dealing with the assessment of technological capability, the model was published by the United Nations Industrial Development Organization (UNIDO) under the title "Technology Needs Assessment (TNA) for Developing Countries". The applicability of the model is supported by the fact that, based on the systematic review of the literature, several later researches dealing with technology evaluation used Hobday's approach, and the model was also applied in practice in several cases (Rusch et al., 2007). The justification for the selection of the model can be found in 2.5. I wrote in more detail in the subsection.

The basic concept of the model is that the evaluation of the technological capabilities of governments, sectors and companies is questioned along the components of technological capabilities, on a four-level evaluation scale. The three levels of the model essentially correspond to three different researches, ideally by filling in three different target groups. Based on Hobday (2002), the components of technological capabilities include awareness, search, core capability, strategy, evaluation and selection, acquisition, application, learning, relationships and collaboration. From the point of view of the research, these dimensions are closely aligned with the functions of technology management, only the protection of technology does not appear as a component of technological capability. Considering the context of the model, the component of technological capability can be confidently matched to the concept of technology management function. Based on these, the function of identification covers awareness and strategy, the function of selection covers search and evaluation and selection, the function of acquisition covers procurement and relationships and cooperation, the function of exploitation covers basic ability and application, and the function of learning covers the component of learning. juice.

The purpose of the model is to explore technological development needs, which also fits well with my research goals, since the results of the evaluation method developed by Hobday (2002) essentially characterize the technological management preparedness and the quality of technological capabilities at the governmental, sectoral and corporate level, so for evaluation and exploratory research it is just as suitable as for the development of development proposals (given that the basis of development proposals is precisely the evaluation). In addition to the general examination of technological capabilities, the model also includes a targeted assessment of sustainable technologies. This logic makes the model suitable so that I can ask about both the special factors associated with the use of Cloud Computing and the general technology management factors when applying it to the goals of my research. The original structure of Hobday's (2002) technology capability assessment model, and a list of government, sector and firm level statements, can be found in Appendix 3.

In terms of the interpretation of my research results, it is important to point out that the model also contains a specific framework for the evaluation of surveys. Four skill levels (passive, reactive, strategic and creative) were defined in relation to each environmental level, which were developed by summing up the points of the responses to the statements in the survey. The relationship between the four levels is the same in terms of the different environmental levels (the passive skill level is the lowest, the creative skill level the highest level of preparedness), however, the four skill levels have different characteristics and explanations for governmental, sectoral and corporate technological capabilities, technology management in terms of preparedness.

The first step in the development of my questionnaire survey was the selection of the model's statements and its application to Cloud Computing. In the structure of the questionnaire survey, I identified the governmental level with the national economic level, and the sectoral level with the domestic SME sector. As a result of the fact that, from the point of view of the research, the assessment of company factors is the most important task, only the statements related to it were kept in total (24 pieces). In the preliminary version of the questionnaire (i.e. prior to expert validation) (Annex 4), 14 of the 30-30 statements included in the model concerning the national economic and sectoral levels were retained. I selected the statements based on whether the given statement is related to the theoretical background of the research and whether it carries relevant information regarding the evaluation of Cloud Computing from a technology management perspective. I also had to remedy the model's shortcoming in that it does not contain a statement regarding the protection of technology at the enterprise level. Protection of technology as a function of technology management covers, based on the relevant literature, the assessment of risks and dangers associated with the application of technology, protection of technology, safe procurement and questions related to the ownership of intellectual products. Keeping the internal ratio of the statements defined by Hobday (2002), I formulated 4 statements related to the enterprise level and 1 statement related to the national economy and sectoral level regarding the defense technology management function. After transforming the model in this way and applying it to Cloud Computing and domestic small and medium-sized enterprises, I subjected the developed questions to expert validation.

The expert validation of the questionnaire took place in two separate steps. In the first step, the structure of the questionnaire and the specific statements were discussed and theoretically examined with 22 academic and company specialists experienced in the scientific field of innovation and technology. In the first step of the validation, the experts got to know both the original question structure and the one I applied and expanded, and they also got to know the theoretical foundations of my research and the goals of the empirical research, specifically the goal of meso-level studies. The date of validation was April 5, 2024, the meeting with the experts lasted about three hours. In possession of this knowledge, the following observations were received from the expert group. In the following list, I only include the most important expert opinions that strongly affect the questionnaire survey, I will not go into the minor amendment proposals (replacement of some terms, proposals concerning demographic issues, order of statements).

- The experts participating in the validation agreed that the application of the model can be appropriate in order to achieve the goals of the research, however, significant changes must be made to it in order for the survey to produce relevant results.
- It is worthwhile to unify the names of the terms in the model and add an explanation to them. Despite the fact that the questionnaire survey is completed by experts, it is important that the respondents and the researcher interpret the concepts involved in the same way, especially regarding the concepts of technology, digital technology and Cloud Computing.
- In order for the survey to produce clear and easy-to-interpret results later, it is necessary to specify the wording of the individual statements and to make the content of the statements as narrow as possible. The original model often formulates its claims in a long-winded and sophisticated way, based on the opinion of the experts, more narrow claims should be included in the survey.
- Several comments were received regarding the fact that the verbs in each statement (knows, knows, is able, is available) should be clarified in each statement, so if possible, a statement should contain one verb.
- The amount of claims about the national economy and the sector must be strongly reduced. The company specialists sitting among the experts specifically emphasized that, despite the fact that the survey is completed by direct inquiry, the time allotted for the survey should be kept to 8-10 minutes. To this end, it was

recommended to reduce the number of statements related to external environmental levels, with which the other members of the expert group also expressed their agreement.

- The expert group accepted and supported the relevance and applicability of the claims I developed based on the literature on protection.
- The expert group clearly confirmed that the target group of the questionnaire survey should not be Hungarian small and medium-sized enterprises in general, but that the survey should be conducted on a narrower sample of experts. Among the experts, there was a quite extreme statement regarding the digital knowledge of the domestic SME sector, in connection with which the experts expressed to me their fear that in a large-scale survey some of the respondents from domestic enterprises would be unable to interpret the statements. As a counter-argument regarding the large-scale survey, it was also stated that even under market conditions, it is not easy to prepare a representative survey concerning the domestic SME sector, so my research resources would definitely be insufficient for this.
- Regarding the implementation of the expert survey, the expert group expressed a positive opinion regarding both the feasibility of the survey and the expected results. Several suggestions were received regarding specialists working in specific small and medium-sized enterprises, who know the technology and the sector well, and who could potentially complete the survey.

In the second step of the questionnaire survey's validation, the questionnaire modified based on the comments received was tested in a narrower circle, also by 5 experts from the academic and corporate spheres. The meeting took place on April 11, 2024, in a time frame of about one and a half hours. In the revised questionnaire survey, I kept the 28 statements from the first version regarding the company level, but I strongly reduced the number of statements concerning the national economy and the SME sector. Regarding the external levels, 1-1 statement related to the technology management functions was retained and formulated, so a total of 6 statements were included in the survey regarding the national economy and the SME sector. In connection with the essential statements of the questionnaire survey, I tried to be clear and use terms in accordance with the expert comments. I also finalized the demographic questions based on the opinions received. In the second step of the validation, typically smaller, wording comments were received on the survey, which were also incorporated into the final version of the questionnaire. The questionnaire survey developed on the basis of these, including all questions and possible answers, is included in Annex 5.

The final form of the questionnaire consisted of two parts, part 1 (demographic questions) asks about the data of the filling-in company (main activity, industry, number of employees), as well as its basic characteristics related to Cloud Computing. Part 2 of the questionnaire (questions related to the evaluation of technology) examines the essential elements revealed by the literature, the use of Cloud Computing, and factors related to their application along the technology management functions. The structure of the questionnaire (part 2) is contained in Table 24. Based on the table, it can be seen that the statements can be interpreted as the intersection of two areas. On the one hand, the statements follow the logic of the classic SWOT analysis, the questions focus on internal and external environmental elements, so the tool system of strategic management appears in them. On the other hand, the statements rely on the theory of technomanagement, since they deal with technomanagement functions revealed on the basis of the literature. The number of statements belonging to each group is contained in the intersection points of the table. Based on this, it can be seen that statements focusing on corporate internal factors appear more prominently in the questionnaire survey, which stems from the meso-level approach of the research. In the structure of the questionnaire, both research questions of the meso-level research stage appear, Q3 is related to internal capabilities and external environmental factors, while Q4 concerns the typical practices of Cloud Computing related to individual technology management functions.

24. Table: The structure of the questionnaire survey and the number of related questions

| | | **Environmental focus** | |
|---|---|---|---|
| | | **Internal environment (enterprise)** | **External environment (SME sector, national economy)** |
| **Techno-management functions** | Identification | 5 | 2 |
| | Selection | 5 | 2 |
| | Acquisition | 6 | 2 |
| | Exploitation | 5 | 2 |
| | Protection | 4 | 2 |
| | Learning | 3 | 2 |

*Source: own compilation*

When developing the statements of the questionnaire, I relied on the theoretical knowledge revealed on the basis of the literature, as well as on the opinions of specialists experienced in the topic and related practice, as described above. The interpretation of the functions of technology management (identification of technology, selection of technology, acquisition of technology, exploitation of technology, protection of technology and learning processes) with regard to services based on Cloud Computing can outline the positive and negative factors of the internal and external environment, and the level of readiness that characterizes the use of technology. Table 25 contains the final statements of part 2 of the questionnaire (dealing with evaluation), their environmental focus, the technology management function associated with the statements, and the variables derived from the statement.

The questionnaire consisted of general questions regarding demographics and Cloud Computing, as well as the statements above. The participants of the survey evaluated the statements in Table 25 according to the extent to which they considered them to be typical of domestic small and medium-sized enterprises, the SME sector, and the national economic environment. According to the original model, the respondents evaluated the individual statements on a four-point ordinal scale, the possible answers are "strongly disagree", "rather disagree", "rather agree", "strongly agree" and "don't know/don't answers" were. When evaluating the questionnaire, the evaluation of each statement can be marked with points from 1 to 4, in which the value 1 corresponds to "strongly disagree" and 4 to "strongly agree".

25. Table: The question structure of the evaluation part of the questionnaire survey and the variables derived from them

| Assertion | Environmental focus | Technology management function | A variable derived from an assertion |
|---|---|---|---|
| Businesses are well aware of the most important Cloud Computing for their business activities. | enterprise | identification | Knowledge of technology from a business perspective |
| Businesses know how to choose the Cloud Computing they need to run their business. | enterprise | identification | Selection of necessary technologies |
| Businesses are prepared to evaluate the opportunities offered by Cloud Computing. | enterprise | identification | Evaluation of opportunities |
| Businesses can easily assess the threats associated with Cloud Computing. | enterprise | identification | Threat assessment |
| Enterprises have a well-developed vision for Cloud Computing. | enterprise | identification | Having a vision |
| Businesses know the best sources for Cloud Computing. | enterprise | selection | Knowledge of procurement sources |
| The application of Cloud Computing plays an important role in the corporate and business strategy of enterprises. | enterprise | selection | The role of technology in corporate and business strategy |
| Enterprises use external organizations (e.g. consulting firms, service providers) for Cloud Computing evaluation. | enterprise | selection | Using external organizations to evaluate the technology |
| The top management of the companies is skilled in the development of the technological strategy necessary to achieve business goals regarding Cloud Computing. | enterprise | selection | Proficiency in technology strategy development |
| Businesses know their main priorities regarding Cloud Computing. | enterprise | selection | Knowledge of technology-related priorities |
| Businesses can effectively acquire Cloud Computing from external sources. | enterprise | acquisition | Procurement efficiency |
| Enterprises have good relationships with important third-party suppliers for Cloud Computing. | enterprise | acquisition | Relationship with suppliers |
| Government policy encourages businesses to invest in Cloud Computing. | enterprise | acquisition | Government incentives for investments |
| Enterprises use external organizations (e.g. consulting firms, service providers) in the development of Cloud Computing. | enterprise | acquisition | Use of external organizations in development |
| Enterprises work together with universities and research institutes in projects involving Cloud Computing. | enterprise | acquisition | Cooperation in development with universities and research institutes |
| Enterprises work together with government institutions, organizations and research institutes in projects related to Cloud Computing. | enterprise | acquisition | Cooperation in development with government institutions |
| Within the enterprises, the technological activities (e.g.: IT, engineering, R&D areas) are efficiently organized with regard to Cloud Computing. | enterprise | exploitation | Organization of internal technological activities |
| Enterprises have clear processes for the implementation of projects involving Cloud Computing (e.g. investment, development, procurement). | enterprise | exploitation | Existence of project processes (investment, development, procurement). |

| Assertion | Environmental focus | Technology management function | A variable derived from an assertion |
|---|---|---|---|
| Enterprises use external organizations (e.g. consulting firms, service providers) in order to implement the technological strategy regarding Cloud Computing. | enterprise | exploitation | Use of external organizations in the implementation of the strategy |
| Businesses have particular strengths in Cloud Computing that they can leverage. | enterprise | exploitation | Exploitation of special strengths |
| Businesses know which services based on Cloud Computing should be developed "in-house" and which should be outsourced. | enterprise | exploitation | Ability to decide on outsourcing or own development |
| Businesses are aware of the risks and dangers associated with the use of Cloud Computing. | enterprise | protection | Technological risks and dangerous knowledge |
| Businesses are able to build effective defenses against Cloud Computing. | enterprise | protection | Building effective protection |
| Businesses know how to securely build or acquire Cloud Computing. | enterprise | protection | Knowledge of secure procurement and development |
| Businesses are aware of the intellectual property rights issues related to Cloud Computing. | enterprise | protection | Knowledge of intellectual property rights issues |
| Businesses have good systems in place for evaluating projects involving Cloud Computing. | enterprise | learning | Quality of project evaluation systems |
| Businesses conduct post-project evaluations of Cloud Computing. | enterprise | learning | Existence of post-project evaluations |
| Businesses are able to learn from a project, they are able to use the experience of the project later in relation to Cloud Computing. | enterprise | learning | Ability to learn from projects |
| Enterprises in the SME sector have the skills to identify opportunities and threats related to Cloud Computing. | SME sector | identification | Identification of opportunities and threats in the SME sector |
| Enterprises in the SME sector are able to review their technology strategy and technology portfolio in the event of changes in environmental factors. | SME sector | selection | Technology strategy, technoportfolio review in the SME sector |
| In the SME sector, the acquisition of Cloud Computing works well. | SME sector | acquisition | Procurement quality in the SME sector |
| For the companies of the SME sector, the costs of developments involving Cloud Computing are greatly exceeded by the benefits that can be realized from them. | SME sector | exploitation | Advantages of Cloud Computing in the SME sector |
| Enterprises in the SME sector are aware of the opportunities and tools for protecting intellectual property in relation to Cloud Computing. | SME sector | protection | Knowledge of intellectual property protection in the SME sector |
| Enterprises in the SME sector are able to review the efficiency and effectiveness of their technological developments in terms of Cloud Computing. | SME sector | learning | Review of developments in the SME sector |
| The government and government policy institutions effectively inform businesses about technological threats and opportunities. | national economic | identification | Government support for identifying opportunities and threats |
| The government's policy priorities regarding digital technologies are clear and coherent. | national economic | selection | Awareness and quality of government policy priorities |
| The government and government policy institutions support cooperation between businesses regarding the acquisition and | national economic | acquisition | Government support for collaborations and procurement processes |

| Assertion | Environmental focus | Technology management function | A variable derived from an assertion |
|---|---|---|---|
| development of digital technologies. | | | |
| The government's policy and regulatory background effectively supports the exploitation (dissemination, utilization of capacities) of digital technologies. | national economic | exploitation | Government support for the exploitation of digital technologies |
| Government policy can provide effective support for the protection of companies' digital technologies. | national economic | protection | Government support for technology protection |
| The government and government policy institutions regularly measure the performance of businesses with regard to digital technologies. | national economic | learning | Measuring the performance of enterprises at the government level |

*Source: own compilation*

### 6.1.2 Description of the further methodological steps of the survey

I used the questionnaire for direct expert interviews. The applicants were selected by direct expert sampling, so I contacted each applicant personally, typically by recommendation. The respondents to the survey were senior employees of small and medium-sized enterprises who have relevant knowledge of the specialties of the domestic SME sector, as well as the characteristics of Cloud Computing, in terms of the application of the technology. At the beginning of the survey, I determined the sufficient sample of experts to be 25 people, however, during the survey, new respondents came into the field of view of the research, with whom the number of expert sample elements of the survey was expanded to a total of 34 people. It is important to note that, as a result of the expert survey, the meso-level examination does not represent the enterprises of the SME sector based on their distribution and statistical characteristics, but rather presents the opinions of experts concerning the domestic SME sector. During the questionnaire survey, I did not aim for stratified or representative sampling (this would have been impossible due to the expert survey), but it is therefore important to state that the results of my analysis cannot be representative of domestic small and medium-sized enterprises. At the same time, the purpose of the meso-level research stage was not to conduct a representative survey, but to supplement the quantitative and population data of the macro-level research, which otherwise relies on representative data, by exploring and interpreting the determining external and internal environmental factors and characteristics, and by assessing the quality of the variables.

After developing and testing the questionnaire, I started contacting the respondents directly. During the direct inquiries, I took advantage of the university network, the opportunity to contact entrepreneurial organizations, specific chambers of industry, and to reach entrepreneurs and professionals who came into contact with me during my professional career. I defined the expert base of the survey before the survey began, the respondents who were asked to fill in later were not used to replace the number of sample items, but to expand the sample.

The first step in the analysis of the questionnaires included the checking of the completed questionnaires, the screening of the deficiencies found in the questionnaires and their filling. In terms of demographic characteristics, the experts participating in the survey - not surprisingly - answered the questions completely. In the case of the statements that make up part 2 of the questionnaire, there were already missing records, in the event that the respondent selected the option "I don't know/don't answer". The proportion of these was extremely small, out of all the respondents (34 people), only 8 people ticked this answer one or more times. Missing data occurred in 9 of the 40 claims, for a total of 31 records, which represents 2.3 percent of all records. In order to be able to run the statistical analyzes and not have to remove all the answers of the 8 people from the sample, I used the Replace Missing Values tool, which I used to replace the missing values with the mode of the given variable. I performed the operation using the SPSS statistical program. After supplementing the survey data, I performed descriptive and pattern-revealing statistical tests. I will discuss the data on the validity and reliability of the individual statistical tests in the framework of the presentation of the results of the given method, in this chapter I will only try to list the different statistical tests I use in order and give a general description.

In order to examine the demographic characteristics of my questionnaire survey, I first performed descriptive statistical tests, in the framework of which the distribution of the general data of the respondents was calculated. I used the Saphiro-Wilk test to check the normal distribution of the variables from the survey statements. I used the Mann-Whitney U test and the Kruskal-Wallis test to check the main characteristics of the filling-in experts (enterprise size and the time of using Cloud Computing), as well as the difference between their answers. The paired comparison of the Kruskal-Wallis test was performed with the Dwass-Steel-Critchlow-Fligner test. I used the JAMOVI statistical program to conduct the tests.

Using the SPSS program, I performed descriptive statistical tests to assess the technological capabilities that determine the application of Cloud Computing, and the strengths and weaknesses that can be deduced from this (Q3). In order to answer my research question, the ability levels defined in the Hobday (2002) model were calculated and analyzed. After that, the mean and mode for each variable were calculated, thereby characterizing the general opinion of the expert sample regarding the individual statements. The ranking analysis of the variables derived from the statements of the questionnaire was also carried out with descriptive statistical tests. I performed the tests in Excel and the SPSS statistical program.

To analyze the technology management functions related to the application of Cloud Computing, I performed statistical studies revealing patterns. First, I used the Structural Equation Modeling (SEM) procedure, which is a statistical procedure based on the methodology of factor analysis, the purpose of which is to reduce variables and dimensions, and to explore the relationships between variables. The SEM procedure allows these latent variables to directly participate in the model and establish relationships between them and the observed variables. The methods used during factor analysis can be divided into two categories: on the one hand, we can perform exploratory factor analysis, the purpose of which is to create new variables, and on the other hand, confirmatory, structure-checking factor analysis, which is used to test an existing model (Sajtos & Mitev, 2007; Szüle, 2016). Due to the number of sample items, it was not possible to carry out an exploratory factor analysis, but at the same time, a structural control factor analysis was better suited to my research goals. The SEM procedure can be considered as an extended procedure of the structural control factor analysis, using it I sorted the internal environmental variables into a common factor based on the technology management function associated with them. After training the factors, I continued to work with a total of 18 variables, which emerged as a product of the 6 technology management functions and the 3 environmental levels. After that, in order to explore the patterns between the technology management functions, I carried out Friedman's test, Spearman's rank correlation, and Network Analysis, the results of which I supplemented by preparing the Centrality measure and the related weight matrix. Pairwise comparisons of the Friedman test were performed using the Durbin-Conover test. I prepared the Friedman test and the Spearman correlation in the JAMOVI statistical program, and the network analysis using the suitable JASP software.

I would like to answer the research questions of the meso-level research stage with the help of descriptive and pattern-revealing statistical analyses. The purpose of the questionnaire survey is to obtain quantifiable information obtained based on primary research on the relevant external and internal factors affecting the use and application of Cloud Computing, defined on the basis of the relevant literature, and the environmental elements, driving forces and barriers determining the application of Cloud Computing can be qualitatively characterized. The questionnaire survey complements macro-level (quantitative) studies on the spread of Cloud Computing as a next dimension. The characteristic statistical data of the variables of the questionnaire survey are contained in Annex 6.

## 6.2 The results of the expert survey

I begin the presentation of the results of the expert survey by presenting the demographic data of the respondents, and by revealing and interpreting the relationship between the demographic data and the results.

26. Table: Data characterizing the people completing the expert questionnaire and the related company

| | | Small enterprises | Medium enterprise | All |
|---|---|---|---|---|
| **Expert position** | **Managing Director** | 13 | 1 | 14 |
| | **Senior manager** | 7 | 3 | 10 |
| | **Middle manager** | 3 | 3 | 6 |
| | **Group leader** | 3 | 1 | 4 |
| **Use of Cloud Computing** | **2-3 years ago** | 5 | 2 | 7 |
| | **4-5 years ago** | 5 | 2 | 7 |
| | **5-10 years ago** | 9 | 4 | 13 |
| | **10-15 years ago** | 7 | 0 | 7 |

*Source: own compilation*

Of the 34 experts participating in the survey, 26 are managers or employees of small enterprises, and 8 of them are medium-sized enterprises. Data on the assignment of the experts and the time of use of Cloud Computing by the enterprise "related to them", according to the categories of enterprise personnel, can be found in Table 26. When answering, the experts did not have to comment on their own business or workplace. It was important to inquire about the time of use of Cloud Computing in order to test the differences between opinions.

In the first steps of the quantitative analyses, I performed latent variable modeling for the purpose of factor formation, and examined the normal distribution of the data. For the later easier and more visual interpretation of the results of the questionnaire survey, for the possibility of conducting certain statistical tests, latent variable modeling was used to check the hypothetical structure of the questionnaire, the tool of which was the Structural Equation Modeling (SEM) procedure, with the help of the DWLS estimation procedure. The purpose of the latent variable modeling (factor formation) was questions related to the internal environment, i.e. to the company level, along the technology management functions associated with the questions. The statistical results of the procedure are contained in Table 27.

27. Table: Latent variable modeling result e

| Function | χ2 | p | CMIN/df | SRMR | RMSEA | CFI |
|---|---|---|---|---|---|---|
| **IDENTIFICATION** | (5)=0.87 | 0.97 | 0.17 | 0.04 | 0.01 | 0.99 |
| **SELECTION** | (2)=0.49 | 0.78 | 0.25 | 0.04 | 0.01 | 0.99 |
| **ACQUISITION** | (9)=10.81 | 0.51 | 1.21 | 0.12 | 0.08 | 0.98 |
| **EXPLOITATION** | (5)=1.95 | 0.51 | 0.39 | 0.06 | 0.01 | 0.99 |
| **PROTECTION** | (2)=0.79 | 0.67 | 0.34 | 0.05 | 0.01 | 0.99 |
| **LEARNING** | (2)=0.41 | 0.875 | 0.22 | 0.01 | 0.01 | 0.99 |

*Source: own compilation*

When interpreting the results, I review the most important fit indicators from the structural equation modeling procedure, with particular regard to the $\chi^2$ (Chi-square) test, the CMIN/df indicator, the SRMR (Standardized Root Mean Square Residual), the RMSEA ( Root Mean Square Error of Approximation) and CFI (Comparative Fit Index). These fit indices evaluate the quality and reliability of the overall fit of the model. The Chi-square test is commonly used to test how well a model fits the observed data. Low Chi-square values (and high p-values) indicate that the model fits the data well, as there is no significant difference between what the model predicts and the actual data. The CMIN/df indicator is the quotient of the Chi-square value and the degrees of freedom, which is a frequently used indicator to evaluate the fit of the model. In general, a CMIN/df value of 2 or less indicates that the model fits well. SRMR is an indicator of model fit that measures the root mean square of the standardized residuals. A SRMR value below 0.08 indicates a good fit. RMSEA is another important goodness-of-fit measure that measures the error in model specification. A value of RMSEA below 0.06 indicates a good fit, while a value below 0.08 is considered acceptable. CFI is one of the most commonly used fit indices, which compares the fit of the model to the null model. A CFI value above 0.90 indicates a good fit.

Based on the results of the $\chi^2$ (Chi-square) test, it is The model of IDENTIFICATION ($\chi^2(5)=0.87$, $p=0.97$) has an extremely good fit as the p-value is high (0.97), meaning that there is no significant difference between the predicted and observed data . The SELECTION ($\chi^2(2)=0.49$, $p=0.78$) model also fits well, the p-value is also high here (0.78). For ACQUISITION ($\chi^2(9)$ 10.81, $p=0.51$), the p-value is still acceptable and the fit can be considered adequate. EXPLOITATION ($\chi^2(5)=1.95$, $p=0.51$), PROTECTION ($\chi^2(2)=0.79$, $p=0.67$) and LEARNING ($\chi^2(2)=0.41$ , $p=0.875$) models also show an excellent fit.

All functions have CMIN/df values significantly below 2, indicating excellent fit. IDENTIFICATION (0.17), SELECTION (0.25), ACQUISITION (1.21), EXPLOITATION (0.39), PROTECTTION (0.34), and LEARNING (0.22) are all high CMIN/df values are shown. Regarding the value of the SRMR, the SRMR value of the IDENTIFICATION (0.04), SELECTION (0.04), PROTECTION (0.05), EXPLOITATION (0.06) and LEARNING (0.01) models are all below 0.08, which means that these models fit well. The SRMR of the ACQUISITION function (0.12) is slightly higher than ideal, but still acceptable, especially considering other metrics. The RMSEA values for all models are very low (between 0.01 and 0.08), indicating that the fit of the models is excellent. The RMSEA value of the ACQUISITION model (0.08) is at the upper limit, but it can still be considered acceptable. The CFI (Comparative Fit Index) value of each model is extremely high (between 0.98-0.99), which indicates an excellent model fit.

Overall, the fit indices of the analyzed models show an extremely good fit to the data. For the IDENTIFICATION, SELECTION, EXPLOITATION, PROTECTION, and LEARNING functions, all tested fit indices ($\chi^2$, CMIN/df, SRMR, RMSEA, CFI) showed excellent or low results. The somewhat higher SRMR (0.12) and RMSEA (0.08) values for the ACQUISITION function are noteworthy, but they are still within acceptable limits, and the other indicators (e.g., CFI = 0.98) indicate an extremely good fit. These results show that the functions created from the variables represent well the relationships between the latent variables and the observable variables. Based on the analysis, it can be concluded that the fit between the data and the models is reliable, and the results strengthen the validation of the functions in terms of answering the research questions.

To check the normal distribution of technology management functions related to different environmental levels, I used the Shapiro-Wilk test. The result of the analysis is contained in Table 28. The results of the Shapiro-Wilk test provide important information for checking the normal distribution of the investigated variables. The results can be evaluated based on the Shapiro-Wilk W statistic and the corresponding p-values.

At the company level, $p>0.05$ for SELECTION, EXPLOITATION, PROTECTION and LEARNING functions, which indicates a normal distribution. In the case of IDENTIFICATION and ACQUISITION, $p<0.05$, which means that the null hypothesis that the data are normally distributed can be rejected. Based on this, we can conclude that the data of the functions do not follow the normal distribution. In the case of the SME sector and the level of the national economy, the data significantly deviates from the normal distribution for all the examined functions, which must be taken into account in subsequent analyses. Based on the results of the Shapiro-Wilk test, it can be concluded that the functions of technology management at different environmental levels typically do not follow a normal distribution.

These results allow us to conclude that the data do not follow a normal distribution during further statistical analyses. This does not prevent the application of non-parametric methods that follow from the nature of the data.

28. Table: Results of the Shapiro-Wilk test

| Environmental level | Technology management function | Shapiro-Wilk W | Shapiro-Wilk p |
|---|---|---|---|
| **Enterprise level** | IDENTIFICATION | 0.910 | 0.009 |
| | **SELECTION** | **0.959** | **0.232** |
| | ACQUISITION | 0.881 | 0.001 |
| | **EXPLOITATION** | **0.960** | **0.242** |
| | **PROTECTION** | **0.957** | **0.193** |
| | **LEARNING** | **0.944** | **0.084** |
| **SME sector** | IDENTIFICATION | 0.749 | <001 |
| | SELECTION | 0.838 | <001 |
| | ACQUISITION | 0.881 | 0.002 |
| | EXPLOITATION | 0.878 | 0.001 |
| | PROTECTION | 0.762 | <001 |
| | LEARNING | 0.766 | <001 |
| **National economy** | IDENTIFICATION | 0.846 | <001 |
| | SELECTION | 0.780 | <001 |
| | ACQUISITION | 0.859 | <001 |
| | EXPLOITATION | 0.841 | <001 |
| | PROTECTION | 0.782 | <001 |
| | LEARNING | 0.857 | <001 |

*Source: own compilation*

I consider it necessary to demonstrate whether the queried demographic characteristics (the size of the respondent's business or the time of use of Cloud Computing) influenced the results of the survey. Examining this is important because we can get an answer to the extent to which the answers of the interviewed experts were influenced by the size of their workplace and the duration of the use of Cloud Computing.

To check the difference between small and medium-sized enterprises, I used the Mann-Whitney U-test. Table 29 contains the results of the test. The results of the Mann-Whitney U-test help to understand whether there is a significant difference between the evaluation of the technology management function in terms of business size.

29. Table: Mann-Whitney test results

| Environmental level | Technology management function | Mann-Whitney U | p |
|---|---|---|---|
| **Enterprise level** | IDENTIFICATION | 95.5 | 0.743 |
| | SELECTION | 100.5 | 0.902 |
| | **ACQUISITION** | **45.5** | **0.017** |
| | EXPLOITATION | 100.5 | 0.902 |
| | PROTECTION | 90 | 0.578 |
| | LEARNING | 81 | 0.355 |

| | | | |
|---|---|---|---|
| **SME sector** | **IDENTIFICATION** | **60** | **0.039** |
| | SELECTION | 90 | 0.551 |
| | ACQUISITION | 83.5 | 0.395 |
| | EXPLOITATION | 99.5 | 0.865 |
| | PROTECTION | 96 | 0.719 |
| | LEARNING | 101.5 | 0.922 |
| **National economy** | IDENTIFICATION | 97.5 | 0.796 |
| | SELECTION | 91 | 0.568 |
| | ACQUISITION | 91.5 | 0.603 |
| | EXPLOITATION | 82.5 | 0.369 |
| | PROTECTION | 70 | 0.121 |
| | LEARNING | 90 | 0.563 |

*Source: own compilation*

Among the examined functions, only the ACQUISITION function related to the company level and the IDENTIFICATION function related to the SME sector showed a significant difference ($p<0.05$). Expert opinions about these two functions may have been influenced by whether the experts work in a small or medium-sized enterprise. I can examine the difference between the groups by comparing the group averages, in the case of the ACQUISITION function at the company level, the group average for small enterprises is 2.46, for medium-sized enterprises 2. Regarding the IDENTIFICATION function, the test also showed a significant difference, in this case the group average for small enterprises is 2.07, that of medium-sized enterprises is 2.33. The obtained results therefore do not point in the same direction. Regarding the ACQUISITION function of the company level, the experts from small enterprises identified more advanced technology management skills compared to the experts from medium-sized enterprises, while the opposite was true for the IDENTIFICATION function of the SME sector. The results do not give a convincing picture that the size of the respondent's related enterprise had a significant influence on the respondent's opinion. Based on the results of the Mann-Whitney U-test, it can be concluded that there is no significant difference between the evaluation of the technology management functions and the size of the enterprise related to the expert.

To compare the answers of the experts and the use of Cloud Computing, I used the Kruskal-Wallis test, because the comparison of more than two groups can be done with this non-parametric procedure. The results of the test are shown in Table 30.

between the groups. For the company level IDENTIFICATION function, the $\chi^2$ value is 9.080 with 3 degrees of freedom, the p-value is 0.028 and the $\varepsilon^2$ (effect size) is 0.275, indicating a medium effect size. This suggests that there are significant differences between the groups in how they rated the IDENTIFICATION feature. Looking at the groups belonging to the function, there was a significant difference between businesses using Cloud Computing for 3-4 years and those using the technology for 5-10 ($p=0.042$) and 10-15 years ($p=0.067$). The group averages for businesses that have been using the technology for 3-4 years are 2.49, those that have been using it for 5-10 years are 3.37, and those that have been using it for 10-

15 years are 3.4, so the results show that experts who have been using the cloud for longer than their business based technology, the IDENTIFICATION function related to the enterprise level was more appreciated. The results are shaded by the fact that the group average of businesses that have been using it for 2-3 years is 3.06, but there is no statistically significant difference there. In the case of the LEARNING function of the company level, ap=0.076, which is close to the significance level, this is for enterprises using Cloud Computing for 3-4 years (group average: 2.14) and enterprises that have been using it for 10-15 years (group average: 2.94) indicates the difference between, with a significance level of p=0.078. As a result of the fact that there is no sign of a significant difference in the case of the other functions, with the exception of the IDENTIFICATION function at the company level, it can be concluded that the expert opinions were not influenced by the use of Cloud Computing by the related company.

30. Table: The result of the Kruskal-Wallis test

| Environmental level | Technology management function | $\chi^2$ | df | p | $\varepsilon^2$ |
|---|---|---|---|---|---|
| **Enterprise level** | **IDENTIFICATION** | **9,080** | **3** | **0.028** | **0.275** |
| | SELECTION | 1,984 | 3 | 0.576 | 0.060 |
| | ACQUISITION | 1,528 | 3 | 0.676 | 0.046 |
| | EXPLOITATION | 4,453 | 3 | 0.217 | 0.135 |
| | PROTECTION | 1,527 | 3 | 0.676 | 0.046 |
| | **LEARNING** | **6,887** | **3** | **0.076** | **0.209** |
| **SME sector** | IDENTIFICATION | 3,459 | 3 | 0.326 | 0.105 |
| | SELECTION | 2,166 | 3 | 0.539 | 0.066 |
| | ACQUISITION | 0.096 | 3 | 0.992 | 0.003 |
| | EXPLOITATION | 0.353 | 3 | 0.95 | 0.011 |
| | PROTECTION | 2,071 | 3 | 0.558 | 0.063 |
| | LEARNING | 0.277 | 3 | 0.964 | 0.008 |
| **National economy** | IDENTIFICATION | 1,294 | 3 | 0.731 | 0.039 |
| | SELECTION | 3,666 | 3 | 0.3 | 0.111 |
| | ACQUISITION | 1,030 | 3 | 0.794 | 0.031 |
| | EXPLOITATION | 2,074 | 3 | 0.557 | 0.063 |
| | PROTECTION | 2,393 | 3 | 0.495 | 0.073 |
| | LEARNING | 2,197 | 3 | 0.532 | 0.067 |

*Source: own compilation*

Among the examined functions, there was only one significant difference ($p<0.05$)

The results of the tests for the analysis of the differences between the groups show that the demographic characteristics of the enterprises did not result in significant differences in the evaluation of the individual functions in the large majority. Based on this, the opinion of the experts participating in the survey sample was not influenced by the fact that they work in a small or medium-sized enterprise, or by how long the enterprise has been using Cloud Computing, their opinion on individual functions is independent of this. This allows us to conclude that the opinions of the experts can be considered independent of the workplace, regarding the assessment of the different levels and functions.

### 6.2.1 Analysis of the variables included in the survey

The first part of the quantitative research deals with the examination of the variables included in the survey. In this chapter, I am looking for answers to how the internal technology management capabilities and external environmental effects of Cloud Computing can be characterized among domestic small and medium-sized enterprises (Q3). In this chapter, I present the results of three analyses, the evaluation and analysis corresponding to the ability levels included in Hobday's (2002) model, the samples of the expert opinions of the variables developed on the basis of the 40 questions included in the survey, and the degree of expert agreement for the variables. The results of the individual analyzes are interpreted based on the environmental levels included in the survey.

The purpose of the scoring evaluation developed by Hobday (2002) is to determine, based on the respondents, the ability level of the technology management preparedness of the audited company, sector or government. During the evaluation, four different skill levels were defined: passive, reactive, strategic and creative. Each level has different bands, which can be calculated from the "total score" of the given survey. "Scores" are calculated based on the responses to each question, with "strongly disagree" as 1, "rather disagree" as 2, "rather agree" as 3 and "strongly disagree" as one" means 4. The maximum "obtainable" point will be the number of questions multiplied by four. In the case of my survey, a maximum of 112 points can be "obtained" at the company level, and a maximum of 24 points at the SME sector and the national economy. Based on the maximum score, the bands belonging to the skill levels are determined according to quartiles. Table 31 contains the results for each level based on the questionnaire survey.

31. Table: Results of the calculation of skill levels

| **Skill level** | **Environment levels** | | | | | |
|---|---|---|---|---|---|---|
| | **Enterprise level** | | **SME sector** | | **National economy** | |
| | Number of expert opinions | Ratio of expert opinions | Number of expert opinions | Ratio of expert opinions | Number of expert opinions | Ratio of expert opinions |
| **PASSIVE** | 0 | 0% | 1 | 3% | 6 | 18% |
| **REACTIVE** | 4 | 12% | **21** | **62%** | **13** | **38%** |
| **STRATEGIC** | **22** | **65%** | 12 | 35% | **12** | **35%** |
| **CREATIVE** | 8 | 24% | 0 | 0% | 3 | 9% |

*Source: own compilation*

The ability level can be determined on the basis of the number of expert opinions and the sum of the scores "given" by the person completing the form. The ratio of expert opinions shows the ratio of opinions belonging to the skill level in relation to the entire sample. According to the opinion of the strong majority (65 percent) of the experts, the strategic ability level belongs to the enterprise level. The average score of the respondents is 76, which also corresponds to the strategic ability level (57-84). In terms of companies, the level of strategic capabilities can be characterized by strong internal technological capabilities and a strategic approach to technology. In some areas, the company may have shortcomings, which weakens its competitive position, but it can build on its strengths and improve its technological capabilities to reach the level of creative ability.

According to the opinion of the overwhelming majority of experts (62 percent), the SME sector belongs to the reactive capability level. The average score of the respondents is 11, which also corresponds to the reactive ability level (7-12). The characteristics of the reactive capability level in the sectoral context are that the sector has certain elements of the technological strategy, but there are no clear priorities regarding the direction of technological development. The sector cannot keep up with emerging technologies. It is not effective in terms of adapting new strategies, information transfer and training are poorly organized. The sector is driven by responding to environmental conditions, companies cannot plan proactively.

In relation to the level of the national economy, there was no majority position in the opinion of the experts. Based on the scores of 38 percent of the respondents, it belongs to the reactive skill level, and 35 percent to the strategic skill level, but it is important to note that this difference covers only one respondent. Based on the respondents' average score (12), the reactive ability level (7-12) belongs to the national economy. The characterization of the reactive capability level in the context of the national economy level is that the national economy has weak capabilities regarding the creation and implementation of policy. In terms of acquiring and developing the technologies required for global competition, it is characterized by following rather than progressing in technological developments. A significant number of companies react to changes rather than prevent them.

Table 32 contains the results of the expert opinions on the technology management functions and their related variables at the company level. The variables were given shorter names for ease of handling, so the fact that these factors were queried in the context of Cloud Computing was omitted from the names of the variables. The analysis focuses on the average values of the variables related to each function, the characteristic expert opinions that can be determined based on them, and the most common expert opinions determined based on the mode. The purpose of the analysis is to understand how the different technology management functions were evaluated by the experts, and to determine the variables where the experts' opinions show a particularly strong or weak evaluation.

In the survey, expert opinions evaluated the technology management functions on four scales, "strongly agree", "rather agree", "rather disagree" and "strongly disagree", the values range from 1 to 4, where 4 value indicates the highest agreement. In the table, the individual variables were ordered based on the most common evaluation (mode), the average between identical evaluations was decided. In the case of ordinal, qualitative variables, the interpretation of the average must be handled very carefully, and conclusions can only be drawn from it within a very limited, narrow framework of interpretation. That is why it is more important to know which was the most frequently given evaluation by the experts in relation to each variable.

32. Table: General expert assessment of internal environmental factors

| Technology management function | Variable | Average | Typical expert opinion | Most common expert opinion |
|---|---|---|---|---|
| IDENTIFICATION | Evaluation of opportunities | 3.35 | You'd rather agree | Definitely agree |
| IDENTIFICATION | Knowledge of technology from a business perspective | 3.32 | You'd rather agree | Definitely agree |
| SELECTION | The role of technology in corporate and business strategy | 3.32 | You'd rather agree | Definitely agree |
| IDENTIFICATION | Selection of necessary technologies | 3.21 | You'd rather agree | Definitely agree |
| SELECTION | Knowledge of priorities in relation to technology | 3.18 | You'd rather agree | Definitely agree |
| ACQUISITION | Acquisition of technology | 3.15 | You'd rather agree | You'd rather agree |
| ACQUISITION | Relationship with suppliers | 3.06 | You'd rather agree | You'd rather agree |
| EXPLOITATION | Ability to decide on outsourcing or own development | 3.06 | You'd rather agree | You'd rather agree |
| PROTECTION | Knowledge of secure procurement and development | 3.06 | You'd rather agree | You'd rather agree |
| SELECTION | Proficiency in developing a technology strategy | 3.03 | You'd rather agree | You'd rather agree |
| PROTECTION | Technological risks and dangerous knowledge | 3.03 | You'd rather agree | You'd rather agree |
| PROTECTION | Building effective protection | 3.03 | You'd rather agree | You'd rather agree |
| IDENTIFICATION | Having a vision | 2.97 | You'd rather agree | You'd rather agree |
| SELECTION | Knowledge of procurement sources | 2.94 | You'd rather agree | You'd rather agree |
| LEARNING | Ability to learn from projects | 2.88 | You'd rather agree | You'd rather agree |
| IDENTIFICATION | Threat assessment | 2.82 | You'd rather agree | You'd rather agree |
| EXPLOITATION | Organization of technological activities | 2.76 | You'd rather agree | You'd rather agree |
| EXPLOITATION | Exploitation of special strengths | 2.71 | You'd rather agree | You'd rather agree |
| EXPLOITATION | Existence of project processes (investment, development, procurement). | 2.56 | You'd rather agree | You'd rather agree |
| PROTECTION | Knowledge of intellectual property rights | 2.5 | You'd rather agree | Rather disagree |
| LEARNING | Existence of post-project evaluations | 2.44 | Rather disagree | Rather disagree |
| LEARNING | Existence of project evaluation systems | 2.29 | Rather disagree | Rather disagree |
| ACQUISITION | Use of external organizations in development | 2.24 | Rather disagree | Rather disagree |
| ACQUISITION | Encouraging investments | 1.94 | Rather disagree | Rather disagree |
| EXPLOITATION | Use of external organizations in the implementation of the strategy | 2.38 | Rather disagree | Strongly disagree |
| SELECTION | Using external organizations to evaluate the technology | 2.09 | Rather disagree | Strongly disagree |
| ACQUISITION | Cooperation in development with universities and research institutes | 1.21 | Strongly disagree | Strongly disagree |

| Technology management function | Variable | Average | Typical expert opinion | Most common expert opinion |
|---|---|---|---|---|
| ACQUISITION | Cooperation in development with government institutions | 1.21 | Strongly disagree | Strongly disagree |

*Source: own compilation*

In the case of five variables, it can be established that the most frequent evaluation is the "strongly agree" option expressing the highest level of agreement. The variables refer to the strengths of the companies according to expert opinions. These variables are Evaluation of Opportunities, Knowledge of Technology from the point of view of business activities, Technology's role in corporate and business strategy, Selection of Necessary Technologies and Knowledge of Priorities vis-à-vis Technology. Each of the variables is related to the IDENTIFICATION or SELECTION function. The expert assessment of "rather agree" occurred most often in the case of 14 variables, "rather disagree" in the case of 5 variables, and "strongly disagree" in the case of 4 variables. The last 4 variables include Cooperation in development with universities and research institutes, Cooperation in development with government institutions, the use of external organizations in the implementation of the strategy, and the use of external organizations for the evaluation of technology . The variables are related to the function ACQUISITION, EXPLOITATION and SELECTION, but at the same time, the possibility of cooperation was formulated in each variable. Their extremely low value leads to the conclusion that, according to the experts, these factors are not currently given priority regarding Cloud Computing in terms of the technology management activities of enterprises.

Looking at the functions, the highest average values and the most positive expert opinions are related to the IDENTIFICATION functions. This suggests that the identification of technological opportunities, the connection of technology to business activities, and the selection of the necessary technologies are key elements in technology management. Regarding the function of SELECTION, the integration of technology into the corporate strategy is also strongly supported, however, the involvement of external organizations in the evaluation of technology is less supported, which may indicate that companies rely more on internal resources. Regarding ACQUISITION, technological procurement and contact with suppliers seem important, but the involvement of external organizations and cooperation with universities is significantly undervalued. This suggests that the acquisition of technology is dominated by internal, corporate resources. In terms of EXPLOITATION, there is rather a medium level of agreement in terms of the utilization of z resources and the organization of project processes, which may indicate that these areas require development. Technological PROTECTION is an important feature, but it does not receive outstanding support. Knowledge of intellectual property rights was rated particularly low, which may be a concern for security aspects of technology management. Low values of the LEARNING function indicate that learning from projects and the existence of evaluation systems are less emphasized in technology management. This highlights the need to develop learning processes in the field of technology management.

Based on the analysis, it can be concluded that the different functions of technology management received different evaluations from the respondents. The IDENTIFICATION and SELECTION functions are of particular importance, while the involvement of external organizations is less prominent in the areas of ACQUISITION and EXPLOITATION. The development of the PROTECTION and LEARNING functions is especially necessary in order to increase the efficiency of technology management for businesses. The results suggest that companies should put more emphasis on external collaborations, protecting intellectual property rights and strengthening learning processes in the field of technology management. These developments can contribute to improving technological capabilities, thereby increasing competitiveness.

33. Table: General expert assessment of external environmental variables

| Technology management function | Variable | Average | Typical expert opinion | Most common expert opinion |
|---|---|---|---|---|
| ACQUISITION | Procurement quality in the SME sector | 2.35 | Rather disagree | Rather disagree |
| SELECTION | Technology strategy, technoportfolio in the SME sector | 2.35 | Rather disagree | Rather disagree |
| EXPLOITATION | Advantages of Cloud Computing in the SME sector | 2.32 | Rather disagree | Rather disagree |
| ACQUISITION | Government support for collaborations and procurement processes | 2.24 | Rather disagree | Rather disagree |
| EXPLOITATION | Government support for the exploitation of digital technologies | 2.15 | Rather disagree | Rather disagree |
| LEARNING | Review of developments in the SME sector | 2.12 | Rather disagree | Rather disagree |
| LEARNING | Measuring the performance of enterprises at the government level | 2.09 | Rather disagree | Rather disagree |
| IDENTIFICATION | Identification of opportunities and threats in the SME sector | 1.97 | Rather disagree | Rather disagree |
| IDENTIFICATION | Government support for identifying opportunities and threats | 1.97 | Rather disagree | Rather disagree |
| PROTECTION | Knowledge of intellectual property protection in the SME sector | 1.94 | Rather disagree | Rather disagree |
| PROTECTION | Government support for technology protection | 1.85 | Rather disagree | Rather disagree |
| SELECTION | Awareness and quality of government policy priorities | 1.79 | Rather disagree | Rather disagree |

*Source: own compilation*

Table 33 contains the results of external environmental, i.e. technology management functions belonging to the SME sector and the national economy, as well as the results of expert opinions on the variables associated with them. The purpose of the analysis is to reveal the areas where the experts show strong support, and those where they disagree less with the statements made, thus enabling the determination of the opportunities, driving forces and dangers and barriers affecting the enterprises in terms of technology management readiness of the external environmental levels.

Based on the table, for all variables, "rather disagree" is the most common opinion. This shows that regarding the external environment, the opinions of the experts are much more balanced, and the answers are much more uniform, so in the case of the external environment, we can find a higher level of expert agreement. The variables with the lowest ratings are for SELECTION (awareness and quality of government policy priorities), PROTECTION (Knowledge of intellectual property protection in the SME sector, government support for technology protection) and for the IDENTIFICATION function (Identification of opportunities and threats in the SME sector, Opportunities, government support for hazard identification) are related. The variables with higher ratings are related to ACQUISITION (Quality of procurement in the SME sector), SELECTION (Technology strategy, technoportfolio in the SME sector) and EXPLOITATION (Advantages of Cloud Computing in the SME sector). It is spectacular that the variables related to the SME sector were generally rated better by the experts, the first three variables receiving the highest evaluation are all related to the environmental level of the SME sector. Based on the analysis, in terms of Cloud Computing, the technology management functions related to the external environment are mostly in need of development. Experts generally have a negative assessment of the development of the technological strategy, the use of innovation opportunities, and the effectiveness of government support. In particular, there are weaknesses in the field of technological protection, protection of intellectual property and government policy priorities, which can hinder the increase of technology management preparedness of small and medium-sized enterprises, and thus their competitiveness.

It can be concluded that the expert evaluation of the external environmental variables shows a much more uniform picture compared to the variables of the internal environment, but the external environmental variables were rated worse overall by the experts. It follows from this that, in terms of technology management capabilities, the experts see the preparedness of enterprises in a more differentiated way, but at the same time, they see the external effects of the SME sector and the level of the national economy, as well as the development of technology management, as being of a lower standard.

Previously, the variables were presented based on the most typical and most frequent expert opinions, in connection with which technology management function the variables are related to. The purpose of further descriptive statistical analyzes – at the level of variables – is to rank and classify the variables in terms of expert consensus. The expert agreement expresses that the respondents marked one of the answers "rather agree" or "strongly agree" in relation to the given variable, so they expressed their agreement and positive opinion regarding the development of the variable covering the given technology management ability. Examining the rate of agreement gives a more accurate picture of the distribution of the variables (since it does not start from the nominal values of the variables, the frequency of occurrence of positive answers), and enables the use of more sensitive grouping and classification methods. To group the variables, I used the principle of frequency analysis according to classes or intervals, the intervals I defined were determined based on the 20 percent segments of the population (which in this case are the variables). As a result, I divided the variables into five intervals and, in order to make the results easier to interpret, I named each interval as shown in Table 34. Below, I describe the results of the agreement rate of the variables related to each internal and external environmental level, as well as the results of the frequency analysis according to the classes.

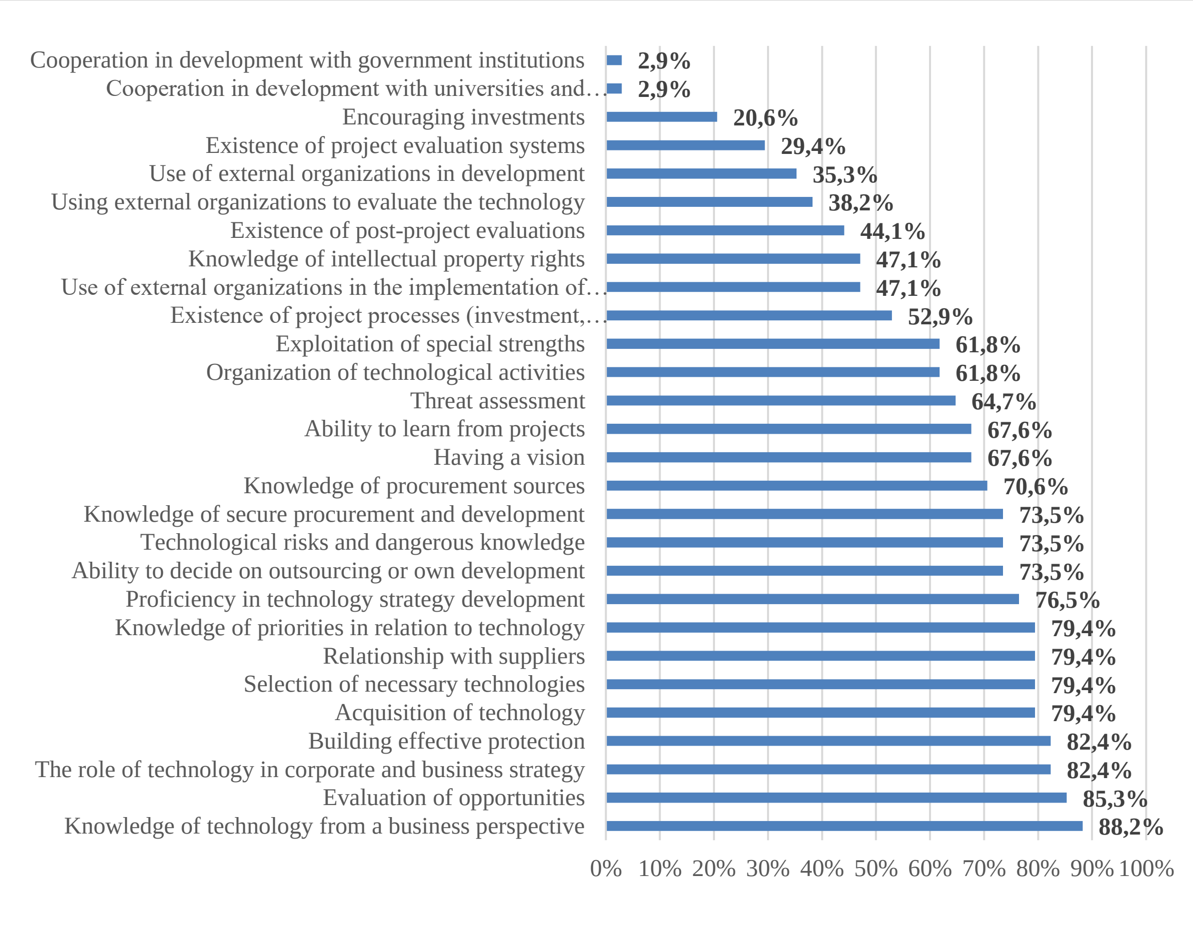
34. Table: Intervals and names of frequency analysis according to classes

| **Interval** | **Interpretation** | **Element number for internal variables** | **Element number for external variables** |
|---|---|---|---|
| from 0 to 19 percent | It is an area to be strongly developed | 2 | 3 |
| up to 20-39 percent | Area to be developed | 4 | 6 |
| up to 40-59 percent | Area requiring attention | 4 | 3 |
| up to 60-79 percent | Supporting area | 14 | 0 |
| Up to 80-100 percent | Strongly supportive area | 4 | 0 |

*Source: own compilation*

Figure 23 shows the distribution of expert opinions expressing agreement on the internal variables belonging to technology management functions. The percentage values for each variable express the extent to which the expert respondents agreed with the statement in the given variable. A high percentage value indicates an advanced, typical technological capability, a lower percentage value indicates an underdeveloped or non-existent technological capability. The variables are analyzed based on each interval.

23. Figure: The proportion of expert agreement with regard to the internal environmental variables




*Source: own compilation*

The figure shows that two variables belong to the category of strongly developed area, both with a 2.9 percent agreement rate. These variables identify critical areas where businesses have serious deficiencies. Collaboration with government institutions and universities in development areas is extremely low, indicating that these capabilities are virtually non-existent. These areas require immediate development in order to increase the technology management readiness of enterprises. Four variables belong to the area to be developed category. The relatively low rate of agreement (20.6 percent) characterizing investment incentives indicates that, based on expert opinions, enterprises encounter very little incentive from the government, which hardly affects the willingness of enterprises to invest. The existence of project evaluation systems (29.4 percent) is also weak, which means that, according to experts, businesses typically do not have well-developed mechanisms in this area. According to the experts, the involvement of external organizations in developments (35.3 percent agreement rate) and in the evaluation of technology (38.2 percent agreement rate) is also not typical of domestic enterprises.

Four variables belong to the category of areas requiring attention. Post-project evaluations (44.1 percent), knowledge of intellectual property law (47.1 percent) and the involvement of external organizations in strategic implementation (47.1 percent) are areas that the majority of experts do not consider to be a strong capability of businesses considering.

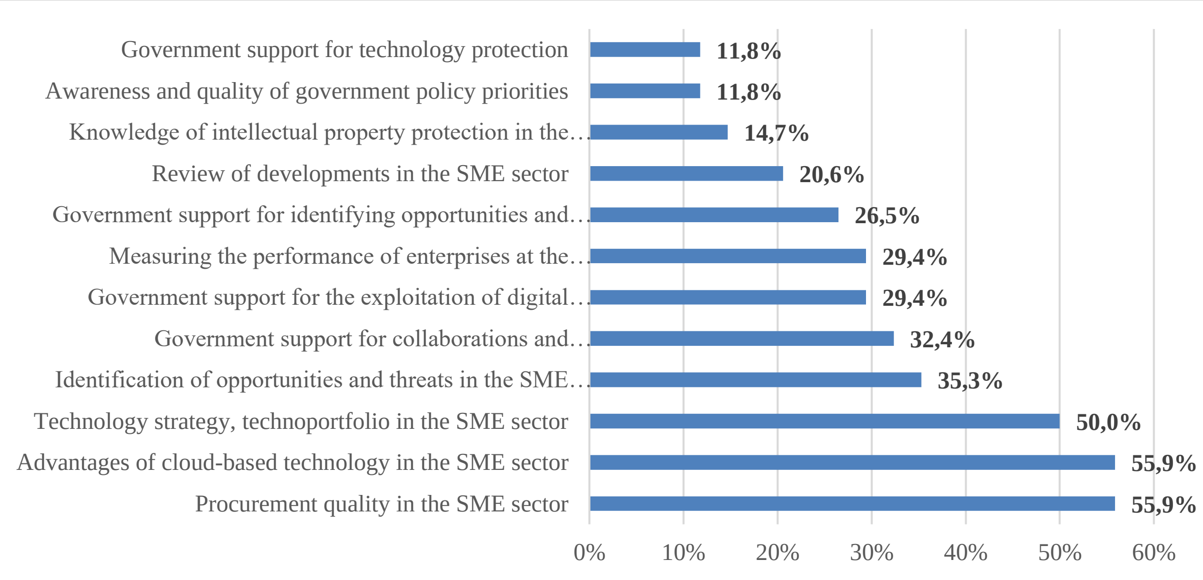
The existence of project processes (52.9 percent) was evaluated positively and in agreement by a very narrow majority. Enterprises must pay special attention to these areas, so that the strengths and support capabilities of enterprises develop from the capabilities indicated by the variables. If companies do not pay enough attention to these areas, the deterioration of the capabilities indicated by the variables can have a negative impact on the technology management preparedness of the companies.

The support area category has the largest number of elements, fourteen variables are found in this interval. These variables indicate that, according to the experts, enterprises in this field have advanced, well-functioning capabilities that can be developed, but can be built upon. The use of special strengths and the organization of technological activities (both characterized by 61.8 percent agreement) show that the organization is able to use its existing resources and has well-functioning processes in terms of Cloud Computing. The ability to learn from projects (67.6 percent) should be emphasized based on expert opinions. The supporting area includes several variables affecting technological strategy, including assessment of threats (64.7 percent), knowledge of technological risks and dangers (73.5 percent), existence of a vision (67.6 percent) and technological strategy proficiency in its design (76.5). Capabilities related to the procurement and development of Cloud Computing can also be classified in the supporting area, the variables are characterized by an agreement rate of between 70-80 percent. This includes knowledge of priorities in relation to technology (79.4 percent), selection of necessary technologies (79.4 percent), ability to decide on outsourcing or own development (73.5 percent), knowledge of procurement sources (70.6 percent). , the acquisition of technology (79.4), the relationship with suppliers (79.4 percent) and the knowledge of safe procurement and development (73.5).

Businesses can seriously base themselves on the variables related to the strongly supporting area, these variables are responsible for the technology management preparedness of the businesses, the technological capabilities related to these variables represent the most important strengths of the businesses and the basis of their technology management activities. Based on expert opinions, four variables belong to the category of strongly supporting areas, the proportion of responses expressing agreement with them is between 80-90 percent. The role of technology in corporate and business strategy (82.4 percent) and knowledge of technology from the point of view of business activity (88.2 percent) indicate strong strategic technology management skills. The construction of effective defense (82.4 percent) characterizes the ability to defend, while the evaluation of opportunities (85.3 percent) characterizes the ability to examine and know the external environment.

Figure 24 shows the distribution of expert opinions expressing agreement on external variables belonging to technology management functions. The percentage values for each variable express the extent to which the expert respondents agreed with the statement in the given variable. A high percentage value refers to a typical, relevant external influence, a lower percentage value indicates a non-typical or non-existent, thus negatively affecting, inhibiting external influence. The variables are analyzed based on each interval.

24. Figure: The proportion of expert agreement with regard to external environmental variables




*Source: own compilation*

Three variables have been included in the category of the area to be developed strongly, these are the areas where the external environmental impact, based on expert opinions, is very little relevant, almost non-existent. These areas indicate the inhibiting factors of the external environment, since these variables do not sufficiently support the technology management activities of enterprises. The evaluations given to the variables government support for technology protection (11.8 percent), awareness and quality of government policy priorities (11.8 percent) and knowledge of intellectual property protection in the SME sector (14.7 percent) show that the experts these factors are not considered typical for Cloud Computing. In this case, the term strongly developed mainly refers to external environmental participants, enterprises can only influence these variables with their own limited resources. It should be noted that both claims related to PROTECTION and related to the external environment were placed in the strongly improved category.

Six variables were included in the category of the area to be developed. Two statements each belonging to the technology management function LEARNING with and IDENTIFICATION fell into this category based on expert evaluations. Taking into account that this interval groups variables with an agreement rate between 20 and 40 percent (in other words, disagreement), this is not very encouraging for businesses regarding the interpretation of these two functions in an external environmental context. The external environmental influences affecting the LEARNING function of enterprises are characterized by an agreement rate of less than 30 percent, the review of developments in the SME sector (20.6 percent), the measurement of the performance of enterprises at the government level (29.4 percent) is essentially absent, according to the experts, as supporting effect. The identification of opportunities and threats in the SME sector (35.3) and government support for this (26.5 percent) were also rated low, but it is striking that the experts evaluated this as an even more relevant and present effect in the SME sector, as far as the supporting power of the government was assessed. Regarding government support, the variables exploitation of digital technologies (29.4 percent) and cooperation and procurement processes (32.4 percent) also require strong development at the government level, based on expert opinions. In the case of external environmental variables, the category with the highest agreement is the area requiring attention, which also means that, based on expert opinions, the SME sector or the "part" of the national economy cannot be identified as a supportive or strongly supportive area of cloud-based enterprises in terms of technology management activities involving technology. From this we can draw the conclusion that if we look at the logic of the SWOT analysis in relation to the research question Q3, we can identify relative factors at most in relation to the opportunities (i.e. regarding the positive, supportive external environmental elements), because the agreement rate of expert opinions is one of the variables did not reach 60 percent, so the three variables described below are only relevant according to a narrow majority of the experts, typical of the SME sector and the national economy. All the variables belonging to the area requiring attention characterize the SME sector, so they appear as positive influencing factors coming from the sector. This includes the technology strategy and technology portfolio in the SME sector (50 percent), the advantages of Cloud Computing in the SME sector (55.9 percent), and the quality of procurement in the SME sector (55.9 percent). The agreement rate of 55.9 percent for the latter two variables is even more alarming in light of how the experts evaluated the same areas in relation to businesses. Based on the results described above, it can be concluded that the experts evaluated these abilities as a typical strength (classified as a supporting or strongly supporting area) for the enterprises. Compared to this, in relation to the SME sector, only 55 .9 percent "rather agree" or "strongly agree" responses were received.

With regard to my research question Q3, i.e. the examination of internal capabilities, strengths and weaknesses, as well as external environmental driving forces and barriers, regarding the application of Cloud Computing, we can make the following important findings.

- I examined the variables formed from the statements in the expert questionnaire survey with descriptive statistical analyses.
- Applying the methodology of Hobday's (2002) ability level analysis, enterprises are characterized by the strategic ability level, the SME sector by the reactive ability level, and the national economy also by the reactive ability level, with the fact that the national economic level is extremely close to the strategic ability level based on the answers.
- The average of internal environmental variables was between 1.21-3.35, for external environmental variables it was 1.79-2.35. In the case of ordinal quality variables (such as those included in the survey), the interpretation of the average is possible within a very narrow framework, but the above values clearly show that the statements related to the company level were evaluated by the experts on a much wider scale, while the external environmental variables were evaluated with a narrower margin. but with worse values. With regard to the external environmental variables, it is typical that the variables related to the SME sector were typically evaluated more by the respondents than those related to the

national economy, so the experts commented somewhat more positively on the effects of the SME sector at the level of the variables, taking into account their evaluation.

- Examining the percentages of agreement given to the variables (i.e. the totality of the "rather agree" or "strongly agree" answers) gives a more accurate picture of the evaluation of the variables. The result of the ranking according to the agreement rate was performed using the frequency analysis according to the classes. Looking at the categories I created based on the method, 18 of the 28 variables affecting businesses are related to the supporting area or the strongly supporting area, while in the case of the external environmental variables, we did not find any variable that received such an evaluation, the highest category is the area requiring attention.
- In terms of weaknesses and inhibiting factors, variables related to cooperation, the involvement of external participants, and the protection of technology can be identified at both environmental levels. At the company level, in terms of strengths, typical, advanced capabilities, variables with a strategic focus and procurement related appeared. Regarding the external environmental effects, positive, supporting factors can be interpreted relative at best, although the highest expert agreement also appeared regarding procurement and the benefits of Cloud Computing, but the level of expert agreement is very unconvincing. Overall, it can be clearly stated that the expert opinions evaluated the statements related to enterprises more positively than the statements concerning the SME sector and the national economy, so in terms of Cloud Computing, they see the technological management preparedness of enterprises as relatively better than the relevance of the external environmental influences influencing it. and its positive influencing power.

### 6.2.2 Characterization of technology management functions

The second part of the quantitative research deals with the investigation of the functions included in the survey, it is aimed at exploring the relationships and correlations between them. In this chapter, I am looking for answers to what characterizes the individual technology management functions of domestic small and medium-sized enterprises in terms of the application of Cloud Computing (Q4). In this chapter, I describe the results of three analyses, the differences between the functions, the similarities between the functions and the network analysis of the functions. The results of the individual analyzes are interpreted based on the environmental levels included in the survey.

The differences between the functions were examined with the Friedman test. Based on the statistical test, the results of the comparative analysis of the individual functions can be summarized below.

- In the case of the IDENTIFICATION function ($\chi^2(2)=31.3$, $p<0.001$), the chi-square value is very high (31.3) and the p-value is significantly less than 0.001.

This means that there are significant differences between the environmental levels in terms of function.

- In the case of the SELECTION function ($\chi^2(2)=30.6$, $p<0.001$) the chi-square value is also high, the p-value here is also significantly lower than 0.001. Based on these, there are significantly significant differences between the environmental levels regarding the function.
- In the case of the ACQUISITION function ($\chi^2(2)=0.149$, $p=0.928$), the chi-square value is very low and the p-value is well above the usual significance level of 0.05. Regarding the function, there is therefore no significant difference between the environmental levels, the evaluation of the function at each level can most likely be said to be similar.
- In the case of the EXPLOITATION function ($\chi^2(2)=6.77$, $p=0.034$), the value of the chi-square can be said to be moderate, but the p-value is significant, although only slightly lower than the significance level of 0.05. This means that in terms of the EXPLOITATION function, there is a significant difference between the environmental levels, but the differences are not statistically significant.
- In the case of the PROTECTION function ($\chi^2(2)=38.5$, $p<0.001$), the chi-square is very high and the p-value is significantly lower than 0.001. This suggests that there are significant differences between the environmental levels.
- In the case of the LEARNING function ($\chi^2(2)=8.33$, $p=0.016$), the chi-square value is medium, and the ap value is significantly lower than 0.05. This indicates that there are significant differences between the environmental levels, but at the same time the differences are not statistically significant.

35. Table: Results of the Friedman test

| | | **SME sector** | | **National economy** | |
|---|---|---|---|---|---|
| | | **Statistics** | **p** | **Statistics** | **p** |
| **Enterprise level** | IDENTIFICATION | **5.41** | **<0.001** | **7.21** | **<0.001** |
| | SELECTION | **3.81** | **<0.001** | **7.35** | **<0.001** |
| | ACQUISITION | 0.19 | 0.85 | 0.19 | 0.85 |
| | EXPLOITATION | 1.14 | 0.257 | **2.69** | **0.009** |
| | PROTECTION | **7,885** | **<0.001** | **8,178** | **<0.001** |
| | LEARNING | **2,552** | **0.013** | **2,698** | **0.009** |
| **Nation economy** | IDENTIFICATION | 1.8 | 0.076 | | |
| | SELECTION | **3.55** | **<0.001** | | |
| | ACQUISITION | 0.38 | 0.705 | | |
| | EXPLOITATION | 1.55 | 0.126 | | |
| | PROTECTION | 0.292 | 0.771 | | |
| | LEARNING | 0.146 | 0.884 | | |

*Source: own compilation*

The results of the Friedman test regarding the comparative analysis of individual functions can be found in Table 35. The table highlights where statistically significant differences are found during the analysis of the differences in functions belonging to different environmental levels.

At the company level, apart from the function of ACQUISITION, all functions differ significantly from the same function of the SME sector and the national economy, only in the case of the EXPLOITATION function, the difference between the environmental levels is different, in this case the function related to the company level and the national economy is significantly different differs, but there is no sign of a significant difference in relation to the SME sector. This means that what I referred to during the previous investigations was also statistically proven, according to the expert evaluations, the corporate sector was evaluated in a significantly different way than the functions related to the external environmental levels. The direction and content of the deviation can be answered by comparing the differences between group averages and group medians. The difference between internal and external levels cannot be demonstrated only in relation to the function of ACQUISITION.

Examining the difference between the functions related to the external environmental levels, we can no longer see such differences based on expert evaluations. A significant difference exists only in the case of the SELECTION function. Due to the fact that in this case the functions essentially represent the specific variables, since the external environmental technology management functions were assessed with one statement per level, we can interpret the meaning of the difference concretely. Based on expert opinions, there is a significant difference between the development of the technological strategy and technoportfolio in the SME sector and the awareness of government policies and priorities. We can also examine the content of the deviation by comparing the group average and the group median. Table 36 contains the group averages and the group median for the company level and the external environment level.

The reasons for the significant differences indicated by the Friedman test are easy to see. In all cases, the group median of the company-level functions exceeds the medians of the external environment functions, the differences (for example, IDENTIFICATION, SELECTION and EXPLOITATION) are very significant in the case of some functions, especially if we take into account that the evaluations were made on a four-point scale. The group averages can provide additional information regarding the differences, not surprisingly, the group average and group median of all functions except for ACQUISITION are higher at the company level than at the external environment levels. In the case of ACQUISITION, although the difference is not statistically significant, the group average of the company level remains below the average of the SME sector and the function belonging to the national economy level.

There is only one significant difference between the functions of the SME sector and the national economic level, concerning the function of SELECTION. In this case, the group average can be a suitable explanation for the content of the difference, all the more so because the median of the functions is the same. On average, the function related to the SME sector received a much higher evaluation, so in relation to the SME sector, in terms of Cloud Computing, the experts rated the existence of a technology strategy and technoportfolio as significantly more characteristic and better than the familiarity and importance of policy priorities related to the government.

36. Table: Group mean and group median of the functions

| | Function | Average | Median |
|---|---|---|---|
| **Enterprise level** | IDENTIFICATION | 3.14 | 3.40 |
| | SELECTION | 2.91 | 2.80 |
| | ACQUISITION | 2.13 | 2.08 |
| | EXPLOITATION | 2.69 | 2.80 |
| | PROTECTION | 2.90 | 2.75 |
| | LEARNING | 2.54 | 2.33 |
| **SME sector** | IDENTIFICATION | 2.35 | 2.00 |
| | SELECTION | 2.35 | 2.00 |
| | ACQUISITION | 2.35 | 2.00 |
| | EXPLOITATION | 2.32 | 2.00 |
| | PROTECTION | 1.94 | 2.00 |
| | LEARNING | 2.12 | 2.00 |
| **Nation economy** | IDENTIFICATION | 1.97 | 2.00 |
| | SELECTION | 1.79 | 2.00 |
| | ACQUISITION | 2.24 | 2.00 |
| | EXPLOITATION | 2.15 | 2.00 |
| | PROTECTION | 1.85 | 2.00 |
| | LEARNING | 2.09 | 2.00 |

*Source: own compilation*

I examined the correlations and correlations between technology management functions using the Spearman rank correlation coefficient.

37. Table: Spearman's rank correlation of corporate functions

| | | | **Enterprise level** | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | **IDENTIFICATION** | **SELECTION** | **ACQUISITION** | **KIAK MARRIAGE** | **PROTECTION** | **LEARNING** |
| **Enterprise level** | **IDENTIFICATION** | rho | | | | | | |
| | | p | | | | | | |
| | **SELECTION** | rho | **0.730** | | | | | |
| | | p | **<0.001** | | | | | |
| | **ACQUISITION** | rho | | | | | | |
| | | p | | | | | | |
| | **EXPLOITATION** | rho | **0.634** | **0.690** | 0.390 | | | |
| | | p | **<0.001** | **<0.001** | 0.023 | | | |
| | **PROTECTION** | rho | **0.609** | **0.531** | 0.369 | **0.536** | | |
| | | p | **<0.001** | **0.001** | 0.032 | **0.001** | | |
| | **LEARNING** | rho | 0.438 | 0.393 | 0.409 | 0.417 | **0.568** | |
| | | p | 0.010 | 0.022 | 0.016 | 0.014 | **<0.001** | |
| **SME sector** | **SELECTION** | rho | | 0.359 | **0.532** | 0.355 | | 0.362 |
| | | p | | 0.037 | **0.001** | 0.039 | | 0.035 |
| | **LEARNING** | rho | | | | | | 0.371 |
| | | p | | | | | | 0.031 |

*Source: own compilation*

I calculated the correlation analysis for all functions (i.e. 18 pieces), defining significance levels of 0.001, 0.01 and 0.05. Table 37 contains demonstrable and therefore significant correlations related to the company level. In my analysis, I focus on the presentation of extremely significant ($p<0.001$ or $p=0.001$) correlations. In addition to the significance value, the interpretation of the results is supported by Spearman's rho, whose value can be between -1 and 1 and indicates the direction and strength of the correlation.

Among the functions of the company level, taking into account my rather strict expectation regarding the level of significance, a correlation between seven functions can be observed. Considering their strength, the closest correlation is between IDENTIFICATION and SELECTION (rho=0.730), the positive relationship indicates that, based on expert opinions, the more advanced IDENTIFICATION function of enterprises is closely correlated with the development of the SELECTION function. A lower but still very strong positive relationship can be observed between SELECTION and EXPLOITATION (rho=0.690), IDENTIFICATION and EXPLOITATION (rho=0.634), IDENTIFICATION and PROTECTION (rho=0.609), PROTECTION and LEARNING (rho=0.568 ) and for the functions EXPLOITATION and PROTECTION (rho=0.536), SELECTION and PROTECTION (rho=0.531). Regarding the practical significance of the results, it can be concluded that the development of the IDENTIFICATION and PROTECTION functions strongly correlates (with the exception of ACQUISITION) with the development of the other functions, so the development of this function (or the technological capabilities that make up the function) can have a positive effect on the development of the other functions and on the other hand. A strong positive correlation can also be seen between SELECTION and EXPLOITATION. In terms of the content of the function, the correlations show that the strategically focused technology management capabilities of enterprises (knowledge of Cloud Computing, assessment of necessary technologies, knowledge of the external environment, vision) and defense-related technological capabilities (assessment of risks and dangers, construction of effective protection , safe procurement, knowledge of intellectual property rights) according to the experts, are strongly correlated with the development of the other functions. The positive relationship between SELECTION and EXPLOITATION perhaps needs less explanation in terms of Cloud Computing, it shows that knowledge of technology procurement sources, technology strategy and knowledge of priorities towards technology go hand in hand with the organization of technological activities, the existence of project processes, by taking advantage of special strengths. Looking at the external environmental levels, there is a strong significant relationship between the SELECTION related to the company level and the ACQUISITION function of the SME sector (rho=0.532). The evaluation of the quality of procurement by the experts in the SME sector therefore correlates positively with the capabilities of the enterprises concerning the SELECTION function.

The correlations between the functions of the SME sector and the correlations between the SME sector and the national economy (considering the p<005 significance level in both cases) are contained in Table 38. In the case of examining the correlations between the functions typical of the SME sector, I relaxed my "expectations" regarding the significance level and in the following I will describe the correlations corresponding to the p<0.01 significance level.

38. Table: Spearman's rank correlation of the functions of the SME sector

| | | | SME sector | | | |
|---|---|---|---|---|---|---|
| | | | **IDENTI-FICATION** | **SELEC-TION** | **ACQUISI-TION** | **PROTEC-TION** |
| **SME sector** | **IDENTIFICATION** | rho | | | | |
| | | p | | | | |
| | **SELECTION** | rho | 0.384 | | | |
| | | p | 0.025 | | | |
| | **ACQUISITION** | rho | **0.482** | **0.575** | | |
| | | p | **0.004** | **<0.001** | | |
| | **PROTECTION** | rho | | 0.418 | | |
| | | p | | 0.014 | | |
| | **LEARNING** | rho | **0.515** | **0.467** | | **0.534** |
| | | p | **0.002** | **0.005** | | **0.001** |
| **Nation economy** | **IDENTIFICATION** | rho | | | **-0.454** | -0.360 |
| | | p | | | **0.007** | 0.037 |
| | **EXPLOITATION** | rho | | | -0.378 | |
| | | p | | | 0.027 | |

*Source: own compilation*

A correlation between the functions typical of the SME sector (less significant than the relations described at the company level, but still significant) can be identified concerning five relations. Positive relationships of approximately the same strength A strong positive relationship can be observed between the LEARNING function and IDENTIFICATION (rho=0.515), SELECTION (rho=0.467) and PROTECTION (rho=0.534). This means that the review and evaluation of developments affecting the SME sector can have a supportive effect on the knowledge of opportunities and threats, on the existence of technology strategy and technoportfolio and on the issue of intellectual property protection, of course the positive relationship between the former functions and LEARNING can be interpreted in the same way in terms of function. A further correlation can be observed between ACQUISITION and IDENTIFICATION (rho=0.004) and ACQUISITION and SELECTION (rho=0.575), so the quality of Cloud Computing procurement is positively correlated at the sector level with the identification of opportunities and threats and the existence of a technology strategic and technoportfolio. In one case, there is a correlation between functions related to the SME sector and the national economy corresponding to the specified significance level. A medium, opposite correlation can be observed between the ACQUISITION function of the SME sector and the IDENTIFICATION function of the national economy. This means that, based on expert opinions, the quality of Cloud Computing in the SME sector goes hand in hand with the level of government support for the assessment of opportunities and threats. This can be interpreted as the fact that while the experts assessed the quality of procurement in the SME sector as relatively advanced, they commented very negatively on government support, so based on the experts' opinion, there is a significant contrast between the quality of procurement processes typical of the sector and the government support for knowledge of the external environment there is a connection. Another opposite direction (although less significant) can be observed between ACQUISITION related to the SME sector and EXPLOITATION characteristic of the national economy, and PROTECTION related to the SME sector and IDENTIFICATION characteristic of the national economy. The negative correlation can be interpreted as the fact that the good quality of procurement processes in the SME sector is inversely correlated with the perceived weak government support of digital technologies, and the weak perception of intellectual property protection in the SME sector is inversely associated with the government influence supporting the recognition of opportunities and threats.

Table 39 contains demonstrable and therefore significant correlations related to the level of the national economy. In my analysis, I will focus on the joint presentation of extremely significant ($p<0.001$) correlations. The examination of the correlations between the functions of the national economy yielded rather one-sided results, as can be seen in the table, in the case of the relationship between all functions, a significant and strong positive correlation relationship can be observed.

39.Table: Spearman's rank correlation of the functions of the national economy

| | | | National economy | | | | |
|---|---|---|---|---|---|---|---|
| | | | **IDENTIFI-CATION** | **SELEC-TION** | **ACQUISI-TION** | **EXPLOIT-ATION** | **LEAR-NING** |
| **National economy** | **IDENTIFICATION** | rho | | | | | |
| | | p | | | | | |
| | **SELECTION** | rho | **0.785** | | | | |
| | | p | **<0.001** | | | | |
| | **ACQUISITION** | rho | **0.604** | **0.722** | | | |
| | | p | **<0.001** | **<0.001** | | | |
| | **EXPLOITATION** | rho | **0.726** | **0.643** | **0.700** | | |
| | | p | **<0.001** | **<0.001** | **<0.001** | | |
| | **PROTECTION** | rho | **0.558** | **0.617** | **0.616** | **0.853** | **0.740** |
| | | p | **<0.001** | **<0.001** | **<0.001** | **<0.001** | **<0.001** |
| | **LEARNING** | rho | **0.579** | **0.625** | **0.707** | **0.712** | |
| | | p | **<0.001** | **<0.001** | **<0.001** | **<0.001** | |

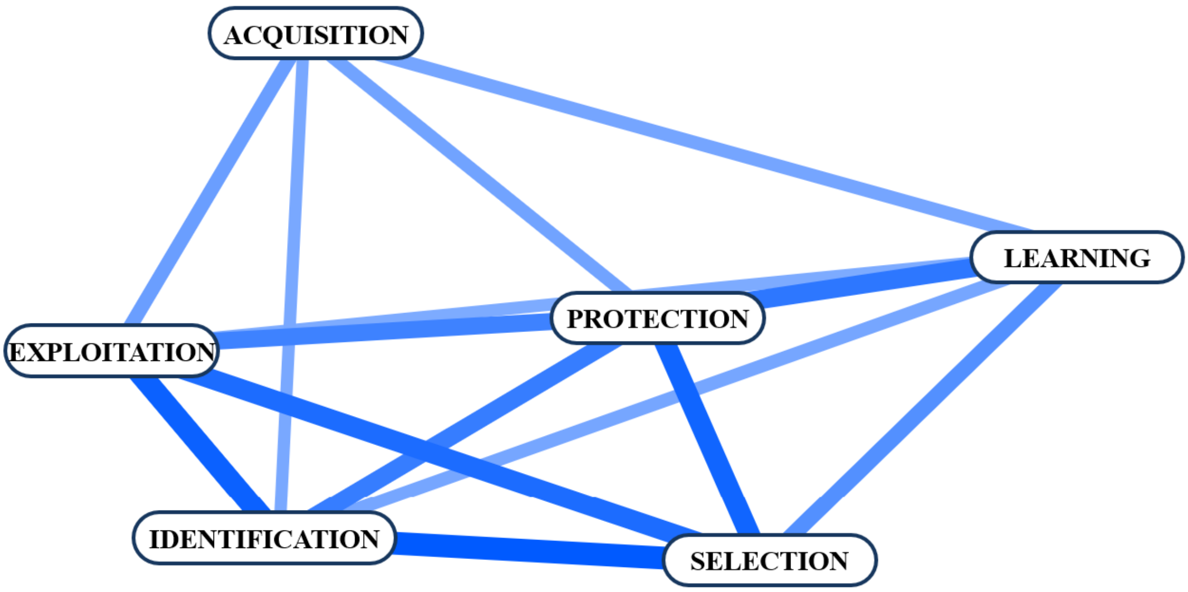
*Source: own compilation*

The results of the analysis show that at the level of the national economy, the relationships between technology management functions are extremely close and directly proportional to each other. This gives the impression of the expert evaluations that the statements related to the functions were typically assessed by the experts in the same way (positive or negative), so the responses are characterized by less differentiated opinions. In four cases, the functions referred to various cases of government support (identification of opportunities, threats, collaborations, procurement processes, exploitation of digital technologies, protection of technology), in addition, the awareness and quality of government policy priorities and the measurement of the performance of enterprises appeared at the government level. The fact that the result of the rank correlation test assumes a strong positive relationship between all factors, in addition to compliance with an extremely strict significance level, means that the experts evaluated the factors in the same way during their responses.

In order to explore patterns and relationships between technology management functions belonging to different environmental levels, a well-interpretable methodology with spectacular results was also applied. Examining the individual environmental levels separately, I used network analysis, also known as network analysis, in order to reveal the relationships between the functions, their strength and nature. With the help of the methodology, the relationships between the individual functions and their strength can be represented, the differences between the functions can be determined in terms of their centrality, and the significant relationships between the functions can be determined based on the results of the weight matrix.

Figure 25 contains the results of the network analysis of technology management functions at the company level. The figure was made with the network analysis module of the JASP statistical software and visualizes the relationships between the technology management functions. The strength and direction of the relationships between functions is indicated by the thickness and color of the lines, where thicker and darker lines represent a stronger relationship, while thinner and lighter lines represent a weaker relationship.

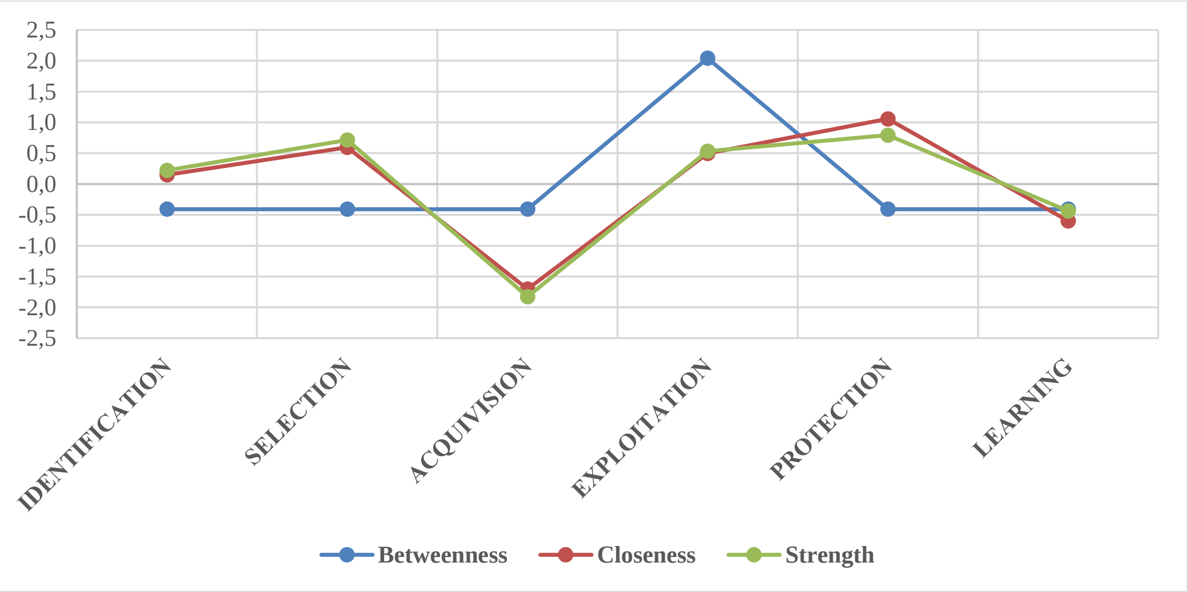
25. Figure: The result of the network analysis of the corporate technology management functions




*Source: own compilation*

We can also detect groupings based on the relationships between functions. There is an apparently stronger relationship between IDENTIFICATION, SELECTION, EXPLOITATION and PROTECTION, which suggests that these functions are more closely related and integrated with each other. The relationship between PROTECTION and LEARNING shows a strong relationship separate from the other functions. The ACQUISITION function is characterized by a weaker relationship with all other functions. In terms of the strength of the connections, the IDENTIFICATION function, in terms of the number of connections, the PROTECTION function seems to be the central element. The interpretation of the results in practice means that, based on expert opinions, connections and correlations of different strength and closeness can be observed between the technology management functions of enterprises. Strategically focused capabilities (external environment analysis, technology forecasting, technology base evaluation, identification of strategic opportunities) are closely related to the exploitation, selection, and protection of technology in terms of Cloud Computing. Defense capabilities (construction of defense, assessment of risks and dangers, issues concerning intellectual property rights) are mostly related to learning capabilities (learning processes, integration, existence of evaluation systems). The acquisition of technology, relations with suppliers, internal development processes and the creation of technological partnerships (ACQUISITION) have a weaker relationship with the other functions in terms of the application of Cloud Computing.

26. Figure: Centrality measures for company functions



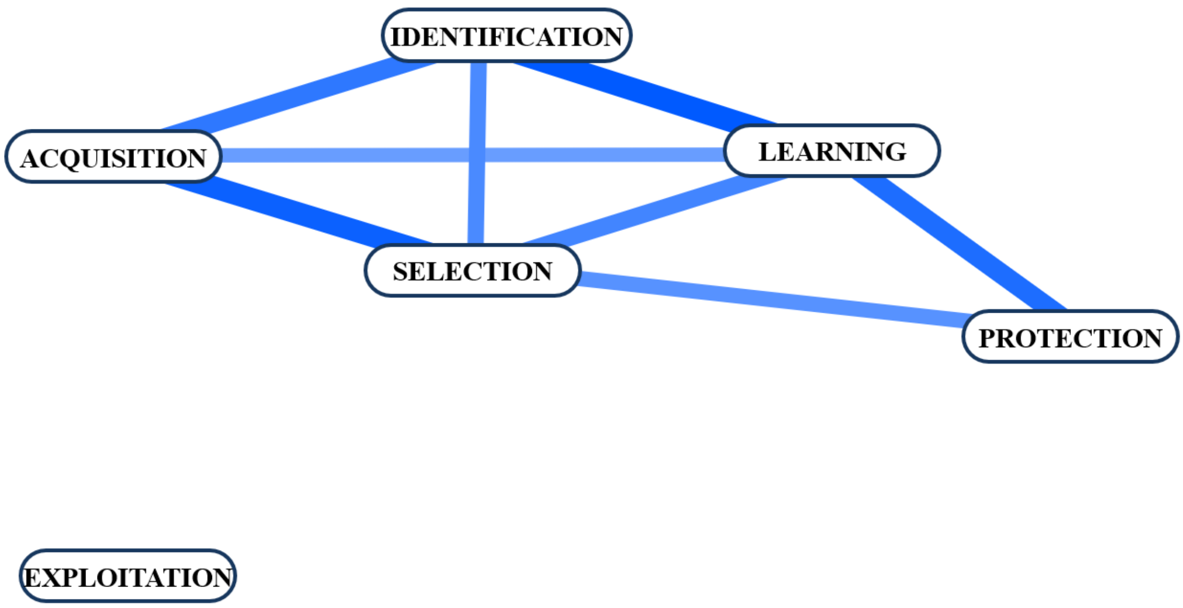

*Source: own compilation*

Figure 26 shows the centrality measures of the various functions of technology management. Centrality is a network analysis concept that measures the centrality of a given node (in this case, a technology management function) in the network. The figure shows three centrality measures, centrality, closeness and strength, which show from different perspectives how each function is connected to other elements of the network. The centrality metric shows how many direct connections a node (function) has with other nodes in the network, with a high value the function plays a central role and is directly connected to many other functions. Proximity centrality measures how far a node (function) is from other nodes in the network, a high value of proximity indicates that the function can reach other nodes quickly, i.e. the shortest path is short to other functions in the network. The strength centrality shows the extent to which a node (function) influences the other nodes of the network, this can be measured or characterized by the sum of the strength of the connection between the functions.

Based on the figure, the EXPLOITATION function shows the highest centrality, which indicates that the technological capabilities related to exploitation play a key role in the technology management preparedness of enterprises regarding Cloud Computing. Taking into account the centrality measures of closeness and strength, we can make the same conclusions. The proximity and strength centrality of IDENTIFICATION, SELECTION, EXPLOITATION and PROTECTION are the highest, which means that these functions can quickly reach other functions in the network, the functions have significant influence in the network, i.e. the connections related to them are strong and decisive in the regarding the technology management activities of enterprises involving Cloud Computing. The proximity and strength values of the Acquisition and LEARNING functions are lower compared to the other functions, they are less dominant in the network.

When interpreting the results of the weight matrix, I only try to describe strong and weak, non-existent relationships. The weight matrix examines the strength of significant connections between functions in a deeper dimension than the correlation, their weight in the network, the matrix shows the weights between nodes with a value between 0 and 1, where a higher value indicates a stronger connection, and 0 indicates a connection that cannot be detected significantly. The strongest relationships are IDENTIFICATION-SELECTION (0.71), IDENTIFICATION-EXPLOITATION (0.63), IDENTIFICATION-PROTECTION (0.67), SELECTION-EXPOLITATION (0.68), and SELECTION-PROTECTION (0.67). 56), this is naturally consistent with the picture shown in Fig. 24. Based on the results of the weight matrix, there is no significant relationship between IDENTIFICATION-ACQUISITION.

27. Figure: The result of the network analysis of the functions related to the SME sector

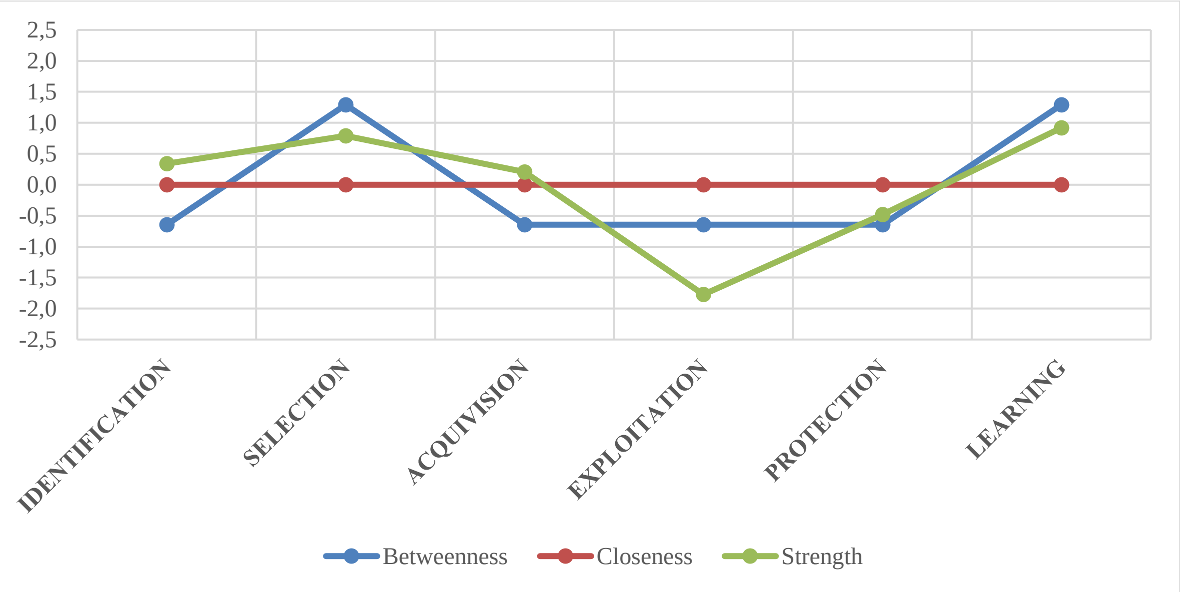



*Source: own compilation*

Figure 27 shows the results of the network analysis of functions related to the SME sector. The results are interpreted with the same logic and criteria as above. Regarding the technology management functions of the SME sector, the central functions are IDENTIFICATION, ACQUISITION, LEARNING and SELECTION, and mutual, strong and close relationships can be identified between them. The function of PROTECTION is –

similarly to the company level – strongly connected to the LEARNING function, but at the same time it is located at a greater distance from the others. The function of EXPLOIT is not related to the other functions. In this regard, we can draw the surprising practical conclusion that, based on expert opinions, the advantages of Cloud Computing in the SME sector are not related to the other technology management functions affecting the SME sector, and have no meaningful impact on them. Among the results of the network analysis, perhaps this is the most surprising and attention-demanding result, showing that, based on expert opinions, the advantages of technology do not significantly influence other technology management functions at the level of the SME sector.

28. Figure: Network analysis centrality metrics for functions related to the SME sector




*Source: own compilation*

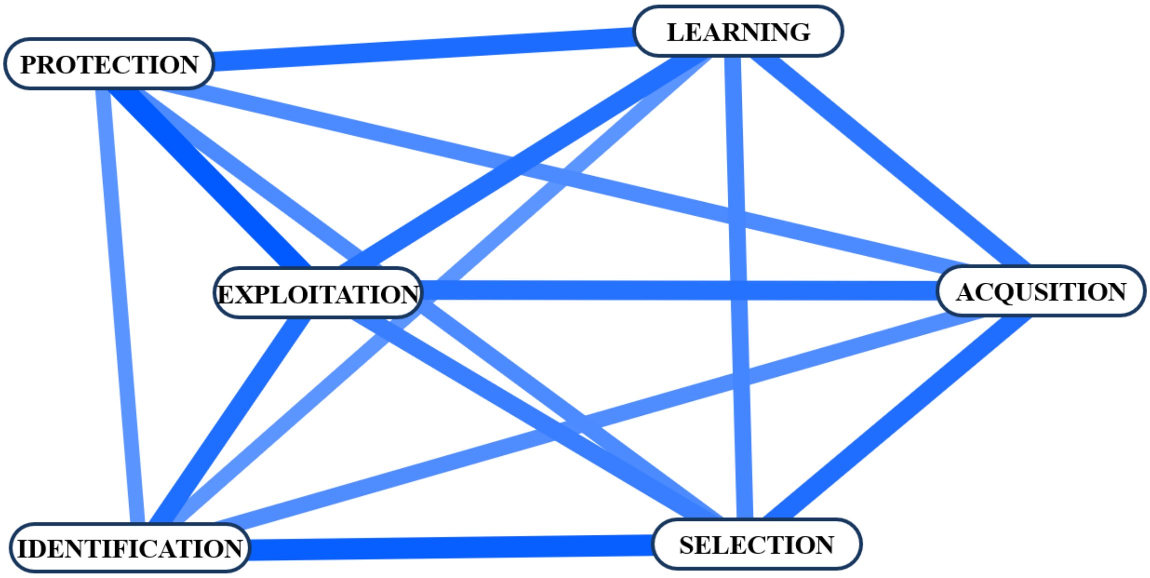
Looking at the centrality metrics (Figure 28), a different pattern emerges compared to the company level. From the point of view of centrality, the central role of SELECTION and LEARNING is spectacular, while the other functions play a less central role in the network. The proximity metric shows that the statistical analysis could not show significant differences in terms of the proximity of the nodes of the network, the functions are located at roughly the same distance from the rest of the network. In terms of strength, the functions of IDENTIFICATION, SELECTION, ACQUISITION, and LEARNING have a stronger effect on the network, while the function of EXPLOITATION has essentially no effect on the other functions.

Considering the results of the weight matrix, the strongest relationship is between IDENTIFICATION-LEARNING (0.577) and SELECTION-ACQUISITION (0.551). This means that among the technology management functions that characterize the SME sector, the closest and strongest relationships exist between the identification of opportunities and the review of developments, as well as the existence of a technology strategy, technoportfolio, and the quality of procurement. Based on the weight matrix, EXPLOITATION has no significant relationship with the other functions, and between IDENTIFICATION-

PROTECTION and ACQUISITON-PROTECTION, the value indicating the weight of the relationship is 0.

Figure 29 shows the results of the network analysis of the functions related to the national economy. Many, strong and close connections can be observed between its elements in the network. On the one hand, this refers to the integration of the technology management functions and the strength of the relationships between them, and on the other hand, it means results that are less interpretable from the point of view of research, because such close relationships between the elements of the network lead to the conclusion that this is due to the homogeneity of expert evaluations.

29. Figure: The result of the network analysis of the functions related to the national economic level

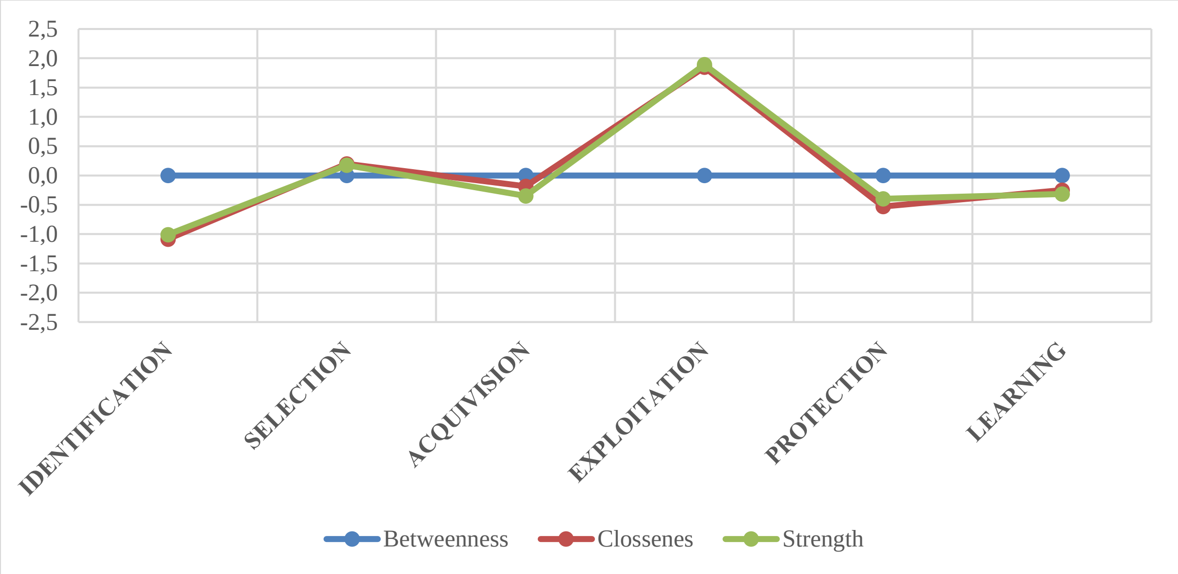



*Source: own compilation*

Based on the figure, essentially every function plays a central role in the network of technology management functions related to the national economy, and the functions form a strong and close relationship with each other. Only in the case of the ACQUISITION function can it be observed that it is located at a greater distance from the IDENTIFICATION, PROTECTION and EXPLOITATION functions, so the relationship between them is strong, but not so close.

The centrality metrics support the above, based on Figure 30. The functions related to the national economy can be characterized with exactly the same value based on the centrality metric. The proximity and strength values move roughly together. Based on these, EXPLOITATION clearly has a prominent role in the network, this function is easily accessible compared to the other functions of the network, in addition, it not only has a central role in the network, but considering its strength has a significant impact on the other functions. In practice, this means that government support for digital technologies is very closely related and strongly determines other technology management functions at the level of the national economy.

30. Figure: Network analysis centrality metrics for functions related to the national economy




*Source: own compilation*

Looking at the results of the weight matrix of the functions related to the national economy, all the connections between the functions can be highlighted, because a strong, significant connection can be identified between each function. For this reason, he summarized the results in a table, Table 40 contains the strength of the relationship between technology management functions at the level of the national economy. Based on the table, it can be concluded that EXPLOITATION has a stronger relationship with the other functions, and a stronger relationship is seen between SELECTION-IDENTIFICATION, SELECTION-ACQUISITION and DEFENSE-LEARNING. The limitations affecting the results of the network analysis of the functions related to the national economy, and my findings that shade the relevance of the results, can be read above.

40. Table: The weight matrix of the network analysis for the functions related to the national economy

| | SELECTION | ACQUISITION | EXPLOITATION | PROTECTION | LEARNING |
|---|---|---|---|---|---|
| IDENTIFICATION | 0.788 | 0.563 | 0.717 | 0.529 | 0.523 |
| SELECTION | 0 | 0.714 | 0.634 | 0.57 | 0.595 |
| ACQUISITION | | 0 | 0.694 | 0.575 | 0.675 |
| EXPLOITATION | | | 0 | 0.814 | 0.707 |
| PROTECTION | | | | 0 | 0.726 |
| LEARNING | | | | | 0 |

*Source: own compilation*

Q4 (What characterizes the individual technology management functions of domestic small and medium-sized enterprises in terms of the application of Cloud Computing?) in the main findings below.

- I examined my research question concerning the functions of technology management with statistical analyzes that reveal patterns and analyze network connections.
- I examined the difference of technology management functions between environmental levels using Friedman's test. With the exception of ACQUISITION, all functions differ significantly in terms of environmental levels regarding Cloud Computing, the results of the statistical analysis showed slightly smaller differences in the case of EXPLOITATION and LEARNING functions.
- The assessment of the technology management functions of enterprises differs significantly in terms of the same functions of the SME sector and the national economy, with the exception of the function of ACQUISITION and EXPLOITATION based on the comparison with the SME sector. The technology management functions affecting the SME sector do not differ significantly from the functions of the national economy level, the only exception being the SELECTION function. According to this, the technology strategy in the SME sector was rated significantly better by the experts than the awareness of government policy priorities.
- In order to examine the association and correlation between the technology management functions, I conducted a Spearman rank correlation test. At the enterprise level, the IDENTIFICATION function is positively correlated with the SELECTION, EXPLOITATION, PROTECTION, and LEARNING functions. The function of PROTECTION is also positively correlated with the functions SELECTION, EXPLOITATION, and LEARNING, and a significant positive correlation can be observed between the functions EXPLOITATION and LEARNING. The technology management functions of the enterprises do not show a correlation with the functions related to the national economy, looking at the functions of the SME sector, a significant positive relationship can be observed between the SELECTION function of the enterprises and the ACQUISITION.
- Among the technology management functions that characterize the SME sector, the LEARNING function has a significantly positive correlation with the IDENTIFICATION, SELECTION and PROTECTION functions. In addition, ACQUISITION correlates with IDENTIFICATION and SELECTION. Among the technology management functions related to the national economic level, all functions have a significant correlation with each other. This allows us to conclude that the functions were evaluated by the individual respondents in an extremely homogeneous and identical manner.
- In order to explore the relationships between technology management functions more deeply, I used network analysis, also known as network analysis. The statistical methodology helps to reveal deeper relationships between the functions, the weight of the relationships gives deeper information than the results of the correlation analysis. At the enterprise level, the EXPLOITATION function plays a

central role, while IDENTIFICATION, SELECTION, EXPLOITATION, and PROTECTION are highly important elements in the network in terms of proximity and strength. The strongest, closest relationships can be identified between IDENTIFICATION and SELECTION, EXPLOITATION and PROTECTION, SELECTION and EXPLOITATION and PROTECTION.

- In the SME sector, the functions are located at the same distance from each other, with the exception of the EXPLOITATION function, which is not a member of the network. The functions of SELECTION and LEARNING play a central role, in terms of the strength of the functions, IDENTIFICATION, SELECTION and LEARNING exert the greatest influence on the other elements of the network. The functions of IDENTIFICATION-LEARNING and SELECTION-ACQUISITION have the strongest and closest connection.
- At the level of the national economy, each function plays a central role, and close, strong relationships can be identified between the functions. In terms of proximity and strength, EXPLOITATION stands out from other features. Considering the results of the weight matrix, there is a significant, strong relationship between all functions. Such a strong integration between the elements of the network suggests that the relevance of the results is still less, and that the homogeneity of the expert responses may be behind the strength of the connections.

# 7. Micro-level research: Exploring the attitudes that characterize acceptance

## 7.1 Methodological steps

In contrast to the quantitatively oriented macro- and meso-level research, the qualitative research approach was dominant in the micro-level research. On the one hand, I wanted to supplement the quantitative analyzes described above with qualitative research, and on the other hand, the exploration of attitudes related to the acceptance of technology is much more in line with qualitative methodologies. Some of the models presented in connection with the topic are specifically based on the exploration of behavioral characteristics and attitudes, which are typically not or only difficult to examine with quantifiable indicators. In order to explore the attitudes that characterize the acceptance of Cloud Computing, I used Bandura's (1986) Social Cognitive Theory model as a basis.

Bandura's (1986) model is one of the behavioral approaches to technology acceptance. The model was originally developed in the field of psychology, but later spread among business research, and is often used in research related to technology acceptance. In my research, I used the structure of the model as a starting point to develop the set of questions for the interview. During the study, I did not perform a full-scale mapping based on the Social Cognitive Theory, but I used the model's structure and key constituent elements in the development of the study dimensions. In the micro-level research, the factors of Social Cognitive Theory were used in formulating the questions of the semi-structured interview. Regarding the acceptance of technology, the model examines attitudes related to acceptance in three dimensions. (1) Personal factors (prior knowledge, expectations, attitudes) cover preconceptions, internal elements, and behavioral characteristics towards technology. (2) The external environmental factors (social norms, relationships, the influencing power of the community) cover social customs and beliefs present at a higher level that cannot be influenced by the individual, as well as community relationships and their influencing power. (3) Behavioral barriers (skills, competences, practice, experience and self-efficacy, self-reflection) mean the concrete factors that create or maintain resistance, which can also be interpreted at the individual level, but are more concrete and better defined elements than personal factors.

During the micro-level research, I conducted semi-structured interviews. The essence of semi-structured interviews is that the "map" assessing the respondent's preferences is interpreted together with the respondent, so the respondent has the opportunity to think through the questions, to interpret them with the interviewer, and to freely justify his statements. During semi-structured interviews, the interviewer prepares several open-ended questions, but at the same time, the questions are not completely written in advance, as the interviewer must adapt to the course of the conversation, the respondent's style and habitus. The structure of the interview is given by groups of questions developed in advance. After evaluating the results of the interviews, it is possible to determine the typical attitudes related to Cloud Computing, the typical reasons and barriers for accepting and rejecting the technology.

The first step of the micro-level research was to reformulate the factors of the Social Cognitive Theory into questions. Using my macro-level research results and the relevant literature, I supplemented the factors of the model with several questions supporting my research goals. When formulating the questions, I made sure to formulate more comprehensive questions that allowed the interviewees to answer freely. The list of questions for the semi-structured interviews can be found in Appendix 7. After developing the interviews, I started contacting the potential interviewees. During the selection of the interviewees, I tried to find professionals familiar with Cloud Computing and small and medium-sized enterprises, who are creative enough to share as much useful information as possible regarding the topic.

After the preliminary contact and the coordination tasks related to the interviews, 5 professionals were finally selected for the interviews. The interviews took place in person, lasting 2-4 hours each. The anonymized characterization of the interviewees can be summarized as follows.

- Interviewee 1: Managing director and owner of a small IT company, senior IT consultant. The company was founded in 2000, and since then they have been engaged in the design and installation of IT systems, as well as providing system administrator services specifically for small and medium-sized enterprises. In terms of Cloud Computing, the interviewee has an extremely deep knowledge of the availability and functions of domestic services, as well as experiences related to their application.
- Interviewee 2: Consultant, proposal writer at a micro-enterprise dealing with tender writing. Its customers include small and medium-sized enterprises. He has extensive experience in the field of IT and technology tenders, and he has extensive experience in the differences between different industries, different development policies and the characteristics of businesses and industry differences.
- Interviewee 3: Academic specialist, university lecturer and researcher, holds a doctorate in the field of economic informatics. He regularly holds training courses for small and medium-sized enterprises in the field of IT developments, systems and available services.
- Interviewee 4: Software developer, technology director of a small computer programming company. He has relevant experience regarding Cloud Computing, both in terms of system use and development. The company's customer base is made up of small and medium-sized enterprises, their individual projects contain different, unique IT solutions, which are often based on a cloud-based solution.
- Interviewee 5: Senior IT consultant at the consulting department of one of the Big Four companies. In the course of his work, he deals with IT project management and consulting. Among its partners and clients, there are mostly medium-sized

and large companies, and it has less contact with small enterprises. In addition to knowledge of Cloud Computing, he has serious experience in terms of technology acceptance and use in general.

## 7.2 Exploring factors related to technology acceptance

In micro-level research, I am looking for the answer to the question, which are the typical attitudes related to the acceptance and use of Cloud Computing among domestic small and medium-sized enterprises (Q5). In order to answer this question, I conducted semi-structured interviews, the results of which are included in the chapter. During the semi-structured interviews, I also asked the interviewees about the results of several questions of the questionnaire survey. During the questionnaire survey, among the general questions about Cloud Computing, I also asked about the advantages and disadvantages of the technology. These opinions already reflect the attitudes towards Cloud Computing, which is why it was presented in this chapter. Table 41 contains the advantages selected by experts from a predefined group, in the order of how many people selected them. (A person filling in could choose a maximum of three factors from the list.) The interviewees were also asked about the individual factors, and I will present their relevant observations and comments along with the results of the questionnaire survey.

41. Table: Advantages of Cloud Computing based on the expert questionnaire survey

| Advantages | Mention |
|---|---|
| Accessibility, availability | 29 |
| The possibility of sharing information | 21 |
| Low infrastructure costs | 12 |
| Possibility of cooperation | 12 |
| Reliability | 8 |
| Speed, efficiency | 5 |
| Flexibility and customization of systems | 5 |
| Possibilities inherent in services | 4 |
| Reduction of investment risks | 3 |
| Scalability, scalability | 3 |

*Source: own compilation*

The most frequently mentioned advantage is accessibility and availability, more than 85 percent of the survey participants mentioned this. The mention of the advantage is not surprising in light of the fact that compared to local systems, it is a strong difference that systems and services based on Cloud Computing are essentially accessible from anywhere (interviewee 1). The second most frequently mentioned advantage is the possibility of sharing information, which was indicated by 62 percent of the respondents. This factor is important from the point of view of collaboration, because cloud-based systems allow users to share information in real time, regardless of physical location, which enables more efficient and free work (interviewee 4). 35-35 percent of the survey participants "mentioned" the low infrastructure costs and the possibility of cooperation. Regarding the low infrastructure costs, the 1st interviewee noted that this is not necessarily the case in reality, since regardless of the fact that physical, local IT systems naturally have higher investment requirements, taking into account their return, Cloud Computing the use of systems and services will no longer be cheaper in 3-5 years. At the same time, the 2nd interviewee confirmed that for businesses, avoiding investment costs and implementing the installation at the most favorable price is a relevant and essential aspect of a technological development. Regarding the possibility of cooperation, several people (interviewees 1, 2, 4) highlighted that this is not only an advantage that can be interpreted in terms of cooperation between employees, but that Cloud Computing can also have a fruitful effect on the flow of information, communication and cooperation between enterprises. In relation to the listed advantages, interviewee 1 noted that, in his opinion, scalability and scalability are mostly irrelevant, since the services available on the market usually provide capacities that do not raise the problem of scalability, in which the company has a more serious capacity requirement, it is not certain , so that it can be organized on a cloud basis. The 2nd, 4th and 5th interviewees emphasized that, in their opinion, the potential of services in the above list is somewhat undervalued, in their opinion, one of the most important advantages of Cloud Computing is that businesses can access completely new services that have a direct impact on their operation, activities and decision-making.

42. Table: Disadvantages of Cloud Computing based on the expert questionnaire survey

| Disadvantages | Mention |
|---|---|
| Access problems, network dependency | 19 |
| Questions related to data protection and data security | 16 |
| Platform dependency | 11 |
| Lack of information, lack of knowledge about systems and services | 6 |
| Problems with accessing service providers | 6 |
| Language addiction | 5 |
| Distrust of systems | 5 |
| Difficulties related to learning and application | 4 |
| A cumbersome, complicated application | 2 |
| Lack of standards, interoperability | 2 |

*Source: own compilation*

Table 42 contains the disadvantages mentioned in relation to Cloud Computing based on the questionnaire survey. While in the case of advantages, all respondents selected the maximum three factors that could be marked, in the case of disadvantages, fewer responses were received than the maximum that could be marked. All respondents could have chosen a total of 102 disadvantages from the list, yet only 76 responses were made. This either indicates that the expert respondents are not so critical of Cloud Computing or that the list below - compiled on the basis of the literature - did not include the factors they considered negative. Among the dominant disadvantages, selected by many, are problems related to access, network dependency (nominated by 56 percent of respondents), issues related to data protection and data security (47 percent) and platform dependency (32 percent). Network dependency expresses being bound to the Internet connection, my interviewees confirmed that in some respects this really means a more serious exposure than the operation of local systems, but at the same time a well-built cloud-based system definitely works more securely than a local one (1., 3., 5 . interviewee). Several interviewees (1st, 3rd, 4th) were surprised to see the high mention of issues related to data protection and data security. In their opinion, systems based on Cloud Computing can now generally be said to be more secure than local systems. They confirmed that data protection is one of the most current and important issues in connection with Cloud Computing, but at the same time, according to them, the dangers associated with it can be apostrophized less and less as disadvantages. Almost all interviewees (1st, 2nd, 4th, 5th) consider platform dependency as a disadvantage to be an equally important and noteworthy disadvantage, for users it is usually advisable to use several services with limited compatibility with each other, and it is very difficult to use different applications and services. there is strong competition in the market. And integrated, wide-ranging, "all-encompassing" solutions are offered only by the largest IT companies (Microsoft, Google, Amazon) (interviewee 1).

The semi-structured interviews included two questions of a more general nature, in addition to questions about the acceptance and use of Cloud Computing. The first question related to the usage data of Cloud Computing measured by KSH, according to which the usage rate of technology-based services among small enterprises is 41.2 percent, in the case of medium-sized enterprises 61.3 percent, which is significantly lower than the 85.8 percent of large companies. The second question referred to what, in the opinion of the interviewee, domestic small and medium-sized enterprises have in terms of the importance of Cloud Computing and its adaptation to the specialties of the SME sector. The answers to the two questions are presented together, edited and processed.

According to the 1st, 3rd, and 4th respondents, the usage rates reported by KSH are not accurate, in their opinion, businesses do not take into account what free cloud-based services they use, even in the cross-section of their corporate and private activities. The 1st interviewee shared his experience in this regard, according to which it happens that employees start using Cloud Computing services belonging to their private accounts for their work activities, as if out of "self-diligence", in order to increase work efficiency. This contains many sources of danger, since the company does not have adequate control over these systems, and the company's data and information are transferred to an individual's account. The 3rd respondent explained that, in his opinion, some of the businesses are not aware that the service they use (he mentioned Microsoft 365, Google Drive and corporate Facebook pages as examples) is based on Cloud Computing. According to the 4th respondent, there may be significant differences between industries and activities, but in his opinion, the rate of application of technology may be higher in reality.

All respondents agreed that there can be significant differences depending on the size of the enterprises, and in the case of a medium-sized enterprise, systems based on Cloud Computing play a much greater role. According to the 2nd respondent, it is not surprising that the usage rate is more significant among large companies, according to him, large companies always have a higher technological maturity, for them it is necessary to adapt the latest technologies in order to stay competitive. This was also mentioned by the 5th interviewee, according to him, in terms of competitiveness and R&D activity, the SME sector generally lags behind large companies, and this, of course, also affects the acceptance of new technologies.

Interviewee 3 spoke very strongly about the extent to which small and medium-sized enterprises know the importance of Cloud Computing. In his opinion, employees in the SME sector often have very low digital skills and a very serious lack of knowledge about Cloud Computing. There is a lack of suitable IT professionals and quality training in the sector, the necessary information is only available to them to a limited extent, and they use it to a small extent. The 1st interviewee sees the general preparedness of the SME sector in terms of Cloud Computing more positively than this, according to which a very serious development has been experienced in the last 3-5 years, the service provider layer has been developed, which has done a serious job in introducing services based on Cloud Computing, "popularization". He sees the lack of knowledge of small and medium-sized enterprises primarily in the fact that he very often encounters concerns and fears related to data security, even though today cloud-based systems can be said to be safer than local systems. Regarding the importance of Cloud Computing, interviewees 2 and 4 reported that even if small and medium-sized enterprises are familiar with cloud-based services and systems, they are not aware of the real advantages and possibilities of individual services and applications. According to them, this is due to the lack of information, the role of which was also confirmed by the 5th respondent.

Based on the prepared and processed interviews, personal factors related to the acceptance and use of Cloud Computing are included in Table 43. In the table, I include the comments of each respondent together, but at the same time in a separate breakdown according to whether the respondent identified the given element as a supporting or hindering factor. (This breakdown was not present in the wording of the question, the respondents were free to talk about the positive and negative factors in any order, or even just one.) In the table, the number of mentions is given in parentheses behind each term, if there are more literal or in terms of meaning mentions were received that could be merged without any loss of information. Regarding the interpretation of the results, I followed a similar logic in relation to the other dimensions. The comments and opinions presented in relation to acceptance and application reflect the viewpoints and impressions of my interviewees.

Among the personal factors, prior knowledge expresses what kind of preconceptions, real or false knowledge and knowledge the decision-makers and employees of small and medium-sized enterprises have regarding Cloud Computing. Among the supporting factors, the majority of the interviewees mentioned that the use of services available as private individuals has a positive effect on the image of enterprises regarding Cloud Computing and the use of the technology. The news, positive examples, and cases that appear about Cloud Computing also strongly support the image of Cloud Computing, thus the acceptance of the technology. In terms of prior knowledge and understanding of Cloud Computing, data security-related concerns have a negative impact on the application of the technology. This includes a lack of technology-related knowledge, bad experiences you've had or heard from others, and partial, incorrect knowledge about Cloud Computing.

43. Table: Personal factors related to the acceptance of Cloud Computing

| | Personal factors | | |
|---|---|---|---|
| | **Prior knowledge** | **Expectations** | **Attitudes** |
| **Supporting factors** | • available services used as a private person (4)<br>• news, information (3)<br>• understanding how technology works (2)<br>• recognition of strategic advantages (2)<br>• adaptation of previous services (2) | • high expectations for increasing efficiency (3)<br>• possibility of automation (3)<br>• hope of cost reduction (2)<br>• increasing competitiveness (2) | • role of age, younger people are more open (5)<br>• strategic and business approach to IT (3)<br>• risk management, risk assessment support (2)<br>• awareness (2)<br>• openness to innovation, interest (2)<br>• flexibility and adaptability |
| **Inhibiting factors** | • data security concerns (5)<br>• lack of knowledge (4)<br>• bad experiences (3)<br>• partial, incorrect knowledge (3)<br>• complexity of systems as a restraining force (2)<br>• they do not know what the services can be used for (2)<br>• fear of tasks involving transition<br>• not tangible technology, it is difficult to understand | • safety-related expectations as an inhibiting factor (5)<br>• its implementation will be too complicated, time-consuming or difficult to manage (4)<br>• they expect a cheaper solution, it is difficult for them to accept it if a better service costs more (3)<br>• excessive expectations, demand for cheaper, more reliable, better service (3)<br>• risks due to transition (3)<br>• lack of physical infrastructure (2)<br>• misconceptions about flexibility<br>• personalization as an expectation<br>• multinational service providers can abuse their position in terms of pricing<br>• the possibility of asserting interests is limited against large companies | • role of age, older people are more dismissive (5)<br>• fear of novelty (4)<br>• fear of the unknown (4)<br>• conservative entrepreneurial attitude (3)<br>• mistrust (3)<br>• lack of adaptability (3)<br>• lack of openness (3)<br>• refusal to issue control (3)<br>• distance from technology (2)<br>• lack of motivation to change (2)<br>• resistance to technological change (2)<br>• resistance to change in general (2)<br>• inability to compromise (2)<br>• arrogance, self-righteousness |

*Source: own compilation*

Among the personal factors, expectations express the typical expectations and wishes of decision-makers and employees of small and medium-sized enterprises regarding the use of Cloud Computing. According to the majority of the interviewees, the use of Cloud Computing is positively influenced if companies have high expectations for increasing efficiency, and the possibility of automation is considered important. Security -related expectations also appeared here as an inhibiting factor, in this sense it means that businesses have personal security-related expectations that prevent them (for real or false reasons) from adopting cloud-based systems. Also among the expectations, the majority of the interviewees mentioned that the introduction of technology-based services will be too complicated, time-consuming or difficult to manage, as well as the overestimation of the risks due to the transition. Another typical inhibiting factor is that businesses expect cheaper solutions, find it difficult to accept if a service costs more than the existing one, and that they have excessive expectations regarding technology.

Among the personal factors, attitudes are the behavioral patterns, personal characteristics, and qualities that can be identified in terms of decision-makers and employees of small and medium-sized enterprises regarding Cloud Computing. Out of all the factors surveyed, this was where the most responses came in, but predominantly the inhibiting elements were mentioned. The interviewees unanimously attribute a large role to age in terms of the acceptance of Cloud Computing, which is not an attitude, but according to the respondents, it is a factor that significantly determines the attitude of the decision-makers of enterprises. Younger people are more open to change, while it is extremely difficult to persuade the older generation to accept technological innovations. As a supportive attitude, the interviewees mentioned that a strategic, business approach positively influences the acceptance and use of technology. From the majority of the experts, an inhibiting factor regarding attitudes was received, including fear of novelty, fear of the unknown, conservative entrepreneurial attitude, mistrust, lack of adaptability, lack of openness and refusal to give up control.

Table 44 illustrates the external factors influencing the acceptance and use of Cloud Computing. Among the external factors, social norms represent those significant, easily identifiable characteristics, habits, and beliefs characteristic of society, which can have an impact on the decision-makers and employees of small and medium-sized enterprises regarding the application of Cloud Computing. According to the majority of the interviewees, such a feature is that there is a different perception of technology in each sector and in those sectors where the role of technology is more significant, there is strong external environmental pressure in the direction of technology acceptance. Openness to innovation among younger people also positively influences the acceptance and use of Cloud Computing. In this element of the external environmental factors, I included the requirements for IT security and the existence of specific legal conditions, which, according to the majority of interviewees, positively affect the use of technology. Among the negative influencing forces, concern about security appears here as well, as a widespread and strong view in society. Fear of change, a conservative approach to technology, mistrust of external service providers, lack of flexibility in the work culture and the importance of exercising control are also inhibiting social characteristics.

Among the external factors, community relations covers direct effects identifiable in the environment of businesses, transactional relationships, information available (or not available to businesses), which influence the decision-makers and employees of small and medium-sized enterprises regarding the application of Cloud Computing. All the interviewees emphasized that suppliers, customers and other partners have an outstanding informal role in the life of enterprises, which can strongly influence (positively) the acceptance of new products. The relationship with experts, the related factor, the role of consulting and education, clusters, industry collaborations, and experience sharing are all elements that support the acceptance and use of Cloud Computing. The opposite of these, the lack of information and information flow and the lack of professionals and experts, were identified by the interviewees as an obstacle to community relations. It should be noted that the external environmental dimension, community relations, and the following factor, the influencing power of the community, occurred only in the case that the interviewees mentioned more supporting factors than obstacles. This supports the fact that among small and medium-sized enterprises, industry and partner relations have a special role, they can strongly influence the acceptance and application of a technology.

44. Table: External environmental factors related to the acceptance of Cloud Computing

| | External environmental factors | | |
|---|---|---|---|
| | **Social norms** | **Community relations** | **Influence of community** |
| **Supporting factors** | • different perception of technology by sector (4)<br>• IT security requirements, specific legal requirements (4)<br>• openness to innovation: typical among younger generations (3)<br>• prejudices against technologically backward companies (2)<br>• a technologically advanced company is preferred<br>• pragmatism, knowledge of specific benefits | • prominent informal role of suppliers, customers and partners (5)<br>• contact with experts (3)<br>• clusters, industry collaborations (3)<br>• the role of counseling and education (3)<br>• experience sharing (3)<br>• pressure from competitors (2)<br>• sharing good examples and good practices (2)<br>• getting to know specific applications and services (2)<br>• specific expectations from customers and suppliers (2). | • good experiences of the entrepreneurial community (3)<br>• positive examples, references (3)<br>• role of collaborations (3)<br>• interviews, general news, related to digitalization (2)<br>• role of social media (2)<br>• social pressure<br>• corporate culture support |
| **Inhibiting factors** | • security concerns (4)<br>• fear of change (4)<br>• conservative view (3)<br>• mistrust of external service providers (3)<br>• lack of flexibility in the work culture (3)<br>• exercising control (3)<br>• protection of private property, importance (2)<br>• fear of information in work culture (2) | • lack of information, information flow (4)<br>• lack of specialists and experts (3)<br>• instead of getting to know the technology, advertising and selling specific services (2)<br>• lack of training and specific programs (2) | • negative news, information about dangers (3)<br>• learning about bad experiences (2)<br>• data loss cases (2) |

*Source: own compilation*

Among the external factors, the influencing power of the community means the direct effects from the narrow environment of the enterprises, information with decisive power, which can affect the decision-makers and employees of small and medium-sized enterprises in terms of the application of Cloud Computing. Fewer responses were received to this factor, in terms of positive influencing elements, the majority of the interviewees highlighted the good experiences of the contractor community, the impact of positive examples and references, and the role of collaborations. Among the inhibiting factors, only negative news and information about dangers were mentioned by the majority of the interviewees.

Table 45 contains the behavioral barriers affecting the acceptance and use of Cloud Computing. Among the behavioral barriers, the first factor represents the abilities and competencies that have a relevant impact on the behavior of decision-makers and employees of small and medium-sized enterprises regarding the acceptance of Cloud Computing. All interviewees mentioned that computer and IT-related competencies positively influence the acceptance and use of technology. Another supporting factor is the ability to adapt, the development and quality of digital literacy and willingness to learn. Among the factors preventing the acceptance of technology are the lack of IT knowledge, general ignorance and lack of information, as well as low digital competence.

45. Table: Behavioral barriers related to the acceptance of Cloud Computing

| | **Behavioral barriers** | | |
|---|---|---|---|
| | **Ability, competence** | **Practice, experience** | **Self-efficacy** |
| **Supporting factors** | • computer, IT-related competencies (5)<br>• adaptability (3)<br>• digital literacy (3)<br>• willingness to learn (3)<br>• problem solving ability<br>• communication skills | • knowledge of specific services (4)<br>• knowledge of software and applications (3)<br>• previous positive (IT) experiences (3)<br>• positive experiences related to data security and data protection (3)<br>• IT practice (3)<br>• role of training and learning (2) | • self reflection (3)<br>• identification of missing (IT) knowledge and skills (3)<br>• learning intention (2)<br>• motivation (2)<br>• positive attitude to change (2)<br>• ability to adapt to new systems (2)<br>• assessment ability<br>• knowledge of connections between systems |
| **Inhibiting factors** | • lack of IT knowledge (5)<br>• ignorance, ignorance (3)<br>• low digital competences (3)<br>• low willingness to learn (3)<br>• lack of English language skills (3)<br>• lack of motivation (2)<br>• lack of ability to search for information (2) | • previous difficulties using computer programs (4)<br>• sticking to known, used programs (4)<br>• missing IT experience (3)<br>• previous bad system use (3)<br>• previous bad program selection (2)<br>• outdated IT skills (2) | • lack of self-reflection, failure to recognize gaps in one's own knowledge (3)<br>• overestimation of available resources (3)<br>• lack of desire and ability to learn about services and opportunities (3)<br>• fear of failure (2)<br>• passivity and resistance (2)<br>• avoidance tactics<br>• procrastination |

*Source: own compilation*

The second set of behavioral barriers covers the practical elements and specific experiential factors that have a relevant impact on the behavior of decision-makers and employees of small and medium-sized enterprises regarding the acceptance of Cloud Computing. Based on the majority opinion, knowledge elements supporting the acceptance and application of technology include knowledge of specific cloud-based services, general knowledge of software and applications, previous positive experiences (related to IT, computers), positive experiences related to data security and data protection, and specific IT exercise. With regard to practice and experience, the majority of the interviewees highlighted previous difficulties related to the use of computer programs, the lack of IT experience, problems resulting from previous bad system use and adherence to already known and used programs.

Among the behavioral barriers, self-efficacy expresses the extent to which the decision-makers and employees of small and medium-sized enterprises are aware of their own abilities, knowledge, and level of knowledge, are they able to realistically assess their own limitations, and what are the factors that in the former, it influences them in a supporting or inhibiting way in terms of the acceptance and application of Cloud Computing. The interpretation and experience of self-efficacy was the most difficult for the interviewees among the surveyed factors. In this regard, the majority highlighted self-reflection as a supporting element, and a closely related factor, the ability to identify missing (IT) knowledge and skills. In contrast to the previous ones, the factor that negatively influences technology acceptance is the lack of self-reflection, the lack of recognition of one's own knowledge gaps, the lack of desire and ability to learn about services and opportunities, and the overestimation of available resources as an element supporting resistance.

The last question of the semi-structured interview was a completely open question, which was about whether the interviewee has any additional comments or opinions that he/she considers important to share after discussing the above questions and topics and expressing the related opinions. . Respondent 1 and respondent 4 again emphasized the importance of the age and generational characteristics of decision-makers. According to them, younger entrepreneurs are much more open-minded, for them the digital world is nothing new, and as a result, they accept technological innovations much easier and faster. The 3rd respondent highlighted the role of the top management and the decision-makers, in his opinion, if the management of a company refrains from change or does not have adequate knowledge regarding, for example, Cloud Computing, then it hinders the acceptance of technology throughout the organization, and strongly hinders innovation openness.

The 5th interviewee explained that the majority of the above factors are also true for the employees of large companies, but due to the characteristics of the large company environment, they are forced to develop and modernize the IT infrastructure and the systems used much earlier, to which the employees have to adapt. The respondent emphasized that, in his opinion, large companies have always been ahead in the acceptance of technology anyway, but at the same time, in his opinion, individual ability and skill deficiencies, which often appear as a strong inhibiting factor, and individual resistance to technological innovations are much more typical of employees in the SME sector, partly the reason is that the employees of large companies do not have the same autonomy regarding the organization of their work processes as the employees of a smaller organization.

According to the 1st respondent, the trends of recent years are extremely encouraging regarding the digital maturity of the SME sector and the application of modern technologies. Mentioning specific factors, he emphasized that the need to use legal systems has become essential in the last five years. This also supports the development and spread of cloud-based systems. new business models have also appeared in which the use of cloud-based solutions plays a central role. In his opinion, informal relationships and spontaneous learning from each other play an extremely important role in the domestic entrepreneurial sector. Any business that comes across a new IT service, application or new business model at a partner's business becomes a user, an "innovator" much more easily. However, in the field of education, the small and medium-sized business sector is driven by the IT companies and professionals who invest sufficient work in mapping, learning about and recommending new technological solutions and services. According to him, the role of IT specialists and consultants in terms of technological education and the support of technological developments is outstanding. Cloud Computing is just one, but extremely important technology solution for businesses, with which its users can enjoy significant benefits, while those who are slower to adapt to technological innovations will be left behind very quickly.

I can summarize my main findings related to the acceptance of Cloud Computing, the attitudes that characterize its use, and the exploration of supporting and inhibiting factors below.

- The research was conducted with a qualitative orientation and a semi-structured interview. The criterion for selecting the interviewees was that they have relevant knowledge and experience regarding the specialties and typical attitudes of domestic small and medium-sized enterprises, as well as the possibilities and circumstances of using Cloud Computing.
- In the context of the micro-level research, the results of the expert questionnaire survey and the study on the advantages and disadvantages of Cloud Computing were presented. The interviewees were asked about this, the results were partially supported (the advantages of Cloud Computing include that it can be accessed from anywhere, it supports the sharing of information and collaborations, the disadvantages are network dependency and platform dependency), and partially they were nuanced (the low infrastructure costs associated with Cloud Computing , as an advantage, data security concerns as a disadvantage).
- Supporting and hindering factors related to the acceptance and application of Cloud Computing were queried using the logic of the Social Cognitive Theory model. The aspects asked of the interviewees regarding technology acceptance are prior knowledge, expectations, attitudes, social norms, community relations, the influencing power of the community, skills, competences, practice, experience and self-efficacy.
- Taking into account both the agreement of the interviewees and the frequency of occurrence of the comments made, the use and application of Cloud Computing among domestic small and medium-sized enterprises is mostly related to industry, business-to-business (supplier, customer, partner) relationships, computer and IT competences and capabilities it is supported by its existence, as well as the involvement of experts and consultants and the resulting education.
- The factors most hindering the acceptance and application of technology are the fears and concerns related to data protection and data security, which are extremely typical among businesses, the lack of knowledge and skills related to Cloud Computing and IT, as well as the resistance resulting from the age of the decision-makers of the businesses, the aversion to novelty, which characterizes the older generation.

# 8. Summary

## 8.1 The results of the research

My research questions based on theoretical research can be interpreted on three levels. The subject of my macro-level investigations is the characterization of the use and future spread of cloud-based services by domestic small and medium-sized enterprises, based on representative data for modeling at the national level. The subject of my meso-level investigations is the research of the characteristics of the use of Cloud Computing by the companies of the Hungarian SME sector, as well as the supporting and inhibiting factors. The subject of my micro-level investigation is the characterization and presentation of the attitudes and soft factors that can be discovered among domestic small and medium-sized entrepreneurs. I present the theses of my dissertation, i.e. the most important results of the theoretical and practical research, along the lines of the research questions.

**Q1. To what extent do domestic small and medium-sized enterprises use Cloud Computing?**

During the macro-level empirical research, I focused on the use of cloud-based services, based on the currently available data, to what degree of use characterizes the domestic SME sector, and to what extent the spread of the technology is expected in the future. Diffusion of the technology started among domestic enterprises in the early 2010s, since then the research of Cloud Computing has become an important topic in the theoretical literature, and its practical application has also become increasingly well-known and important for enterprises. The specialties and characteristics of Cloud Computing are well suited to the specialties of small and medium-sized enterprises, from this point of view a relevant research question is what characterizes the domestic SME sector in terms of the application of technology. In my empirical research, I examined the current prevalence of Cloud Computing and the degree of expected diffusion among domestic enterprises and companies.

Representative data on the use of Cloud Computing is available for the period between 2014 and 2023. Based on these, the use of technology has increased in each of the different categories of business staff, but the pace of these shows a very different picture. It can be concluded that a larger company size (in terms of personnel categories) presupposes a higher rate of technology use. In the examined period, technology spread much more strongly among large companies than among small and medium-sized enterprises, and the difference between the sectors - excluding the data for 2023 - also increased every year. By 2023, 41.2 percent of small enterprises, 61.3 percent of medium-sized enterprises, and 85.8 percent of large companies will have used Cloud Computing. In light of the fact that, in connection with the use of technology, companies do not, or only to a negligible extent, encounter infrastructural barriers and obstacles related to the use of devices, this is a rather serious difference in terms of the staffing categories of the enterprises.

**Q2. What future spread (diffusion) can be expected regarding Cloud Computing in the domestic SME sector?**

I examined the future diffusion of technology using the Bass model. For each staffing category, I received a forecast with a suitable fit. The model, in line with the existing time series data, continued to estimate serious differences in terms of the spread of technology in terms of company size. Looking at Rogers' categories of innovation acceptance, while the market spread has essentially been achieved in the case of large companies (the late majority of companies also apply the technology and the laggards are already starting to use it), in the case of medium-sized companies this is by 2033, in the case of small companies by 2043 can be predicted. It should be noted that the model gave a rather conservative estimate, as the usage rate indicated for 2023 was slightly below the actual usage rate typical for businesses in all categories, so it is conceivable - if the value in 2023 is not just a one-time outlier - that in reality the diffusion will take place somewhat faster than estimated by the model. The model's forecast in this form can therefore be considered a negative scenario.

If we do not examine the diffusion of Cloud Computing in terms of employee categories of enterprises, but according to the average value ranges for innovation and imitation coefficients in the literature, then the diffusion of Cloud Computing in Hungary cannot be assessed as slow in any way. In the case of small and medium-sized enterprises, the innovation effect is essentially the same as the average value, while in the case of large enterprises, the willingness to innovate is much higher than the average noted in the literature. At the same time, the imitation effect falls short of the average range for all personnel categories. However, from the point of view of the interpretation of the results, it is more important to look at the innovation and imitation coefficients estimated by the model within a data set, since these values in themselves have a characteristic force in terms of diffusion. In the case of small enterprises and the SME sector, the propensity to innovate can be said to be average, which is exceeded by the propensity to imitate, which develops similarly in the case of medium-sized enterprises and large companies. The innovation propensity of medium-sized enterprises is almost double that of small enterprises, while large enterprises have almost four times as much innovation propensity as small enterprises.

Investigating the diffusion of a technology is not only an interesting field of research from the point of view of the characterization of technology as innovation, but also from a practical point of view. With regard to my research question, the spread of Cloud Computing among domestic enterprises and companies in the examined years is spectacular, and the rate of future diffusion can be said to be average according to the model. At the same time, the differences between the individual personnel categories are clear. Looking at the use of technology so far and its predictable application, it is also noticeable that large companies have a greater willingness and acceptance of innovation compared to the SME sector, but the use of technology by medium-sized companies also exceeds that of small companies regarding Cloud Computing. Considering the characteristics of Cloud Computing, this difference is not justified between small and medium-sized enterprises, large enterprises and the SME sector. Therefore, the differences presented in relation to the staffing categories of domestic enterprises do not arise from the specialties of Cloud Computing, but rather from the different willingness of small and medium-sized enterprises and large enterprises to innovate.

**Q3. How can the internal technology management capabilities and the external environmental effects of Cloud Computing be characterized among domestic small and medium-sized enterprises?**

In the meso-level empirical research, I looked for the answer to what characterizes the application of Cloud Computing among small and medium-sized enterprises, and in terms of technology management functions, what characteristics and patterns can be observed in the context of Cloud Computing at different environmental levels. During meso-level research, the use of quantitative methodologies dominated. The research and analyzes were based on an expert survey based on Hobday's (2002) model dealing with the evaluation of technological capabilities. The survey respondents were professionals who are well-versed in the application of Cloud Computing and the specialties of small and medium-sized enterprises. I submitted the results of the survey to various descriptive and pattern-analyzing statistical tests, and I planned to present them in more detail earlier. The methodologies used during some investigations of the meso-level research were also described. In the following, I will try to present the results in a concrete, practical and synthesizing way along the lines of the research questions. In order to summarize the results of my meso-level research, I have prepared several organizing tables, in which I include the results of the various studies together. Regarding the interpretation of the results, I tried to present and explain my test results for different purposes not out of their interpretation framework, but in the broader context of the research question. It partly follows from this that, when summarizing the results, I preferred the practical, business context this time over the use of precise methodological concepts, in order to be able to successfully highlight the practical, "tangible" benefits and results of my empirical investigations.

Within the framework of the meso-level research, I examined the skill levels belonging to the different environmental levels. By summarizing the experts' answers and applying the methodology of Hobday's (2002) ability level analysis, I came to the conclusion that enterprises are characterized by the level of strategic ability, the SME sector by the level of reactive ability, and the national economy also by the level of reactive ability. At the same time, it is important to note that the answers received based on this, the level of the national economy is extremely close to the level of strategic capabilities. The reactive level is the second level of capabilities after the passive level, characterized by the fact that technological readiness is generally of medium or low quality, the willingness to innovate is low, and the country's companies and sectors are characterized by slow follow-up regarding the acceptance of technological innovations. The strategic level refers to a higher degree of technological preparedness, (in this case) companies have advanced technological capabilities that can be a source of competitive advantage, but at the same time they are also characterized by serious shortcomings. The technological preparedness of enterprises corresponding to the level of strategic capabilities is of a medium-high standard, in their case, the individual technology management areas are characterized by different preparedness.

The further steps of the expert questionnaire survey include the development of the various environmental levels (corporate, SME sector, national economy) and the technology management functions characteristic of them (identification, selection, acquisition, exploitation, protection, learning), the examination of the technological capabilities that make up the functions, and the were concerned with the exploration of existing relationships. In the survey, the technology management functions were accompanied by various statements that referred to the various technological capabilities characterizing the environmental levels. These technological capabilities were transformed into variables that were the subject of my empirical analyses. In the following, I describe my results related to variables and functions that can be characterized and analyzed based on expert evaluations.

Looking at the variables related to the different environmental levels, it can be concluded that the experts typically rated the company variables (that is, belonging to the internal environmental level) better than the variables of the external environmental level. On average, I received a worse evaluation of the external environmental statements, and the responses are characterized by a much smaller standard deviation. The evaluation of statements related to the company level shows a greater difference and better evaluations. Regarding the external environmental variables, it is characteristic that the variables related to the SME sector were typically valued more by the respondents than those related to the national economy. Based on this, it can be concluded that the respondents of the survey see the technology management preparedness of the enterprises as slightly better in terms of Cloud Computing than the SME sector, and the national economic effects regarding the application of Cloud Computing.

The above is supported by the analysis of the agreement rates given to the variables (i.e. the totality of the "rather agree" or "strongly agree" responses). The ranking of the variables based on the agreement ratio gives a more accurate and sensitive picture of the distribution of the variables according to the evaluation. At the company level, an agreement rate of over 80 percent characterizes 4 variables (these are knowledge of Technology from the point of view of business activity, evaluation of Opportunities, the role of Technology in the company and business strategy and the establishment of Effective protection), between 60 and 80 percent agreement characterizes the half of the variables, 14 in total, 8 variables "received" an agreement rate of between 20 and 60 percent, and 2 variables were rated below 20 percent. An agreement rate below 50 percent essentially expresses disagreement, since in this case there were several answers to the given variable in which the respondent chose the evaluation "rather disagree" or "rather agree". An agreement rate of less than 50 percent characterized 9 variables, these are the use of external organizations in the implementation of the strategy, knowledge of intellectual property rights, the existence of post-project evaluations, the use of external organizations for the evaluation of technology, the use of external organizations in development, the existence of project evaluation systems, encouraging investments, cooperation in development with universities, research institutes and Cooperation in development with government institutions. The external environmental variables (that is, the SME sector and the variables related to the national economy) were evaluated together, an agreement rate of over 60 percent does not characterize any of the variables, an evaluation of over 50 percent (thus expressing real agreement) and came to only three variables (Protection of Intellectual Property knowledge in the SME sector, awareness and quality of government policy priorities, government support for technology protection). An agreement rate between 20 and 50 percent characterizes 6 variables, a value below 20 percent characterizes 3 variables, knowledge of the protection of Intellectual Property in the SME sector, the familiarity and quality of Government policy priorities and government support for the protection of Technology. Based on the experts' responses to the external variables, it can be concluded that the impact of the SME sector and the national economy on the technological capabilities and preparedness of Cloud Computing is of extremely low quality, and in several cases it can be evaluated as an external environmental (otherwise supportive according to its purpose and content) impact cannot be interpreted at all in terms of this technology.

Based on the evaluations given to the variables and the tests carried out on them, the strong and weak points, as well as the supporting and inhibiting effects from the external environment, which characterize the use of Cloud Computing from the point of view of technology management among small and medium-sized enterprises, can be determined. Table 46 contains the organization of the variables, their quality (ie positive or negative content), and their connection to the environmental level.

46. Table: The most important factors determining the use of Cloud Computing

| | | **Quality content of ability and effect** | |
|---|---|---|---|
| | | **Positive, supportive elements** | **Negative, inhibiting factors** |
| **Environmental focus** | **Internal environment** | • Evaluation of opportunities<br>• The role of technology in corporate and business strategy<br>• Selection of required technology<br>• Knowledge of priorities in relation to technology<br>• Acquisition of technology<br>• Knowledge of technology from a business perspective<br>• Building effective protection | • Cooperation in development with universities<br>• Cooperation in development with government institutions<br>• Use of external organizations in development<br>• Encouraging investments<br>• Existence of project evaluation systems<br>• Existence of post-project evaluation<br>• Knowledge of intellectual property protection |
| | **External environment** | • Advantages of Cloud Computing in the SME sector<br>• Technology strategies technoportfolio in the SME sector<br>• Procurement quality in the SME sector | • Awareness and quality of government policy priorities<br>• Identification of opportunities and threats in the SME sector<br>• Government support for identifying opportunities and threats<br>• Government support for collaborations and procurement processes<br>• Review of developments in the SME sector<br>• Measuring the performance of enterprises at the government level<br>• Government support for technology protection<br>• Knowledge of intellectual property protection in the SME sector |

*Source: own compilation*

From the point of view of Cloud Computing, strengths and advanced capabilities include positive, supportive elements related to the company level, while weaknesses and areas to be developed-capabilities are contained in the negative, inhibiting factors of the internal environment. The set of positive, supporting elements of the external environment includes the driving forces that can be identified in connection with Cloud Computing, the factors that support the readiness of technology management and technological capabilities, while the negative, inhibiting factors of the external environment include the application of technology and the development of technological capabilities related to Cloud Computing we can find inhibiting and hindering environmental effects.

At the level of the internal environment, in terms of strengths and advanced capabilities, variables with a strategic focus and selection and procurement appeared. Regarding the external environmental effects, positive, supporting factors can be interpreted relative at best, although the highest expert agreement also appeared regarding procurement and the benefits of Cloud Computing, but the level of expert agreement is very unconvincing. In terms of weaknesses and inhibiting factors, variables related to cooperation, the involvement of external actors, the protection of technology, and learning processes can be identified at both environmental levels. Overall, it can be clearly stated that the expert opinions evaluated the statements related to enterprises more positively than the statements concerning the SME sector and the national economy, so in terms of Cloud Computing, they see the technological management preparedness of enterprises as relatively better than the relevance of the external environmental influences influencing it. and their positive influence.

The internal-external, supporting-inhibiting factors affecting the use of Cloud Computing were explored using descriptive statistical methodologies. On the basis of the relevant analyses, it can be concluded that the respondents of the survey see the technology management preparedness of the enterprises in terms of Cloud Computing somewhat better than the SME sector, and the national economic effects regarding the application of Cloud Computing. At the level of the internal environment, the abilities with a strategic focus and those related to selection and procurement appeared as strengths, among the weaknesses I identified abilities related to collaborations, involvement of external participants, and learning processes. The supporting effects from the SME sector and the national economy can only be interpreted as relative support, and there was a rather low level of expert agreement in this area. The inhibiting factors related to the external environmental level showed the insufficiency of governmental support, protective and learning technological capabilities. It can be concluded that, regarding Cloud Computing, the experts' opinions see the technology management preparedness of the enterprises and the quality of the technological capabilities of the enterprises as relatively better than the relevance and positive influencing power of the external environmental influences that influence it.

**Q4. What characterizes the individual technology management functions of domestic small and medium-sized enterprises in terms of the application of Cloud Computing?**

Regarding the application of Cloud Computing, the technology management functions that characterize and determine the application of the technology were also analyzed. My goal was to explore the correlations and relations between the functions, taking the environmental levels into account. At the enterprise level, the functions can be interpreted as a set of variables, while at the external environmental levels, individual technology management functions can be identified with the corresponding variable. I organized the most important results of the examination of the technology management functions determining the application of Cloud Computing in Table 47. Below, I describe the most important findings of the tests affecting the functions in relation to the individual environmental levels.

47. table: Relationships and correlations between technology management functions of Cloud Computing

| | Enterprise level | SME sector | National economy |
|---|---|---|---|
| **IDENTIFICATION** | • It is characterized by a significantly better evaluation than the function of the SME sector and the national economy<br>• Close correlation with SELECTION, EXPLOITATION, PROTECTION and LEARNING functions<br>• Close, strong element among functions<br>• Strong and close connection with SELECTION, EXPLOITATION, PROTECTION functions | • There is no significant difference compared to the function of the national economy<br>• Close correlation with the ACQUISITION, LEARNING functions<br>• A strong element in the network of functions | • There is no significant difference compared to the function of the SME sector<br>• Close correlation with all other functions<br>• All functions are centrally located |
| **SELECTION** | • It is characterized by a significantly better evaluation than the function of the SME sector and the national economy<br>• Close correlation with IDENTIFICATION, EXPLOITATION, PROTECTION functions<br>• Close correlation with the ACQUISITION function of the SME sector<br>• Close, strong element among functions<br>• Strong and close connection with IDENTIFICATION, EXPLOITATION, PROTECTION functions | • It is characterized by a significantly better evaluation than the function of the national economy<br>• Close correlation with the ACQUISITION function<br>• Central element among functions<br>• A strong element in the network of functions | • There is no significant difference compared to the function of the SME sector<br>• Close correlation with all other functions<br>• All functions are centrally located |
| **ACQUISITION** | • There is no significant difference between the function of the SME sector and the national economy<br>• It is not characterized by correlation with other functions<br>• A weak, insignificant member of the network of functions<br>• It is not closely related to any function | • There is no significant difference compared to the function of the national economy<br>• Close correlation with the IDENTIFICATION, SELECTION function<br>• Negative correlation with the IDENTIFICATION and EXPLOITATION function of the national economy | • There is no significant difference compared to the function of the SME sector<br>• Close correlation with all other functions<br>• All functions are centrally located |
| **EXPLOITATION** | • It is characterized by a significantly better evaluation than the function of the national economy<br>• Close correlation with IDENTIFICATION and PROTECTION functions<br>• Central element among functions<br>• Close, strong element among functions<br>• It has a strong, close relationship with IDENTIFICATION and SELECTION | • There is no significant difference compared to the function of the national economy<br>• Not part of the feature network | • There is no significant difference compared to the function of the SME sector<br>• Close correlation with all other functions<br>• All functions are centrally located<br>• Close, strong element among functions |

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|---|---|---|---|
| **PROTECTION** | • It is characterized by a significantly better evaluation than the function of the SME sector and the national economy<br>• Close correlation with the IDENTIFICATION, SELECTION, EXPLOITATION, LEARNING functions<br>• Close, strong element among functions<br>• It has a strong, close relationship with IDENTIFICATION and SELECTION | • There is no significant difference compared to the function of the national economy<br>• Close correlation with the LEARNING function<br>• Negative correlation with the IDENTIFICATION function of the national economy | • There is no significant difference compared to the function of the SME sector<br>• Close correlation with all other functions<br>• All functions are centrally located |
| **LEARNING** | • It is characterized by a significantly better evaluation than the function of the SME sector and the national economy<br>• Close correlation with IDENTIFICATION and PROTECTION functions<br>• It is not a strong, central member of the network of functions | • There is no significant difference compared to the function of the national economy<br>• Close correlation with the IDENTIFICATION, SELECTION, PROTECTION functions<br>• Central element among functions<br>• A strong element in the network of functions | • There is no significant difference compared to the function of the SME sector<br>• Close correlation with all other functions<br>• All functions are centrally located |

*Source: own compilation*

The experts rated the enterprise level function as clearly better than the same functions belonging to the external environmental level, of which only ACQUISITION (Technology acquisition, Relationship with suppliers, Investment stimulation, Use of external organizations in development, Cooperation in development with universities and research institutes, Cooperation in in development with government institutions) is an exception.

Among the functions, EXPLOITATION (Organization of technological activities, existence of project processes (investment, development, procurement), use of external organizations in the implementation of the strategy, utilization of special strengths, ability to decide on outsourcing or own development) plays a central role. In the network of functions, IDENTIFICATION (Knowledge of technology from the point of view of business activity, Selection of necessary technologies, Evaluation of opportunities, Assessment of threats, Existence of a vision), SELECTION (Knowledge of procurement sources, Role of technology in company and business strategy, Use of external organizations to evaluate technology, Technological proficiency in strategy formation, knowledge of priorities in relation to technology), EXPLOITATION and PROTECTION (Knowledge of technological risks and dangers, Building effective protection, Knowledge of safe procurement and development, Knowledge of intellectual property rights) are elements that are close to each other and have a strong impact on the other functions. Regarding the ranking of the variables, we reached the same result, it can be stated that the technology management functions that are most important from the point of view of the application of Cloud Computing and can be evaluated as better from the point of view of preparedness are IDENTIFICATION, EXPLOITATION, SELECTION and PROTECTION. The function of LEARNING (existence of project evaluation systems, existence of post-project evaluations, ability to learn from projects) is located further away from the other functions in terms of their network.

Several strong, close and correlational relationships can be identified between Cloud Computing functions. The strength and closeness of the relationships indicate that the development of each function can have a positive effect on the other function, the correlation means that, based on expert opinions, the evaluations given to the functions show a correlation, so it can be concluded that the higher evaluation of one function is the other function resulted in a higher rating. At the enterprise level, the strongest and closest relationship can be demonstrated between IDENTIFICATION and SELECTION, EXPLOITATION, PROTECTION, and between SELECTION and EXPLOITATION, PROTECTION. I reached mostly similar results regarding the correlation relationships, including the positive correlation relationship between the SELECTION function of the company level and the ACQUISITION (Quality of acquisitions in the SME sector) function of the SME sector, not mentioned above.

Looking at the external environmental level, there are no significant differences between the same functions belonging to the SME sector and national economy levels, so the expert evaluations typically evaluated the functions in the same way, regardless of whether they contained a sectoral or national economic impact. An exception to this is the SELECTION function, in which case the Technology strategy, technoportfolio in the SME sector received a significantly better evaluation than the familiarity and quality of Government policy priorities. According to the experts, the (supporting) impact of the SME sector is stronger and more characteristic of Cloud Computing than the impact of the national economy.

In the SME sector, the functions of SELECTION (Technology strategy, technoportfolio in the SME sector) and LEARNING (Review of developments in the SME sector) play a central role. In terms of function proximity, all functions are at the same distance, close to each other, except for the EXPLOITATION (Advantages of Cloud Computing in the SME sector) function, which is not a member of the network. In the SME sector, the IDENTIFICATION (Identification of opportunities and threats in the SME sector), SELECTION and LEARNING functions can exert a strong influence on other elements of the network of functions. In terms of the national economy, all functions play a central role, but in terms of the proximity and strength of the functions, the function of EXPLOITATION (Government support for the exploitation of digital technologies) stands out.

Examining the relationships between the functions belonging to the external environment level, a strong and close relationship can be identified between IDENTIFICATION and LEARNING in the SME sector, and between SELECTION and ACQUISITION (Quality of acquisition in the SME sector). EXPLOIT is essentially unrelated to other functions. Looking at the correlational relationships, we can find less significant relationships than at the corporate or national economic level, but we can identify between LEARNING and IDENTIFICATION, SELECTION, PROTECTION (Knowledge of intellectual property protection in the SME sector), and between ACQUISITION and IDENTIFICATION, SELECTION trips together. At the level of the national economy, there is essentially a strong and close connection between all functions, this is also the same as the result of the exploration of correlational relationships. The fact that we can identify such strong connections and synergies among the technology management functions related to the national economic level is not only characterized by the close integration between the variables. The strong correlations can also result from the fact that the experts are less differentiated in their responses and the individual respondents evaluated the functions in the same way, so due to the homogeneity of the answers, the patterns and differences between the functions cannot emerge in any meaningful way.

In the course of my meso-level research, I used different practical methodologies to examine the internal and external factors affecting the application of Cloud Computing in relation to technology management functions. Looking at the individual functions, IDENTIFICATION, SELECTION and EXPLOITATION have the greatest role in terms of Cloud Computing. Regarding the IDENTIFICATION and SELECTION functions, the effects of the national economy (Government support for the identification of opportunities and threats, the awareness and quality of Government policy priorities) are extremely serious inhibiting factors in terms of the technology management preparedness of enterprises. Regarding the EXPLOITATION in the SME sector, I came to a rather interesting result, looking at the advantages of Cloud Computing - about which the majority of the experts expressed their agreement - it seems that as a function variable it cannot have an impact on the evaluation of the elements related to the other SME sector. The national economic impact related to EXPLOITATION, government support for the exploitation of Digital technologies can have an extremely strong impact on the quality of other functions. In relation to PROTECTION, I received results at all environmental levels that confirm the importance of the function and its relationship with other functions, but at the same time, it does not appear as a central element at any level. In several cases, the association between PROTECTION and LEARNING could be identified. The function of ACQUISITION and LEARNING needs improvement at all levels. The LEARNING function was typically isolated, fewer connections could be identified between it and the other functions. ACQUISITION is the function with the lowest evaluation at the company level, and several of its variables have an exceptionally low rate of agreement. It also got poorer results on external environmental levels. This means that collaborations, joint developments, and knowledge transfer related to Cloud Computing work very poorly between businesses and sectoral and national economic participants.

**Q5. What are the typical attitudes related to the acceptance and use of Cloud Computing among domestic small and medium-sized enterprises?**

The micro-level research aimed to explore the factors influencing the acceptance and use of Cloud Computing. As part of the research, I conducted semi-structured interviews, applying the framework and factors of Social Cognitive Theory to the topic. The aim of the research was to complement the macro- and micro-level studies, and to map with a qualitative orientation the factors that are not visible in my previous research due to the methodology, which have an impact (whether positive or negative) on the acceptance and application of Cloud Computing by domestic small and medium-sized enterprises. around. In the context of the micro-level research, the results of the expert questionnaire survey and the study on the advantages and disadvantages of Cloud Computing were presented. The interviewees were asked about this, the results were partially supported (the advantages of Cloud Computing include that it can be accessed from anywhere, it supports the sharing of information and collaborations, the disadvantages are network dependency and platform dependency), and partially they were nuanced (the low infrastructure costs associated with Cloud Computing, as an advantage, data security concerns as a disadvantage).

Supporting and hindering factors related to the acceptance and application of Cloud Computing were queried using the logic of the Social Cognitive Theory model. The variables of the model can be classified into three groups. Personal factors include individual knowledge, expectations and attitudes towards technology. Environmental factors include social norms, community relations, and the influence and ability of other members of society. The third, behavioral factors, include the existence of the necessary skills, practice, experience and self-efficacy, which is the individual's belief in his own abilities in order to successfully complete his tasks. The guiding thread of the interview included open questions about the factors in the model. The most important effects mentioned by the interviewees, and the effects mentioned several times along the individual factors, can be summarized below.

Among the personal factors, in terms of prior knowledge, positive news about available services and technology used by private individuals has a supportive effect. Inhibiting factors include concerns about data security, lack of knowledge about technology, and bad experiences you've heard or heard from others. The supporting factor regarding expectations is the high expectations for increasing efficiency and the possibility of automation. Expectations with an inhibiting, negative influence are (typically false) expectations related to security, and that the introduction of the technology will be too complicated, time-consuming or difficult to handle. Among the attitudes that determine the acceptance and application of Cloud Computing, according to the interviewees, the most important factor is the role of age, the younger generation is much more open to technological innovations. The strategic and business view of IT as an attitude was mentioned several times as a supporting factor. Regarding the inhibiting factors, all respondents mentioned that the older generation is much more reluctant towards Cloud Computing. Fear of the new and the unknown as an attitude, as well as mistrust and lack of openness, were also mentioned.

Among the defining social norms around the external environmental factors are IT security requirements and specific legal requirements that determine typical behaviors in this regard. Most of the interviewees said that there is a very different perception of technology in each sector, which is a socially perceptible and present effect. Among the inhibiting factors, the presence of security-related concerns and the fear of change were again mentioned. Regarding the influencing power of community relations, the prominent informal role of suppliers, customers and partners, the relationship with experts and the supporting effect of clusters and industry collaborations were mentioned several times. The inhibiting factors related to community relations are the lack of information and information flow and the lack of specialists and experts, insufficient availability for businesses. Regarding the influencing power of the community, it was said that the acceptance and application of technology is positively affected by the good experiences of the business community, as well as by the positive examples and references heard by businesses, and the role of collaborations. Negative influences include negative news and information about dangers.

In terms of behavioral barriers influencing the acceptance of Cloud Computing, in terms of specific abilities and competencies, the interviewees mentioned the existence of computer and IT-related competencies as the most important supporting element. Among the inhibiting factors are the lack of IT knowledge, ignorance, ignorance, and low digital competences. The practices that influence the acceptance of Cloud Computing, in terms of experience, knowledge of specific services, knowledge of software, applications and previous positive (IT) experiences support the acceptance and application of the technology. Previous difficulties in using computer programs and adherence to known, used programs appeared as a very important factor contributing to resistance. Among the behavioral barriers to self-efficacy, the interviewees mentioned the following. Self-reflection and the identification of missing (IT) knowledge and skills greatly promote the acceptance and application of Cloud Computing. In contrast, the lack of self-reflection, the lack of recognition of one's own knowledge gaps, and the lack of desire and ability to learn about services and opportunities are extremely important inhibiting factors.

Summarizing the comments of the interviewees, the use and application of Cloud Computing among domestic small and medium-sized enterprises is mostly driven by industry and business-to-business (supplier, customer, partner) relationships, the existence of computer and IT competencies and capabilities, and the role of experts and consultants. and is supported by the resulting education. The factors most hindering the acceptance and application of technology are the fears and concerns related to data protection and data security, which are extremely typical among businesses, the lack of knowledge and skills related to Cloud Computing and IT, as well as the resistance resulting from the age of the decision-makers of the businesses, the aversion to novelty, which characterizes the older generation.

The interviewees' critical comments regarding the SME sector largely referred to the lack of digital competencies typical of small and medium-sized enterprises, and to the lack of knowledge regarding Cloud Computing. All interviewees emphasized the role of age in technology acceptance. However, the respondents also reported positive trends and development in terms of technology acceptance among small and medium-sized enterprises. One of the interviewees explained that new business models have appeared in which the use of cloud-based solutions plays a central role. In his opinion, informal relationships and spontaneous learning from each other play an extremely important role in the domestic entrepreneurial sector. A business that comes across a new IT service, application or new business model at a partner's business becomes a user much more easily. However, in the field of education, the small and medium-sized business sector is driven by the IT companies and professionals who invest sufficient work in mapping, learning about and recommending new technological solutions and services. According to him, the role of IT specialists and consultants in terms of technological education and the support of technological developments is outstanding. Cloud Computing is just one, but extremely important technology solution for businesses, with which its users can enjoy significant benefits, while those who are slower to adapt to technological innovations will be left behind very quickly.

## 8.2 Theses of the research

My doctoral dissertation deals with the techno-management readiness of domestic small and medium-sized enterprises, the challenges affecting the sector, through the examination of the application of Cloud Computing. My research topic involves several scientific disciplines that can be interpreted in their own right, however, when creating the theoretical background of the research, I did not aim to present these disciplines in full, but rather to synthesize them, to outline topics of a multidisciplinary nature that are relevant to the research and can be interpreted at the intersection of different disciplines. The theoretical background of this research is mainly provided by technology management and its area that interacts with strategy, strategic technology management. During the research, I also draw from the scientific field of innovation, primarily regarding the adaptation of technology and the spread of technology, in terms of diffusion. In addition, the subject of my research is the examination of services based on Cloud Computing, focusing on domestic small and medium-sized enterprises. During the theoretical literature processing, i.e., I undertook to process the literature concerning different scientific fields, so the results of the literature research are both related to the description and interpretation framework of the strategic technology management discipline, to the exploration of factors affecting the application and evaluation of technology, to the interpretation and systematization of Cloud Computing (Cloud Computing), and also to the for research concerning small and medium-sized enterprises and their specialties and characteristics. The purpose of my thesis is to investigate whether the factors that support the importance of Cloud Computing, the definable characteristics and advantages of the application of the technology, i.e. the suitability of Cloud Computing to the SME sector, can be confirmed among domestic small and medium-sized enterprises. . The theses of my doctoral dissertation are summarized below.

- **Thesis 1:** There are significant differences between domestic small and medium-sized enterprises, as well as the SME sector and large companies, in terms of the use of Cloud Computing, this difference is not justified in terms of the characteristics of the technology or the infrastructural development of the SME sector.
- **Thesis 2:** The future spread of Cloud Computing in the SME sector will be slower than among large companies, the background of this is the lower willingness of medium-sized enterprises and even more so small enterprises to innovate.
- **Thesis 3:** In relation to the application of Cloud Computing, the strengths of businesses can be identified in relation to their strategic activities and procurement, their weaknesses affect collaborations, protection of technology and learning processes.

- **Thesis 4:** With regard to Cloud Computing, the technology management of enterprises is of a higher standard in terms of internal functions and capabilities, while the supporting factors and pulling mechanisms at the macro and industry level are missing or weak.
- **Thesis 5:** Regarding the acceptance of Cloud Computing in the domestic SME sector, the most important factor is the age of the decision-makers, the older generation is aloof from technological innovations. This is related to the fact that lower-level IT knowledge and skills hinder the use of Cloud Computing, which can be helped by education and relationships between businesses.

The limitation of the research is that I could not rely on representative data regarding domestic small and medium-sized enterprises in terms of the meso-level investigation. Due to the fact that this type of data on the use of Cloud Computing was not available to me, and the available data collection sources did not allow such a level of inquiry, I did not have the opportunity to examine the businesses of the sector based on direct, large-scale data. The future direction of the research may be to expand the expert survey in other groups or by touching on new topics. Regarding the application of Cloud Computing, an additional research opportunity is to examine the topic in the context of strategic techno-management maturity. Taking into account the empirical results, a different future research direction could be if we examine the technology management preparedness of small and medium-sized enterprises in general, not in relation to a specific technology. In this case, we can focus on the extent to which the technology management preparedness of enterprises is influenced by the effects of different environmental levels, i.e. how the contribution of technology management within the company is modified by the supporting and inhibiting effects of the external environment, as well as the presence or absence of individual contribution.

Above, I summarized the most important results of the research along the lines of the research questions. I developed my research questions and the related data collection and analysis methodologies based on the results of the processed literature. During the theoretical research, I looked for the answer to how the practical application of Cloud Computing can be examined from a strategic point of view, with what theoretical background and framework. As a result of processing the theoretical topics involved in the research, I determined the most important points of connection and interpretation of Cloud Computing in the areas of innovation, technology and strategic management. My theoretical research also provided answers to the practical gaps in the topic, which formed the basis of my empirical research and research questions. The novel results of the doctoral research include

- the interpretation of Cloud Computing as a technological innovation,
- the mapping of the examination approaches of technology at different environmental levels (diffusion, evaluation, acceptance) in the context of strategic technomanagement,
- interpretation of data characterizing the use of Cloud Computing in relation to the domestic SME sector and large companies,

- Adapting Hobday's model for assessing technological capabilities to the topic, using the questionnaire survey,
- and the exploration of attitudes related to the acceptance and use of Cloud Computing.

The new results of the research include

- the application of the Bass model to Cloud Computing,
- determination of technological capability levels for companies, the SME sector and the national economy,
- exploring the readiness of internal, individual technology management functions that characterize the application of Cloud Computing, as well as the quality of internal technological capabilities in relation to domestic enterprises,
- the mapping of the existence of external (macro and sectoral) technology management factors influencing the use of Cloud Computing, as well as their supporting and inhibiting effects,
- network analysis of technology management functions affecting Cloud Computing with regard to enterprises, the SME sector and the national economy.

The aim of my research was a practical examination of the suitability of Cloud Computing for the SME sector. Being an exploratory research, I formulated the research questions in order to fulfill my research goals, and examined the research questions using relevant methodologies. The theses described above, the new and innovative results show that my research goal can be considered successful, I gave relevant, scientifically supported answers to the research questions determined based on the processing of the theoretical literature.

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# 10. Annex

## 10.1 Annex 1: Data characterizing the use of Cloud Computing

| Category | Use of a cloud-based service | E-mail | Office software application | Database storage on the Internet | Storing files on the Internet | Use of financial and accounting applications | Using a CRM application | Use of computing capacity |
|---|---|---|---|---|---|---|---|---|
| | | As a cloud-based service | | | | | | |
| **2014 SME** | **7,8** | **5.0** | **3.4** | **2.6** | **3.6** | **2.8** | **1.9** | **1.6** |
| 2014 Small enterprises (10-49 people) | 7.3 | 4.7 | 3.3 | 2.4 | 3.3 | 2.6 | 1.8 | 1.5 |
| 2014 Medium enterprises (50-249 employees) | 11.8 | 6.8 | 4.3 | 3.8 | 5.4 | 3.6 | 2.9 | 2.0 |
| 2014 Large companies (250-) | 18.3 | 10.3 | 6.9 | 5.3 | 9.4 | 5.3 | 4.5 | 3.3 |
| **2015 SME** | **10.1** | **6.6** | **4.0** | **3.2** | **4.9** | **3.3** | **2.5** | **1.7** |
| 2015 Small enterprises (10-49 people) | 9.2 | 6.0 | 3.6 | 2.9 | 4.6 | 3.1 | 2.2 | 1.6 |
| 2015 Medium enterprises (50-249 employees) | 16.0 | 10.7 | 6.7 | 4.8 | 7.1 | 5.2 | 4.2 | 2.5 |
| 2015 Large companies (250-) | 25.7 | 15.2 | 10.8 | 8,9 | 13.8 | 7.5 | 6.9 | 4.6 |
| **2016 SME** | **11.6** | **8.1** | **5.7** | **4.3** | **6.3** | **4.0** | **3.1** | **2.5** |
| 2016 Small enterprises (10-49 people) | 10.5 | 7.3 | 5.1 | 4.0 | 5.7 | 3.6 | 2.7 | 2.4 |
| 2016 Medium enterprises (50-249 employees) | 18.6 | 13.2 | 9.7 | 6.7 | 10.0 | 6.5 | 5.0 | 3.7 |
| 2016 Large companies (250-) | 32.6 | 20.7 | 17.2 | 11.1 | 18.0 | 8.5 | 9.2 | 6.4 |
| **2017 SME** | **15.7** | **10.4** | **8.0** | **5.8** | **8,9** | **5.4** | **4.0** | **4.6** |
| 2017 Small enterprises (10-49 people) | 14.6 | 9.5 | 7.3 | 5.4 | 8.2 | 4.9 | 3.5 | 4.2 |
| 2017 Medium enterprises (50-249 employees) | 23.0 | 16.0 | 12.2 | 8.1 | 13.7 | 8.1 | 7.4 | 7.2 |
| 2017 Large companies (250-) | 38.7 | 23.8 | 21.3 | 13.4 | 22.7 | 11.0 | 11.7 | 12.4 |
| **2018 SME** | **17.3** | **12.6** | **9.6** | **6.6** | **10.1** | **6.1** | **4.6** | **5.2** |
| 2018 Small enterprises (10-49 people) | 15.4 | 11.3 | 8.5 | 6.1 | 9.0 | 5.5 | 4.0 | 4.8 |
| 2018 Medium enterprises (50-249 people) | 29.1 | 21.2 | 16.3 | 9.6 | 17.1 | 10.2 | 8.2 | 8.1 |
| 2018 Large companies (250-) | 45.0 | 28.3 | 27.0 | 17.5 | 28.0 | 12.3 | 14.2 | 15.0 |
| **2019 SME** | **22.5** | **17.3** | **13.1** | **9.2** | **12.9** | **8,9** | **5,6** | **7.1** |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 2019 Small enterprises (10-49 people) | 19.9 | 15.5 | 11.2 | 8.2 | 11.0 | 8.0 | 4.7 | 6.2 |
| 2019 Medium enterprises (50-249 people) | 33.1 | 25.6 | 20.9 | 13.1 | 20.4 | 13.3 | 9.0 | 10.3 |
| 2019 Large companies (250-) | 53.9 | 35.0 | 35.2 | 21.1 | 35.9 | 14.8 | 17.3 | 19.4 |
| **2020 SME** | **24.3** | **17.5** | **14.4** | **11.5** | **16.0** | **9.1** | **5.8** | **7.6** |
| 2020 Small enterprises (10-49 people) | 22.4 | 15.8 | 12.9 | 10.7 | 14.6 | 8.5 | 5.3 | 6.8 |
| 2020 Medium enterprises (50-249 people) | 36.7 | 28.5 | 23.8 | 16.7 | 24.6 | 13.4 | 9.1 | 12.6 |
| 2020 Large companies (250-) | 58.8 | 42.7 | 46.1 | 26.8 | 42.7 | 15.7 | 15.6 | 23.0 |
| **2021 SME** | **25.3** | **18.1** | **15.1** | **11.0** | **15.3** | **10.3** | **5.0** | **7,8** |
| 2021 Small enterprises (10-49 people) | 22.8 | 16.0 | 13.1 | 9.8 | 13.5 | 9.3 | 4.2 | 6.8 |
| 2021 Medium enterprises (50-249 people) | 43.3 | 31.4 | 28.0 | 18.5 | 27.1 | 17.0 | 10.6 | 14.0 |
| 2021 Large companies (250-) | 64.5 | 52.4 | 53.6 | 32.2 | 48.1 | 24.7 | 18.6 | 28.1 |
| **2022 SMEs** | **46.5** | **22.1** | **18.8** | **18.9** | **11.9** | **5.8** | **14.3** | **9.1** |
| 2022 Small enterprises (10-49 people) | 25.7 | 18.5 | 15.2 | 15.7 | 10.3 | 4.4 | 11.7 | 7.0 |
| 2022 Medium enterprises (50-249 employees) | 46.5 | 37.8 | 33.3 | 31.9 | 18.4 | 12.2 | 25.1 | 16.8 |
| 2022 Large companies (250-) | 71.7 | 58.8 | 60.7 | 54.0 | 29.1 | 20.9 | 41.1 | 34.8 |
| **2023 SMEs** | **43.8** | **38.5** | **28.1** | **22.0** | **28.8** | **21.4** | **8.2** | **15.9** |
| 2023 Small enterprises (10-49 people) | 41.2 | 36.2 | 25.6 | 20.7 | 26.8 | 20.4 | 7.2 | 14.8 |
| 2023 Medium enterprises (50-249 employees) | 61.3 | 53.9 | 44.8 | 30.4 | 42.4 | 28.2 | 14.8 | 23.1 |
| 2023 Large companies (250-) | 85.8 | 75.5 | 73.3 | 44.4 | 67.5 | 38.0 | 28.2 | 41.5 |

## 10.2 Annex 2: Estimates of the Bass model regarding the spread of Cloud Computing

| Year | Expected use of cloud-based services among small enterprises | E-mail | Office software application | Database storage on the Internet | Storing files on the Internet | Use of financial and accounting applications | Using a CRM application | Use of computing capacity to run software |
|---|---|---|---|---|---|---|---|---|
| **2014** | 3,096 | 1.623 | 1,296 | 0.859 | 1,590 | 0.809 | 0.504 | 0.642 |
| **2015** | 6,296 | 3,485 | 2,757 | 1,879 | 3,279 | 1.726 | 1,100 | 1,376 |
| **2016** | 9,589 | 5,610 | 4,397 | 3,086 | 5,069 | 2,765 | 1.805 | 2,211 |
| **2017** | 12,963 | 8,018 | 6,229 | 4,507 | 6,960 | 3,938 | 2,635 | 3,161 |
| **2018** | 16,403 | 10,726 | 8,266 | 6,173 | 8,952 | 5,257 | 3,611 | 4,238 |
| **2019** | 19,896 | 13,745 | 10,518 | 8,114 | 11,045 | 6,736 | 4,753 | 5,456 |
| **2020** | 23,424 | 17,080 | 12,994 | 10,357 | 13,235 | 8,388 | 6,085 | 6,827 |
| **2021** | 26,972 | 20,724 | 15,697 | 12,931 | 15,520 | 10,223 | 7,631 | 8,366 |
| **2022** | 30,522 | 24,661 | 18,626 | 15,854 | 17,894 | 12,254 | 9,415 | 10,085 |
| **2023** | 34,058 | 28,862 | 21,776 | 19,141 | 20,354 | 14,487 | 11,463 | 11,997 |
| **2024** | 37,563 | 33,285 | 25,134 | 22,791 | 22,891 | 16,929 | 13,795 | 14,111 |
| **2025** | 41,020 | 37,878 | 28,681 | 26,790 | 25,497 | 19,580 | 16,430 | 16,435 |
| **2026** | 44,415 | 42,579 | 32,394 | 31,110 | 28,164 | 22,439 | 19,379 | 18,973 |
| **2027** | 47,733 | 47,319 | 36,240 | 35,702 | 30,883 | 25,497 | 22,646 | 21,726 |
| **2028** | 50,962 | 52,027 | 40,183 | 40,502 | 33,641 | 28,741 | 26,225 | 24,688 |
| **2029** | 54,090 | 56,636 | 44,183 | 45,433 | 36,427 | 32,153 | 30,095 | 27,849 |
| **2030** | 57,108 | 61,081 | 48,197 | 50,407 | 39,230 | 35,708 | 34,226 | 31,193 |
| **2031** | 60,007 | 65,310 | 52,182 | 55,335 | 42,037 | 39,376 | 38,570 | 34,697 |
| **2032** | 62,782 | 69,279 | 56,096 | 60,131 | 44,836 | 43,123 | 43,070 | 38,332 |
| **2033** | 65,428 | 72,958 | 59,899 | 64,716 | 47,614 | 46,912 | 47,660 | 42,066 |
| **2034** | 67,941 | 76,329 | 63,557 | 69,028 | 50,361 | 50,704 | 52,266 | 45,861 |
| **2035** | 70,321 | 79,384 | 67,041 | 73,018 | 53,064 | 54,460 | 56,814 | 49,678 |
| **2036** | 72,567 | 82,127 | 70,328 | 76,658 | 55,712 | 58,143 | 61,235 | 53,475 |
| **2037** | 74,681 | 84,569 | 73,402 | 79,935 | 58,297 | 61,718 | 65,467 | 57,213 |
| **2038** | 76,664 | 86,725 | 76,253 | 82,849 | 60,810 | 65,155 | 69,457 | 60,855 |
| **2039** | 78,519 | 88,616 | 78,877 | 85,413 | 63,243 | 68,428 | 73,168 | 64,365 |
| **2040** | 80,251 | 90,266 | 81,274 | 87,648 | 65,589 | 71,518 | 76,574 | 67,718 |
| **2041** | 81,864 | 91,696 | 83,451 | 89,580 | 67,843 | 74,409 | 79,665 | 70,888 |
| **2042** | 83,362 | 92,931 | 85,415 | 91,239 | 70,002 | 77,095 | 82,437 | 73,860 |
| **2043** | 84,752 | 93,993 | 87,179 | 92,655 | 72,062 | 79,570 | 84,901 | 76,623 |
| **2044** | 86,038 | 94,904 | 88,754 | 93,856 | 74,022 | 81,837 | 87,072 | 79,172 |
| **2045** | 87,227 | 95,682 | 90,156 | 94,872 | 75,881 | 83,900 | 88,970 | 81,507 |
| **2046** | 88,323 | 96,346 | 91,399 | 95,726 | 77,638 | 85,767 | 90,619 | 83,631 |
| **2047** | 89,333 | 96,911 | 92,496 | 96,444 | 79,295 | 87,447 | 92,043 | 85,552 |
| **2048** | 90,261 | 97,390 | 93,463 | 97,044 | 80,853 | 88,953 | 93,266 | 87,281 |
| **2049** | 91,115 | 97,797 | 94,312 | 97,546 | 82,315 | 90,298 | 94,312 | 88,828 |
| **2050** | 91,898 | 98,141 | 95,056 | 97,964 | 83,684 | 91,493 | 95,204 | 90,207 |
| **2051** | 92,615 | 98,432 | 95,707 | 98,312 | 84,962 | 92,553 | 95,962 | 91,432 |
| **2052** | 93,273 | 98,679 | 96,275 | 98,602 | 86,153 | 93,489 | 96,604 | 92,516 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **2053** | 93,874 | 98,887 | 96,770 | 98,842 | 87,262 | 94,315 | 97,147 | 93,472 |
| **2054** | 94,424 | 99,062 | 97,202 | 99,041 | 88,291 | 95,041 | 97,606 | 94,313 |
| **2055** | 94,926 | 99,210 | 97,576 | 99,207 | 89,246 | 95,678 | 97,992 | 95,051 |
| **2056** | 95,385 | 99,335 | 97,902 | 99,344 | 90,130 | 96,237 | 98,317 | 95,697 |
| **2057** | 95,803 | 99,440 | 98,185 | 99,457 | 90,948 | 96,725 | 98,590 | 96,262 |
| **2058** | 96,184 | 99,529 | 98,430 | 99,551 | 91,703 | 97,152 | 98,819 | 96,756 |
| **2059** | 96,532 | 99,603 | 98,642 | 99,629 | 92,399 | 97,525 | 99,012 | 97,186 |
| **2060** | 96,849 | 99,666 | 98,826 | 99,693 | 93,040 | 97,850 | 99,173 | 97,560 |
| **2061** | 97,137 | 99,719 | 98,986 | 99,746 | 93,631 | 98,133 | 99,308 | 97,886 |
| **2062** | 97,399 | 99,764 | 99,124 | 99,790 | 94,174 | 98,379 | 99,421 | 98,169 |
| **2063** | 97,638 | 99,801 | 99,243 | 99,827 | 94,672 | 98,594 | 99,516 | 98,415 |
| **2064** | 97,855 | 99,833 | 99,346 | 99,857 | 95,130 | 98,780 | 99,595 | 98,628 |
| **2065** | 98,053 | 99,859 | 99,435 | 99,882 | 95,550 | 98,942 | 99,662 | 98,813 |
| **2066** | 98,232 | 99,882 | 99,512 | 99,902 | 95,936 | 99,082 | 99,717 | 98,973 |
| **2067** | 98,396 | 99,900 | 99,579 | 99,919 | 96,288 | 99,204 | 99,764 | 99,112 |
| **2068** | 98,544 | 99,916 | 99,636 | 99,933 | 96,612 | 99,310 | 99,802 | 99,232 |
| **2069** | 98,679 | 99,930 | 99,686 | 99,945 | 96,907 | 99,402 | 99,835 | 99,336 |
| **2070** | 98,801 | 99,941 | 99,729 | 99,954 | 97,178 | 99,482 | 99,862 | 99,426 |
| **2071** | 98,912 | 99,950 | 99,766 | 99,962 | 97,425 | 99,551 | 99,885 | 99,504 |
| **2072** | 99,013 | 99,958 | 99,798 | 99,969 | 97,652 | 99,611 | 99,904 | 99,571 |
| **2073** | 99,104 | 99,965 | 99,826 | 99,974 | 97,858 | 99,663 | 99,919 | 99,629 |
| **2074** | 99,188 | 99,970 | 99,850 | 99,979 | 98,047 | 99,708 | 99,933 | 99,680 |
| **2075** | 99,263 | 99,975 | 99,870 | 99,982 | 98,219 | 99,747 | 99,944 | 99,723 |
| **2076** | 99,331 | 99,979 | 99,888 | 99,986 | 98,377 | 99,781 | 99,953 | 99,761 |
| **2077** | 99,394 | 99,982 | 99,903 | 99,988 | 98,520 | 99,810 | 99,961 | 99,793 |
| **2078** | 99,450 | 99,985 | 99,916 | 99,990 | 98,651 | 99,836 | 99,967 | 99,821 |
| **2079** | 99,501 | 99,988 | 99,928 | 99,992 | 98,771 | 99,858 | 99,973 | 99,846 |
| **2080** | 99,548 | 99,990 | 99,938 | 99,993 | 98,880 | 99,877 | 99,977 | 99,867 |
| **2081** | 99,590 | 99,991 | 99,946 | 99,994 | 98,980 | 99,893 | 99,981 | 99,885 |
| **2082** | 99,628 | 99,993 | 99,954 | 99,995 | 99,070 | 99,907 | 99,984 | 99,901 |
| **2083** | 99,663 | 99,994 | 99,960 | 99,996 | 99,153 | 99,920 | 99,987 | 99,914 |
| **2084** | 99,694 | 99,995 | 99,965 | 99,997 | 99,228 | 99,931 | 99,989 | 99,926 |
| **2085** | 99,722 | 99,996 | 99,970 | 99,997 | 99,297 | 99,940 | 99,991 | 99,936 |
| **2086** | 99,748 | 99,996 | 99,974 | 99,998 | 99,360 | 99,948 | 99,992 | 99,945 |
| **2087** | 99,772 | 99,997 | 99,978 | 99,998 | 99,417 | 99,955 | 99,993 | 99,952 |
| **2088** | 99,793 | 99,997 | 99,981 | 99,999 | 99,469 | 99,961 | 99,995 | 99,959 |
| **2089** | 99,812 | 99,998 | 99,983 | 99,999 | 99,516 | 99,966 | 99,995 | 99,964 |
| **2090** | 99,830 | 99,998 | 99,986 | 99,999 | 99,559 | 99,971 | 99,996 | 99,969 |
| **2091** | 99,846 | 99,998 | 99,988 | 99,999 | 99,599 | 99,975 | 99,997 | 99,973 |
| **2092** | 99,860 | 99,999 | 99,989 | 99,999 | 99,635 | 99,978 | 99,997 | 99,977 |
| **2093** | 99,873 | 99,999 | 99,991 | 99,999 | 99,667 | 99,981 | 99,998 | 99,980 |
| **2094** | 99,885 | 99,999 | 99,992 | 100,000 | 99,697 | 99,984 | 99,998 | 99,983 |
| **2095** | 99,896 | 99,999 | 99,993 | 100,000 | 99,724 | 99,986 | 99,998 | 99,985 |
| **2096** | 99,905 | 99,999 | 99,994 | 100,000 | 99,749 | 99,988 | 99,999 | 99,987 |
| **2097** | 99,914 | 99,999 | 99,995 | 100,000 | 99,771 | 99,989 | 99,999 | 99,989 |
| **2098** | 99,922 | 100.00 | 99,996 | 100,000 | 99,792 | 99,991 | 99,999 | 99,990 |
| **2099** | 99,930 | 100.00 | 99,996 | 100,000 | 99,810 | 99,992 | 99,999 | 99,992 |
| **2100** | 99,936 | 100.00 | 99,997 | 100,000 | 99,827 | 99,993 | 99,999 | 99,993 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **2101** | 99,942 | 100.00 | 99,997 | 100,000 | 99,843 | 99,994 | 99,999 | 99,994 |
| **2102** | 99,947 | 100.00 | 99,998 | 100,000 | 99,857 | 99,995 | 100,000 | 99,995 |
| **2103** | 99,952 | 100.00 | 99,998 | 100,000 | 99,870 | 99,995 | 100,000 | 99,995 |
| **2104** | 99,957 | 100.00 | 99,998 | 100,000 | 99,881 | 99,996 | 100,000 | 99,996 |
| **2105** | 99,961 | 100.00 | 99,998 | 100,000 | 99,892 | 99,997 | 100,000 | 99,997 |
| **2106** | 99,964 | 100.00 | 99,999 | 100,000 | 99,902 | 99,997 | 100,000 | 99,997 |
| **2107** | 99,968 | 100.00 | 99,999 | 100,000 | 99,910 | 99,997 | 100,000 | 99,997 |
| **2108** | 99,971 | 100.00 | 99,999 | 100,000 | 99,918 | 99,998 | 100,000 | 99,998 |
| **2109** | 99,974 | 100.00 | 99,999 | 100,000 | 99,926 | 99,998 | 100,000 | 99,998 |
| **2110** | 99,976 | 100.00 | 99,999 | 100,000 | 99,932 | 99,998 | 100,000 | 99,998 |
| **2111** | 99,978 | 100.00 | 99,999 | 100,000 | 99,938 | 99,999 | 100,000 | 99,999 |
| **2112** | 99,980 | 100.00 | 99,999 | 100,000 | 99,944 | 99,999 | 100,000 | 99,999 |
| **2113** | 99,982 | 100.00 | 100,000 | 100,000 | 99,949 | 99,999 | 100,000 | 99,999 |

| Year | Expected use of cloud-based services among medium-sized enterprises | E-mail | Office software application | Database storage on the Internet | Storing files on the Internet | Use of financial and accounting applications | Using a CRM application | Use of computing capacity to run software |
|---|---|---|---|---|---|---|---|---|
| **2014** | 5,992 | 3,412 | 2,401 | 1,424 | 3,212 | 1,792 | 1,473 | 1,198 |
| **2015** | 11,964 | 7,185 | 5,174 | 3.141 | 6,489 | 3,684 | 3,026 | 2,565 |
| **2016** | 17,871 | 11,313 | 8,347 | 5,196 | 9,821 | 5,676 | 4,661 | 4,119 |
| **2017** | 23,670 | 15,776 | 11,937 | 7,634 | 13,197 | 7,767 | 6,377 | 5,879 |
| **2018** | 29,320 | 20,540 | 15,948 | 10,499 | 16,603 | 9,955 | 8,174 | 7,860 |
| **2019** | 34,786 | 25,557 | 20,366 | 13,825 | 20,028 | 12,236 | 10,052 | 10,077 |
| **2020** | 40,036 | 30,765 | 25,160 | 17,635 | 23,458 | 14,607 | 12,008 | 12,544 |
| **2021** | 45,045 | 36,092 | 30,273 | 21,931 | 26,880 | 17,064 | 14,041 | 15,267 |
| **2022** | 49,793 | 41,459 | 35,631 | 26,689 | 30,282 | 19,599 | 16,148 | 18,250 |
| **2023** | 54,267 | 46,784 | 41,141 | 31,857 | 33,650 | 22,205 | 18,326 | 21,488 |
| **2024** | 58,458 | 51,987 | 46,700 | 37,354 | 36,973 | 24,874 | 20,568 | 24,970 |
| **2025** | 62,363 | 56,996 | 52,200 | 43,069 | 40,239 | 27,596 | 22,871 | 28,676 |
| **2026** | 65,984 | 61,751 | 57,538 | 48,873 | 43,438 | 30,362 | 25,229 | 32,579 |
| **2027** | 69,325 | 66,203 | 62,623 | 54,630 | 46,559 | 33,161 | 27,634 | 36,641 |
| **2028** | 72,394 | 70,319 | 67,382 | 60,206 | 49,594 | 35,981 | 30,080 | 40,818 |
| **2029** | 75,204 | 74,081 | 71,762 | 65,486 | 52,536 | 38,811 | 32,559 | 45,063 |
| **2030** | 77,766 | 77,481 | 75,733 | 70,377 | 55,378 | 41,639 | 35,062 | 49,321 |
| **2031** | 80,094 | 80,524 | 79,282 | 74,818 | 58,115 | 44,452 | 37,581 | 53,541 |
| **2032** | 82,205 | 83,226 | 82,415 | 78,778 | 60,742 | 47,240 | 40,108 | 57,671 |
| **2033** | 84,111 | 85,605 | 85,151 | 82,251 | 63,257 | 49,990 | 42,634 | 61,663 |
| **2034** | 85,831 | 87,686 | 87,517 | 85,254 | 65,658 | 52,694 | 45,149 | 65,479 |
| **2035** | 87,377 | 89,495 | 89,546 | 87,819 | 67,944 | 55,340 | 47,645 | 69,084 |
| **2036** | 88,765 | 91,060 | 91,274 | 89,987 | 70,115 | 57,920 | 50,114 | 72,455 |
| **2037** | 90,009 | 92,407 | 92,737 | 91,803 | 72,171 | 60,425 | 52,547 | 75,575 |
| **2038** | 91,122 | 93,563 | 93,969 | 93,312 | 74,115 | 62,850 | 54,937 | 78,437 |
| **2039** | 92,116 | 94,552 | 95,002 | 94,559 | 75,948 | 65,188 | 57,277 | 81,040 |
| **2040** | 93,004 | 95,394 | 95,865 | 95,583 | 77,673 | 67,434 | 59,561 | 83,389 |
| **2041** | 93,794 | 96,111 | 96,583 | 96,422 | 79,294 | 69,585 | 61,782 | 85,495 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **2042** | 94,498 | 96,719 | 97,180 | 97,106 | 80,814 | 71,638 | 63,936 | 87,371 |
| **2043** | 95,124 | 97,234 | 97,675 | 97,662 | 82,237 | 73,592 | 66,019 | 89,033 |
| **2044** | 95,681 | 97,670 | 98,084 | 98,113 | 83,567 | 75,446 | 68,027 | 90,498 |
| **2045** | 96,175 | 98,039 | 98,423 | 98,478 | 84,808 | 77,200 | 69,958 | 91,784 |
| **2046** | 96,614 | 98,350 | 98,702 | 98,774 | 85,965 | 78,856 | 71,809 | 92,909 |
| **2047** | 97,003 | 98,612 | 98,933 | 99,013 | 87,042 | 80,415 | 73,579 | 93,889 |
| **2048** | 97,348 | 98,833 | 99,122 | 99,205 | 88,043 | 81,880 | 75,268 | 94,741 |
| **2049** | 97,654 | 99,019 | 99,279 | 99,360 | 88,973 | 83,252 | 76,875 | 95,479 |
| **2050** | 97,925 | 99,175 | 99,407 | 99,485 | 89,835 | 84,536 | 78,402 | 96,118 |
| **2051** | 98,165 | 99,307 | 99,513 | 99,586 | 90,634 | 85,735 | 79,848 | 96,669 |
| **2052** | 98,378 | 99,418 | 99,600 | 99,667 | 91,375 | 86,852 | 81,216 | 97,144 |
| **2053** | 98,566 | 99,511 | 99,671 | 99,732 | 92,059 | 87,891 | 82,508 | 97,553 |
| **2054** | 98,732 | 99,589 | 99,730 | 99,785 | 92,692 | 88,856 | 83,724 | 97,905 |
| **2055** | 98,879 | 99,655 | 99,778 | 99,827 | 93,277 | 89,752 | 84,869 | 98,207 |
| **2056** | 99,009 | 99,710 | 99,818 | 99,861 | 93,817 | 90,582 | 85,944 | 98,466 |
| **2057** | 99.125 | 99,757 | 99,851 | 99,888 | 94,316 | 91,349 | 86,952 | 98,688 |
| **2058** | 99,226 | 99,796 | 99,877 | 99,910 | 94,775 | 92,059 | 87,896 | 98,878 |
| **2059** | 99,316 | 99,829 | 99,899 | 99,928 | 95,199 | 92,713 | 88,778 | 99,041 |
| **2060** | 99,396 | 99,856 | 99,917 | 99,942 | 95,589 | 93,317 | 89,603 | 99,180 |
| **2061** | 99,466 | 99,879 | 99,932 | 99,953 | 95,948 | 93,874 | 90,372 | 99,300 |
| **2062** | 99,528 | 99,899 | 99,944 | 99,963 | 96,279 | 94,386 | 91,089 | 99,402 |
| **2063** | 99,583 | 99,915 | 99,954 | 99,970 | 96,583 | 94,858 | 91,757 | 99,489 |
| **2064** | 99,632 | 99,929 | 99,962 | 99,976 | 96,863 | 95,291 | 92,378 | 99,564 |
| **2065** | 99,675 | 99,940 | 99,969 | 99,981 | 97,121 | 95,690 | 92,955 | 99,627 |
| **2066** | 99,713 | 99,950 | 99,975 | 99,984 | 97,357 | 96,055 | 93,491 | 99,682 |
| **2067** | 99,746 | 99,958 | 99,979 | 99,987 | 97,575 | 96,391 | 93,988 | 99,728 |
| **2068** | 99,776 | 99,965 | 99,983 | 99,990 | 97,775 | 96,699 | 94,449 | 99,768 |
| **2069** | 99,802 | 99,970 | 99,986 | 99,992 | 97,959 | 96,981 | 94,877 | 99,802 |
| **2070** | 99,825 | 99,975 | 99,989 | 99,993 | 98,127 | 97,240 | 95,272 | 99,831 |
| **2071** | 99,846 | 99,979 | 99,991 | 99,995 | 98,282 | 97,477 | 95,639 | 99,856 |
| **2072** | 99,864 | 99,982 | 99,992 | 99,996 | 98,424 | 97,694 | 95,978 | 99,877 |
| **2073** | 99,879 | 99,985 | 99,994 | 99,997 | 98,555 | 97,892 | 96,291 | 99,895 |
| **2074** | 99,894 | 99,988 | 99,995 | 99,997 | 98,675 | 98,074 | 96,581 | 99,910 |
| **2075** | 99,906 | 99,990 | 99,996 | 99,998 | 98,785 | 98,241 | 96,849 | 99,923 |
| **2076** | 99,917 | 99,991 | 99,996 | 99,998 | 98,886 | 98,393 | 97,096 | 99,935 |
| **2077** | 99,927 | 99,993 | 99,997 | 99,999 | 98,978 | 98,532 | 97,324 | 99,944 |
| **2078** | 99,935 | 99,994 | 99,998 | 99,999 | 99,063 | 98,659 | 97,535 | 99,952 |
| **2079** | 99,943 | 99,995 | 99,998 | 99,999 | 99,141 | 98,776 | 97,730 | 99,959 |
| **2080** | 99,949 | 99,996 | 99,998 | 99,999 | 99,212 | 98,882 | 97,909 | 99,965 |
| **2081** | 99,955 | 99,996 | 99,999 | 99,999 | 99,278 | 98,979 | 98,074 | 99,970 |
| **2082** | 99,961 | 99,997 | 99,999 | 100,000 | 99,338 | 99,068 | 98,227 | 99,975 |
| **2083** | 99,965 | 99,997 | 99,999 | 100,000 | 99,393 | 99,149 | 98,368 | 99,978 |
| **2084** | 99,969 | 99,998 | 99,999 | 100,000 | 99,444 | 99,223 | 98,497 | 99,982 |
| **2085** | 99,973 | 99,998 | 99,999 | 100,000 | 99,490 | 99,291 | 98,617 | 99,984 |
| **2086** | 99,976 | 99,998 | 100,000 | 100,000 | 99,533 | 99,353 | 98,727 | 99,987 |
| **2087** | 99,979 | 99,999 | 100,000 | 100,000 | 99,572 | 99,409 | 98,828 | 99,989 |
| **2088** | 99,981 | 99,999 | 100,000 | 100,000 | 99,607 | 99,461 | 98,921 | 99,990 |
| **2089** | 99,983 | 99,999 | 100,000 | 100,000 | 99,640 | 99,508 | 99,007 | 99,992 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **2090** | 99,985 | 99,999 | 100,000 | 100,000 | 99,670 | 99,551 | 99,087 | 99,993 |
| **2091** | 99,987 | 99,999 | 100,000 | 100,000 | 99,698 | 99,590 | 99,160 | 99,994 |
| **2092** | 99,989 | 99,999 | 100,000 | 100,000 | 99,723 | 99,626 | 99,227 | 99,995 |
| **2093** | 99,990 | 100,000 | 100,000 | 100,000 | 99,746 | 99,658 | 99,289 | 99,996 |
| **2094** | 99,991 | 100,000 | 100,000 | 100,000 | 99,767 | 99,688 | 99,345 | 99,996 |
| **2095** | 99,992 | 100,000 | 100,000 | 100,000 | 99,787 | 99,716 | 99,398 | 99,997 |
| **2096** | 99,993 | 100,000 | 100,000 | 100,000 | 99,804 | 99,740 | 99,446 | 99,997 |
| **2097** | 99,994 | 100,000 | 100,000 | 100,000 | 99,821 | 99,763 | 99,490 | 99,998 |
| **2098** | 99,995 | 100,000 | 100,000 | 100,000 | 99,836 | 99,784 | 99,531 | 99,998 |
| **2099** | 99,995 | 100,000 | 100,000 | 100,000 | 99,850 | 99,803 | 99,569 | 99,998 |
| **2100** | 99,996 | 100,000 | 100,000 | 100,000 | 99,862 | 99,820 | 99,603 | 99,999 |
| **2101** | 99,996 | 100,000 | 100,000 | 100,000 | 99,874 | 99,836 | 99,635 | 99,999 |
| **2102** | 99,997 | 100,000 | 100,000 | 100,000 | 99,884 | 99,850 | 99,664 | 99,999 |
| **2103** | 99,997 | 100,000 | 100,000 | 100,000 | 99,894 | 99,863 | 99,691 | 99,999 |
| **2104** | 99,997 | 100,000 | 100,000 | 100,000 | 99,903 | 99,875 | 99,716 | 99,999 |
| **2105** | 99,998 | 100,000 | 100,000 | 100,000 | 99,911 | 99,886 | 99,739 | 99,999 |
| **2106** | 99,998 | 100,000 | 100,000 | 100,000 | 99,918 | 99,896 | 99,760 | 99,999 |
| **2107** | 99,998 | 100,000 | 100,000 | 100,000 | 99,925 | 99,905 | 99,779 | 100,000 |
| **2108** | 99,998 | 100,000 | 100,000 | 100,000 | 99,931 | 99,914 | 99,797 | 100,000 |
| **2109** | 99,999 | 100,000 | 100,000 | 100,000 | 99,937 | 99,921 | 99,813 | 100,000 |
| **2110** | 99,999 | 100,000 | 100,000 | 100,000 | 99,942 | 99,928 | 99,828 | 100,000 |
| **2111** | 99,999 | 100,000 | 100,000 | 100,000 | 99,947 | 99,934 | 99,842 | 100,000 |
| **2112** | 99,999 | 100,000 | 100,000 | 100,000 | 99,952 | 99,940 | 99,855 | 100,000 |
| **2113** | 99,999 | 100,000 | 100,000 | 100,000 | 99,956 | 99,945 | 99,866 | 100,000 |

| Year | Expected use of cloud-based services in the SME sector | Expected use of cloud-based services among large companies |
|---|---|---|
| **2014** | 3,508 | 11,253 |
| **2015** | 7,087 | 21,798 |
| **2016** | 10,724 | 31,546 |
| **2017** | 14,403 | 40,442 |
| **2018** | 18,109 | 48,467 |
| **2019** | 21,826 | 55,632 |
| **2020** | 25,538 | 61,968 |
| **2021** | 29,228 | 67,526 |
| **2022** | 32,880 | 72,365 |
| **2023** | 36,481 | 76,553 |
| **2024** | 40,014 | 80,156 |
| **2025** | 43,467 | 83,242 |
| **2026** | 46,829 | 85,874 |
| **2027** | 50,088 | 88,112 |
| **2028** | 53,236 | 90,009 |
| **2029** | 56,265 | 91,613 |
| **2030** | 59,169 | 92,966 |
| **2031** | 61,944 | 94,105 |

| | | |
|---|---|---|
| **2032** | 64,588 | 95,064 |
| **2033** | 67,097 | 95,869 |
| **2034** | 69,473 | 96,544 |
| **2035** | 71,716 | 97,110 |
| **2036** | 73,827 | 97,584 |
| **2037** | 75,811 | 97,981 |
| **2038** | 77,669 | 98,313 |
| **2039** | 79,406 | 98,591 |
| **2040** | 81,027 | 98,823 |
| **2041** | 82,536 | 99,017 |
| **2042** | 83,940 | 99,180 |
| **2043** | 85,242 | 99,315 |
| **2044** | 86,448 | 99,428 |
| **2045** | 87,565 | 99,523 |
| **2046** | 88,597 | 99,602 |
| **2047** | 89,549 | 99,667 |
| **2048** | 90,427 | 99,722 |
| **2049** | 91,235 | 99,768 |
| **2050** | 91,979 | 99,807 |
| **2051** | 92,663 | 99,839 |
| **2052** | 93,291 | 99,865 |
| **2053** | 93,868 | 99,888 |
| **2054** | 94,397 | 99,906 |
| **2055** | 94,881 | 99,922 |
| **2056** | 95,325 | 99,935 |
| **2057** | 95,732 | 99,945 |
| **2058** | 96,104 | 99,955 |
| **2059** | 96,445 | 99,962 |
| **2060** | 96,756 | 99,968 |
| **2061** | 97,040 | 99,974 |
| **2062** | 97,301 | 99,978 |
| **2063** | 97,538 | 99,982 |
| **2064** | 97,755 | 99,985 |
| **2065** | 97,953 | 99,987 |
| **2066** | 98,134 | 99,989 |
| **2067** | 98,299 | 99,991 |
| **2068** | 98,450 | 99,993 |
| **2069** | 98,587 | 99,994 |
| **2070** | 98,712 | 99,995 |
| **2071** | 98,826 | 99,996 |
| **2072** | 98,931 | 99,996 |
| **2073** | 99,026 | 99,997 |
| **2074** | 99,112 | 99,997 |
| **2075** | 99,191 | 99,998 |
| **2076** | 99,263 | 99,998 |
| **2077** | 99,329 | 99,999 |
| **2078** | 99,389 | 99,999 |
| **2079** | 99,443 | 99,999 |

| | | |
|---|---|---|
| **2080** | 99,493 | 99,999 |
| **2081** | 99,538 | 99,999 |
| **2082** | 99,579 | 99,999 |
| **2083** | 99,617 | 100,000 |
| **2084** | 99,651 | 100,000 |
| **2085** | 99,682 | 100,000 |
| **2086** | 99,710 | 100,000 |
| **2087** | 99,736 | 100,000 |
| **2088** | 99,760 | 100,000 |
| **2089** | 99,781 | 100,000 |
| **2090** | 99,801 | 100,000 |
| **2091** | 99,818 | 100,000 |
| **2092** | 99,835 | 100,000 |
| **2093** | 99,849 | 100,000 |
| **2094** | 99,863 | 100,000 |
| **2095** | 99,875 | 100,000 |
| **2096** | 99,886 | 100,000 |
| **2097** | 99,896 | 100,000 |
| **2098** | 99,906 | 100,000 |
| **2099** | 99,914 | 100,000 |
| **2100** | 99,922 | 100,000 |
| **2101** | 99,929 | 100,000 |
| **2102** | 99,935 | 100,000 |
| **2103** | 99,941 | 100,000 |
| **2104** | 99,946 | 100,000 |
| **2105** | 99,951 | 100,000 |
| **2106** | 99,955 | 100,000 |
| **2107** | 99,959 | 100,000 |
| **2108** | 99,963 | 100,000 |
| **2109** | 99,966 | 100,000 |
| **2110** | 99,969 | 100,000 |
| **2111** | 99,972 | 100,000 |
| **2112** | 99,975 | 100,000 |
| **2113** | 99,977 | 100,000 |

## 10.3 Appendix 3: Evaluation structure of Hobday's (2002) Technology Needs Assessment (TNA) model

| Sequence number of statements | National economic level | Strongly disagree (1) | Rather disagree (2) | Rather agree (3) | Strongly agree (4) |
|---|---|---|---|---|---|
| 1 | Technology plays an important part in our national development strategy. | | | | |
| 2 | Our government's technology policy priorities are clear and coherent. | | | | |
| 3 | Our technology policy is agreed and understood by key national actors. | | | | |
| 4 | Our government can assess technology threats and opportunities rapidly. | | | | |
| 5 | We are able to evaluate the effectiveness of our environmental policies. | | | | |
| 6 | Environmental issues are given a very high priority. | | | | |
| 7 | Technology policy responsibilities are delegated to the correct bodies within government | | | | |
| 8 | We are able to revise our policies quickly in the light of new environmental (EST) demands. | | | | |
| 9 | Most of our initiatives are driven by industry needs. | | | | |
| 10 | We contribute to international technology groups and forums. | | | | |
| 11 | We are able to support leading sectors in the acquisition of technology from abroad. | | | | |
| 12 | We are able to help our leading sectors form technology strategies. | | | | |
| 13 | We are able to help industry implement EST projects effectively. | | | | |
| 14 | Our technology institutes are effective at meeting industries' needs. | | | | |
| 15 | We have a wide range of technology acquisition mechanisms to meet industry needs. | | | | |
| 16 | Industrialists believe our technology representatives are highly skilled. | | | | |
| 17 | Our technology acquisition mechanisms help us catch up with advanced countries. | | | | |
| 18 | Our policies help us to shape environmental technologies to our advantage. | | | | |
| 19 | We have specific groups responsible for ESTs. | | | | |
| 20 | Our technology groups gain valuable knowledge and experience from working with international agencies. | | | | |
| 21 | Our technology acquisition mechanisms change rapidly according to new external EST regulations. | | | | |
| 22 | We are able to adjust our technology priorities rapidly. | | | | |
| 23 | We can point to several major government-led technology achievements. | | | | |
| 24 | We met our environmental technology | | | | |

| Sequence number of statements | National economic level | Strongly disagree (1) | Rather disagree (2) | Rather agree (3) | Strongly agree (4) |
|---|---|---|---|---|---|
| | targets last year. | | | | |
| 25 | We know our EST priorities for the next five years. | | | | |
| 26 | We regularly ask firms for their views on our technology performance. | | | | |
| 27 | We are able to charge companies for participation in our programmes. | | | | |
| 28 | Our technology programmes are run efficiently. | | | | |
| 29 | Our EST initiatives are generally low cost but high value. | | | | |
| 30 | Our technology initiatives contribute directly to export generation. | | | | |

| Sequence number of statements | Sector level | Strongly disagree (1) | Rather disagree (2) | Rathe r agree (3) | Strongly agree (4) |
|---|---|---|---|---|---|
| 1 | This sector plays a key part in our national development strategy. | | | | |
| 2 | Our sector's technology priorities are clearly defined. | | | | |
| 3 | Our sector's technology strategy is understood and shared by the key actors involved. | | | | |
| 4 | We have learned a great deal from previous sector projects. | | | | |
| 5 | We are acquiring new EST's rapidly. | | | | |
| 6 | The sector is able to diffuse ESTs rapidly to large and small firms. | | | | |
| 7 | Our strategy is geared towards increasing exports and raising wages. | | | | |
| 8 | We are able to revise our strategies quickly in the light of new environmental needs. | | | | |
| 9 | Most of our initiatives are driven by industry needs. | | | | |
| 10 | Our sector contributes to international sector bodies. | | | | |
| 11 | We work with all the key players in our sector. | | | | |
| 12 | Major firms play a key role in developing our strategy. | | | | |
| 13 | Our sector is well represented in Government. | | | | |
| 14 | Our sector groups are well informed as to new EST requirements. | | | | |
| 15 | Our technology acquisition mechanisms work well at the supply chain level. | | | | |
| 16 | We know exactly 'who is responsible for what' in dealing with EST issues in our sector. | | | | |
| 17 | We have a wide range of technology acquisition mechanisms (e.g. institutes, programmes, projects). | | | | |
| 18 | 18 Our education/training approach ensures a goods supply of technical skilled people in | | | | |

| Sequence number of statements | Sector level | Strongly disagree (1) | Rather disagree (2) | Rathe r agree (3) | Strongly agree (4) |
|---|---|---|---|---|---|
| | our area. | | | | |
| 19 | We evaluate the effectiveness of our environmental projects. | | | | |
| 20 | Our sector groups are able to influence international agencies dealing with technology. | | | | |
| 21 | The leading firms believe our technology strategy is being implemented effectively. | | | | |
| 22 | We regularly consult with industry to assess our sector's EST performance. | | | | |
| 23 | We can point to several major EST project achievements. | | | | |
| 24 | Environmental regulations pose no threat to our export targets. | | | | |
| 25 | The costs of our technology acquisition programmes are greatly exceeded by the benefits. | | | | |
| 26 | We are meeting our employment and export goals. | | | | |
| 27 | Industrial users are happy to pay for our commercial EST services. | | | | |
| 28 | Our programmes mechanisms are regularly reviewed for their efficiency and effectiveness. | | | | |
| 29 | Our technology initiatives are low cost but high value. | | | | |
| 30 | Our future sector initiatives are likely to be met. | | | | |

| Sequence number of statements | Enterprise level | Strongly disagree (1) | Rather disagree (2) | Rather agree (3) | Strongly agree (4) |
|---|---|---|---|---|---|
| 1 | My company is well aware of the technologies most important to its business. | | | | |
| 2 | Technology plays an important part in my company's business strategy. | | | | |
| 3 | My firm is well equipped to assess technological opportunities. | | | | |
| 4 | My company can assess technology threats without difficulty. | | | | |
| 5 | My company has special technological strengths which it is able to exploit. | | | | |
| 6 | My company knows which technologies to outsource and which to develop internally. | | | | |
| 7 | Our management is skilled at formulating a technology strategy to meet business goals. | | | | |
| 8 | Our firm knows its main technology priorities. | | | | |
| 9 | Our firm has a well developed technology 'vision'. | | | | |
| 10 | Our firm knows how to select the technology needed for its business. | | | | |

| Sequence number of statements | Enterprise level | Strongly disagree (1) | Rather disagree (2) | Rather agree (3) | Strongly agree (4) |
|---|---|---|---|---|---|
| **11** | Our company knows which are the best sources of technology. | | | | |
| **12** | Our company is effective at acquiring technology from external sources. | | | | |
| **13** | Our company has good links with important external suppliers of technology. | | | | |
| **14** | Our technology activities (e.g. engineering and R&D) are organised effectively within our company. | | | | |
| **15** | We have clear processes for carrying out technology projects. | | | | |
| **16** | Our company has a good system for assessing technology projects. | | | | |
| **17** | Our firm carries out post-project reviews. | | | | |
| **18** | We are able to learn from one technology project to another. | | | | |
| **19** | Government policies encourage us to invest in technology. | | | | |
| **20** | We use external organisations (e.g. consultancy firms) to assist us with technology assessment. | | | | |
| **21** | We use outside bodies to help us develop technology. | | | | |
| **22** | External organisations help us implement our technology strategy. | | | | |
| **23** | We work with universities in key technology projects. | | | | |
| **24** | We work with government research institutes in important technology projects. | | | | |

## 10.4 annex: The questions of the questionnaire survey before the validation

| Sequence number of statements | National economic level | Strongly disagree (1) | Rather disagree (2) | Rather agree (3) | Strongly agree (4) |
|---|---|---|---|---|---|
| **1** | Digital technologies play an important role in the development strategy of the national economy. | | | | |
| **2** | The government's policy priorities regarding digital technologies are clear and coherent. | | | | |
| **3** | The government is able to assess the threats and opportunities related to digital technologies and to inform the relevant economic actors about this. | | | | |
| **4** | The government has created an appropriate institutional and organizational background for policy tasks related to digital technologies. | | | | |
| **5** | The government's objectives and programs concerning digital technologies are guided by the needs of businesses and companies. | | | | |
| **6** | The government is able to support enterprises and companies in the effective implementation of their digitization developments. | | | | |
| **7** | On the part of the government, a wide range of programs is available to enterprises and companies to support digitalization-related collaborations. | | | | |
| **8** | The government's procurement mechanisms for digital technologies help to catch up with the more developed countries of the European Union than the average. | | | | |
| **9** | The government's policy and regulatory background effectively supports the exploitation of digital technologies. | | | | |
| **10** | Institutions and organizations responsible for the development of domestic digital technologies gain valuable knowledge and experience during cooperation with international institutions. | | | | |
| **11** | Key government developments and achievements regarding digital technologies can be identified. | | | | |
| **12** | Businesses and companies know the government's priorities for Cloud Computing for the next six years. | | | | |
| **13** | The government regularly measures the performance of businesses and companies with regard to digital technologies. | | | | |
| **14** | Government digital technology programs work effectively. | | | | |

| Sequence number of statements | Sector level | Strongly disagree (1) | Rather disagree (2) | Rather agree (3) | Strongly agree (4) |
|---|---|---|---|---|---|
| **1** | The SME sector plays a key role in the government's digitalization strategy. | | | | |
| **2** | Regarding the SME sector, the government's priorities regarding digital technologies are clearly defined. | | | | |
| **3** | In the SME sector, Cloud Computing has spread and is spreading rapidly. | | | | |
| **4** | Enterprises in the SME sector are able to revise their technological strategy when environmental factors change. | | | | |
| **5** | The use of Cloud Computing in the SME sector is driven by industry needs. | | | | |
| **6** | The actors of the SME sector are well represented in government institutions and organizations. | | | | |
| **7** | Enterprises in the SME sector are sufficiently informed about the policy affecting digital technologies. | | | | |
| **8** | In terms of supply chains in the SME sector, Cloud Computing procurement is working well. | | | | |
| **9** | Enterprises in the SME sector have a wide range of collaborations involving digital technologies at their disposal. | | | | |
| **10** | Education and training programs provide a good supply of professionals with technical and IT qualifications in the SME sector. | | | | |
| **11** | Enterprises in the SME sector effectively create and implement their digital technologies strategy. | | | | |
| **12** | For the companies of the SME sector, the costs of developments involving Cloud Computing are greatly exceeded by the benefits that can be realized from them. | | | | |
| **13** | Developments involving digital technologies in the SME sector effectively support the growth of employment and exports. | | | | |
| **14** | Enterprises in the SME sector are happy to pay for services based on Cloud Computing. | | | | |

| Sequence number of statements | Enterprise level | Strongly disagree (1) | Rather disagree (2) | Rather agree (3) | Strongly agree (4) |
|---|---|---|---|---|---|
| **1** | The company is well aware of the most important technologies for its business activities. | | | | |
| **2** | The application of technology plays an important role in the company's business strategy. | | | | |
| **3** | The company is prepared to evaluate the opportunities offered by the technology. | | | | |
| **4** | The company can easily assess technological threats. | | | | |
| **5** | The company has special technological | | | | |

| Sequence number of statements | Enterprise level | Strongly disagree (1) | Rather disagree (2) | Rather agree (3) | Strongly agree (4) |
|---|---|---|---|---|---|
| | strengths that it can exploit. | | | | |
| **6** | The company knows which technology should be developed "in-house" and which should be outsourced. | | | | |
| **7** | The company's senior management is skilled in developing the technology strategy necessary to achieve business goals. | | | | |
| **8** | The company knows its main priorities regarding technology. | | | | |
| **9** | The company has a well-developed vision for technology. | | | | |
| **10** | The company knows how to select the technologies necessary for the operation of the company. | | | | |
| **11** | The company knows the best sources for acquiring technology. | | | | |
| **12** | The company can effectively acquire technology from external sources. | | | | |
| **13** | The company has good relations with important external suppliers regarding technology. | | | | |
| **14** | Within the company, technological activities (e.g. IT, engineering, R&D areas) are efficiently organized. | | | | |
| **15** | The company has clear processes for the implementation of technology projects (e.g. investment, development, procurement). | | | | |
| **16** | The company has a good system for evaluating technology projects. | | | | |
| **17** | The company conducts post-project evaluations of technology projects. | | | | |
| **18** | The company can learn from a technology project. | | | | |
| **19** | Government policy encourages companies to invest in technology. | | | | |
| **20** | The company uses external organizations (e.g. consulting companies, service providers) for technology evaluation. | | | | |
| **21** | The company uses external organizations (e.g. consulting companies, service providers) to develop the technology. | | | | |
| **22** | The company uses external organizations (e.g. consulting firms, service providers) in order to implement the technology strategy. | | | | |
| **23** | The company works together with universities and research institutes in key technological projects. | | | | |
| **24** | The company works with government institutions, organizations and research institutes in key technological projects. | | | | |

## 10.5 Appendix 5: Structure of the questionnaire survey

| Demographic and screening questions | Possible answers |
|---|---|
| What is the name of the company you work for? (it is not mandatory to fill in, entering the name does not serve to identify the person filling in) | Individual response. |
| In what position/job do you work at the company? | • Managing Director<br>• Senior manager<br>• Middle manager<br>• Group leader<br>• Employed |
| What year was the company founded? | Individual response. |
| Based on the number of employees, in which category can the company be classified? | • Small business<br>• Medium enterprise |
| In which county (or capital city) is the company headquartered? | Individual response. |
| In which municipality is the headquarters of the company located? | Individual response. |
| How many employees does the company have? | Individual response. |
| Does the business use a service based on Cloud Computing? | • Yes<br>• Not |
| How long has the business been using a cloud-based service? | • 2-3 years ago<br>• 4-5 years ago<br>• 5-10 years ago<br>• 10-15 years ago<br>• More than 15 years ago |
| If so, what types of services does the business use? (multiple answers can be marked) | • Email service<br>• Office software application<br>• Database storage on the Internet<br>• Storing files on the Internet<br>• Use of financial and accounting applications<br>• Using a CRM application<br>• Use of computing capacity by running software |
| In your opinion, what are the most important advantages of Cloud Computing for domestic small and medium-sized enterprises? (A maximum of three answers can be marked.) | • Low infrastructure costs<br>• Reduction of investment risks<br>• Possibility of cooperation<br>• Speed, efficiency<br>• Accessibility, availability<br>• The possibility of sharing information<br>• Reliability<br>• Flexibility and customization of systems<br>• Scalability, scalability<br>• Possibilities inherent in services |
| In your opinion, what are the most important disadvantages of Cloud Computing for domestic small and medium-sized enterprises? (A maximum of three answers can be marked.) | • Questions related to data protection and data security<br>• Access problems, network dependency<br>• Lack of information, lack of knowledge about systems and services<br>• A cumbersome, complicated application<br>• Language addiction<br>• Platform dependency<br>• Distrust of systems<br>• Lack of standards, interoperability<br>• Problems with accessing service providers<br>• Difficulties related to learning and application |

| Concept | Concept interpretation, definition |
|---|---|
| Technology | Any tool, technique, product or process, or equipment or method for doing something, with which human abilities and possibilities can be expanded. (Schön, 1967) |
| Technology strategy | Identification, selection, acquisition, application and protection of specific technologies, technological competences and knowledge elements necessary for the company, i.e. management of the company's technology portfolio. (Burgelman et al., 2001) |
| Cloud Computing | Cloud Computing is an IT model that enables users to access shared, customizable computer resources from anywhere, conveniently, and on demand. Services based on Cloud Computing (such as networks, servers, storage, applications and other services) are available quickly and require minimal management effort or interaction with the service provider. Cloud Computing can be applied as computer software, platform or infrastructure. (Mell & Grance, 2011) |
| A service based on Cloud Computing | It is a service built or used by the company, the IT background of which is provided by Cloud Computing. |
| Digital technologies | Technologies based on digitization or created as a result of it (e.g. online technologies, ICT, Big Data, Cloud Computing, AI, AR, etc.). (National Digitalization Strategy, 2022) |
| Digitization strategy | The 2022-2030- government strategy reflecting the expected challenges of the period. (National Digitalization Strategy, 2022) |

| Statement related to technology management function | Strongly disagree (1) | Rather disagree (2) | Rather agree (3) | Strongly agree (4) |
|---|---|---|---|---|
| Businesses are well aware of the most important Cloud Computing for their business activities. | | | | |
| Businesses know how to choose the Cloud Computing they need to run their business. | | | | |
| Businesses are prepared to evaluate the opportunities offered by Cloud Computing. | | | | |
| Businesses can easily assess the threats associated with Cloud Computing. | | | | |
| Enterprises have a well-developed vision for Cloud Computing. | | | | |
| Businesses know the best sources for Cloud Computing. | | | | |
| The application of Cloud Computing plays an important role in the corporate and business strategy of enterprises. | | | | |
| Enterprises use external organizations (e.g. consulting firms, service providers) for Cloud Computing evaluation. | | | | |
| The top management of the companies is skilled in the development of the technological strategy necessary to achieve business goals regarding Cloud Computing. | | | | |
| Businesses know their main priorities regarding Cloud Computing. | | | | |
| Businesses can effectively acquire Cloud Computing from external sources. | | | | |
| Enterprises have good relationships with important third-party suppliers for Cloud Computing. | | | | |
| Government policy encourages businesses to invest in Cloud Computing. | | | | |

| Statement related to technology management function | Strongly disagree (1) | Rather disagree (2) | Rather agree (3) | Strongly agree (4) |
|---|---|---|---|---|
| Enterprises use external organizations (e.g. consulting firms, service providers) in the development of Cloud Computing. | | | | |
| Enterprises work together with universities and research institutes in projects involving Cloud Computing. | | | | |
| Enterprises work together with government institutions, organizations and research institutes in projects related to Cloud Computing. | | | | |
| Within the enterprises, the technological activities (e.g.: IT, engineering, R&D areas) are efficiently organized with regard to Cloud Computing. | | | | |
| Enterprises have clear processes for the implementation of projects involving Cloud Computing (e.g. investment, development, procurement). | | | | |
| Enterprises use external organizations (e.g. consulting firms, service providers) in order to implement the technological strategy regarding Cloud Computing. | | | | |
| Businesses have particular strengths in Cloud Computing that they can leverage. | | | | |
| Businesses know which services based on Cloud Computing should be developed "in-house" and which should be outsourced. | | | | |
| Businesses are aware of the risks and dangers associated with the use of Cloud Computing. | | | | |
| Businesses are able to build effective defenses against Cloud Computing. | | | | |
| Businesses know how to securely build or acquire Cloud Computing. | | | | |
| Businesses are aware of the intellectual property rights issues related to Cloud Computing. | | | | |
| Businesses have good systems in place for evaluating projects involving Cloud Computing. | | | | |
| Businesses conduct post-project evaluations of Cloud Computing. | | | | |
| Businesses are able to learn from a project, they are able to use the experience of the project later in relation to Cloud Computing. | | | | |
| Enterprises in the SME sector have the skills to identify opportunities and threats related to Cloud Computing. | | | | |
| Enterprises in the SME sector are able to review their technology strategy and technology portfolio in the event of changes in environmental factors. | | | | |
| In the SME sector, the acquisition of Cloud Computing works well. | | | | |
| For the companies of the SME sector, the costs of developments involving Cloud Computing are greatly exceeded by the benefits that can be realized from them. | | | | |
| Enterprises in the SME sector are aware of the opportunities and tools for protecting intellectual property in relation to Cloud Computing. | | | | |
| Enterprises in the SME sector are able to review the | | | | |

| Statement related to technology management function | Strongly disagree (1) | Rather disagree (2) | Rather agree (3) | Strongly agree (4) |
|---|---|---|---|---|
| efficiency and effectiveness of their technological developments in terms of Cloud Computing. | | | | |
| The government and government policy institutions effectively inform businesses about technological threats and opportunities. | | | | |
| The government's policy priorities regarding digital technologies are clear and coherent. | | | | |
| The government and government policy institutions support cooperation between businesses regarding the acquisition and development of digital technologies. | | | | |
| The government's policy and regulatory background effectively supports the exploitation (dissemination, utilization of capacities) of digital technologies. | | | | |
| Government policy can provide effective support for the protection of companies' digital technologies. | | | | |
| The government and government policy institutions regularly measure the performance of businesses with regard to digital technologies. | | | | |

## 10.6 Annex 6: Characteristic data of the variables

| Environmental level | Function | Variable | Average | Spread | Median | Mode |
|---|---|---|---|---|---|---|
| Corporate | IDENTIFICATION | Knowledge of technology from a business perspective | 3.32 | 0.589 | 3.00 | 4 |
| | | Selection of necessary technologies | 3.21 | 0.714 | 3.00 | 4 |
| | | Evaluation of opportunities | 3.35 | 0.660 | 4.00 | 4 |
| | | Threat assessment | 2.82 | 0.756 | 3.00 | 3 |
| | | Having a vision | 2.97 | 0.757 | 3.00 | 3 |
| | SELECTION | Knowledge of procurement sources | 2.94 | 0.663 | 3.00 | 3 |
| | | The role of technology in corporate and business strategy | 3.32 | 0.589 | 3.50 | 4 |
| | | Using external organizations to evaluate the technology | 2.09 | 1,295 | 2.00 | 1 |
| | | Proficiency in technology strategy development | 3.03 | 0.635 | 3.00 | 3 |
| | | Knowledge of priorities in relation to technology | 3.18 | 0.695 | 3.00 | 4 |
| | ACQUISITION | Acquisition of technology | 3.15 | 0.553 | 3.00 | 3 |
| | | Relationship with suppliers | 3.06 | 0.966 | 3.00 | 3 |
| | | Encouraging investments | 1.94 | 0.724 | 2.00 | 2 |
| | | Use of external organizations in development | 2.24 | 0.913 | 2.00 | 2 |
| | | Cooperation in development with universities and research institutes | 1.21 | 0.350 | 1.00 | 1 |
| | | Cooperation in development with government institutions | 1.21 | 0.350 | 1.00 | 1 |
| | EXPLOITATION | Organization of technological activities | 2.76 | 0.852 | 3.00 | 3 |
| | | Existence of project processes (investment, development, procurement). | 2.56 | 0.678 | 3.00 | 3 |
| | | Use of external organizations in the implementation of the strategy | 2.38 | 1,274 | 2.00 | 1 |
| | | Exploitation of special strengths | 2.71 | 0.759 | 3.00 | 3 |
| | | Ability to decide on outsourcing or own development | 3.06 | 0.724 | 3.00 | 3 |
| | PROTECTION | Technological risks and dangerous knowledge | 3.03 | 0.696 | 3.00 | 3 |
| | | Building effective protection | 3.03 | 0.393 | 3.00 | 3 |
| | | Knowledge of secure procurement and development | 3.06 | 0.602 | 3.00 | 3 |
| | | Knowledge of intellectual property rights | 2.50 | 0.864 | 2.00 | 2 |
| | LEARNING | Existence of project evaluation systems | 2.29 | 0.578 | 2.00 | 2 |
| | | Existence of post-project evaluations | 2.44 | 0.860 | 2.00 | 2 |
| | | Ability to learn from projects | 2.88 | 0.652 | 3.00 | 3 |
| SME sector | IDENTIFICATION | Identification of opportunities and threats in the SME sector | 2.35 | 0.357 | 2.00 | 2 |
| | SELECTION | Technology strategy, technoportfolio in the SME sector | 2.35 | 0.538 | 2.00 | 2 |
| | ACQUISITION | Procurement quality in the SME sector | 2.35 | 0.902 | 2.00 | 2 |
| | EXPLOITATION | Advantages of Cloud Computing in the SME sector | 2.32 | 0.953 | 2.00 | 2 |
| | PROTECTION | Knowledge of intellectual property protection in the SME sector | 1.94 | 0.360 | 2.00 | 2 |
| | LEARNING | Review of developments in the SME sector | 2.12 | 0.410 | 2.00 | 2 |
| National economic | IDENTIFICATION | Government support for identifying opportunities and threats | 1.97 | 0.696 | 2.00 | 2 |
| | SELECTION | Awareness and quality of government policy priorities | 1.79 | 0.411 | 2.00 | 2 |
| | ACQUISITION | Government support for collaborations and procurement processes | 2.24 | 0.852 | 2.00 | 2 |
| | EXPLOITATION | Government support for the exploitation of digital technologies | 2.15 | 1,038 | 2.00 | 2 |
| | PROTECTION | Government support for technology protection | 1.85 | 0.493 | 2.00 | 2 |
| | LEARNING | Measuring the performance of enterprises at | 2.09 | 0.871 | 2.00 | 2 |

| Environmental level | Function | Variable | Average | Spread | Median | Mode |
|---|---|---|---|---|---|---|
| | | the government level | | | | |

## 10.7 Annex 7: Questions of the semi-structured interviews

| Question number | Group of questions | Question |
|---|---|---|
| 1. | Introductory, general questions | Based on representative data from the KSH, in 2023 the rate of use of Cloud Computing was 41.2 percent for small enterprises and 61.3 percent for medium-sized enterprises. This is significantly lower than the 85.8 percent of large companies. What do you think could be behind this? How would you rate the level of use of Cloud Computing among small and medium-sized enterprises? |
| 2. | | Services based on Cloud Computing appeared among domestic businesses about 15 years ago. It is considered a mature technology that is particularly well suited to the specialties of the SME sector. How true do you think it is for domestic small and medium-sized enterprises that they have adequate knowledge and skills regarding the importance of Cloud Computing? |
| 3. | Validation and interpretation of questionnaire survey results | The expert questionnaire survey carried out as part of the research yielded the following results regarding the advantages of Cloud Computing. What do you think about this? |
| 4. | | The expert questionnaire survey carried out as part of the research yielded the following results regarding the disadvantages of Cloud Computing. What do you think about this? |
| 5. | Personal factors influencing the acceptance and use of technology | How do you think the prior knowledge of Cloud Computing affects the acceptance and use of the technology among domestic small and medium-sized enterprises? What supporting or hindering factors could you mention in relation to prior knowledge of Cloud Computing? |
| 6, | | How do you think the expectations that can be identified in relation to Cloud Computing influence the acceptance and use of the technology among domestic small and medium-sized enterprises? What supporting or hindering factors could you mention in relation to prior expectations regarding Cloud Computing? |
| 7. | | What do you think, how do typical attitudes towards Cloud Computing affect the acceptance and use of the technology among domestic small and medium-sized enterprises? What supporting and hindering factors could you mention regarding attitudes towards Cloud Computing? |
| 8. | External factors affecting the acceptance and use of technology | How do you think the typical social norms related to Cloud Computing influence the acceptance and use of the technology among domestic small and medium-sized enterprises? What supporting and hindering factors could you mention regarding the social norms affecting Cloud Computing? |
| 9. | | How do you think the community relations typical of Cloud Computing influence the acceptance and use of the technology among domestic small and medium-sized enterprises? What supporting and hindering factors could you mention with regard to community relations involving Cloud Computing? |
| 10. | | What do you think about Cloud Computing, how does the influencing power of the community affect the acceptance and use of the technology among domestic small and medium-sized enterprises? What supporting or hindering factors could you mention regarding the influencing power of the community regarding Cloud Computing? |
| 11. | Behavioral factors influencing the acceptance and use of technology | How do you think the capabilities and competencies that can be identified in connection with Cloud Computing influence the acceptance and use of the technology among domestic small and medium-sized enterprises? What supporting or inhibiting factors could you mention in relation to the |

| | | |
|---|---|---|
| | | necessary and/or missing skills and competence elements related to Cloud Computing? What behavioral barriers can we infer from these? |
| **12.** | | How do you think typical practices and knowledge related to Cloud Computing influence the acceptance and use of the technology among domestic small and medium-sized enterprises? What supporting or hindering factors could you mention regarding practice and knowledge related to Cloud Computing? What behavioral barriers can we infer from these? |
| **13.** | | How do you think the self-efficacy that can be identified in connection with Cloud Computing affects the acceptance and use of the technology among domestic small and medium-sized enterprises? What supporting or hindering factors could Cloud Computing mention in relation to self-efficacy and self-reflection skills? What behavioral barriers can we infer from these? |
| **14.** | Closing questions | In terms of your own experiences, opinions, and the discussed topics, how do you generally see the behavior and characteristics of the SME sector regarding the acceptance and use of technology? |
| **15.** | | Regarding the topics and concepts covered in the interview, do you have any additional comments or observations that could supplement and expand the information revealed? |